1st International Meeting of the Young Transportations Geotechnics Engineers of the ISSMGE

September 4th 2016 - School of Sciences - University of Minho

3rd International Conference on Transportation Geotechnics
September 2016 | Guimarães | Portugal

1st International Meeting of the Young Transportations Geotechnics Engineers of the ISSMGE (1st YTGE meeting)

September 4th 2016
School of Sciences, University of Minho
Guimarães

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1st International Meeting of the Young Transportations Geotechnics Engineers of the ISSMGE

3rd International Conference on Transportation Geotechnics

September 4th 2016 | Guimarães | Portugal

Venue:

University of Minho, School of Science, Guimarães, Portugal

Website:

http://civil.uminho.pt/3rd-ICTG2016/YTGE.php

Editors:

Joaquim Tinoco | ISISE - University of Minho

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Cristina Alves Ribeiro | University of Porto

Organized by

University of Minho (UM)

Portuguese Geotechnical Society (SPG)

International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE)

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PRESENTATIONS e-BOOK

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PREFACE

The 1st International Meeting of the Young Transportations Geotechnics Engineers (1st YTGE meeting), associated with the 3rd International Conference on Transportation Geotechnics 2016 (3rd ICTG 2016), aimed to provide an international forum for doctoral and post-doctoral students as well as research engineers and engineers involved in innovation in transportation geotechnics, to present and discuss their main research results and to identify future research and engineering practice needs.

The 1st YTGE meeting, held in Guimarães, Portugal, on September 4th 2016, intended to create a knowledge exchange network and compile what the best and most advanced practices worldwide in the transportation geotechnics field are, either in academic or in industrial domains. It were covered all the disciplines in transportation geotechnics (roads, highways, bridges, airports, railways, waterways, canals and terminals-harbors) under the umbrella of ISSMGE - TC 202.

It is hoped that the 1st YTGE meeting will be a solid 'foundation' for subsequent international events through the YTGE network.

The Editors: **Joaquim Tinoco** | **André Paixão** | **Cristina Alves Ribeiro**

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The future of geotechnical engineering (only some aspects or ideas for thought ...)

SIMSG ISSMGE

Roger Frank
Ecole des Ponts ParisTech, Navier-CERMES

Outline

- The specificities of GE
- The general challenges of GE in this early 21st century
- ‘Methodological’ issues
- ‘Ethical’ issues. Conclusions

Outline

- The specificities of GE
- The general challenges of GE in this early 21st century
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- ‘Ethical’ issues. Conclusions

- Nice profession !
- Each geot/CE work is a prototype
- Mixture of rational mechanics (and other sciences) with the art-of-the-engineer
- There is no ‘truth’
- It is a science of observation

Outline

- The specificities of GE
- The general challenges of GE in this early 21st century
- ‘Methodological’ issues
- ‘Ethical’ issues. Conclusions

General (‘Social’) challenges

- Geohazards
- Environmental geotechnics
- Transportation geotechnics
- Production of renewable energies
- Existing structures. Cultural heritage…
- Safety, Health, Sustainability

Geohazards

- Typhoons, tsunamis, storms
- Floods, mud flows, soil and rock slides, avalanches
- Volcanos (ashes and … clouds), earthquakes (liquefaction and other damages…)
- « karsts », sinkholes, collapsible-swelling soils, subsidence (natural or anthropic)

GEOHAZARDS, WHAT ARE THEY?

"Events caused by geological conditions or processes, which represent serious threats for human lives, property or the natural environment"

Onshore	**Offshore**
Volcanism	Slope instability
Earthquakes	Tsunamis
Slides/debris flows	Shallow gas/hydrates
Floods	Diapirism

Natural disasters are one of the main threats to improve-ment of the standard of living in many developing countries.

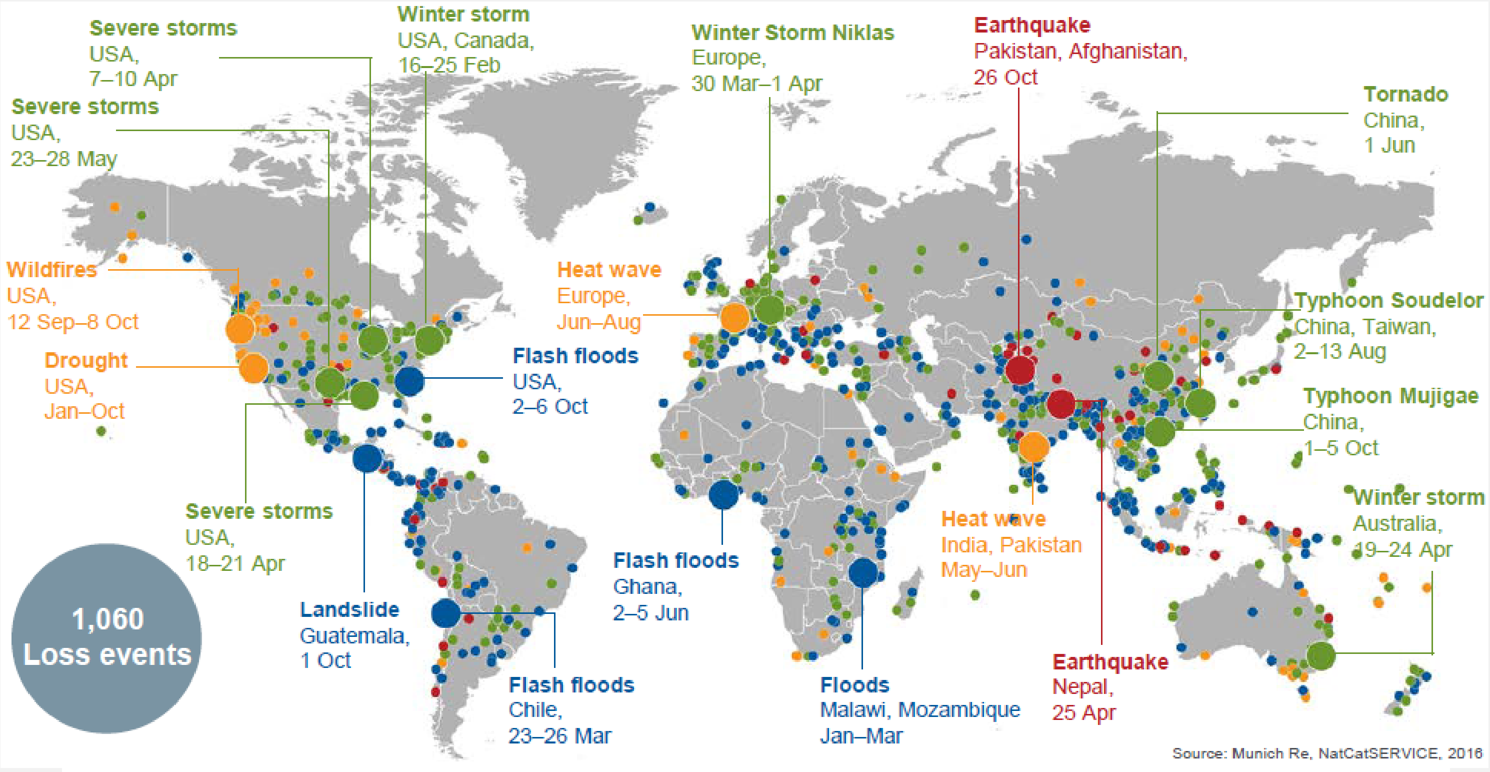
S. Lacasse, NGI, 2005

Geohazards

- Unprecedented scales
- with… denser cities !
- Risks and reliability analyses
- No financial constraints on geot engnrs?
- Influence of climate change (melting of permafrost, zero level cities)
- Emotion is important

Natural loss events worldwide 2015
Geographical overview

Munich RE



Geophysical events
(Earthquake, tsunami, volcanic activity)

Meteorological events
(Tropical storm, extratropical storm, convective storm, local storm)

Hydrological events
(Flood, mass movement)

Climatological events
(Extreme temperature, drought, forest fire)

Loss events

Selection of catastrophes

Influence of climate change : zero level cities

Origin: Goverment of the Netherlands, Delta Programme Commissionner

Sea level rising more rapidly

News item | 11-05-2016 | 08:34

See also

→ Delta Programm

The media are focusing a great deal of attention on the publication by Nature magazine, in which scientists describe how the Antarctic ice sheet is melting faster than current data shows. According to the scientists, this is due to several processes that have previously not been recognised. The result may be that in the centuries ahead, the sea level will rise by more than is currently expected.

Origin: Goverment of the Netherlands, Delta Programme Commissionner

In the Delta Programme, we are working with the latest insights that have been properly investigated. The new scientific insights regarding the melting Antarctic ice caps must be taken seriously. For that reason, it is important for the IPCC, the UN climate panel, to translate these new insights into a future sea level forecast. This is expected to be accomplished in 2018. The Royal Netherlands Meteorological Institute KNMI is currently examining the probability of such a scenario developing. For the time being, sand replenishments along the coast will enable the Netherlands to cope with the predicted +1 meter scenarios until 2100. The new IPCC analyses may be reason for the Netherlands to take even farther-reaching steps.

The essence of the Dutch approach is that we factor in multiple scenarios for 2100 and beyond, adapting them where appropriate. We adjust our course if need be, keeping level-headed and alert. The issue is urgent, yet not acute. We must continue to expend our best efforts on reducing the temperature rise by quickly making our country sustainable. However, the report on the Antarctic ice caps once more indicates that climate adaptation is an issue requiring continued and urgent effort, in the Netherlands as well as across the globe.

The Dutch approach sets an example for the world. We are collaborating with many nations, for example in the Delta Coalition initiated by Minister Schultz van Haegen. The Netherlands is well prepared. The law stipulates that water policy must be focused on disaster prevention. We have been working on that since 2010 in the Delta Programme, the Delta Plan for the 21st century - with a Delta Fund of an annual 1 billion euros and a dedicated government commissioner, the Delta Programme Commissioner, who draws up the plans together with all the parties involved. This is unique in the world. The Cabinet recognises the importance of this quite clearly and continues to allocate resources. We must not shirk our obligations. Upon a positive evaluation of the Delta Act – which is now being conducted, after 5 years – we must keep up the pace in our work on the delta.

Origin: Goverment of the Netherlands, Delta Programme Commissionner

Environmental geotechnics

- Cleaning of polluted soils
- Constructing on brownfields
- Waste disposal (including nuclear waste..)

Main problems
in
Environmental Geotechnics
(from I. Vaníček, GeoMos 2010)

- Waste deposition on surface
  - Landfills
  - Tailing dams
  - Spoil heaps
    - » impact on environment
    - » Utilization of surface for new construction
- Remediation of contaminated ground
- Construction on brownfields
- Utilization of different waste in CE
  - Ash
  - Material of spoil heaps => e.g. in Earth structures
  - Slag33

Production of renewable energy

- Oil production
- Geothermy, energy piles
- Hydroelectric dams
- Foundations of electric pylons, wind generators
- etc.

Existing structures. Cultural heritage…

- Ageing of geotechnical structures: foundations, earth structures (dams, etc.)
- Assesssment of existing structures
- Maintenance, Repair

Challenges at the level of geot engng

- serviceability of structures (predicting movements of foundations – eg see EC7)
- prediction of long duration movements
- soil movements; upper values of soil parameters
- **observational method**; compensation grouting, etc.
- **disturbance when retrofitting**

Challenges at the level of geot engng (cntd)

- validity of continuum mechanics (development of micromechanics…)
- use of physical models (centrifuge, etc.)
- tunelling in soft ground , **urban projects**

Observational method or Interactive design – See EC 7

2.7 Observational method

(1) When prediction of geotechnical behaviour is difficult, it can be appropriate to apply the approach known as "the observational method", in which the design is reviewed during construction.

(2)P The following requirements shall be met before construction is started:

— acceptable limits of behaviour shall be established;

— the range of possible behaviour shall be assessed and it shall be shown that there is an acceptable probability that the actual behaviour will be within the acceptable limits;

— a plan of monitoring shall be devised, which will reveal whether the actual behaviour lies within the acceptable limits. The monitoring shall make this clear at a sufficiently early stage, and with sufficiently short intervals to allow contingency actions to be undertaken successfully;

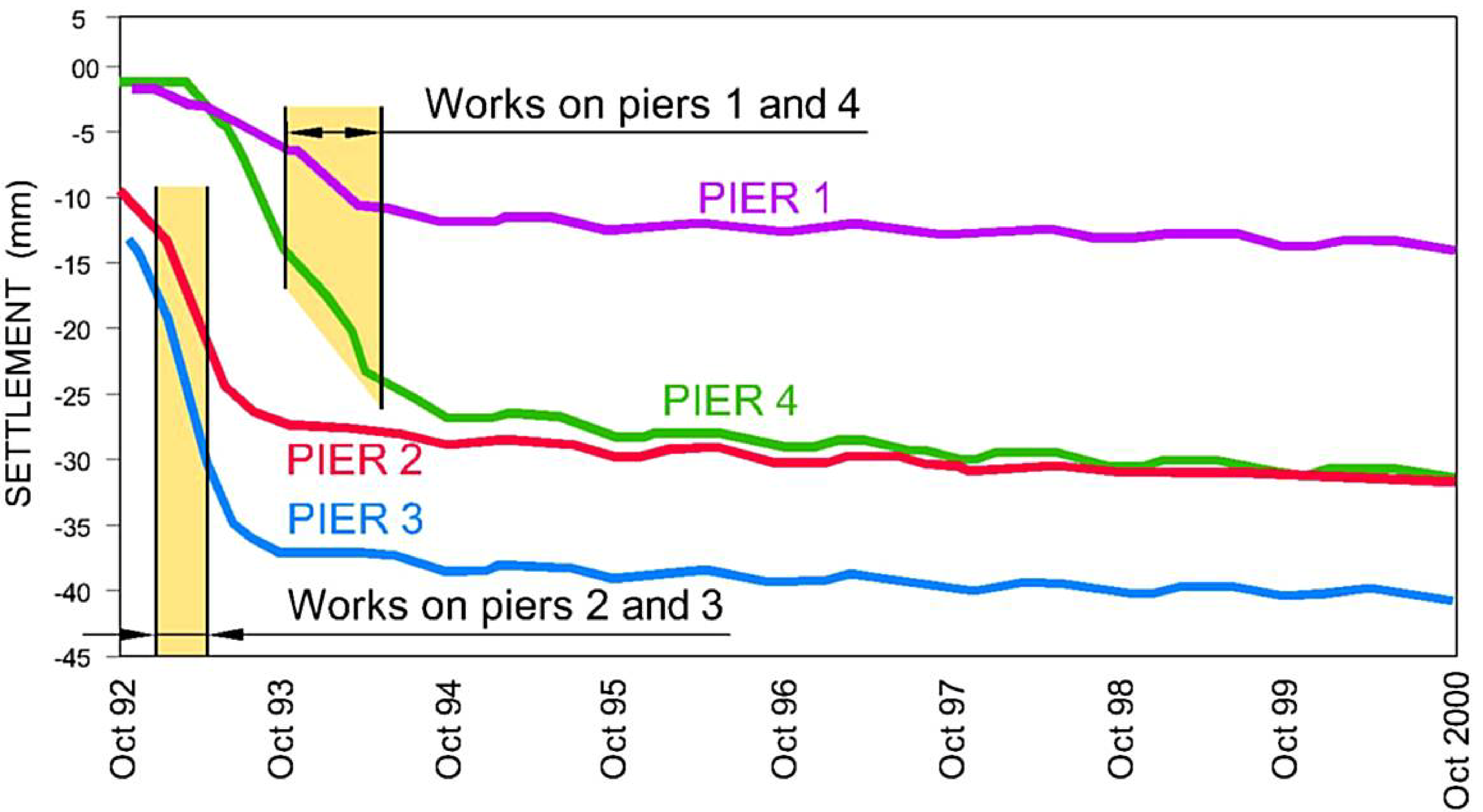
— the response time of the instruments and the procedures for analysing the results shall be sufficiently rapid in relation to the possible evolution of the system;

— a plan of contingency actions shall be devised, which may be adopted if the monitoring reveals behaviour outside acceptable limits.

Disturbance when retrofitting…

Origin: FOREVER, National Resarch Project on Micropiles, 2004

STABILIZATION OF THE SETTLEMENTS AFTER MICROPILES INSTALLATION



Origin: FOREVER, National Resarch Project on Micropiles, 2004

R Frank The future of geotech engng, Inaugural Lecture, 1st YGTE meeting, Guimaraes, 4-7/9/2016

Outline

- The specificities of GE
- The general challenges of GE in this early 21st century
- ‘Methodological’ issues
- ‘Ethical’ issues. Conclusions

- Numerical results are <u>not</u> the reference
- The real ‘judge’ is the ‘real’ (full-scale) behaviour
- Interdisciplinary approach to many problems
- Understand what we do to/with the soil
- The investment into soil investigation should be severely increased (from ~1% to ~3%?)

to conclude on the challenges of geot engng :

- Eurocode 7: “It should be considered that knowledge of the ground conditions depends on the extent and quality of the geotechnical investigations. Such knowledge and the control of workmanship are usually more significant to fulfilling the fundamental requirements than is precision in the calculation models and partial factors.”

(Fundamental requirements : safe, economic, sustainable)

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Civil Engineering :
A People Serving Profession

Origin: http://slideplayer.com/slide/10654726/#.WCHrnRqZewk.gmail published by Emerald Harper

Civil Engineering

- In the beginning, Civil Engineering included all engineers that did not practice military engineering; said to have begun in 18th century France
- First "Civil Engineer" was an Englishman, John Smeaton in 1761
- Civil engineers have saved more lives than all the doctors in history --- development of clean water and sanitation systems

Origin: http://slideplayer.com/slide/10654726/#.WCHrnRqZewk.gmail published by Emerald Harper

Thank you for your attention!

… and enjoy the conference!

Enjoy your stay in Guimarães !

Journal Publishing and the Basket of Metrics

1ST YOUNG TRANSPORTATION GEOTECHNICS ENGINEERS MEETING

Christopher Greenwell

Publishing Director
Elsevier

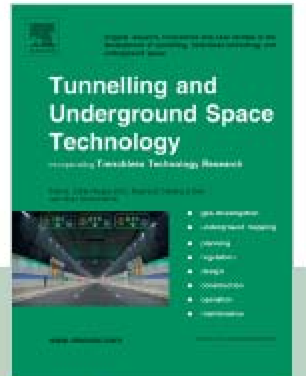
Elsevier's Engineering Team

131 Journals

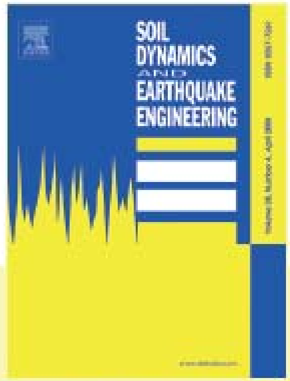
Chemical Engineering;
Mechanical Engineering;
Civil Engineering;
Aerospace Engineering;
Computational Engineering;
Ocean Engineering;
Etc.

ELSEVIER

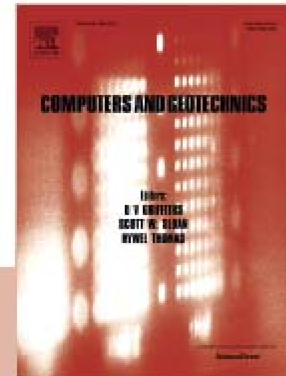
Geotechnical Engineering Journal Portfolio



2014 Impact Factor 1.741
5 year IF: 2.005
SNIP: 2.160
SJR: 2.023
elsevier.com/locate/tust



2014 Impact Factor 1.481
5 year IF: 1.897
SNIP: 1.787
SJR: 1.516
elsevier.com/locate/soildyn

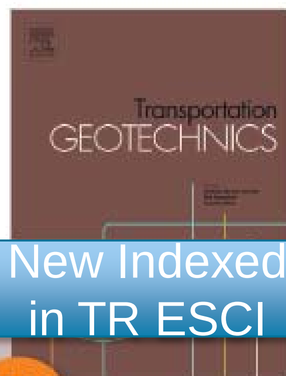


2014 Impact Factor 1.705
5 year IF: 2.179
SNIP: 2.073
SJR: 2.033
elsevier.com/locate/compgeo

Updated Impact Factor

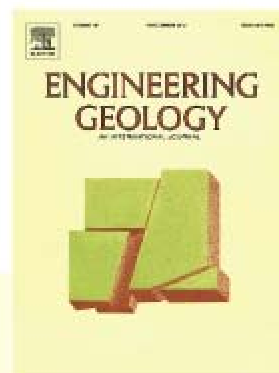
2014 Impact Factor 1.686
5 year IF: 2.312
SNIP: 2.607
SJR: 1.849
elsevier.com/locate/ijrmms

2014 Impact Factor 2.366
5 year IF: 2.682
SNIP: 2.367
SJR: 2.952
elsevier.com/locate/geotexmem

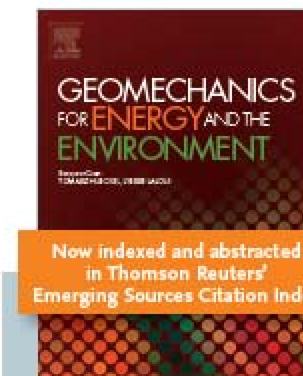


New Indexed in TR ESCI

NEW Journal
SNIP: 0.595
SJR: 0.281
elsevier.com/locate/trgeo



2014 Impact Factor 2.196
5 year IF: 2.663
SNIP: 1.865
SJR: 1.810
elsevier.com/locate/enggeo



Now indexed and abstracted in Thomson Reuters' Emerging Sources Citation Index

elsevier.com/locate/gete

Content

- Introduction to Scholarly Publishing
- Basket of Metrics
- Getting Your Paper Noticed

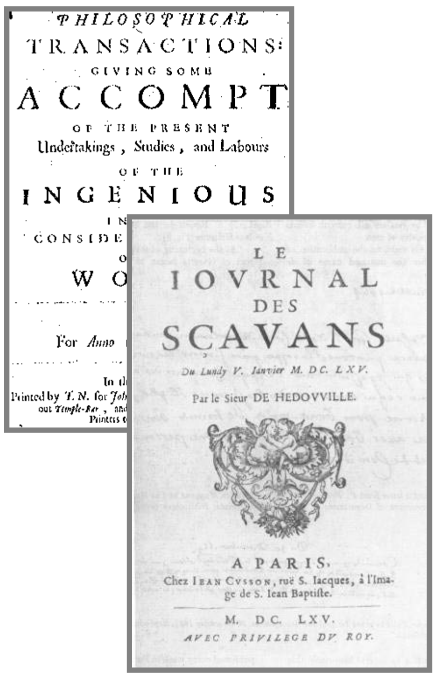
ELSEVIER

Introduction to Scholarly Publishing

Elsevier Publishing Campus

Let’s Start at the Beginning

Journal publishing has thrived for over 350 years but the fundamental role of Publishers remains unchanged



First scientific journals published in 1665

Registration

Timestamp

⇩

Certification

Peer review – validity & integrity

⇩

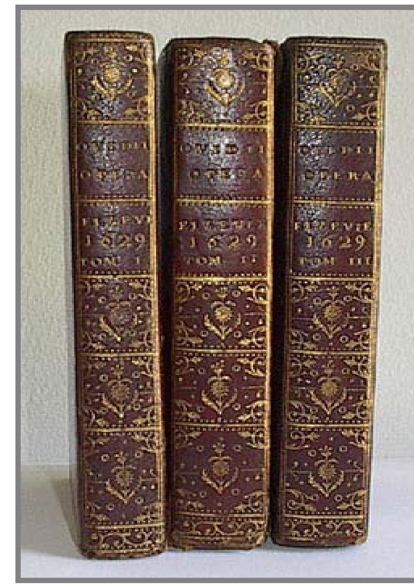
Dissemination

Medium to share findings

⇩

Preservation

Preserve and archive records of science



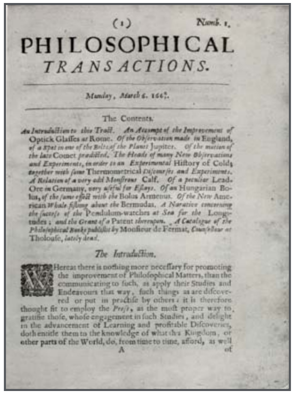
Elzevirianas circa 1629

Each year

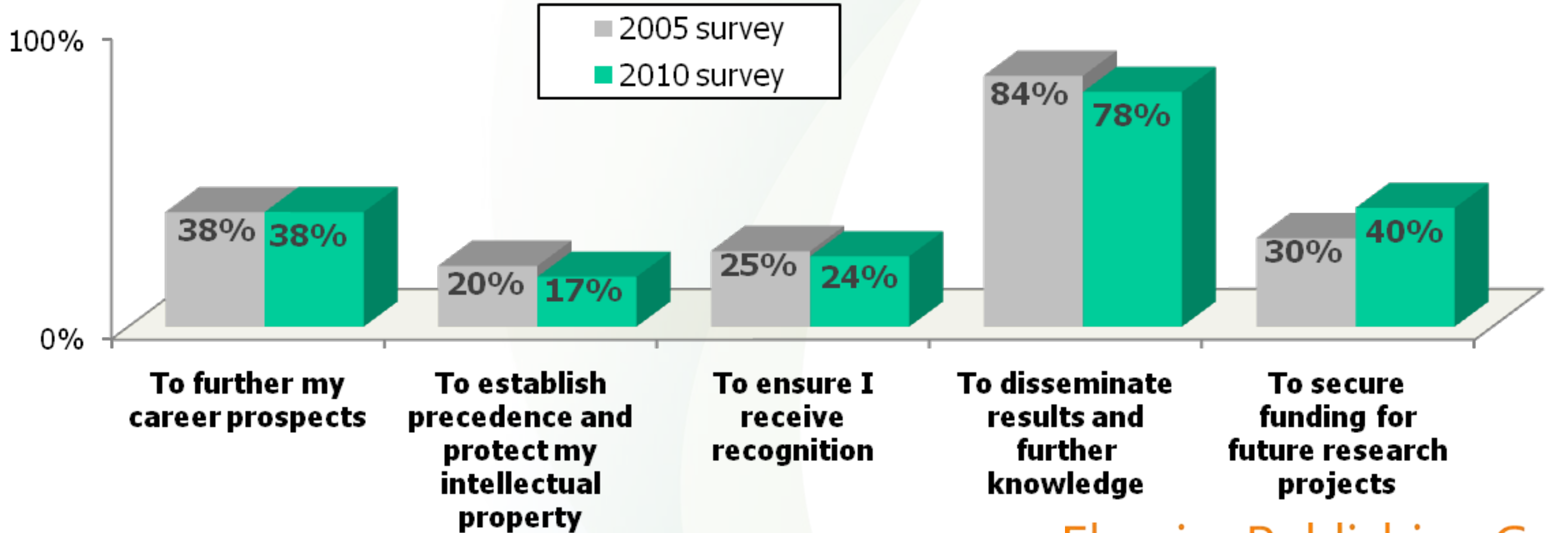
- **3 million articles submitted**
- **1.5 million articles published**
- **30 million readers**
- **2 billion digital article downloads**
- **30 million article citations**

Source: Knowledge Networks and Nations: Royal Society 2011 http://royalsociety.org/uploadedFiles/Royal_Society_Content/Influencing_Policy/Reports/2011-03-28-Knowledge-networks-nations.pdf

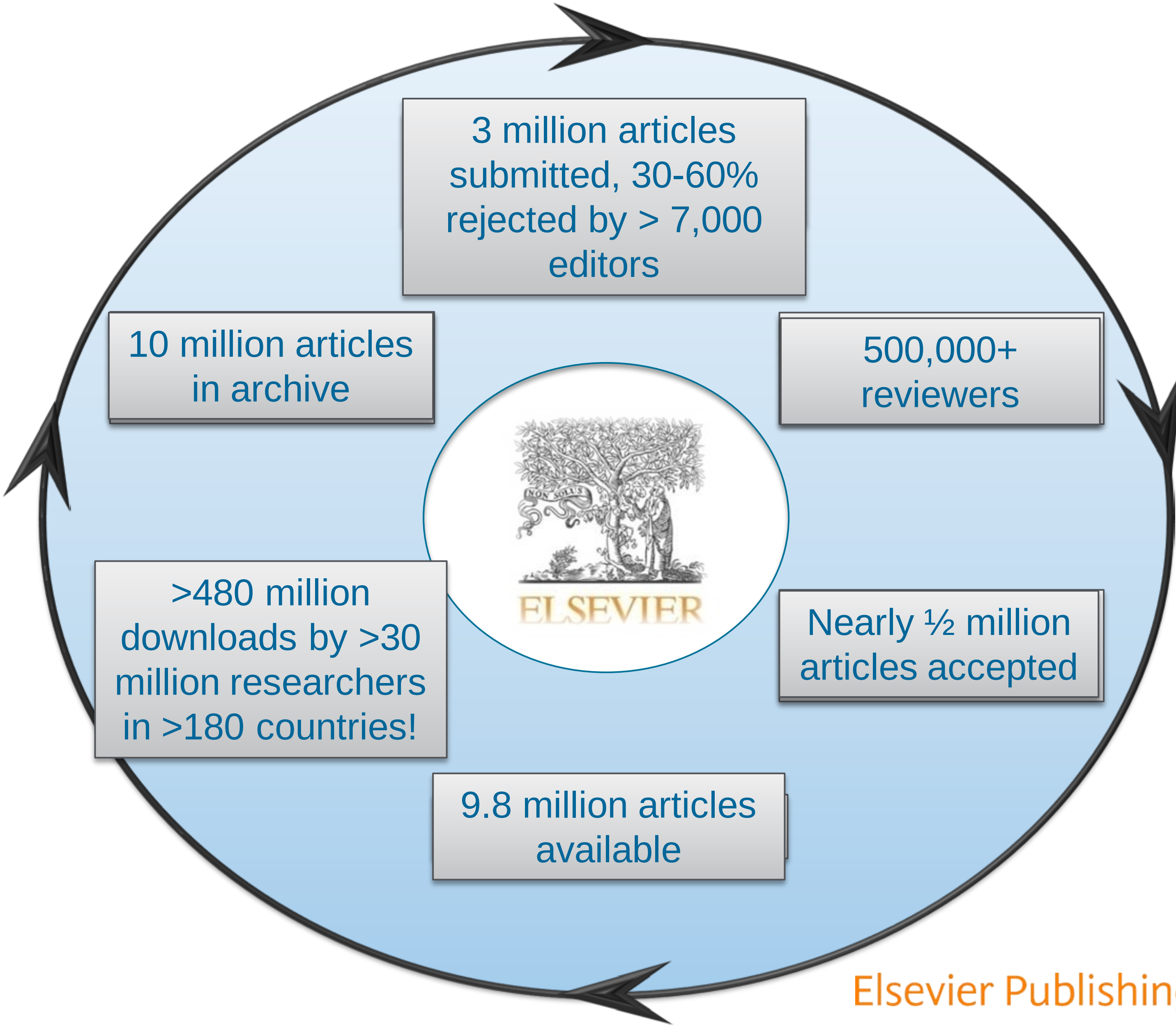
Why Do People Publish



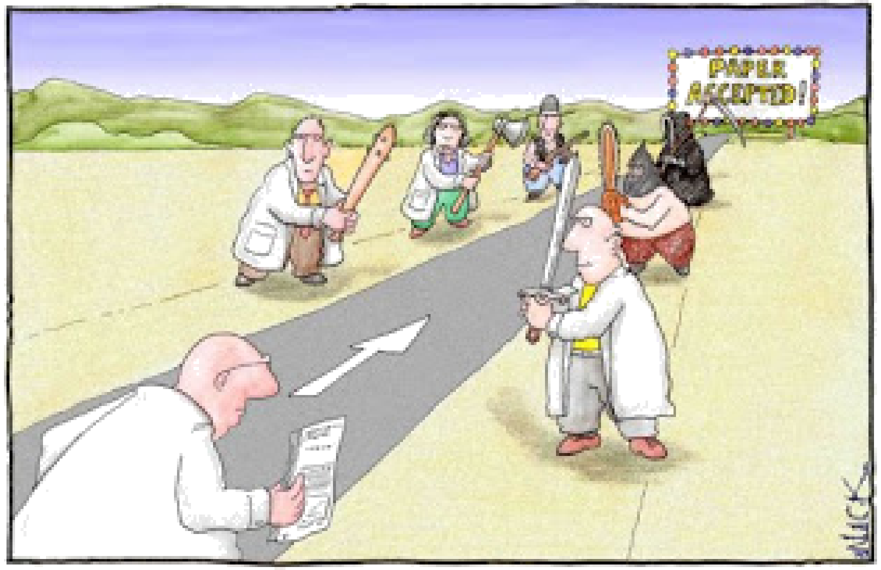
- First peer-reviewed journal founded in 1665 by Royal Society
- Journal publishing has evolved dramatically since, but its core functions remain:
  - Registration of new research findings
  - Quality assurance through peer review
  - Dissemination globally
  - Archiving in perpetuity



The Publishing Cycle



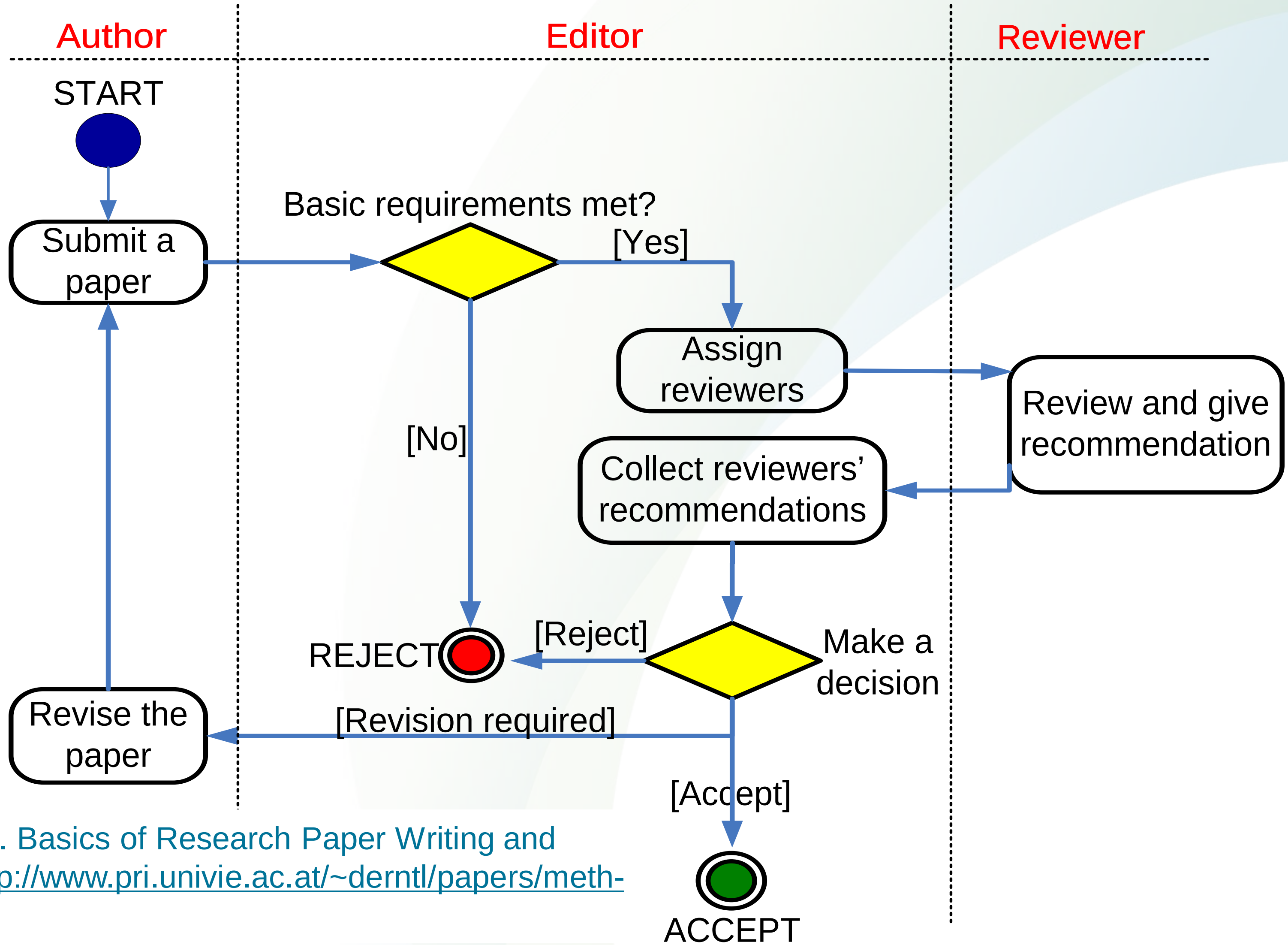
Peer Review



Most scientists regarded the new streamlined peer-review process as 'quite an improvement.'

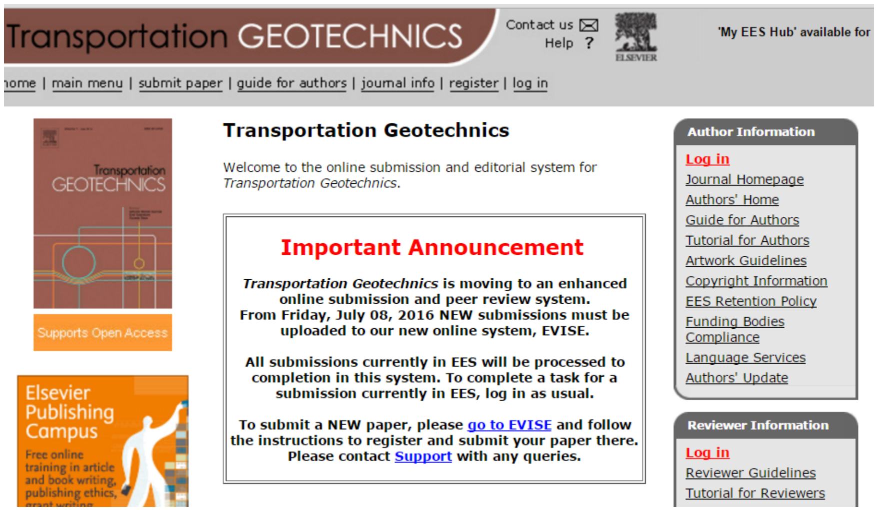
- Helps to determine the quality, validity, significance, and originality of research
- Helps to improve the quality of papers
- Publishers are outside the academic process and are not prone to prejudice or favour
- Publishers facilitate the review process by investing in online review systems and providing tools to help Editors and Reviewers

Demystifying the 'Black Hole'



Michael Derntl. Basics of Research Paper Writing and Publishing. http://www.pri.univie.ac.at/~derntl/papers/meth-se.pdf

Online Peer Review Systems



Online peer review systems accept manuscript submissions and facilitate online peer review

Online systems can handle hundreds of thousands of submissions and reviews per year

Journal Article Production

- **Preprint**

  Author submits manuscript
- **Manuscript accepted**
- **Document proof**

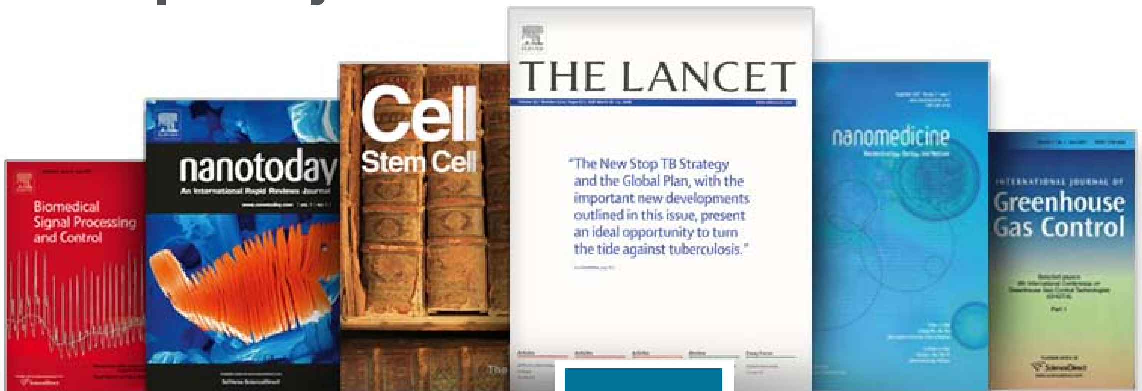
  Copy editing, Author proofing, preparation for publishing
- **Published journal article**

  Logo, pagination, branding
- **Electronic Warehouse**

  Published as print, HTML or PDF copy

Methods of Dissemination

Traditional print journals



and

Electronic journal platforms

like Elsevier's ScienceDirect improve online dissemination and access

ScienceDirect

Other Publishing Models

Traditional publishing

- Authors publish free of charge
- Institutions or individuals subscribe to journals

Open access publishing

- Author (or institution/funding agency) pays an article publication fee
- Article is made freely available to all online
- Some journals publish exclusively open access
- Other subscription journals offer open access options

Gold Open Access vs. Green Open Access

	GOLD OPEN ACCESS	GREEN OPEN ACCESS
Access	• Free public access to the final published article. • Access is immediate and permanent.	• Free public access to a version of your article. • Time delay may apply (embargo period).
Fee	• Open access fee is paid by the author, or on their behalf (for example by a funding body).	• No fee is payable by the author, as costs are covered by library subscriptions.
Use	• Determined by your user license.	• Authors retain the right to use their articles for a wide range of purposes. All open versions of your article should have a user license attached.
Options	1. Publish in an open access journal. 2. Publish in a journal that supports open access (also known as a hybrid journal).	1. Link to your article. 2. For selected journals Elsevier makes the articles freely available after an embargo period in the open archives. 3. Self-archive your manuscript.

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After embargo	**Author manuscripts can be shared:** • Publicly on non-commercial platforms. • Publicly on commercial partner sites.[3]

1 Preprint is your initial write up of your results and analysis that has not yet have been peer reviewed or submitted to a journal.
2 Accepted manuscript is a version of your manuscript which typically includes any changes you have incorporated through the process of submission, peer review and in your communications with the editor.
3 For an overview of how and where you can share your article, please see elsevier.com/sharing-articles

Preservation and Archiving

- Publishers partner with organizations to keep multiple archives of all published research.

- **Elsevier partners with:**
  - The National Library of Netherlands
  - Portico
  - CLOCKSS

KONINKLIJKE BIBLIOTHEEK

PORTICO

CLOCKSS

Basket of Metrics

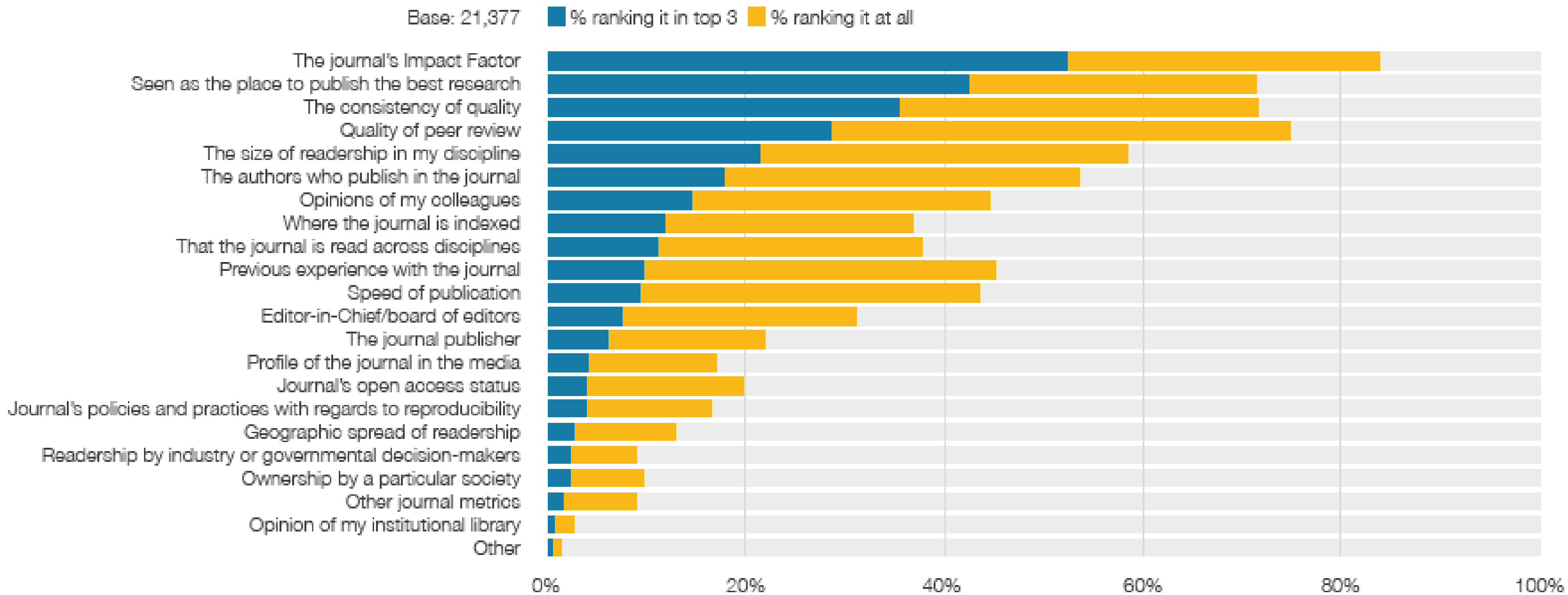
‘Publish or Perish’ Drives Reliance on the Impact Factor

5

Factors contributing to journal reputation

“What is it about this journal that gives it a high reputation? Please select the 8 most significant factors from the list below, in terms of how you judge the reputation of this journal.”

Factors that contribute most to the perception of a journal’s reputation are **Impact Factor** and **‘seen as the place to publish the best research by my community’**.



Impact Metrics: What Do They Offer?

- Impact metrics are used to measure research impact for benchmarking and quality comparison purposes.
- Metrics allow us to measure research impact at a variety of different levels:

> **' There is no single "best" indicator that could accommodate all facets of the new reality of journal metrics '**
>
> Wolfgang Glanzel, of the Expertisecentrum O&O Monitoring (Centre for R&D Monitoring, ECOOM)

- Problems arise when metrics are used for assessment in ways they weren't intended for.

The Tide Has Turned…

THE CHRONICLE OF HIGHER EDUCATION

RESEARCH

The Number That's Devouring Science

The impact factor, once a simple way to rank scientific journals, has become an unyielding yardstick for hiring, tenure, and grants

By RICHARD MONASTERSKY | OCTOBER 14, 2005

THE WORLD UNIVERSITY RANKINGS TIMES HIGHER EDUCATION

PROFESSIONAL JOBS SUMMITS RANKINGS

Journal impact factors 'no longer credible'

The measure of scholarly impact is now being manipulated so much that it has ceased to be meaningful, editorial claims

November 5, 2015

Impact Factor

To all items (regardless of type)

'Source' items only

Cites in 2014 to items published in: 2013 =2563
2012 =2801
Sum: 5364

Number of items published in: 2013 =803
2012 =703
Sum: 1506

$$\text{Calculation} = \frac{\text{Cites to recent items}}{\text{Number of recent items}} \qquad \frac{5364}{1506} = \mathbf{3.562}$$

What is counted as a 'Source' item?

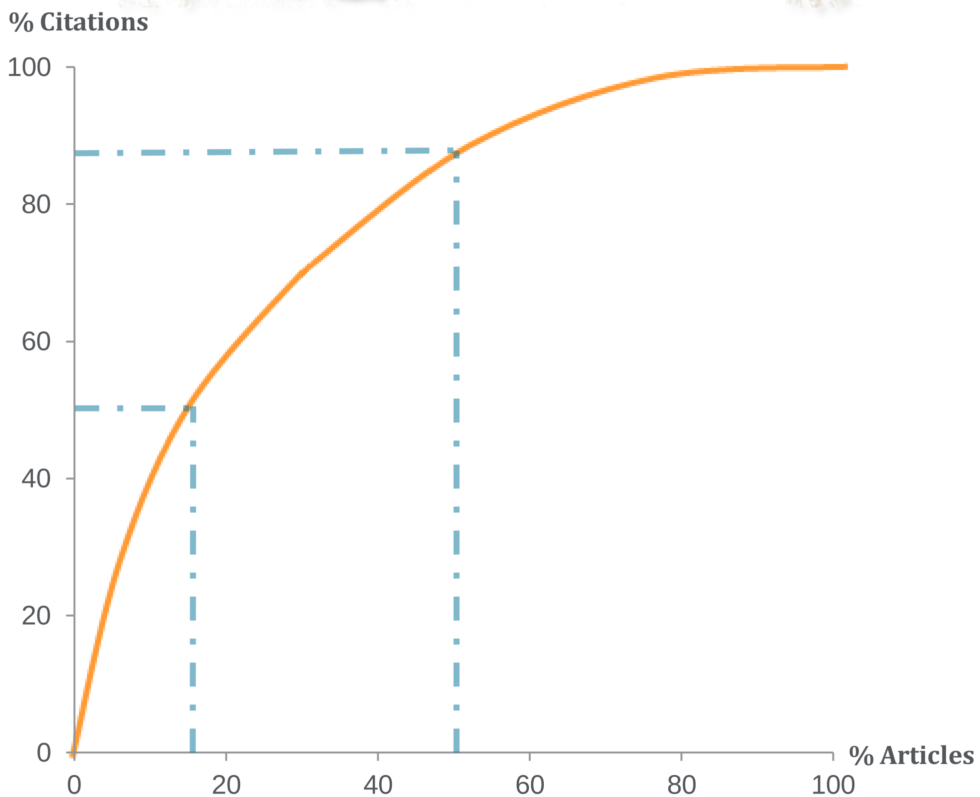
- Original research articles
- Review articles
- Proceedings papers
- Technical notes

(Any publication that can significantly impact the world of research will be counted)

Skewed Distribution of Citations Across Articles

thebmj Why the impact factor of journals should not be used for evaluating research

Seglen, P.O., *BMJ* (15th Feb 1997): Vol. 314, pp. 497



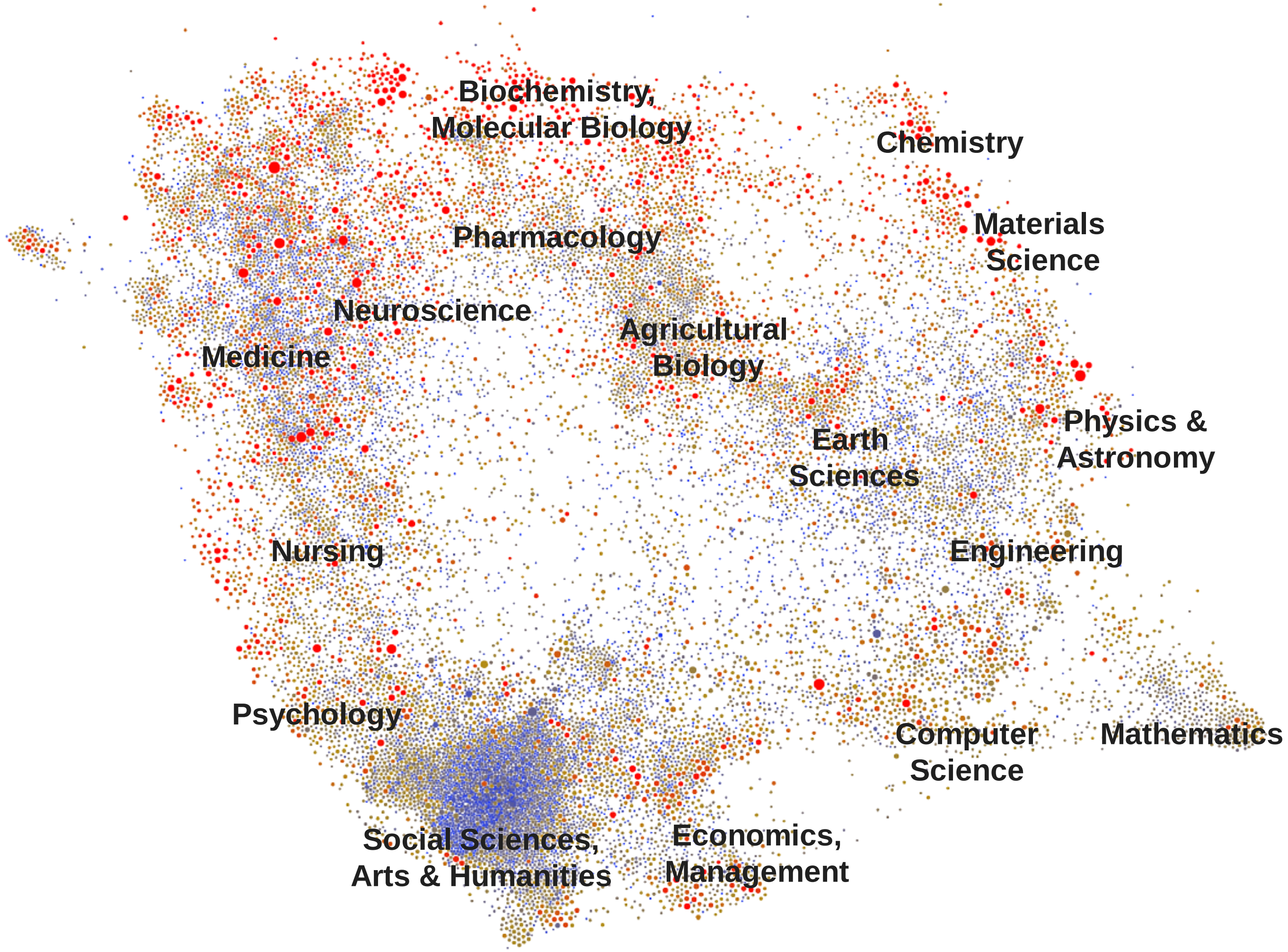
Skewed Distribution of Citations Across Journals

InCites™ Journal Citation Reports® THOMSON REUTERS™

Rank	Full Journal Title	Total Cites	Journal Impact Factor
1	NEW ENGLAND JOURNAL OF MEDICINE	268,652	55.873
2	LANCET	185,361	45.217
3	JAMA-JOURNAL OF THE AMERICAN MEDICAL ASSOCIATION	126,479	35.289
4	ANNALS OF INTERNAL MEDICINE	48,356	17.81
5	BMJ-British Medical Journal	89,031	17.445
6	ARCHIVES OF INTERNAL MEDICINE	38,021	17.333
7	PLOS MEDICINE	18,649	14.429
8	JAMA Internal Medicine	2,934	13.116
9	BMC Medicine	5,708	7.356
10	Journal of Cachexia Sarcopenia and Muscle	713	7.315
11	MAYO CLINIC PROCEEDINGS	9,990	6.262
12	JOURNAL OF INTERNAL MEDICINE	8,802	6.063
13	Cochrane Database of Systematic Reviews	43,592	6.035
14	CANADIAN MEDICAL ASSOCIATION JOURNAL	12,121	5.959
15	MEDICINE	4,912	5.723
16	ANNALS OF FAMILY MEDICINE	3,556	5.434
17	Translational Research	2,112	5.03
18	AMERICAN JOURNAL OF MEDICINE	22,662	5.003
19	AMERICAN JOURNAL OF PREVENTIVE MEDICINE	15,857	4.527
20	MEDICAL JOURNAL OF AUSTRALIA	10,268	4.089

Source: Top 20 journals ranked by Impact Factor in the Medicine, General & Internal category

Skewed Distribution of Citations Across Fields



Source: Elsevier analysis of Scopus data (20k journals with citation edges for layout and coloured by average citations per article)

Overview of Selected Journal Citation Metrics

Impact Factor

ISI JOURNAL CITATION reports.

+ Easy calculation
+ Easy-to-handle value
– Short citation window (2 yrs)
– Field-dependent
+/– Self-citations included
– Available for 11k journals (paid)
– Numerator & denominator misaligned

SNIP

– Complex calculation
+ Easy-to-handle value
+ Medium citation window (3 yrs)
+ Normalized to local citation environment
+/– Self-citations included
+ Available for 22k journals (free)

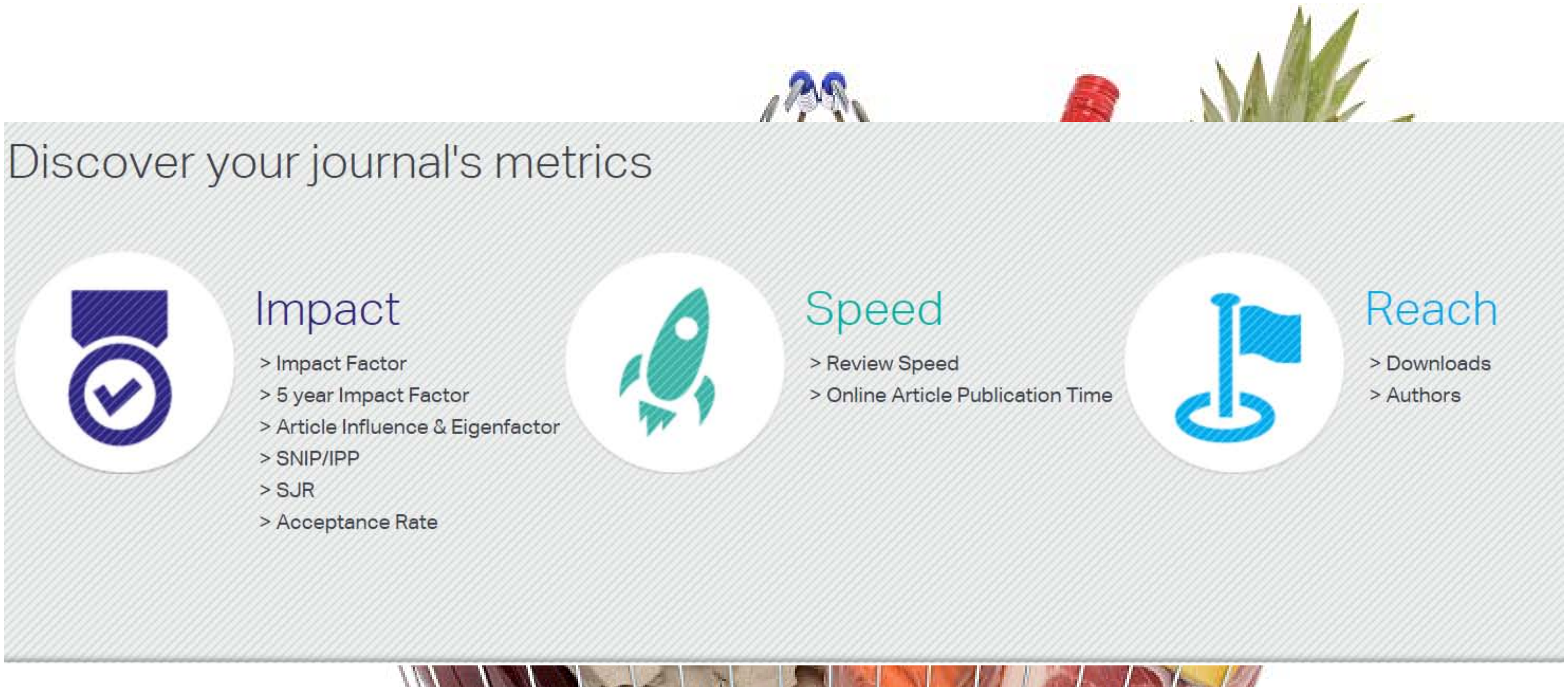
eigenFACTOR

– Complex calculation
– Hard-to-handle value
+ Long citation window (5 yrs)
+ Measures journal prestige
+/– Self-citations excluded
– Available for 11k journals (paid)
– Journal size influences score

SJR

– Complex calculation
+ Easy-to-handle value
+ Medium citation window (3 yrs)
+ Measures journal prestige
+/– Self-citations limited
+ Available for 22k journals (free)

The Basket of Metrics



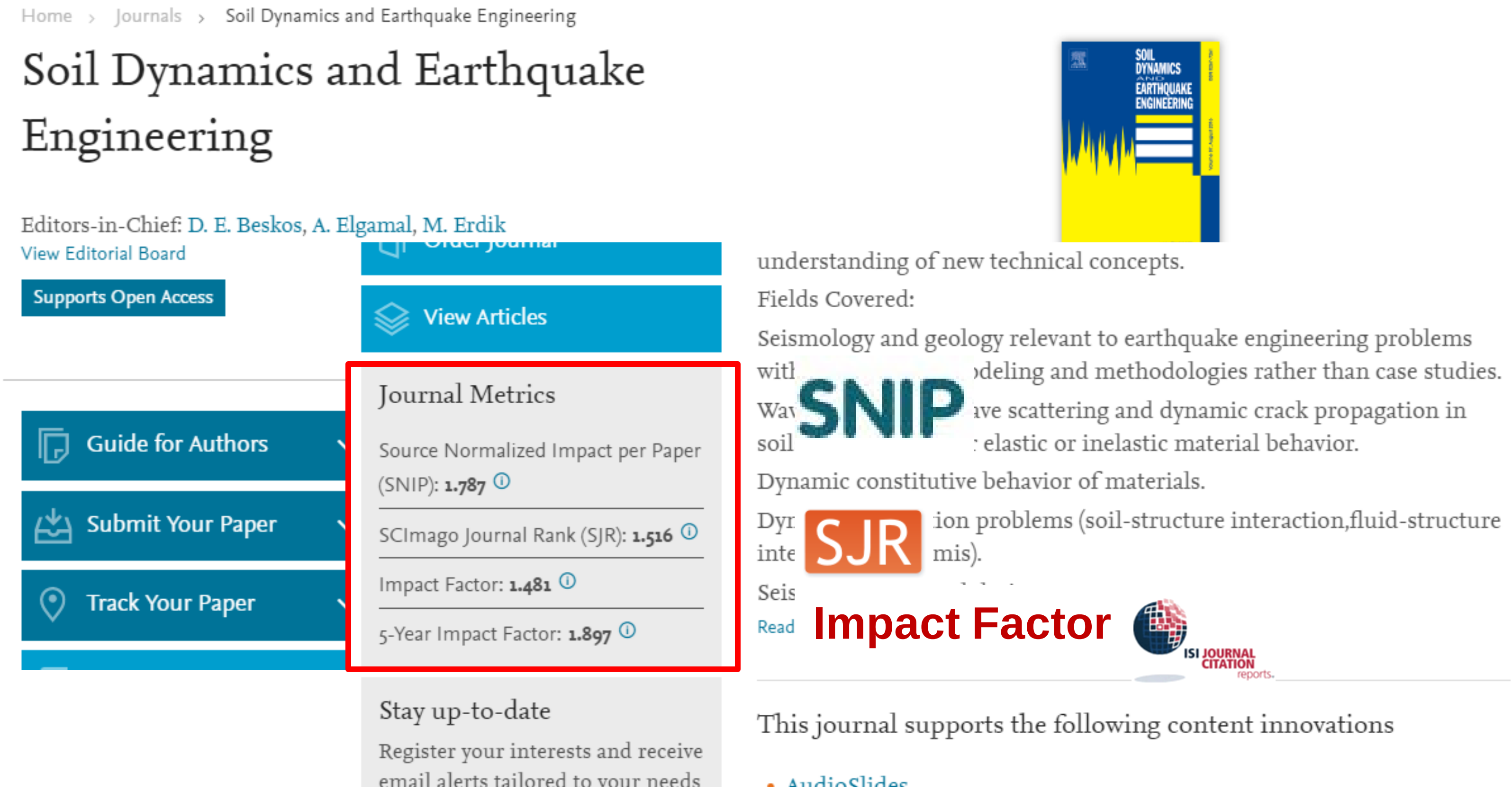
A "basket of metrics": flexible and sophisticated, breadth and depth

Portfolio
Journals
Sections
Conferences
Book series

Community	Contributions	Consumption	Esteem	Impact
Editor Board Authors	**Outputs**	**Usage Citations Audience**	**Scholarly Activity Academic opinion**	**Social Activity Media Activity**

Journal Metrics, Where to Find Them?

Journal Homepage



Getting Your Paper Noticed

Starting point for finding scholarly information

- **Search Engine** — 33%: Google, Yahoo!, bing
- *Specific to scholarly research*:
  - **Full Text Services** — 40%: ScienceDirect, PubMed Central, arXiv.org
  - **A&I Services** — 19%: ISI Web of Science, SciFinder, PubMed
  - **Inst. Info Services** — 3%

- **Social Media** — 2%: ResearchGate, Facebook, Academia.edu (share research), LinkedIn
- **Other** — 3%

Physical scientists typically start in Google
Health and Life scientists typically start in PubMed
Social scientists typically start in Google Scholar

Source: Survey of 4,668 published authors in December 2014

Search Efficiency

43' average time of a search & discovery session
24' seeking a known article
47' keeping up to date in the field or expanding knowledge outside the field

6h59' average time spent searching & reading articles per week
2h36' searching
4h23' reading

5.4 average number of articles downloaded per week

56% of articles downloaded are regarded as useful

Source: Survey of 6,009 published authors in Q3 2013

Be Clear!

- Use keywords in your title and abstract – people are more likely to come to your work through these
- Think about the search terms you use in your research
- Research is becoming more interdisciplinary – you know your core audience, but you may be able to reach people outside of your field
- Be concise and engaging in your communication – highlight the challenge you are addressing and specify what your research adds to this area

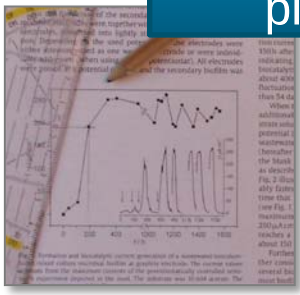
More You Can Do to Get Your Paper Noticed

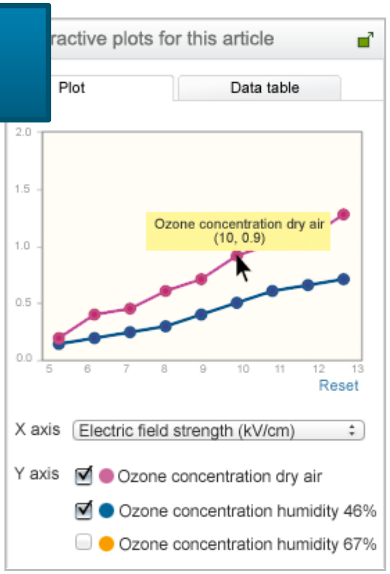
https://www.publishingcampus.elsevier.com/pages/193/Colleges/College-of-Skills-Training/Getting-noticed/How-to-get-your-research-article-noticed-.html

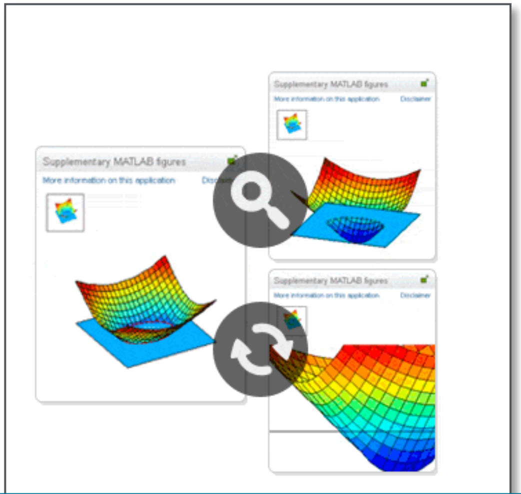
Express Your Research More Fully

Nurture insights, give your readers more than clear text & professional images

Interactive plots

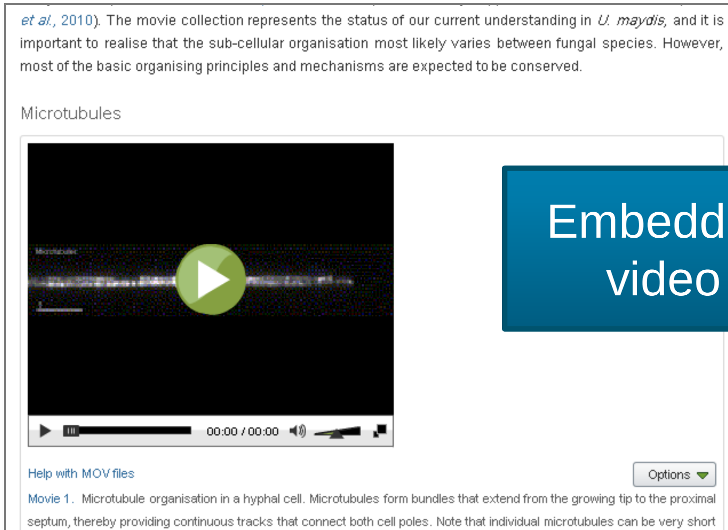




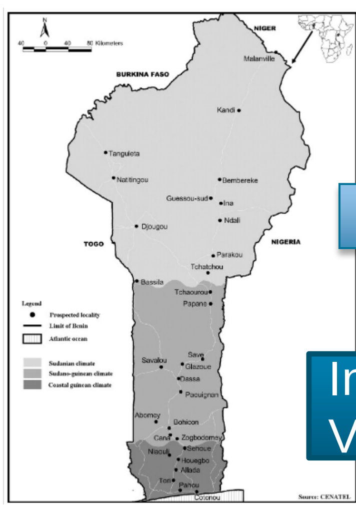


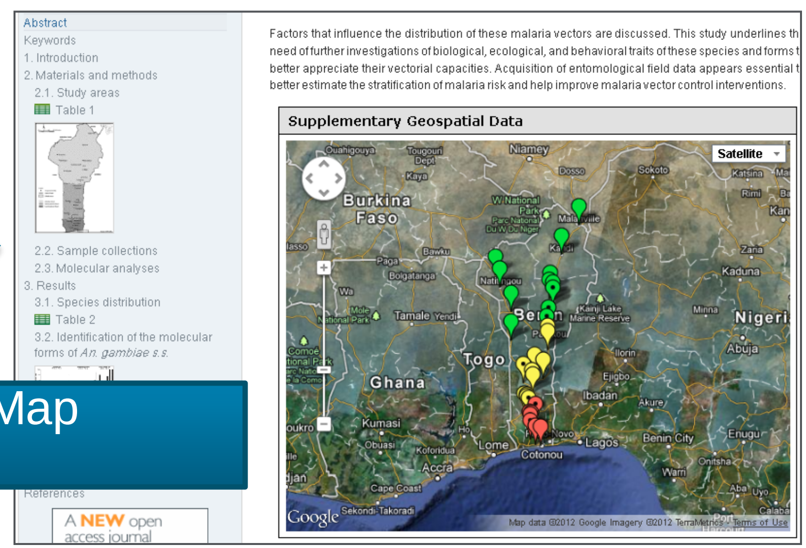
Integrated digital content, such as 3-d images

Express Your Research More Fully



Embedded video

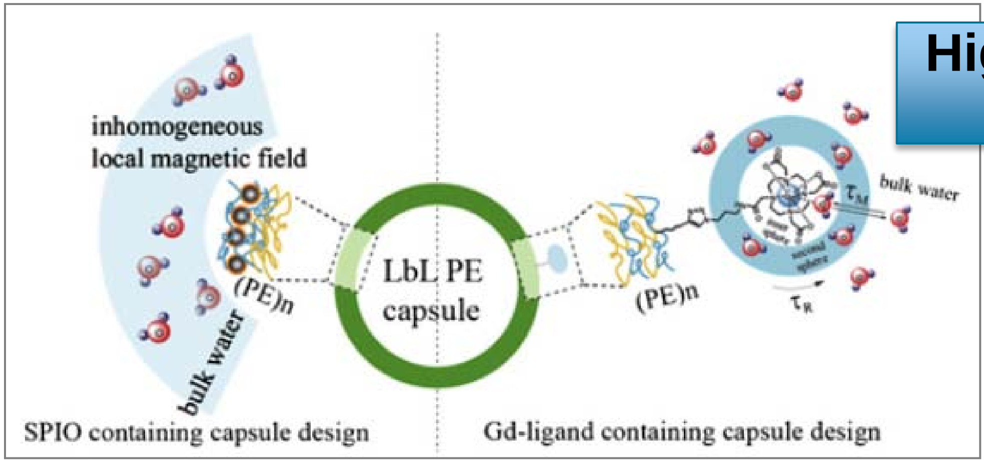




Interactive Map Viewer

Express Your Research More Fully

Help readers to quickly see why the paper is of interest



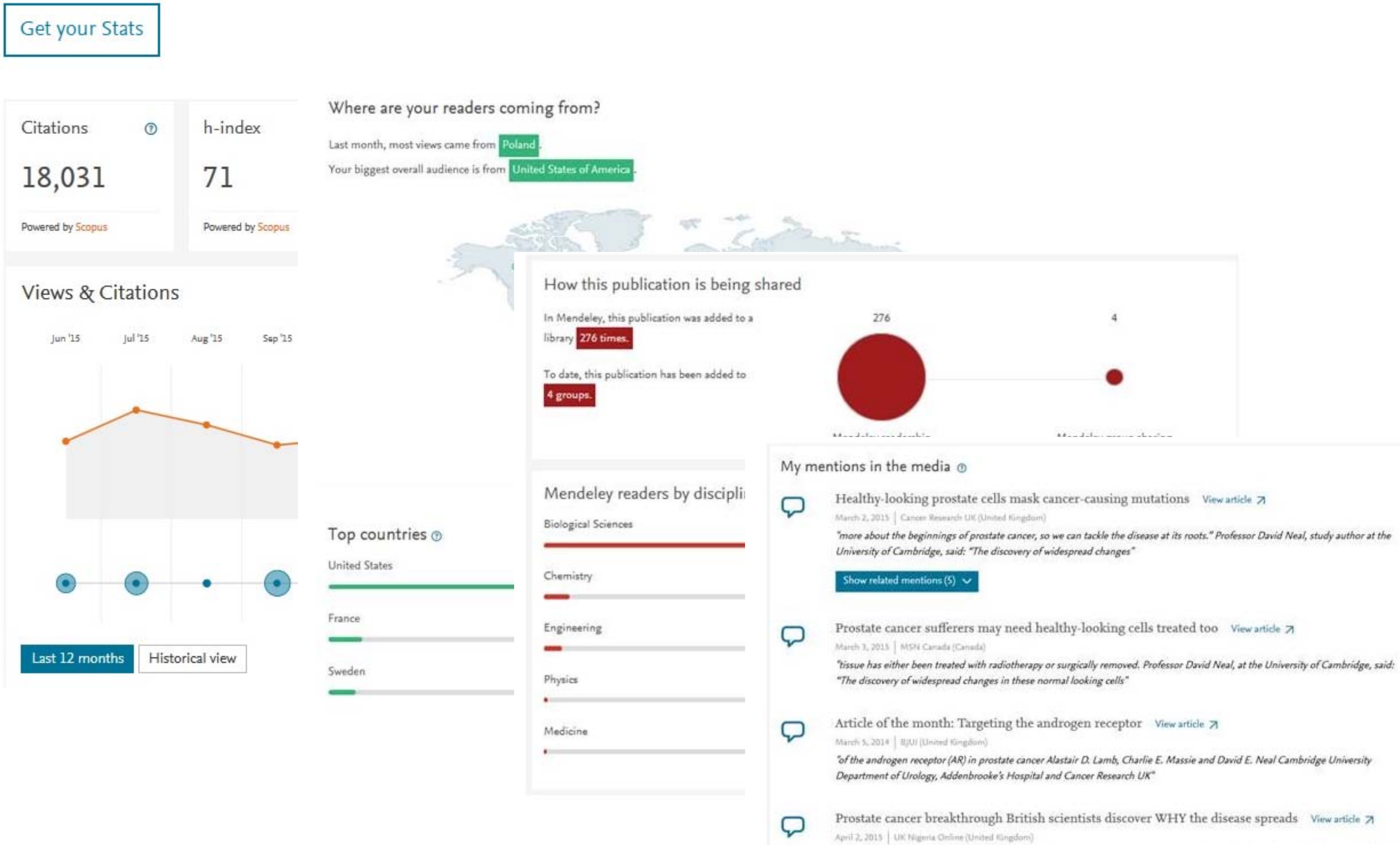
High Quality Graphical Abstracts

Highlights

Highlights

- A conformational two-state mechanism for proton pumping complex I is proposed.
- The mechanism relies on stabilization changes of anionic ubiquinone intermediates.
- Electron-transfer and protonation should be strictly controlled during turnover.
- The mechanism explains the full reversibility of complex I.

Mendeley Stats
Views and Citations shown in real time



Thank you!

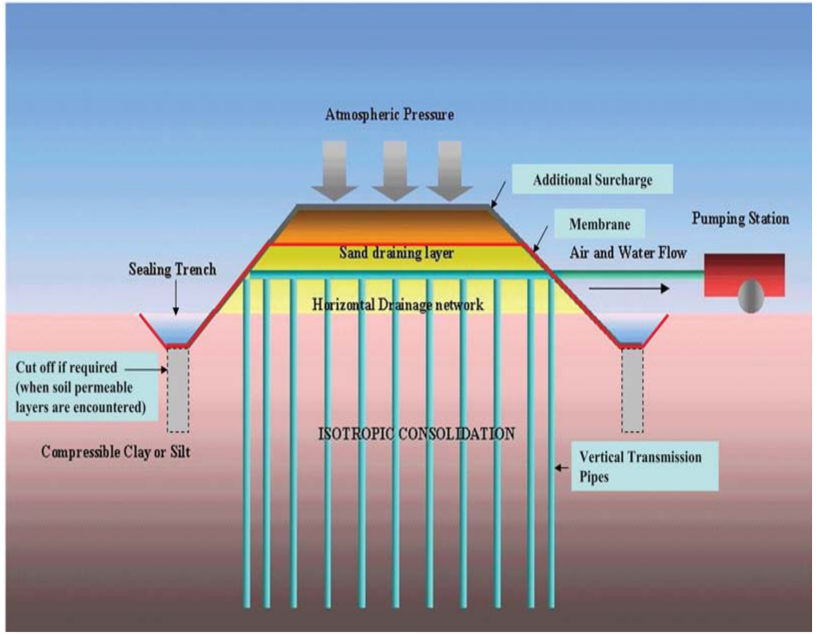
We hope that we have given you the necessary information for journal publishing and metrics.

Good luck with the publication of your work!

Large Strain and Nonlinearity in PVD-assisted Consolidation

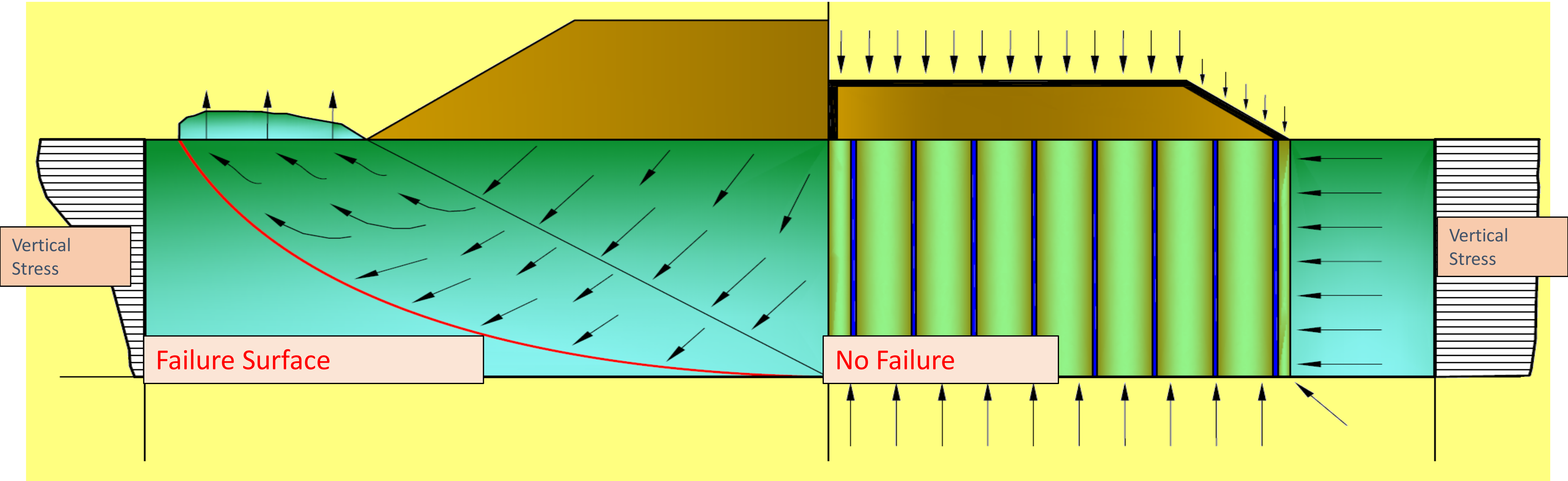
• **Rui Zhong**

PhD, Research Associate
Centre for Geomechanics and Railway Engineering
University of Wollongong, Wollongong, Australia


Atmospheric Pressure
Additional Surcharge
Membrane
Pumping Station
Sand draining layer
Air and Water Flow
Sealing Trench
Horizontal Drainage network
Cut off if required
(when soil permeable
layers are encountered)
Compressible Clay or Silt
ISOTROPIC CONSOLIDATION
Vertical Transmission
Pipes

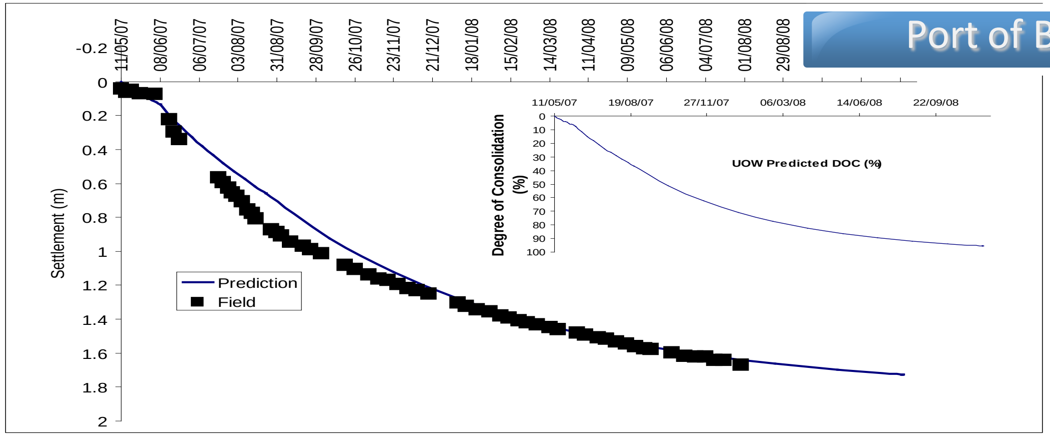
Surcharge Loading
Anisotropic Load

Vacuum Preloading with PVD
Isotropic Loading



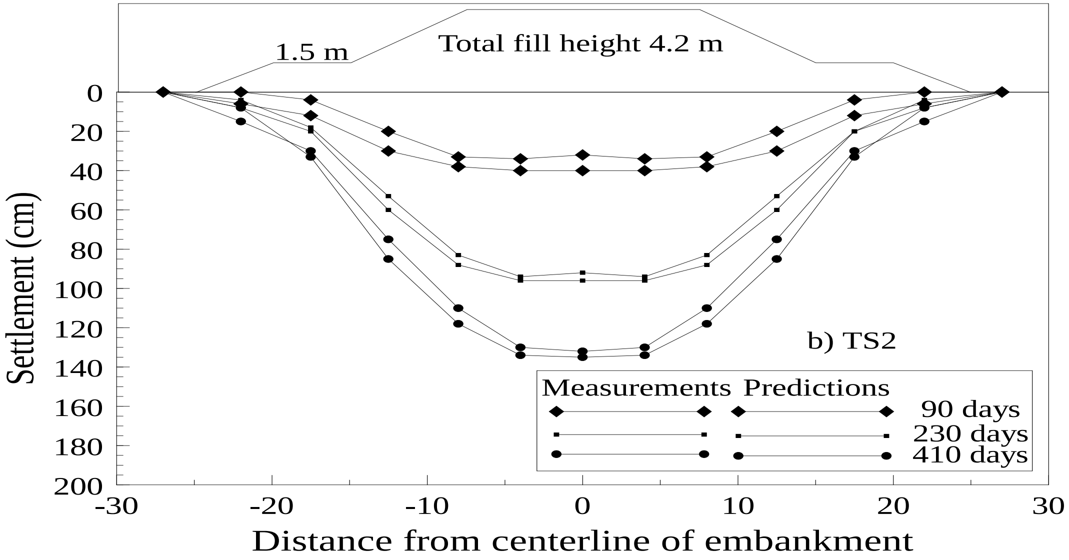
Risk of shear failure is minimized by the use of Vacuum Preloading

Port of Brisbane



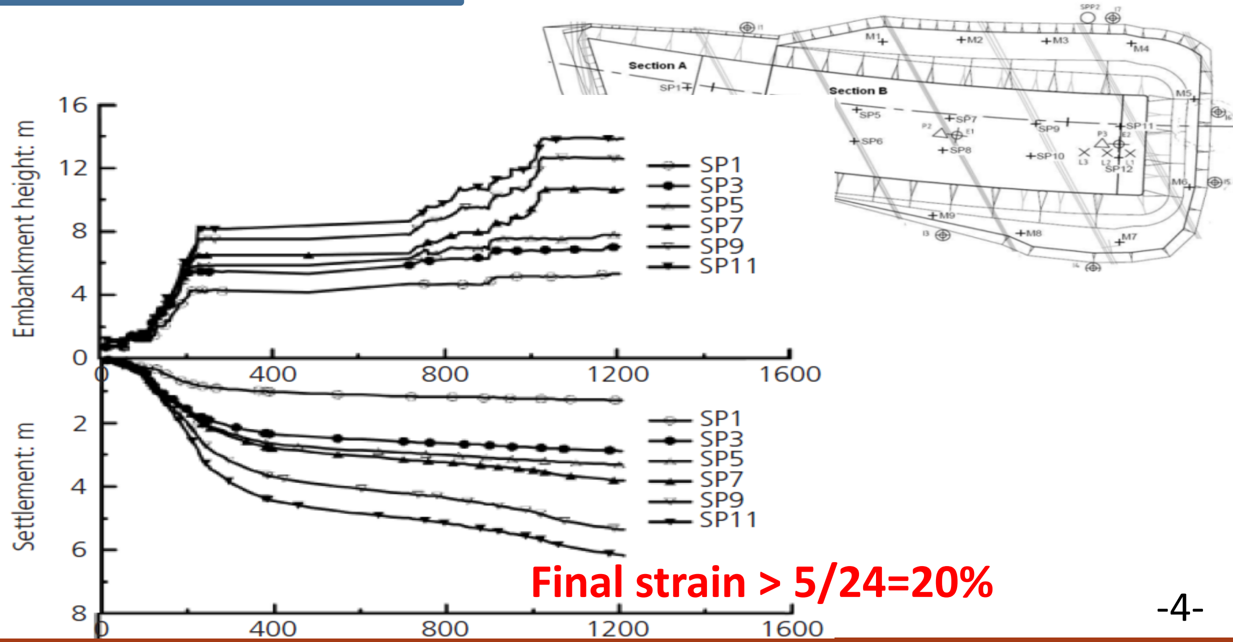
Final strain > 1.6/30=5.3%

Tianjin Port



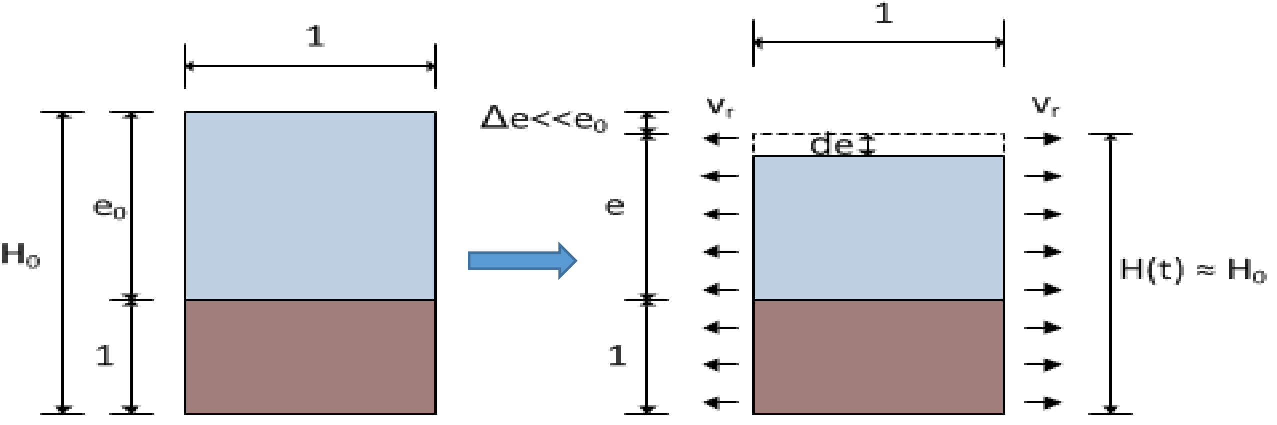
Final strain > 1.2/20=6%

Ballina Bypass



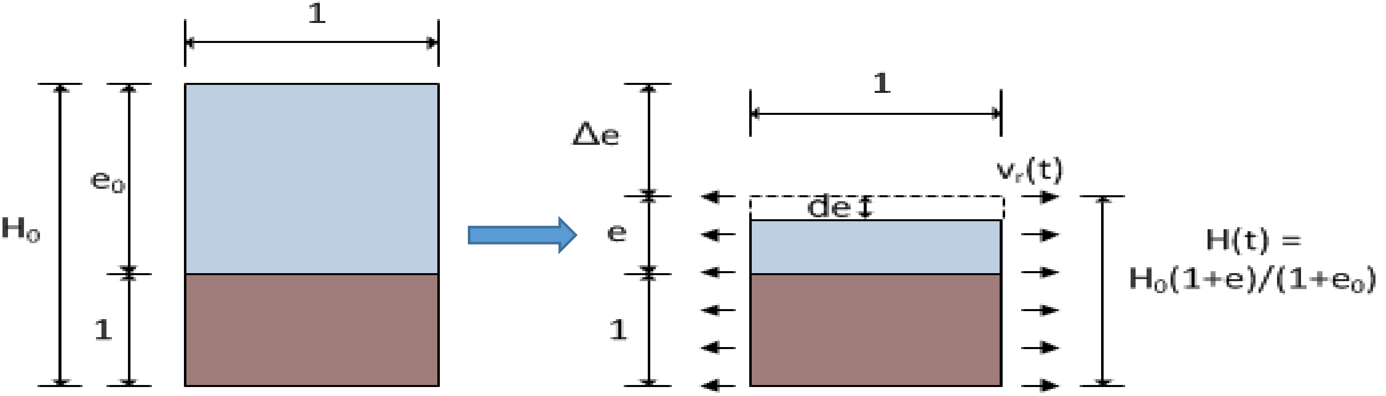
Final strain > 5/24=20%

Small strain:



$$\frac{H_0}{1+e_0}\frac{de}{dt} = -v_r H_0$$

Large strain:

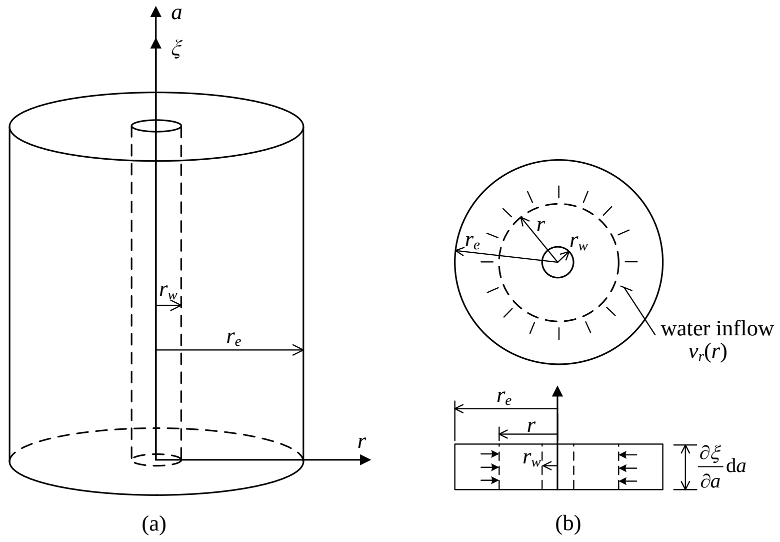


$$\frac{H_0}{1+e_0}\frac{de}{dt} = -v_r H_0 \frac{1+e}{1+e_0}$$

Conventional solution: Small Strain & linear permeability and compressibility

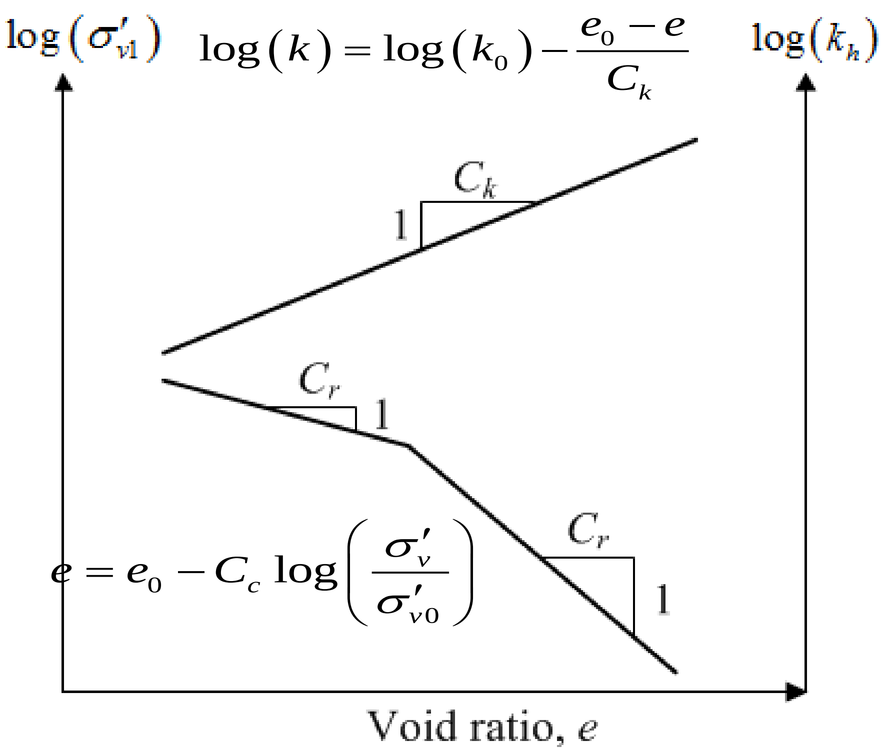
$$\frac{k_h}{m_v\gamma_w}\left(\frac{1}{r}\frac{\partial u}{\partial r}+\frac{\partial^2 u}{\partial r^2}\right)+\frac{k_v}{m_v\gamma_w}\frac{\partial^2 u}{\partial z^2}=\left(\frac{\partial u}{\partial t}-\frac{dq}{dt}\right)$$

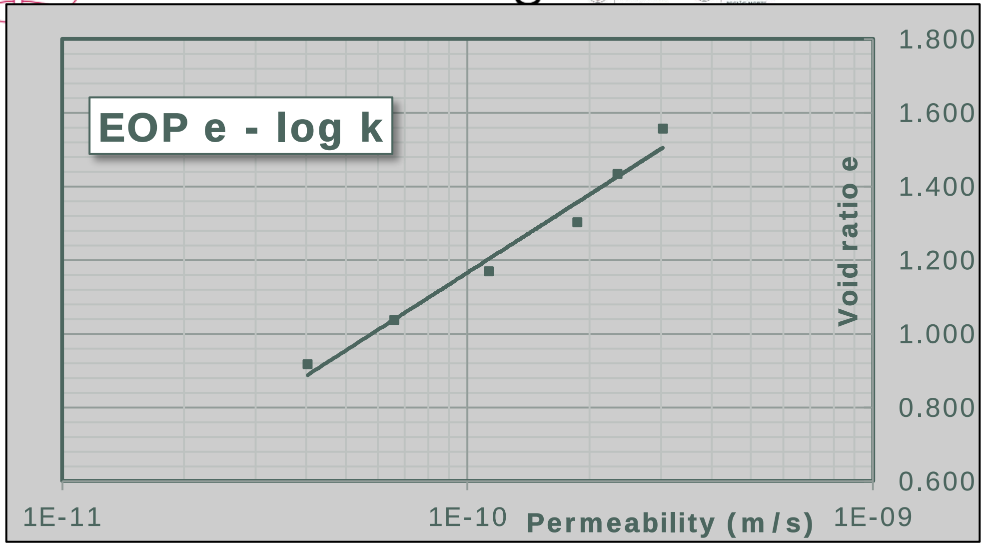
Large strain coordinate system



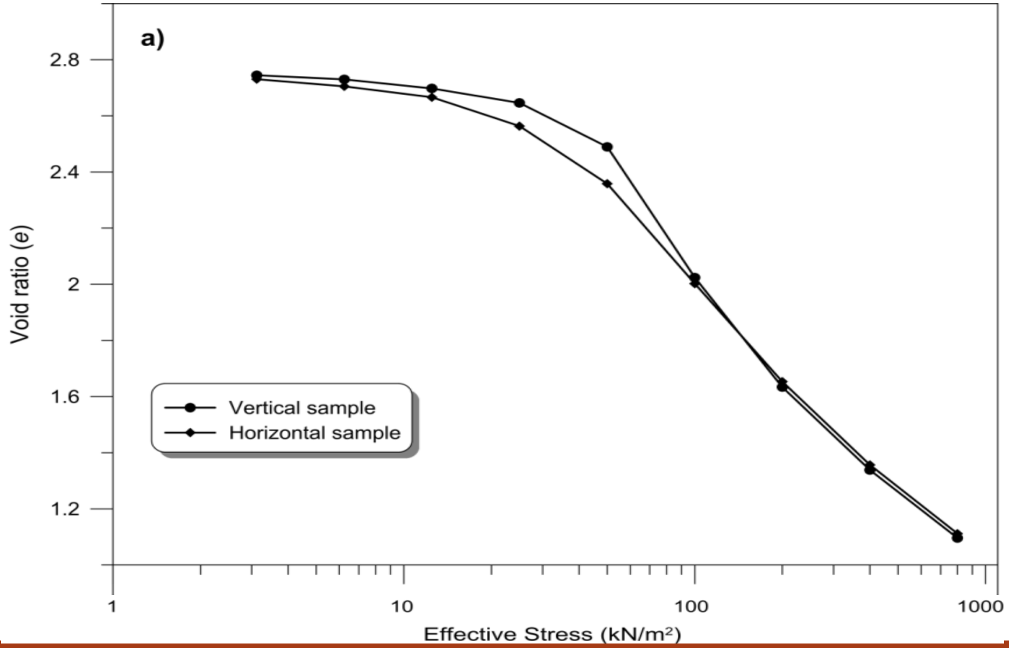
Nonlinearities

Void ratio-dependent permeability and compressibility

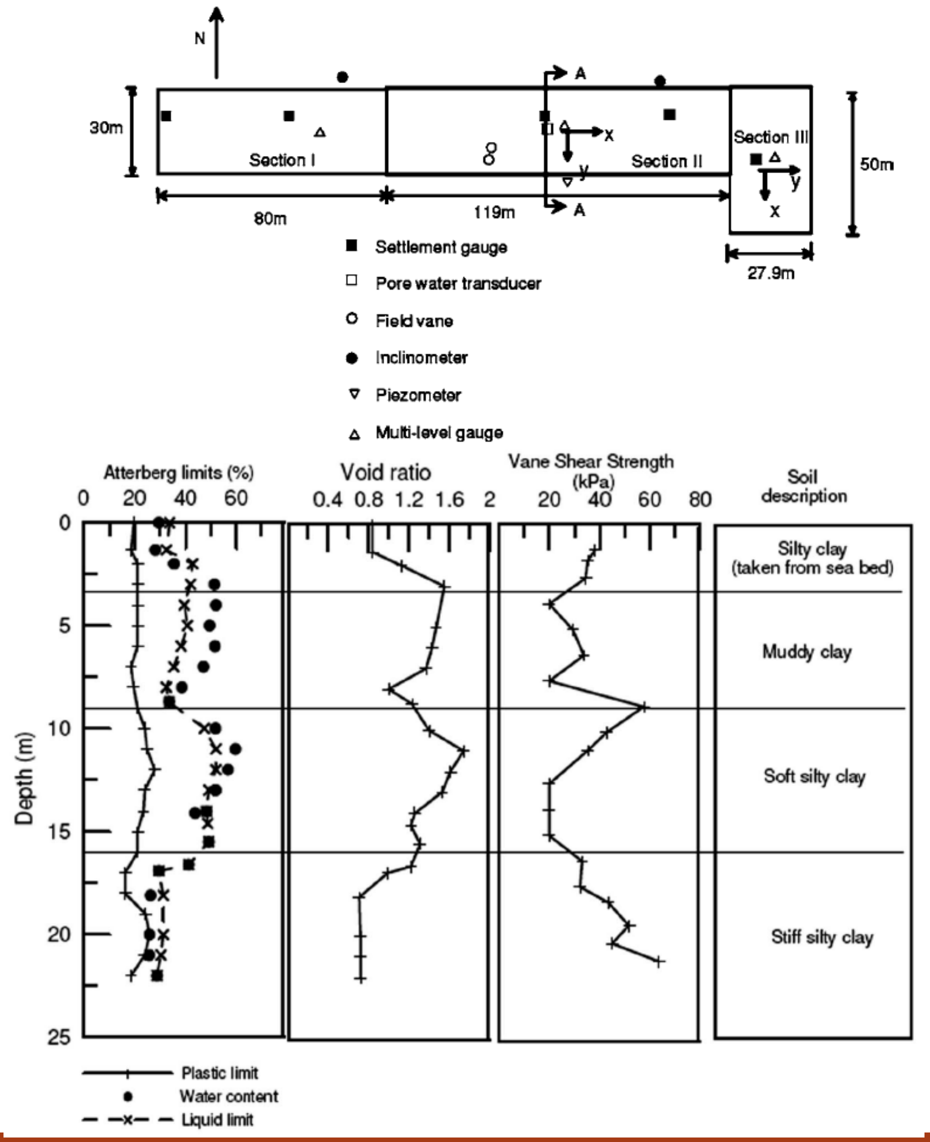


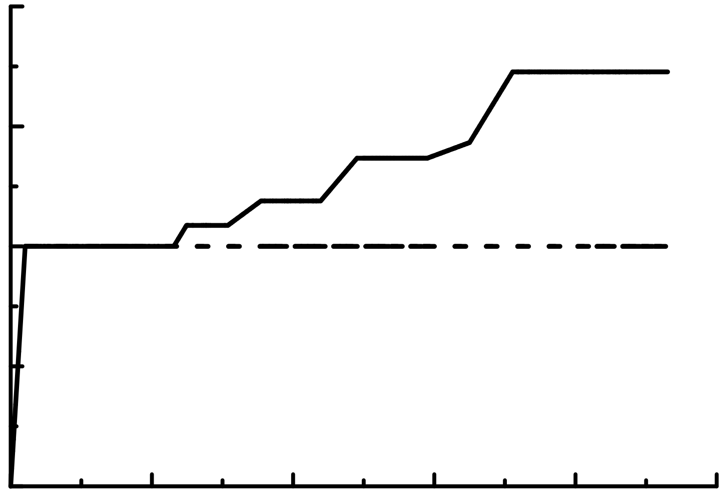


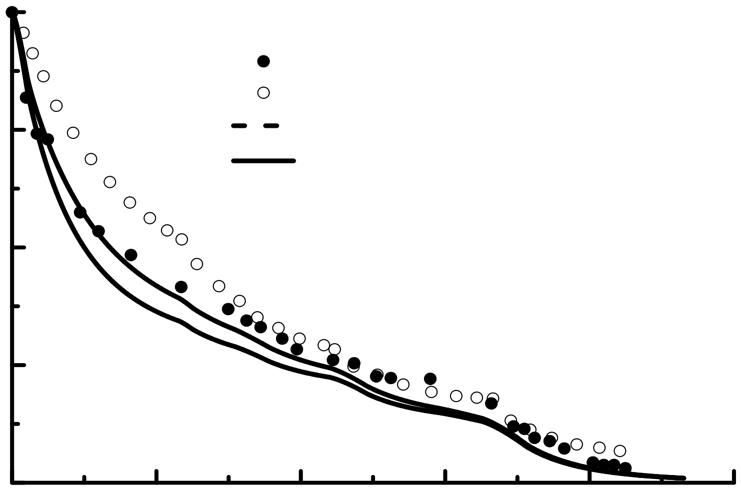
Ballina samples



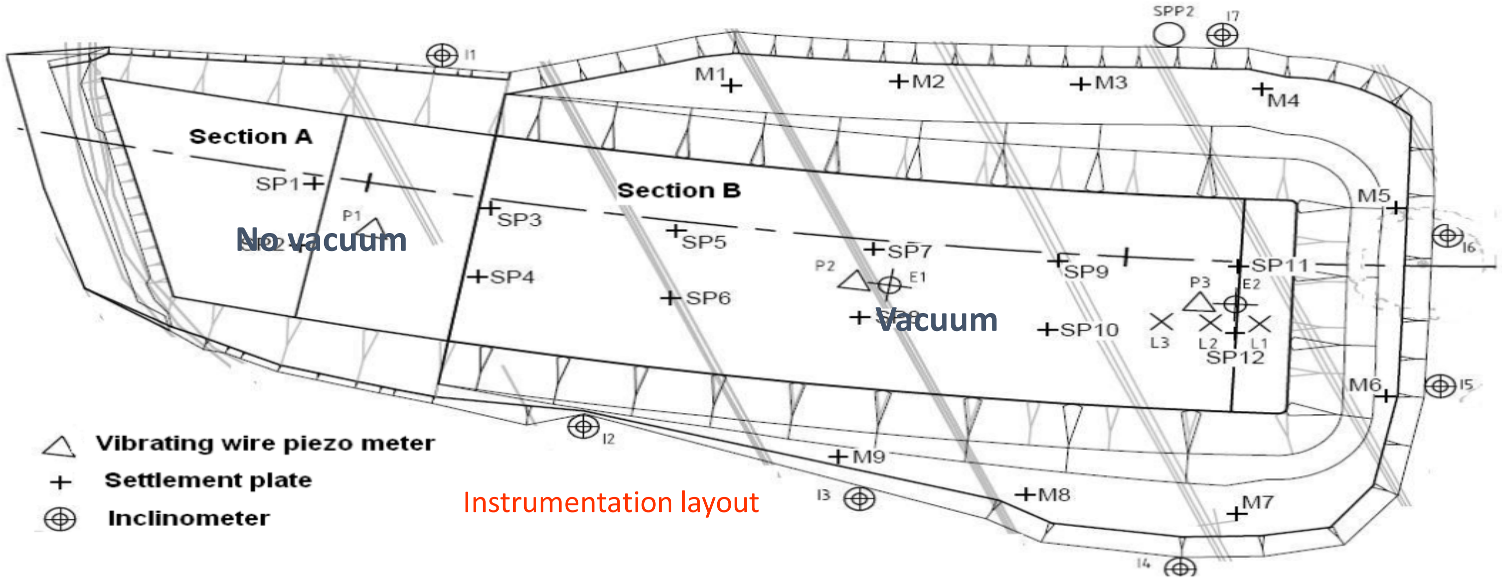
Tianjin Port Yan and Chu (2008), Rujikiatkamjorn et al. (2008)

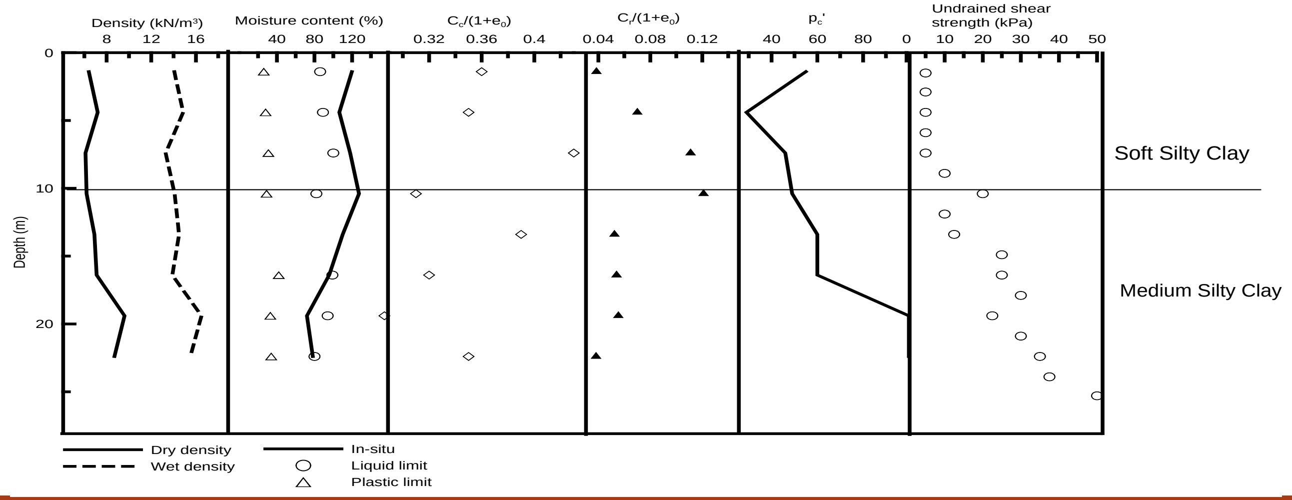


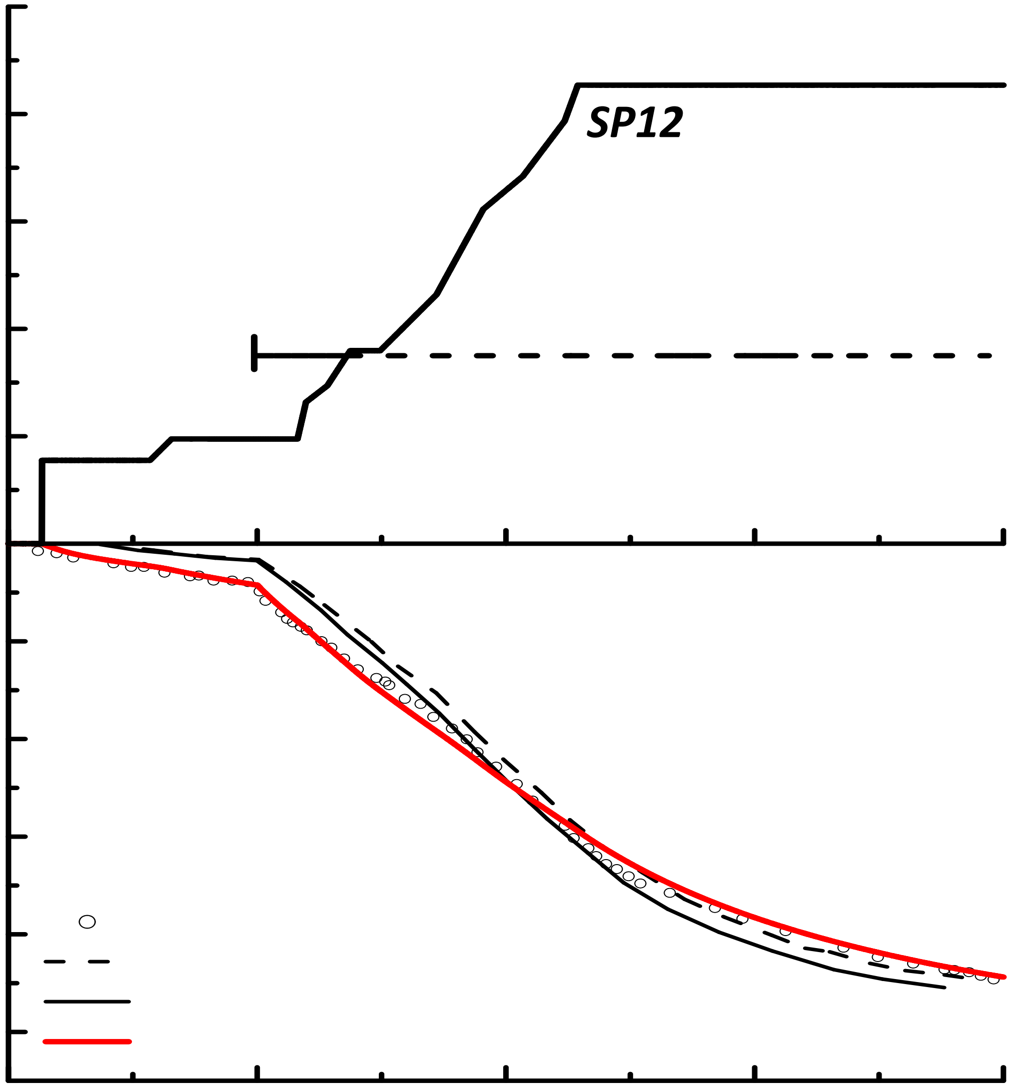




Trial Embankment Stabilized with PVD and Vacuum Preloading, Ballina Bypass, Australia







(1)The conventional small-strain solution may over-predict the degree of consolidation.

(2)Although in many cases the conventional small-strain model is still acceptable, in some cases of deep estuarine clay deposits the large-strain solution becomes significantly more accurate.

Acknowledgements:

Prof. Buddhima Indraratna and A/Prof. Cholachat Rujikiatkamjorn;

ARC Centre of Excellence for Geotechnical Science and Engineering;

Industry Partners and Institutions: Queensland Department of Main Roads, Port of Brisbane Corporation, Roads and Traffic Authority, Coffey Geotechnics, Polyfabrics, Geofabrics, ARUP, Douglas Partners, Sydney Trains, ARTC, Chemstab and Austress Menard

UoW staff and students

Thank You for your attention!

Dynamic Nonlinear Finite Element Simulation of Light Falling Weight Deflectometer (LWD) Tests on Unsaturated Road Foundation Layers

Zhen Zhang[1], Liuxin Chen[2]

1. *Central South University, Changsha, China*
2. *Central South University, Changsha, China*

- Introduction
- Modulus of Unsaturated Granular Materials
- Finite Element Modeling of LWD Deflection Targets
- References

Introduction

pavement design procedures → empirical inputs → CBR, Hveem R-value → light falling weight deflectometer (LWD)

pavement design procedures → mechanistic structural analysis and design → resilient modulus (MR) → light falling weight deflectometer (LWD)

Introduction

light falling weight deflectometer (LWD) → models (backcalculating geomaterial moduli) → major drawbacks → variations of in-situ moisture levels; suction

The primary objective of this study was to address those drawbacks affecting moduli backcalculation of foundation layers from LWD tests.

Introduction

A two-dimensional (2D) axisymmetric finite element (FE) modeling approach

in-situ LWD measurements recorded

establish LWD deflection targets for road foundation layers at various moisture levels.

Modulus of Unsaturated Granular Materials

- First introduced for use by Siekmeier et al. (2009)
- The origins of the MR constitutive equation can be found elsewhere (NCHRP 2004)
- the plastic limit (PL) was used to estimate the volumetric moisture content at saturation
- Both PL and field moisture content were used to estimate LWD
- target : compacted fine-grained soils.

Modulus of Unsaturated Granular Materials

$$M_R = k_1 p_a \left(\frac{\sigma_{eb} + f_s \theta_w \psi}{p_a} \right)^{k_2} \left(\frac{\tau_{oct}}{p_a} + 1 \right)^{k_3}$$

$$k_1 = 800 \times \left(\frac{1}{5\theta_{sat}} \right)^{1.5} \left(\frac{1}{\log_{10}(\psi)} \right); k_2 = \log_{10}(\psi) - 1; k_3 = -8\theta_{sat}; f_s = \theta_w^{10\theta_{sat}^3}; \theta_w = \left[1 - \frac{\ln\left(1 + \frac{\psi}{\psi_r}\right)}{\ln\left(1 + \frac{10^6}{\psi_r}\right)} \right] \times \frac{\theta_{sat}}{\left[\ln\left[e + (\alpha\psi)^n\right]\right]^m}$$

$$\psi_r = 500\sqrt{\theta_r}; \theta_r = 1.6\theta_{sat}^2; \alpha = \frac{1}{(100\theta_r)^2}; \theta_{sat} = -0.000431PL^2 + 0.0336PL - 0.162; n = \frac{1}{(1-m)}; m = 0.8\theta_{sat}$$

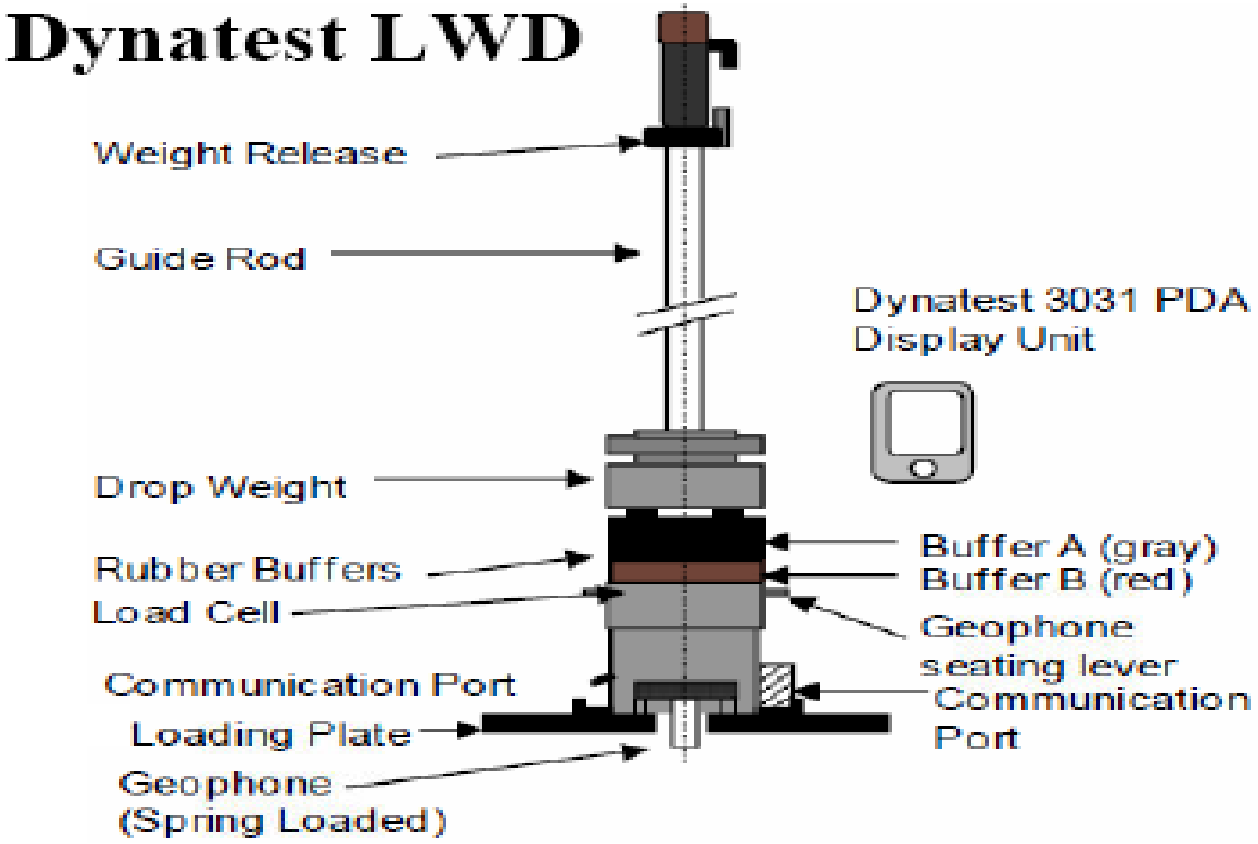
Finite Element Modeling of LWD Deflection Targets

- Abaqus®
- The Dynatest LWD was modeled, as shown in Figure 1(a).
- Soil, LWD loading plate , the 200-mm diameter LWD loading plate.
- The example FE model results of vertical stress distribution and LWD deflection targets at varying moisture levels are shown in Figure 2(b) and Figure 2(c).
- LWD deflection targets.

THANKS FOR LISTENING

Finite Element Modeling of LWD Deflection Targets

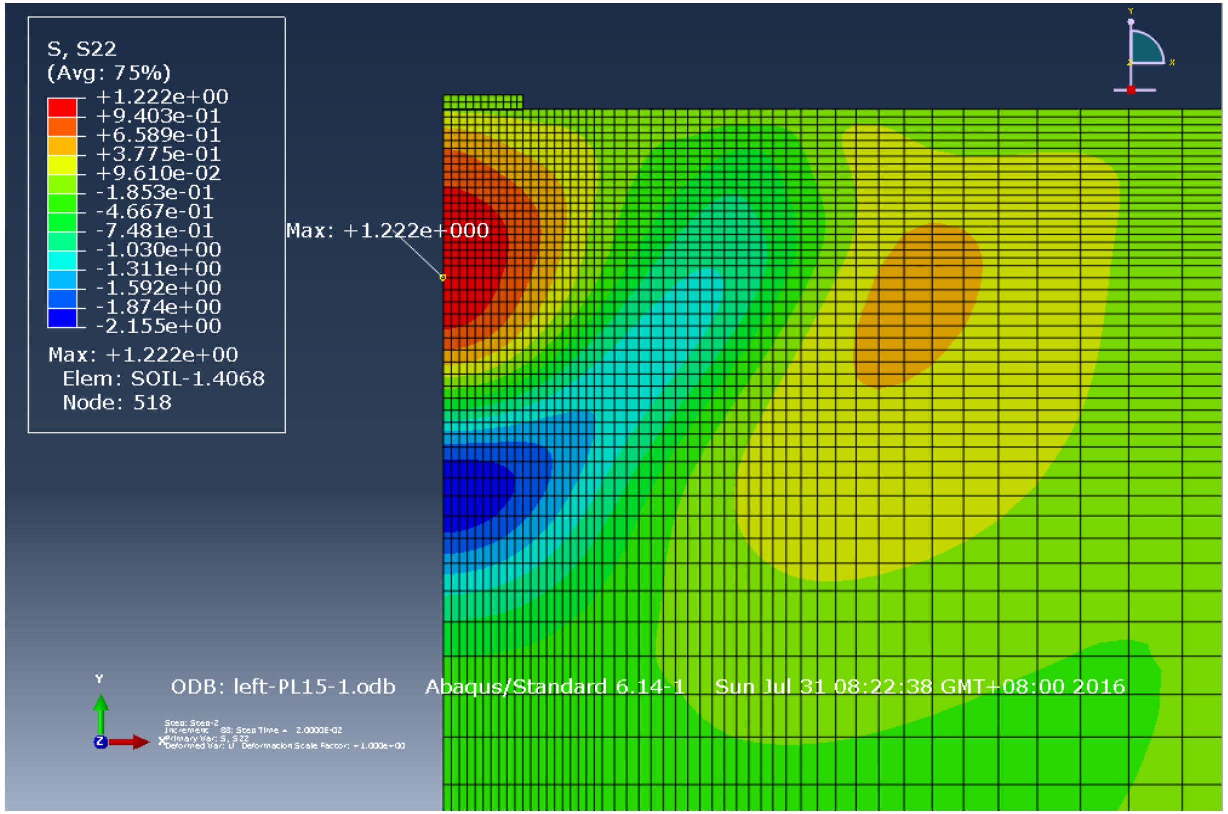
- Figure 1: (a) Schematic views of LWD device



Back

Finite Element Modeling of LWD Deflection Targets

- Figure 1:(b)example finite element model results of vertical stress distribution



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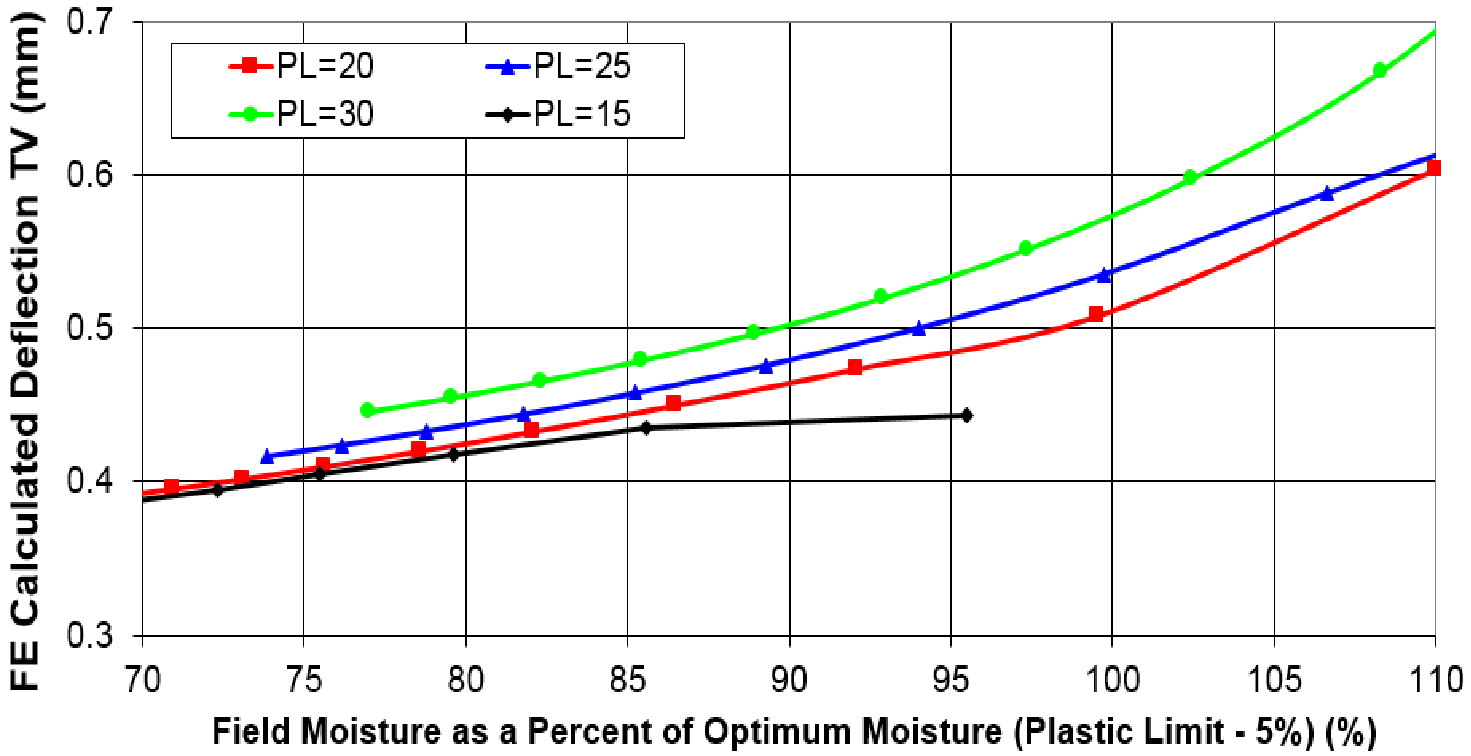
Finite Element Modeling of LWD Deflection Targets

- Figure 1:(c) LWD deflection targets at varying moisture levels



Back

Evaluation of Granular Material Degradation in Repeated Load Triaxial Test

Caroline Lima, Carlos Correia e Silva, and Laura Motta

Federal University of Rio de Janeiro, Brazil

Objective

- This study aims to evaluate the resistance of two granular material's mechanical degradation during testing in Repeated Load Triaxial (RLT) using the idea of Índice de Degradação Proctor - IDP (Proctor Compaction Degradation Index), in other words a RLTDI (Repeated Load Triaxial Degradation Index).

Methods and Materials

- Mechanical characterization test: Los Angeles (LA) abrasion, Treton and Slake Durability.

- Index degradation (IDP and RLTDI) to measure the degradation of granular materials during the Proctor compaction test and Repeated Triaxial Loading tests (permanent deformation test and resilient modulus test).

- Two typical granite-gneiss granular materials from different Brazilian quarries.
  - Three different granulometric distribution.

Los Angeles Abrasion (LA)

DNER-ME 035/98 Standard test method

- Evaluate the toughness, abrasion resistance and hardness of this aggregate

Treton

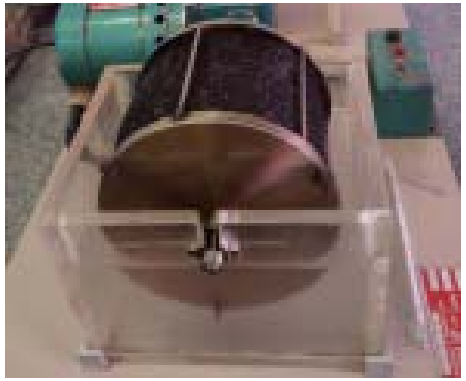
DNER ME 399/99 Standard test method

- Evaluate the loss, due to shock , of the stone material in Treton device.

Slake Durability test

ASTM D4644–08 Standard Test Method

- Evaluate the breakage and rock alteration (durability) in contact with water.



IDP – Índice de Degradação Proctor

DNER-ME 398/99

The objective of this analysis in this research is to see where there were major breaks: in the compaction or in the repeat load triaxial test.

IDP conditions in this study:

- new size distribution standard to adjust the quantity of available material,
- sample homogenization at optimum moisture content,
- modified Proctor energy,
- three samples molded in 10x20cm tripartite cylinder.

Reasons for changes:

To adjust the quantity of available material and for better comparison to RLTDI results.

IDP – Índice de Degradação Proctor

Calculation: average of the percentage differences between the mean percentage and the gradation percentage passing for each sieve.

Size Distributions	% passing						
	Original standard particle size	Chosen standard particle size for this study	Particle size after compaction				Percentage Difference (D)
			Sample 1	Sample 2	Sample 3	Average	
1 " - 25.0 mm	100	100					
3/8" - 9.5 mm	65	69					
# 4 - 4.8 mm	50	53					
#10 - 2.0 mm	35	38					
# 40 - 0.40 mm	20	20					
#200 - 0.075 mm	5	10					

$$IDP = \frac{\sum D}{5}$$

RLTDI – Repeated Load Triaxial Degradation Index

Two different size distribution were studied for two materials.

The RLT test:

- nine dynamic tests (permanent deformation before resilient modulus),
- at least 150,000 cycles for permanent deformation test,
- one stress stage for sample at permanent deformation test,
- frequency of 1 or 2 Hz.

The degradation index after the RLT test is calculated the same way as an IDP. In this case, each RLTDI had to be calculated for nine samples.

All samples after the RLT tests were deranged and sieved as IDP procedure, and with these results it was possible to analyze the final particle size distribution to compare degradation

RLTDI – Repeated Load Triaxial Degradation Index

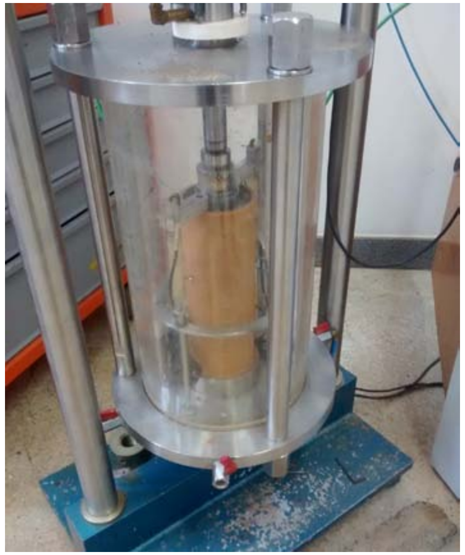
RESILIENT MODULUS

Sample	Stress (kPa) σd	Stress (kPa) σ3
1	69	69
2	207	69
3	309	103

Sample	Stress (kPa) σd	Stress (kPa) σ3
1	21	
2	41	21
3	62	
4	34	
5	69	34
6	103	
7	51	
8	103	51
9	155	
10	69	
11	137	69
12	206	
13	103	
14	206	103
15	309	
16	137	
17	275	137
18	412	

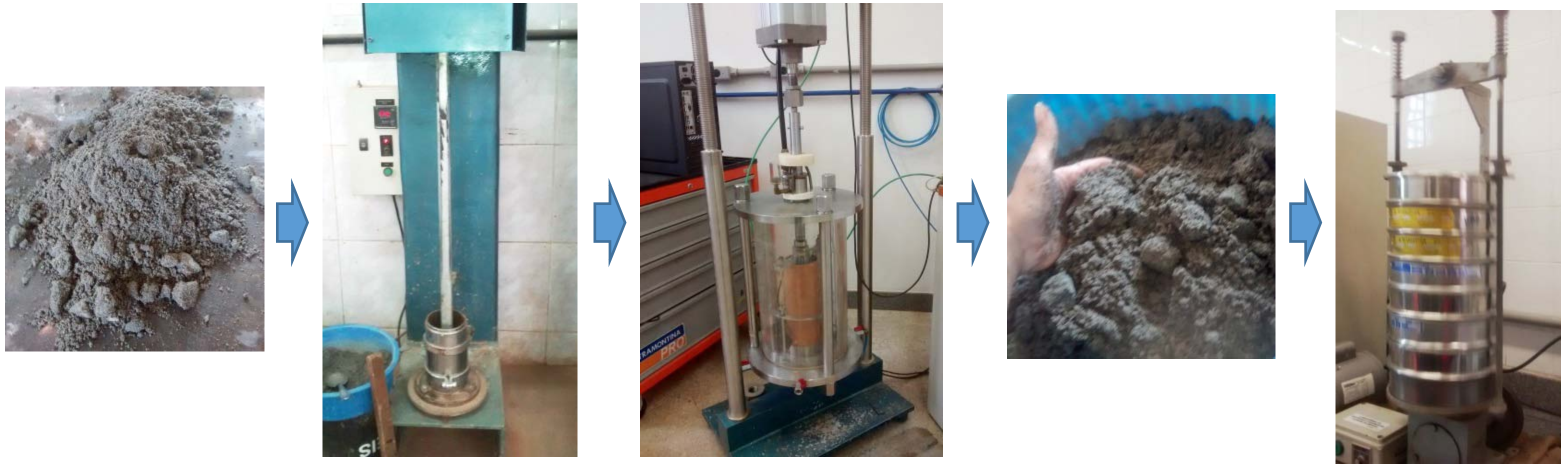
PERMANENT DEFORMATION

Sample	Stress (kPa) σd	Stress (kPa) σ3
1	50	
2	100	50
3	150	
4	80	
5	160	80
6	240	
7	120	
8	240	120
9	360	



Procedure

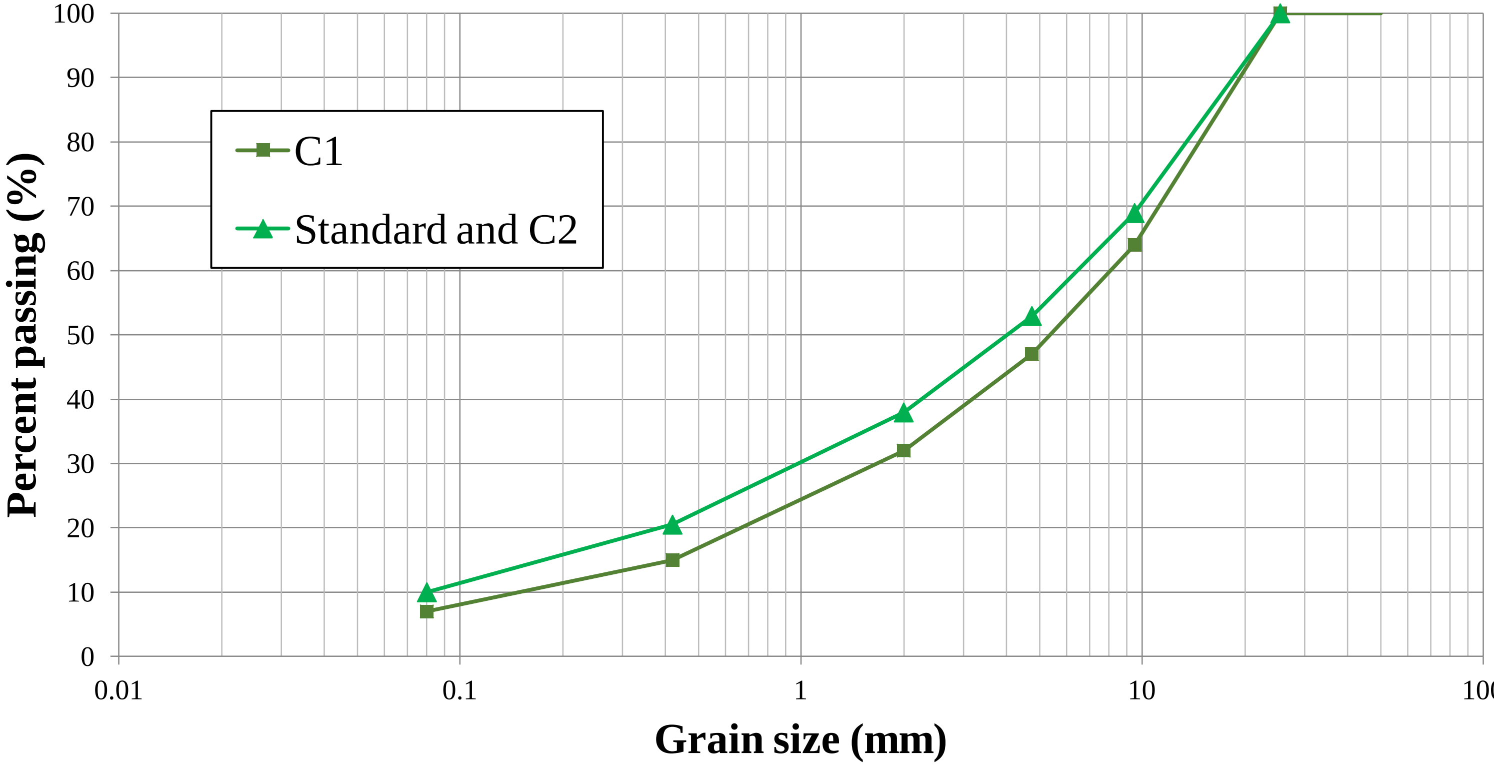
IDP



RLTDI

Material

Size Distributions	% Passing C1	% Passing C2
1 " - 25.0 mm	100.0	100
3/8" - 9.5 mm	64.0	68.9
# 4 - 4.8 mm	47.0	52.9
#10 - 2.0 mm	32.0	37.9
# 40 - 0.40 mm	15.0	20.5
#200 - 0.075 mm	7.0	10.0



Material

Description	Material 1		Material 2	
	C1	C2	C1	C2
OMC (%)	4.9	5.4	5.0	5.7
γdmax (g/cm³)	2.288	2.111	2.223	2.03
γcoarse (g/cm³)	2.62		2.64	
γfine (g/cm³)	2.7		2.6	
Absorption (%)	0.8		0.5	

Results and Analysis

Size Distributions	% Passing					
	Material 1			Material 2		
	Standard IDP	C1 RLTDI	C2 RLTDI	Standard IDP	C1 RLTDI	C2 RLTDI
1" – 25.0 mm	100	100	100	100	100	100
3/8" – 9.5 mm	69	64	68.9	69	64	68.9
#4 – 4.8 mm	53	47	52.9	53	47	52.9
#10 – 2.0 mm	38	32	37.9	38	32	37.9
#40 – 0.40 mm	20	15	20.5	20	15	20.5
#200 – 0.075 mm	10	7	10.0	10	7	10.0
Degradation Index	8.47	7.24	6.17	11.08	7.46	2.19
Trenton (%)	24			-		
LA (%)	41			43		
Slake Durability test (%)	99.5			-		

- The IDP of the material 1 showed little breakage during compaction and the IDP for the aggregate material 2 was slightly greater than for the material 1, but in accordance with a granite-gneiss.

Remembering: Materials with standard curves were only subjected to Proctor compaction

Results and Analysis

Size Distributions	% Passing					
	Material 1			Material 2		
	Standard IDP	C1 RLTDI	C2 RLTDI	Standard IDP	C1 RLTDI	C2 RLTDI
1” – 25.0 mm	100	100	100	100	100	100
3/8” – 9.5 mm	69	64	68.9	69	64	68.9
#4 – 4.8 mm	53	47	52.9	53	47	52.9
#10 – 2.0 mm	38	32	37.9	38	32	37.9
#40 – 0.40 mm	20	15	20.5	20	15	20.5
#200 – 0.075 mm	10	7	10.0	10	7	10.0
Degradation Index	8.47	7.24	6.17	11.08	7.46	2.19
Trenton (%)	24			-		
LA (%)	41			43		
Slake Durability test (%)	99.5			-		

- The degradation value for curves of material 1 showed no significant difference after RLT indicating that the material degradation most occurred along the Proctor compaction.

Conclusions

- For both materials the most breaks and abrasion occurred during the compaction process, but all of the materials showed few breakages;
- Tests efforts, LA and Treton, were consistent but it is necessary to try more flexible criteria for granular layers;
- It is important make an evaluation of the degradation resistance using an image technique to measure the effects of degradation on angularity, texture, sphericity and form.

Thank you

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Intelligent Earthworks Optimization System

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University of Minho, Portugal

Overview

- Background: Earthworks as an optimization problem

- Soft Computing tools
  - Metaheuristics
  - Data Mining
  - Geographic Information Systems

- System architecture
  - Overview
  - Solution assessment

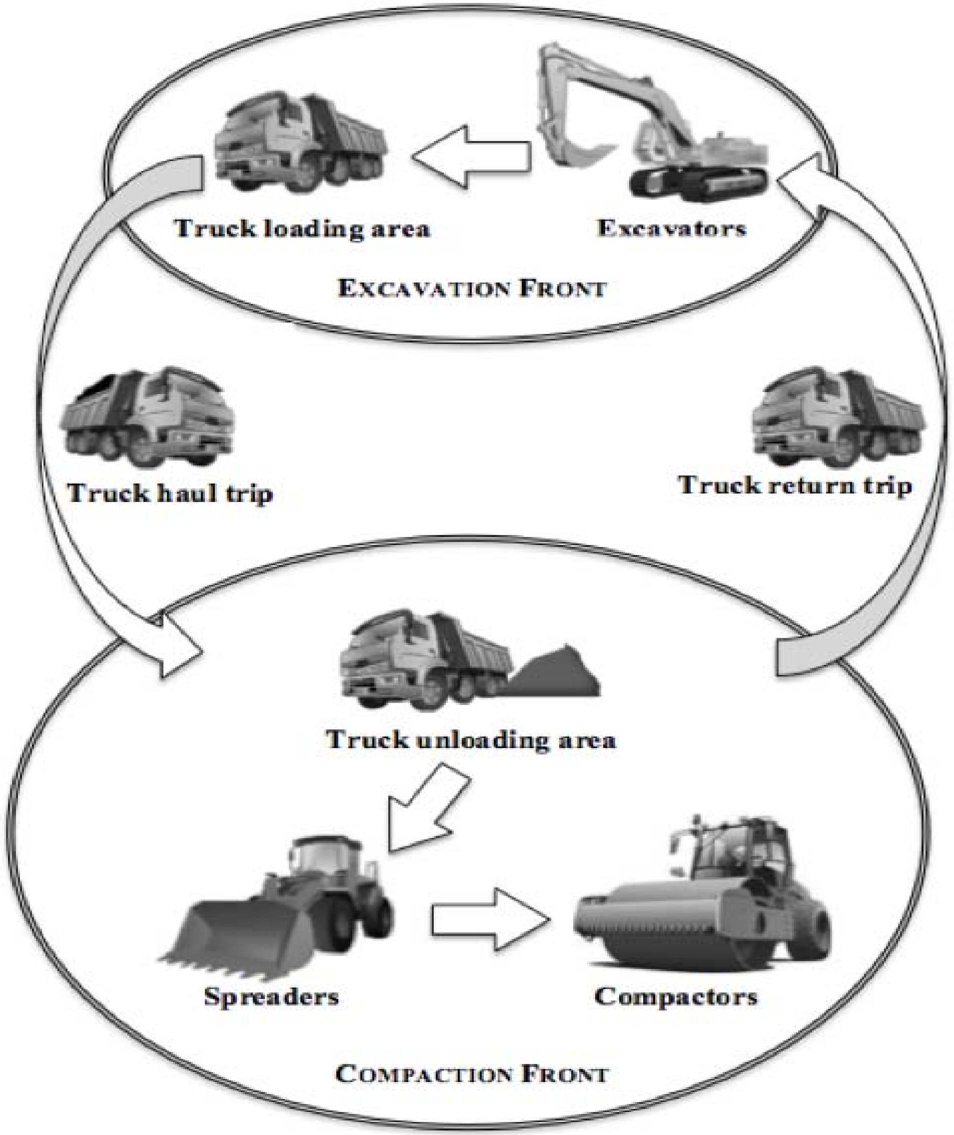
- Application results

Background Earthworks as an optimization problem

Ground levelling in Engineering precedes any type of structural construction. Earthworks achieve this by:

- Excavating geomaterials from areas above the target height
- Transporting them to areas below target height, where they are spread into layers and compacted

As an optimization problem, earthworks can be translated into several production lines that require different types of resources (mechanical equipment).



Background

Earthworks as an optimization problem

An earthwork production line:

- Is associated with high construction costs and durations in transportation infrastructure projects;
- Involves repetitive sets of sequential and interdependent tasks, strongly based on mechanical equipment;
- Is highly susceptible to being optimized, even though few attempts have been carried out, due to their complex and dynamic nature.

Several production lines can be active simultaneously:
Where to start?
How to distribute the available equipment through construction site?

Overview

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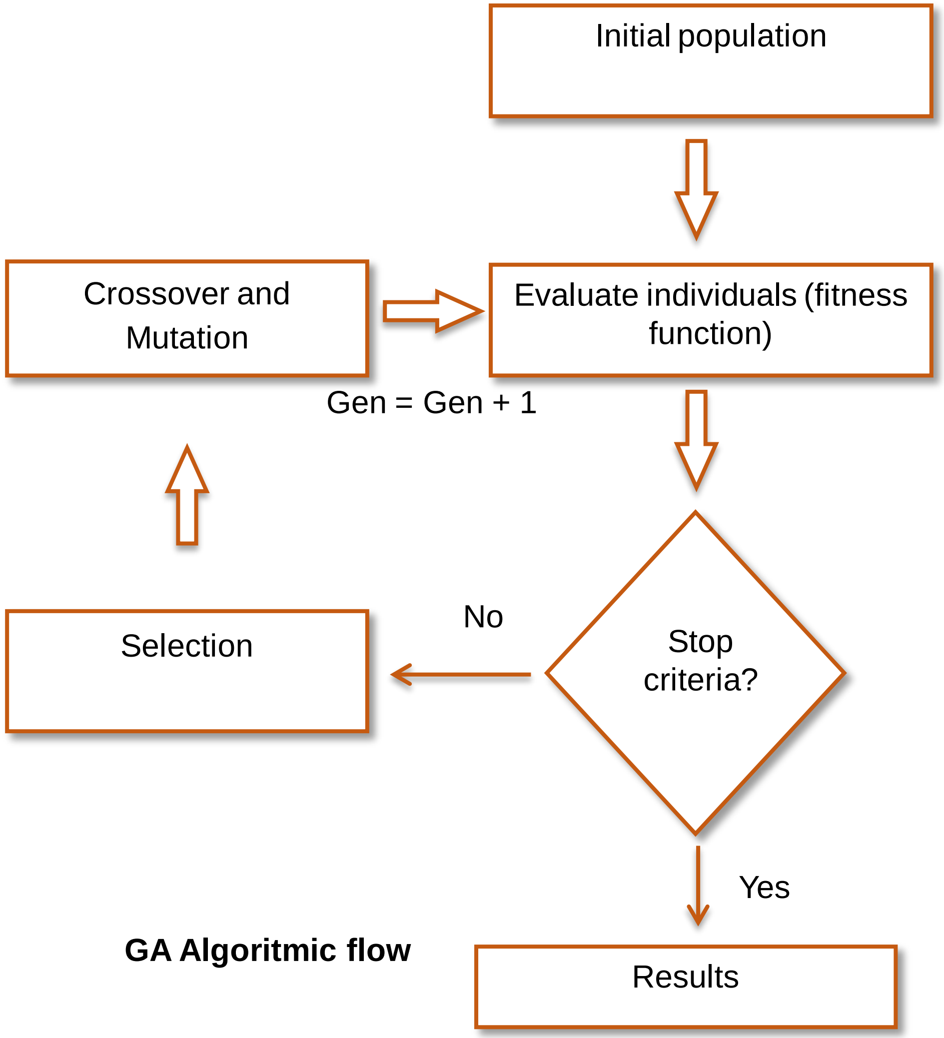
Soft Computing tools Metaheuristics



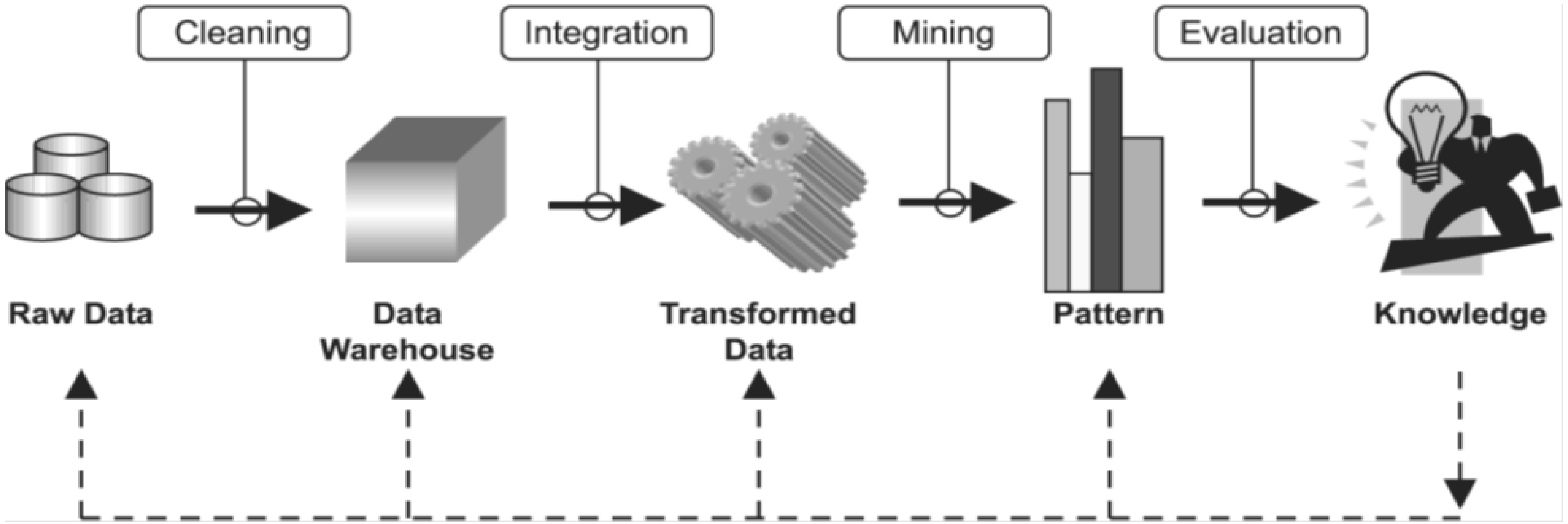
GA Algoritmic flow

Genetic algorithms (GA):

- Based on evolutionary ideas of natural selection and genetics
- Can deal with large search spaces within reasonable computational effort
- In each iteration, the GA improves on the best-found solutions of the previous one

Gradually tend towards an optimal solution for the problem

Soft Computing tools Data Mining



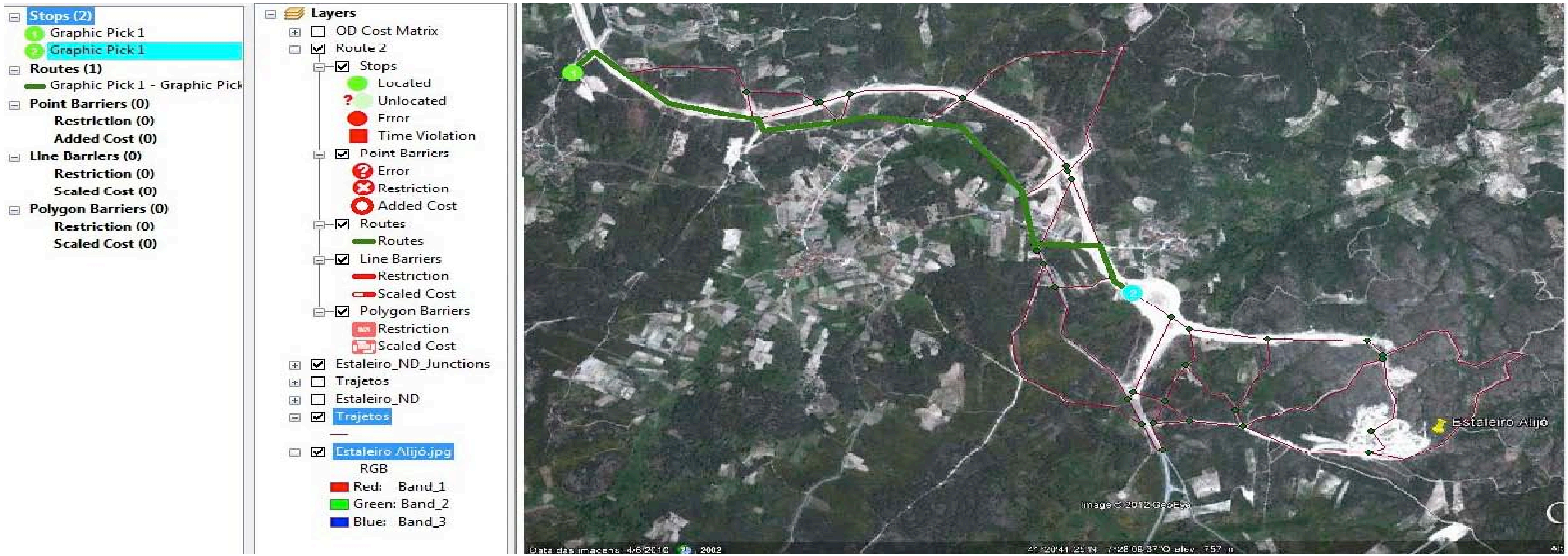
DM Process

Data Mining (DM):

- Applied to databases where results are known
- Can be used to predict the behaviour of new data in similar conditions/situations

Prediction of unknown earthworks parameters (e.g. equipment productivity)

Soft Computing tools Geographic Information Systems



Route optimization

Geographic information systems (GIS):

- Path finder algorithms are an effective and efficient means of finding the best trajectories in a network

Optimization of earthworks transportation routes

Overview

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  - Data Mining
  - Geographic Information Systems
- System architecture
  - Overview
  - Solution assessment
- Application results

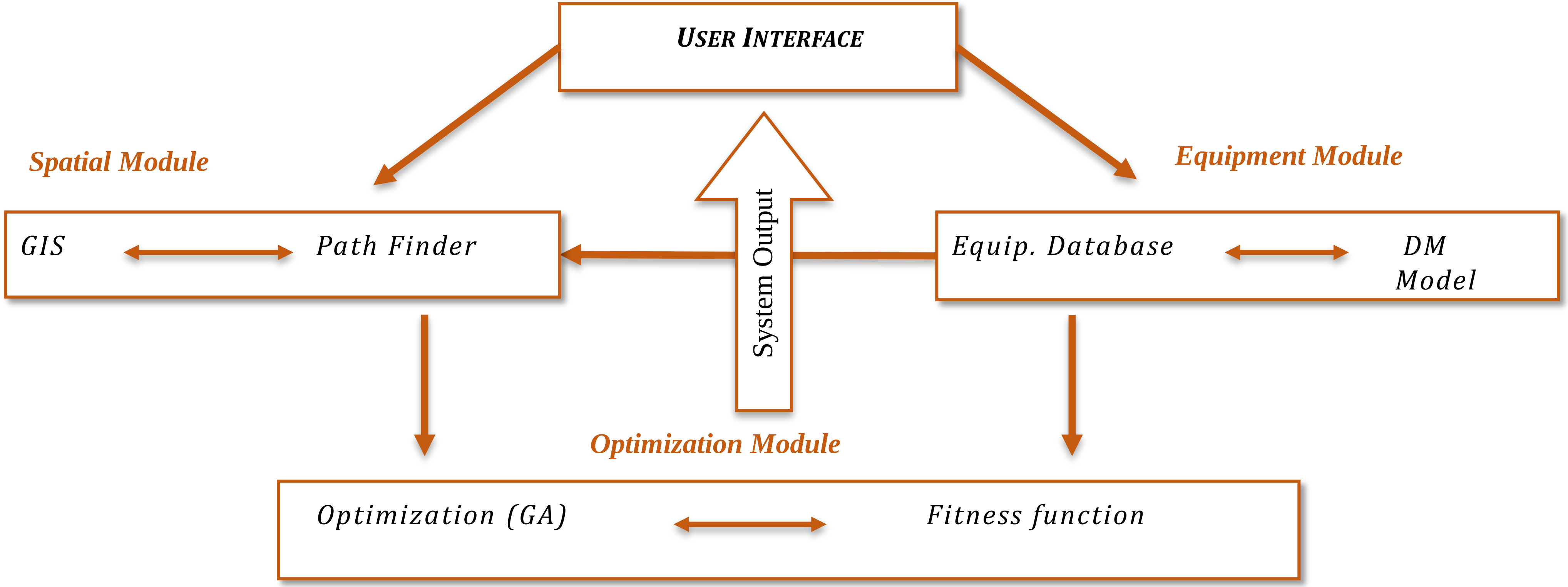
System architecture Overview

Intelligent earthwork optimization system:

- 3 modules
- Each module is based on a different technology
- Integrated modules

Module	Technology	Implementation tool	Function
Equipment	Data Mining	R/rminer	• user inputs; • estimation of productivity & costs
Spatial	Geographic Information Systems	R, QGIS, ArcGIS	• modelling of construction site; • path finder
Optimization	Metaheuristics	R/mco	• (near) optimal selection of equipment fleet depending on availability; • (near) optimal equipment fleet allocation throughout construction phase; • return output to user.

System architecture Overview



Module integration

System architecture

Solution assessment

Load DM models for compactor productivity

GIS data / OD cost matrix

Construction phase 1

PL1 = 10000 m^3

PL2 = 10000 m^3

System architecture

Solution assessment

Load DM models for compactor productivity

GIS data / OD cost matrix

⇩

Population generation (compactor distribution)

Construction phase 1

PL1 = 10000 m^3

Q_{PL1} = 1000 m^3/h

PL2 = 10000 m^3

Q_{PL2} = 500 m^3/h

System architecture

Solution assessment

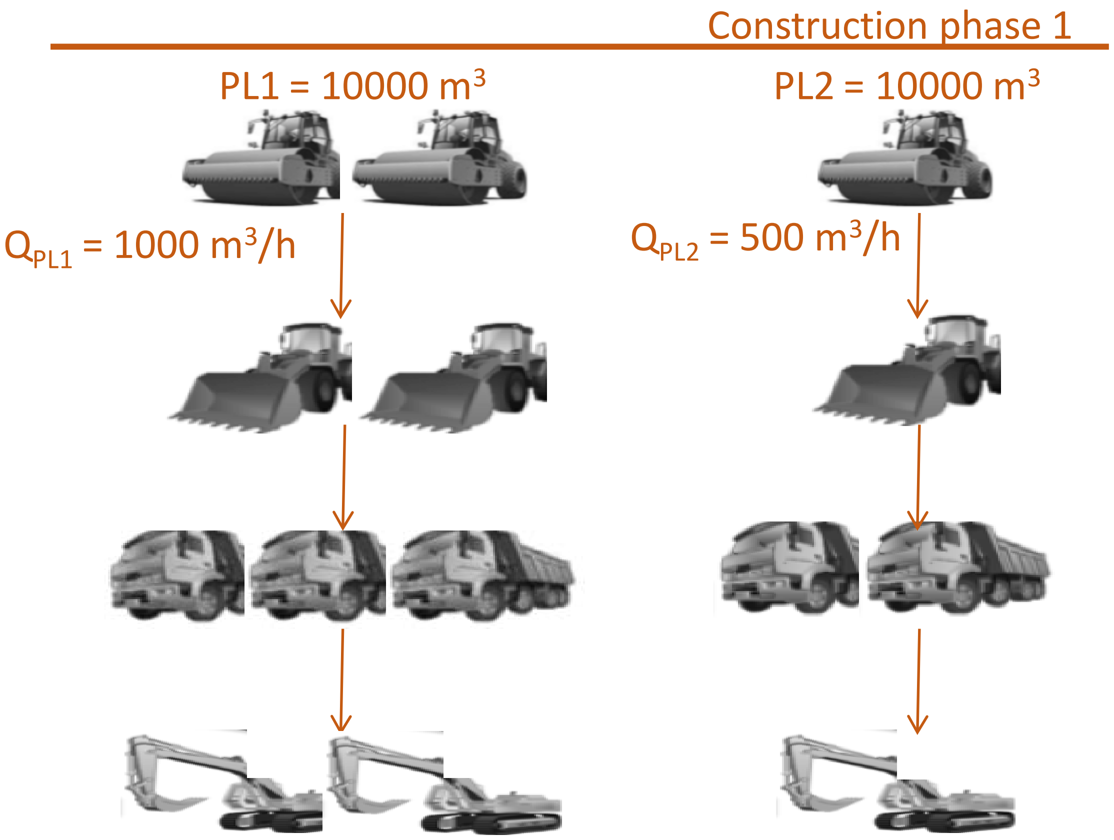
Load DM models for compactor productivity

GIS data / OD cost matrix

Population generation (compactor distribution)

Fitness evaluation (for each solution)

Equipment allocation in other tasks



System architecture

Solution assessment

Load DM models for compactor productivity

GIS data / OD cost matrix

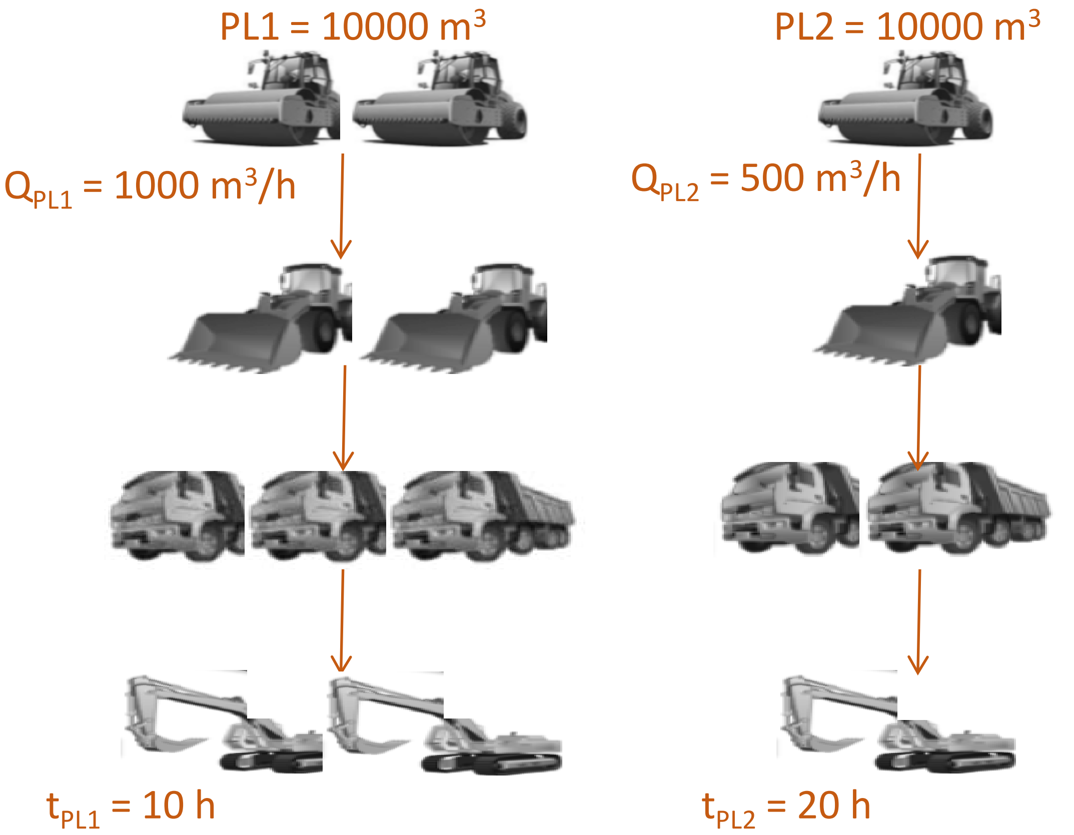
Population generation (compactor distribution)

Fitness evaluation (for each solution)

Equipment allocation in other tasks

Calculate compaction duration and costs

Construction phase 1



System architecture

Solution assessment

Load DM models for compactor productivity

GIS data / OD cost matrix

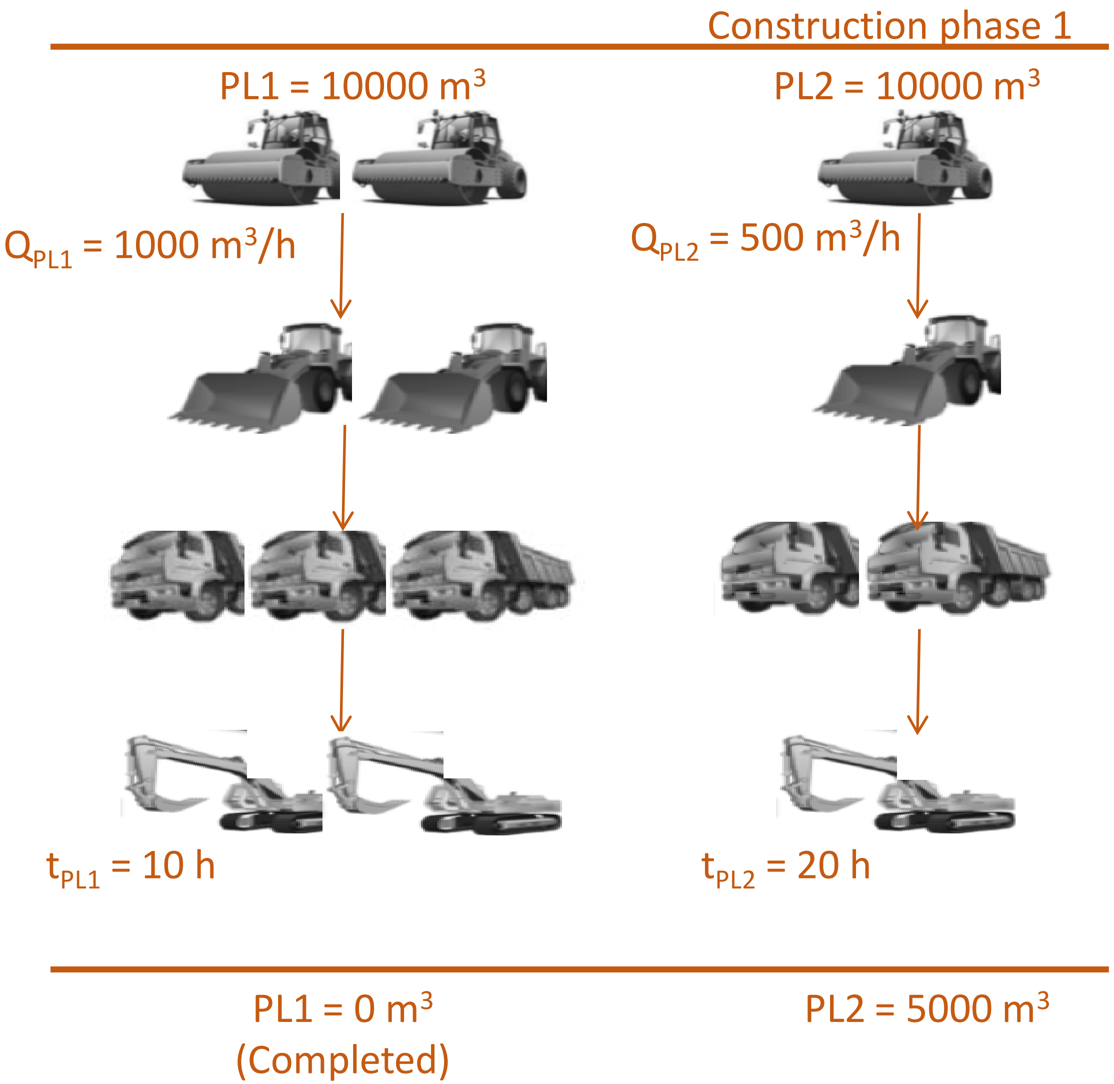
Population generation (compactor distribution)

Fitness evaluation (for each solution)

Equipment allocation in other tasks

Calculate compaction duration and costs

Update material volumes in all fronts



System architecture

Solution assessment

Load DM models for compactor productivity

GIS data / OD cost matrix

↓

Population generation (compactor distribution)

↓

Fitness evaluation (for each solution) →

Repeat fitness function for each construction phase:

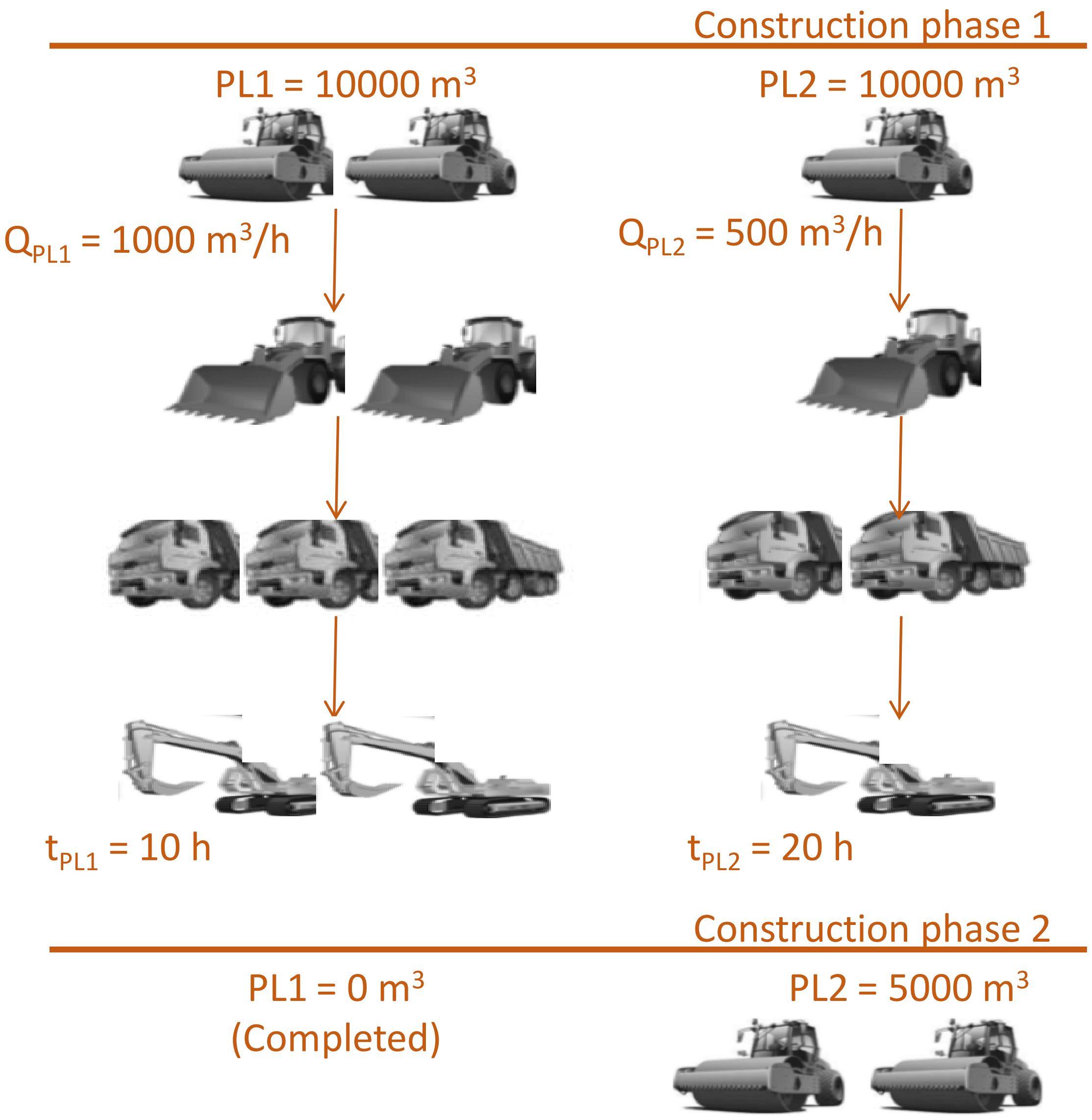
Equipment allocation in other tasks

↓

Calculate compaction duration and costs

↓

Update material volumes in all fronts



System architecture

Solution assessment

Load DM models for compactor productivity

GIS data / OD cost matrix

Population generation (compactor distribution)

Fitness evaluation (for each solution)

Crossover & mutation for new population generation

No

Stop criteria?

Yes

Output

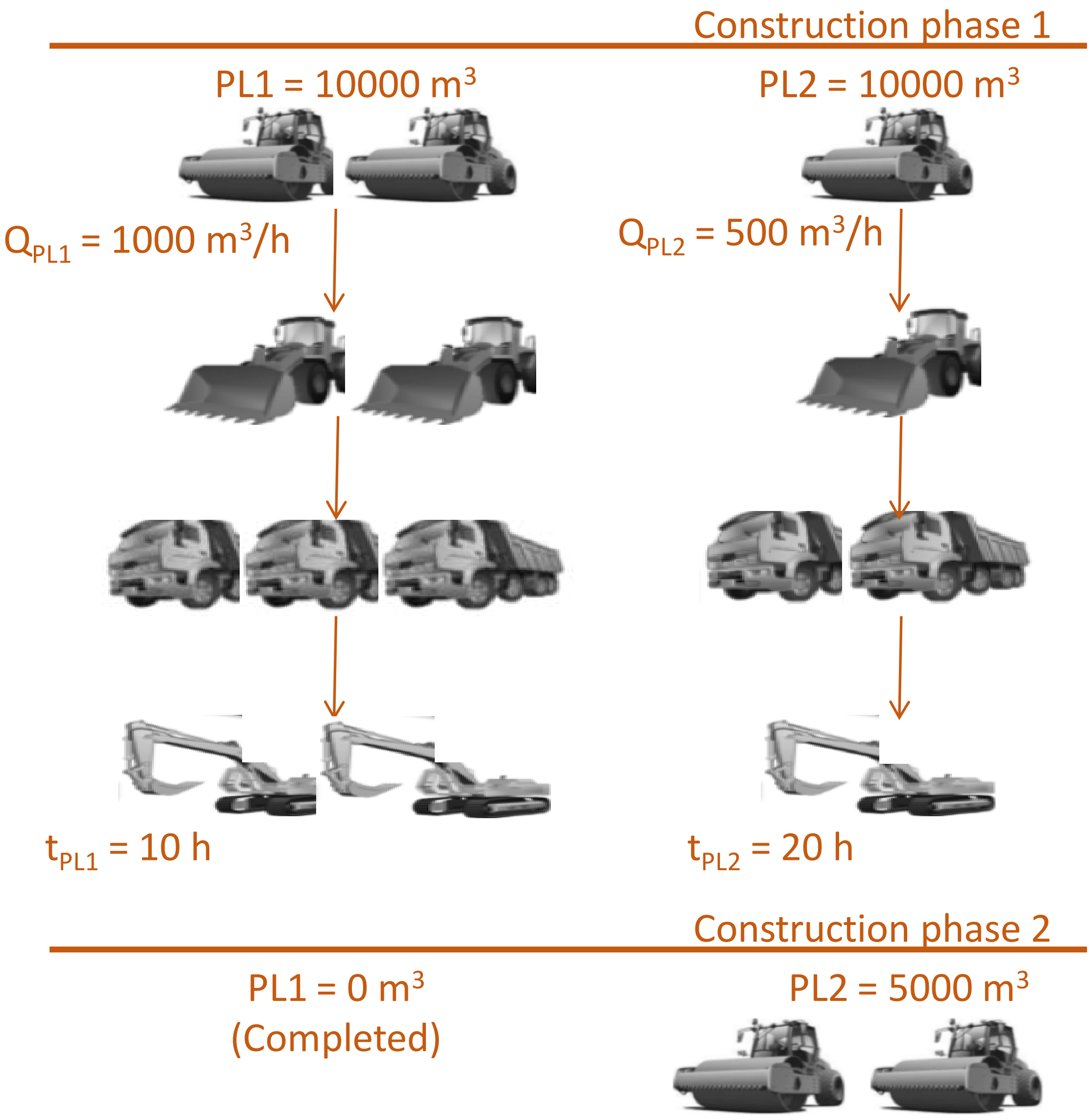
Repeat fitness function for each construction phase:

Equipment allocation in other tasks

Calculate compaction duration and costs

Update material volumes in all fronts

System **algoritmic flow**



Overview

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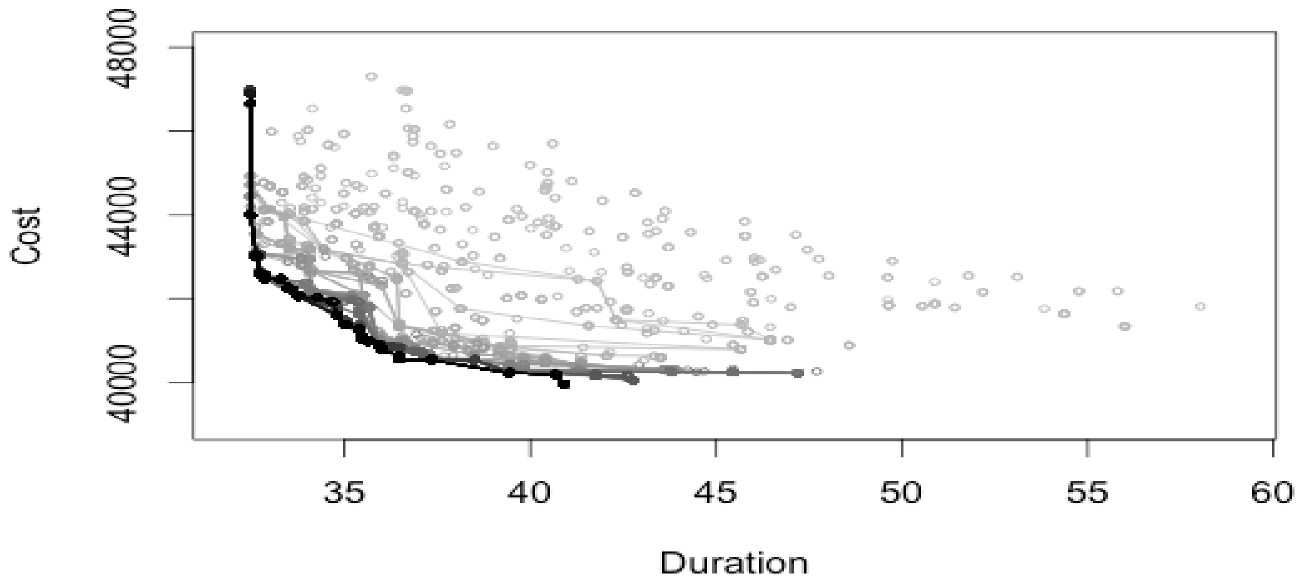
Application results

Implementation of the system has been successfully achieved, including validation with real construction data from a Portuguese construction site.

Assessment of optimization algorithm convergence towards Pareto-optimal front:



This type of solution representation increases the versatility of the system from the designer point of view

Algorithm convergence –
Cost in euro; Duration in hours.

Application results

Parameter	Conventional allocation	Optimized allocation
Approximate distance to excavation front (m)	500	
Number of compactors	1	1
Compactor work rate (m^3/h)	683	683
Number of spreaders	1	1
Spreader work rate (m^3/h)	675	820
Number of dumper trucks	3	2
Dumper truck work rate (m^3/h)	1280	880
Number of excavators	1	2
Excavator work rate (m^3/h)	540	743

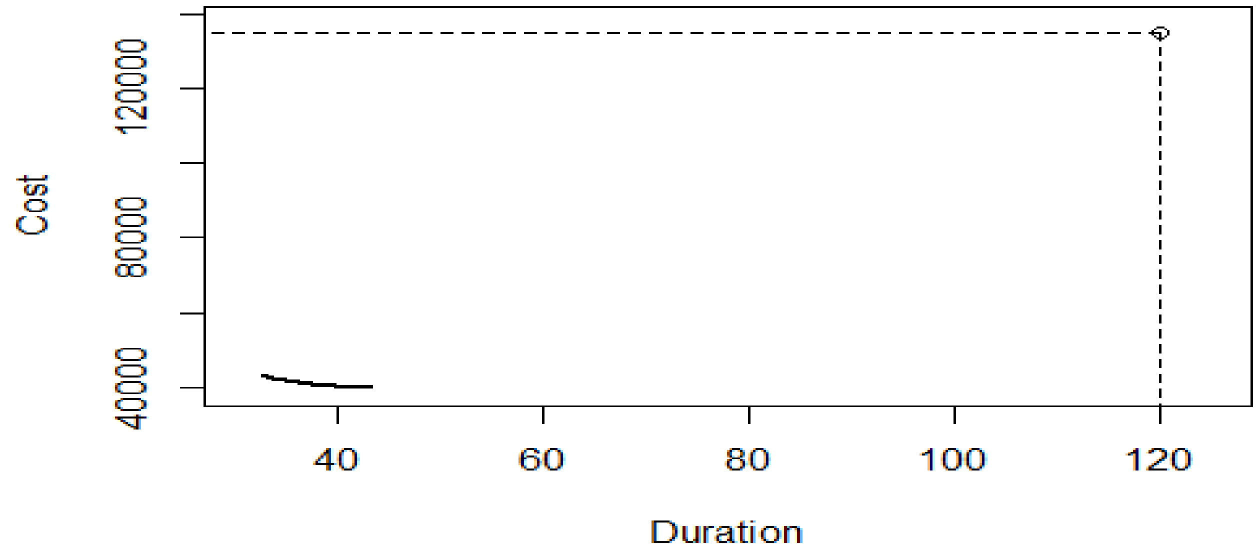
Example – comparison between the optimized solution and the conventional solution obtained by manual design:

- Conventional allocation:
  - Limited by the excavation team work rate
  - Over-allocation of dumper trucks
- The optimized allocation finds the most homogeneous allocation solution given the available resources

Resources are used at full efficiency (e.g. no idle time)

Application results

Overall comparison between the obtained Pareto-optimal solutions and the original manual solution adopted by the designer:



Dot: **Original human solution**
Line: **Obtained Pareto front of solutions**

Competitive results were achieved by the proposed system (reduction of 20-50% in project cost and duration when compared with human solution), stressing the advantages of intelligent optimization tools in the design of earthworks.

Publications

Data mining applications

Parente, M., Correia, A., & Cortez, P. (2014). Use of DM techniques in earthworks management: a case study. In S.-E. Chen, D. T.-T. Chang, & Y.-L. Lee (Eds.), *ASCE Geotechnical Special Publication (GSP), GeoHubei 2014 International Conference - Earthwork Project Management, Slope Stability Analysis, and Wave-Based Testing Techniques* (pp. 1–8). Yichang, Hubei, China: American Society of Civil Engineers. doi:10.1061/9780784478523.001

Parente, M., Gomes Correia, A., & Cortez, P. (2014). Artificial Neural Networks Applied to an Earthwork Construction Database. In D. Toll, H. Zhu, A. Osman, W. Coombs, X. Li, & M. Rouainia (Eds.), *Second International Conference on Information Technology in Geo-Engineering* (pp. 200–205). Durham, UK: IOS Press.

Optimization algorithm

Parente, M., Cortez, P., & Gomes Correia, A. (2015). An evolutionary multi-objective optimization system for earthworks. *Expert Systems with Applications*, *42*(11), 6674–6685.

System development and application

Parente, M., Cortez, P., & Gomes Correia, A. (2015). Combining Data Mining and Evolutionary Computation for Multi-Criteria Optimization of Earthworks. In A. Gaspar-Cunha, C. H. Antunes, & C. Coello (Eds.), *Lecture Notes in Computer Science Vol: 9019. 8th International Conference on Evolutionary Multi-Criterion Optimization (EMO 2015)*. Guimarães, Portugal: Springer.

Parente, M., Gomes Correia, A., & Cortez, P. (2015). Modern optimization in earthwork construction. In M. G. Winter, D. M. Smith, P. J. L. Edlred, & D. G. Toll (Eds.), *Proceedings of the XVI ECSMGE* (pp. 343–348). ICE Publishing. doi:10.1680/ecsmge.60678

Intelligent Earthworks Optimization System

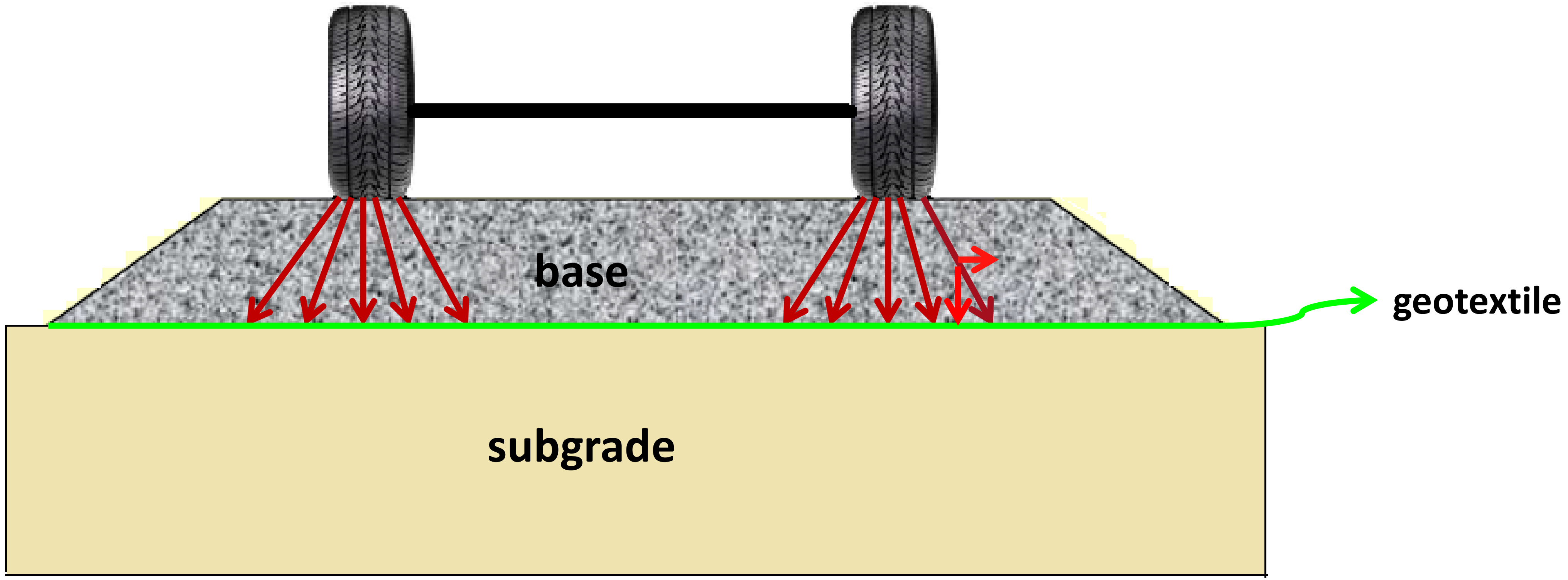
Thank you

OPTIMUM DESIGN OF UNPAVED ROADS REINFORCED WITH GEOTEXTILES: COMPARISON OF INTERNATIONALLY PUBLISHED METHODOLOGIES

Karavasili Styliani[1], Tastani Sousana[2], Markou Ioannis[3]

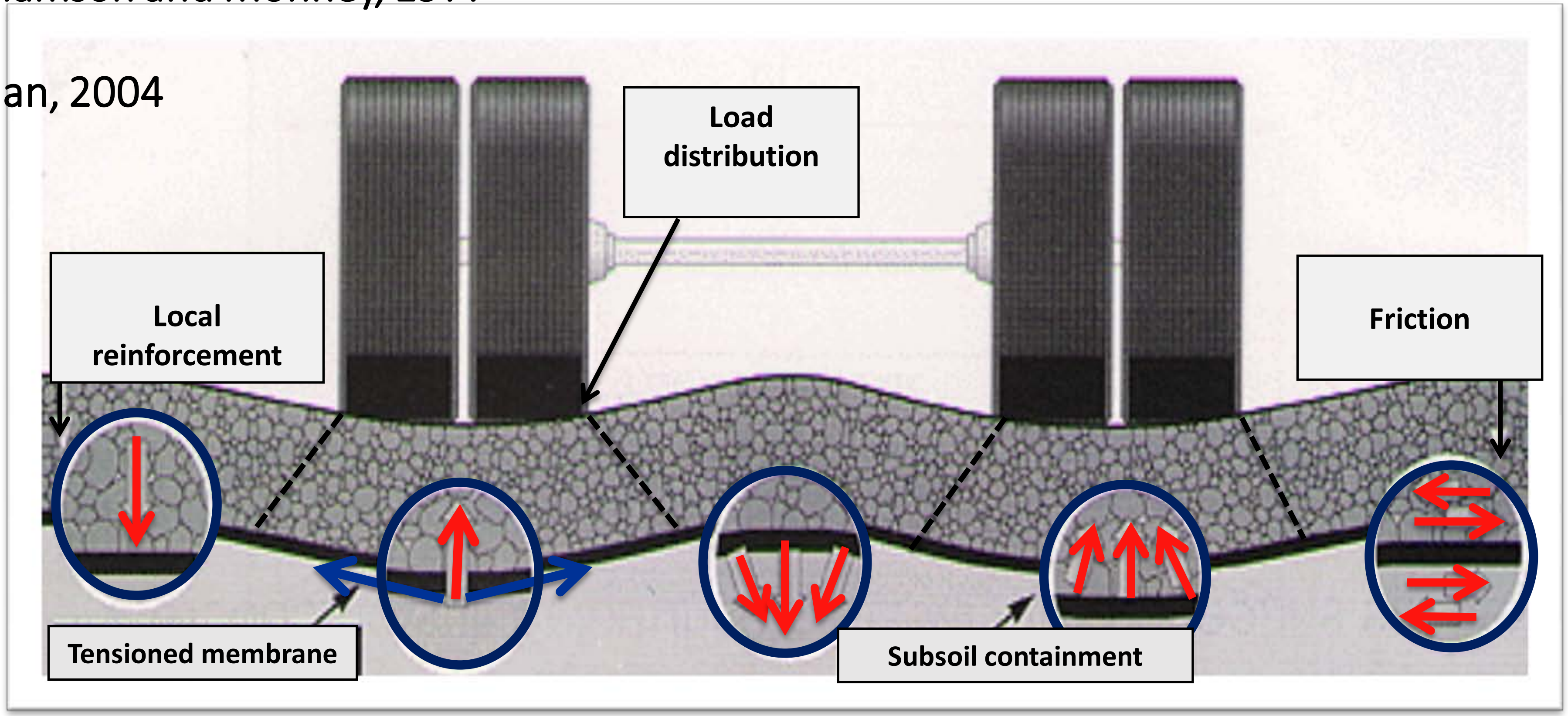
1. *Thrace Nonwovens & Geosynthetics, Technical Support*
2. *Democritus University of Thrace, Lecturer*
3. *Democritus University of Thrace, Associate Professor*

LOAD DISTRIBUTION

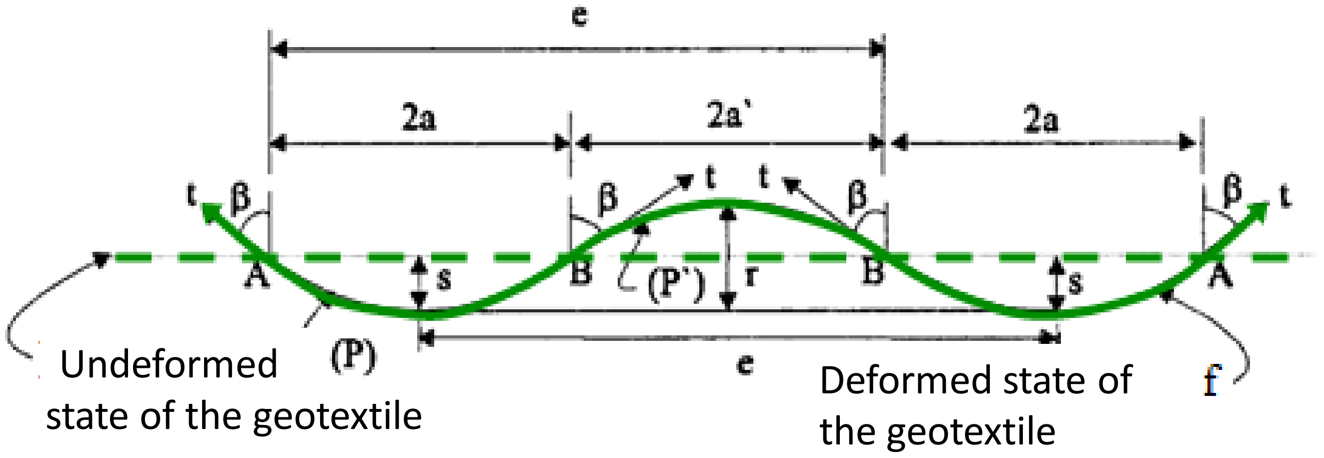


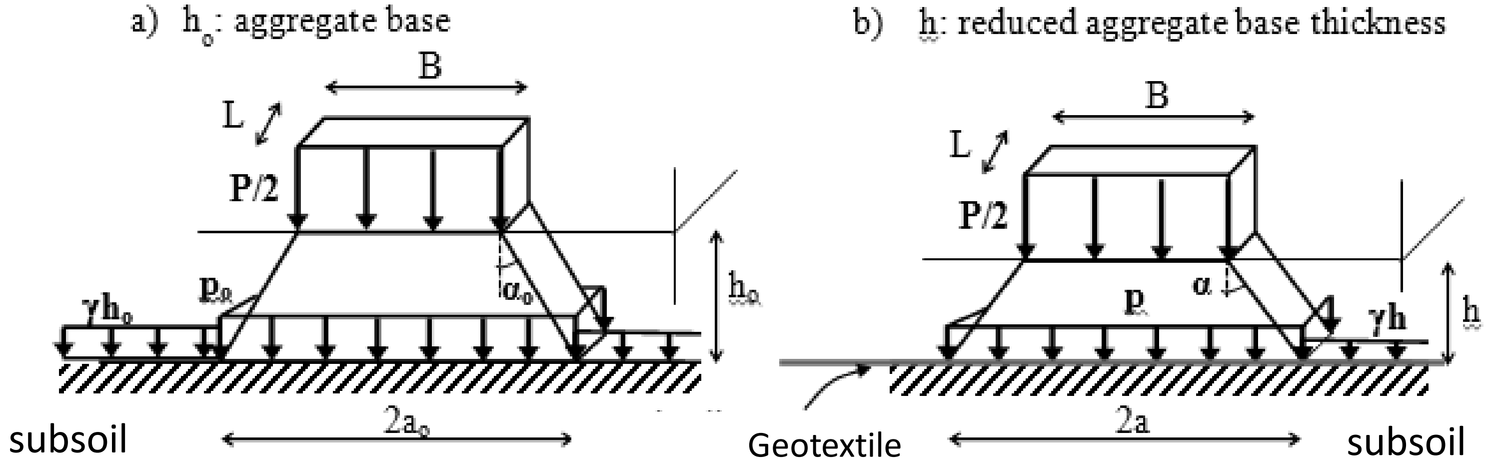
REINFORCEMENT FUNCTION

- Giroud and Noiray 1981 and Giroud et. al, 1985
  (Holtz and Sivakugan 1987 examples considered)
- Steward, Williamson and Mohney, 1977
- Giroud and Han, 2004

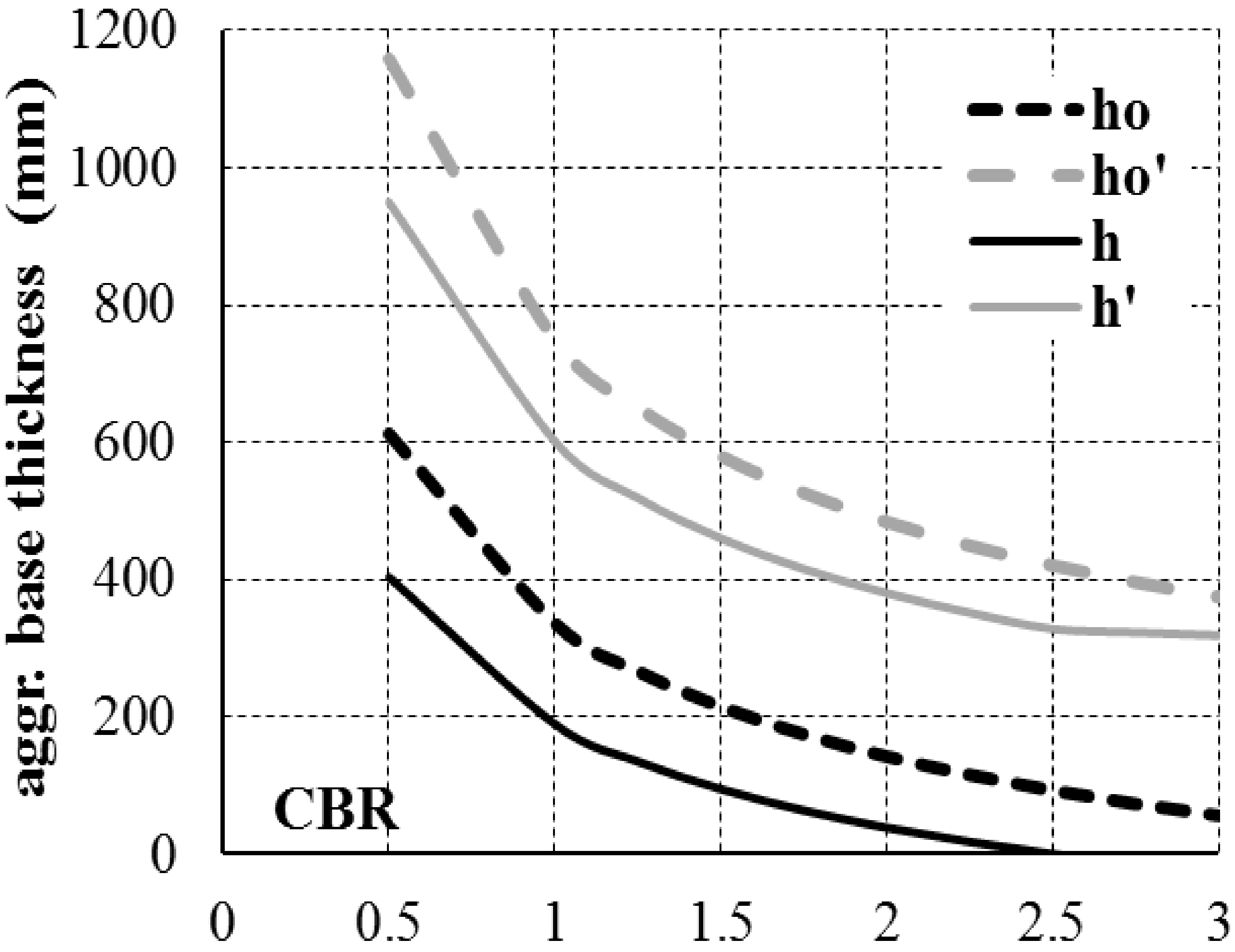


GIROUD & NOIRAY (1981) – GIROUD et al. (1985)





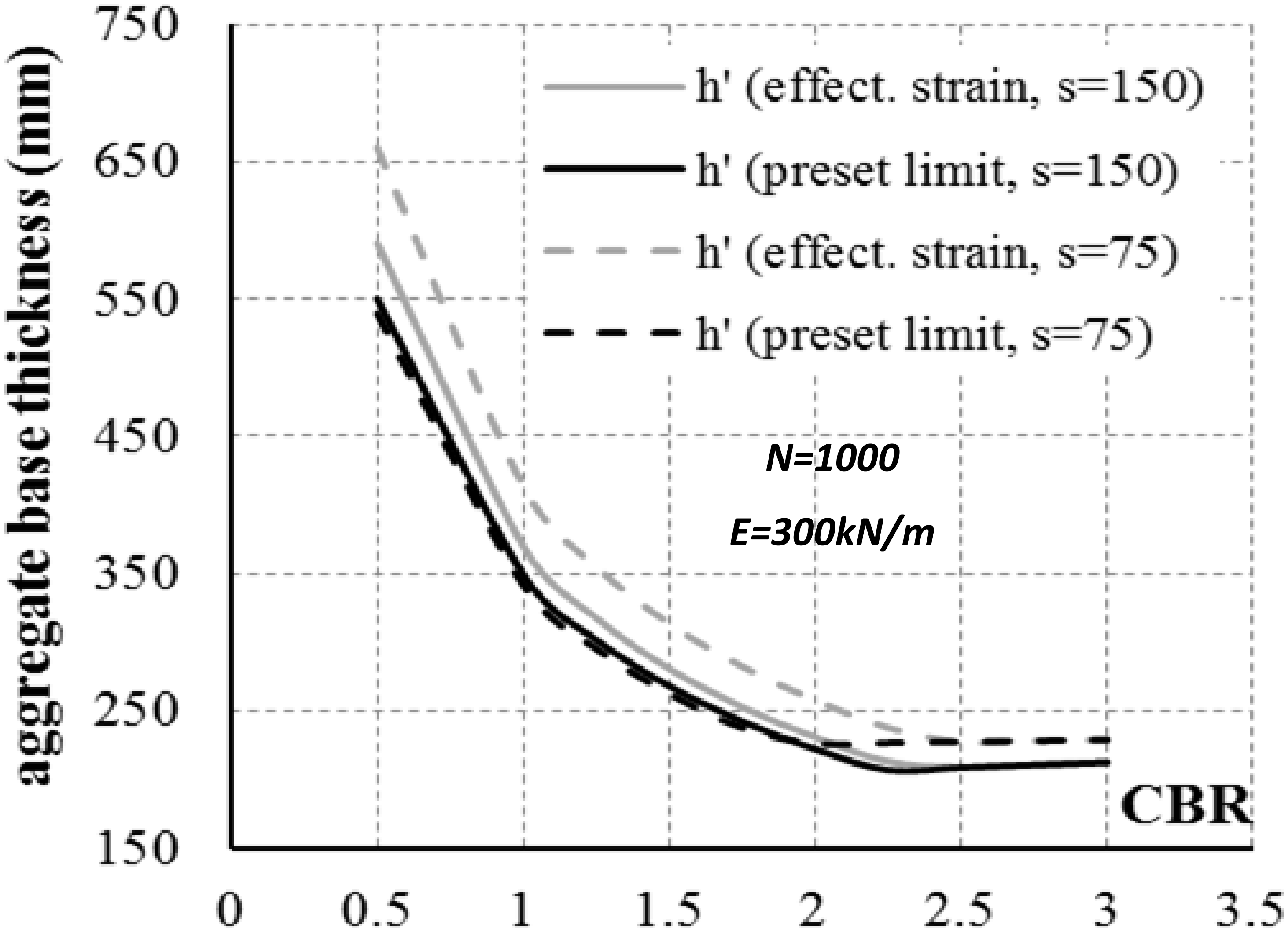
qualitative representation of the aggregate thickness –vs- CBR values of the considered unreinforced (- - -) and reinforced (——) unpaved roads



COMPARISON OF DESIGN METHOLOGIES

<table>
<tr><td rowspan="2">Calculation of the aggregate base thickness</td><td colspan="2">Giroud and Noiray</td><td>Holtz and Sivakugan</td><td>Giroud and Han</td><td>Steward, Williamson and Mohney</td></tr>
<tr><td colspan="5"><u>Common parameters for all methods:</u> CBR = 1, axle load P=80kN, Tire inflation pressure p_c =480kPa, Number is passes N=1000 (and 10.000), Rut depth s=75mm, E=200kN/m
Note: Values in parenthesis refer to N=10.000</td></tr>
<tr><td>h_o (mm)</td><td colspan="2">313 (313)</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>h_o' (mm)</td><td colspan="2">570 (760)</td><td>555 (740)</td><td>465 (510)</td><td>475 (475)</td></tr>
<tr><td rowspan="2">h (mm)</td><td>Calculated strain: 0.013 (0.014)</td><td>160 (160)</td><td rowspan="2">-</td><td rowspan="2">-</td><td rowspan="2">-</td></tr>
<tr><td>Preset strain 0.1</td><td>113 (113)</td></tr>
<tr><td rowspan="2">h' (mm)</td><td>Calculated strain: 0.013 (0.014)</td><td>417 (607)</td><td rowspan="2">432 (616)</td><td rowspan="2">315 (365)</td><td rowspan="2">325 (325)</td></tr>
<tr><td>Preset strain 0.1</td><td>370 (560)</td></tr>
</table>

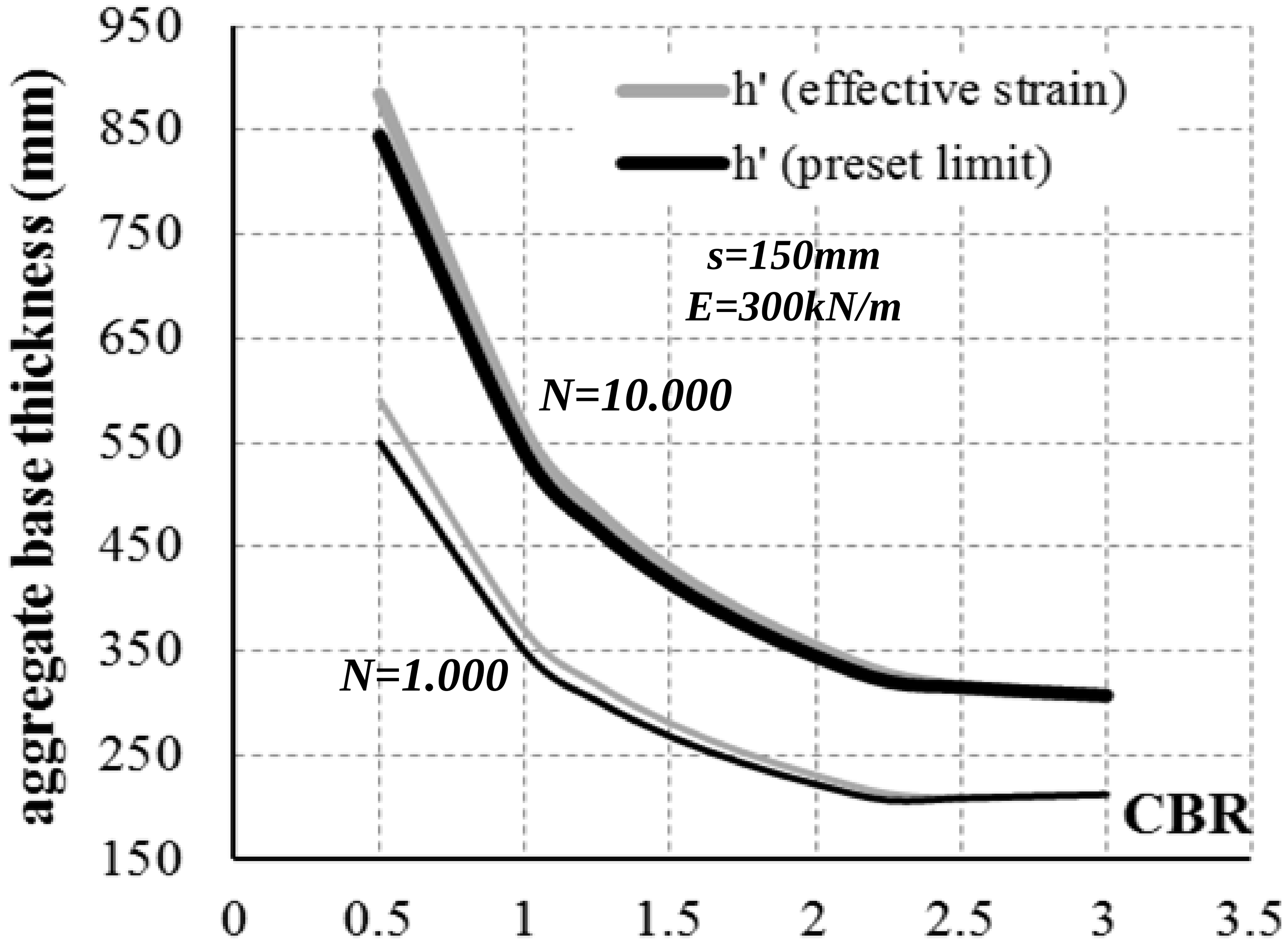
PARAMETRIC ANALYSIS: the influence of rut depth, s



The higher *s* is, the fabric is mobilized to undertake higher effective strains in the vicinity of the preset limit resulting in very similar base thickness for a given CBR value.

- For *s*=75mm, the fabric is practically inert thus the required aggregate base thickness is maximized.

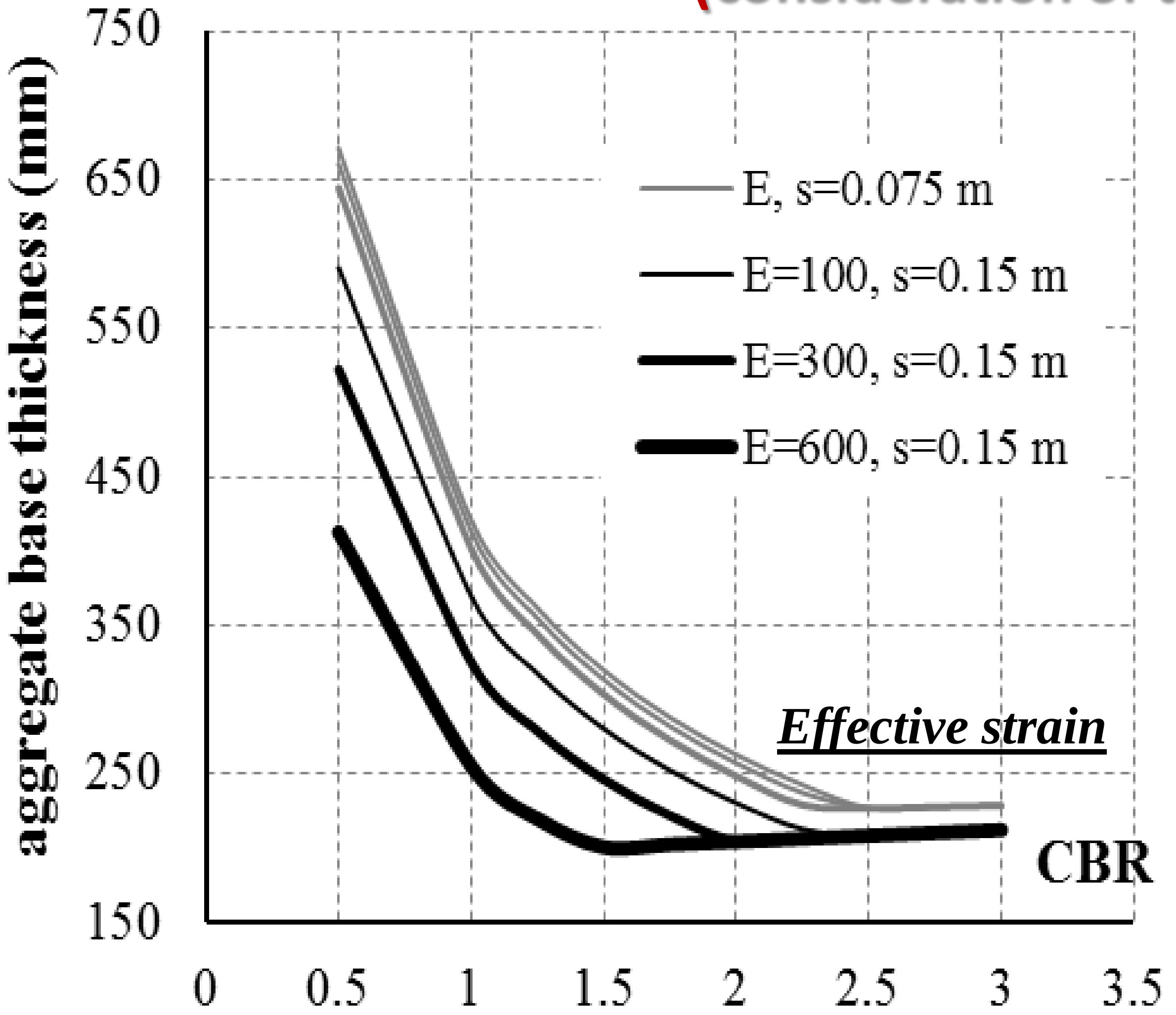
PARAMETRIC ANALYSIS: the influence of passes number, N



The higher N is, a broader aggregate base is required

- For high value of s ➔ both strain alternatives result in similar h'.

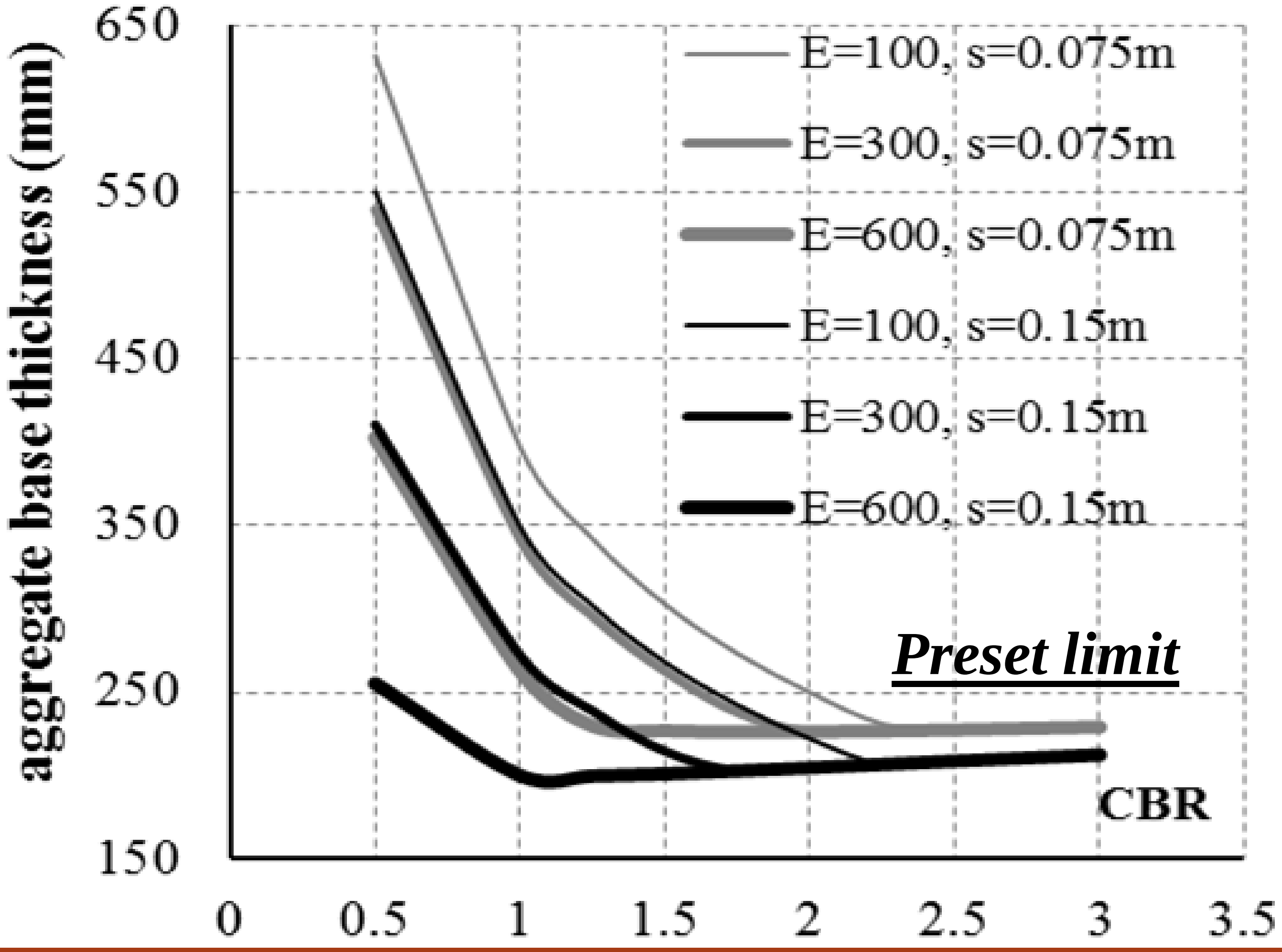
PARAMETRIC ANALYSIS: the influence of *s* and material stiffness E (consideration of the effective strain)



Stiffer materials develop higher strains when *s* is important else the fabric is practically inert.

- grey curves: for *s*=0.075m, they aren't affected by *E* values ➔ geotextile operates mainly as separator between the layers

PARAMETRIC ANALYSIS: the influence of *s* and material stiffness E (consideration of a preset strain limit)



Geotextiles with high *E*, allow for lower thickness *h'*. Given that the effective (**actual**) strain is usually lower than the preset value, the latter resultant h' are higher.

Note: When the designer choses a preset strain limit, the material probably will not develop it, thus the resulting *h'* will be lower than required.

- ➔ The actual bearing capacity is lower than assumed
- ➔ The performance of the reinforced unpaved road corresponds to that of a lower number of vehicle passes.
- ➔ This is more critical when *s* is minimum and *E* is high.

CONCLUSIONS

- Internationally accepted methodologies for design of reinforced unpaved roads were collected and critically assessed
- Method of Giroud and Noiray (1981) and Giroud et al. (1985), was considered for parametric analyses
- Spreadsheets were developed with embedded subroutines
- Parametric studies were conducted considering the main design parameters
- The importance of the geotextile strain (preset limit vs effective strain) on the required aggregate base thickness was highlighted

OPTIMUM DESIGN OF UNPAVED ROADS | COMPARISON OF INTERNATIONALLY PUBLISHED METHODOLOGIES

Thank you for your attention

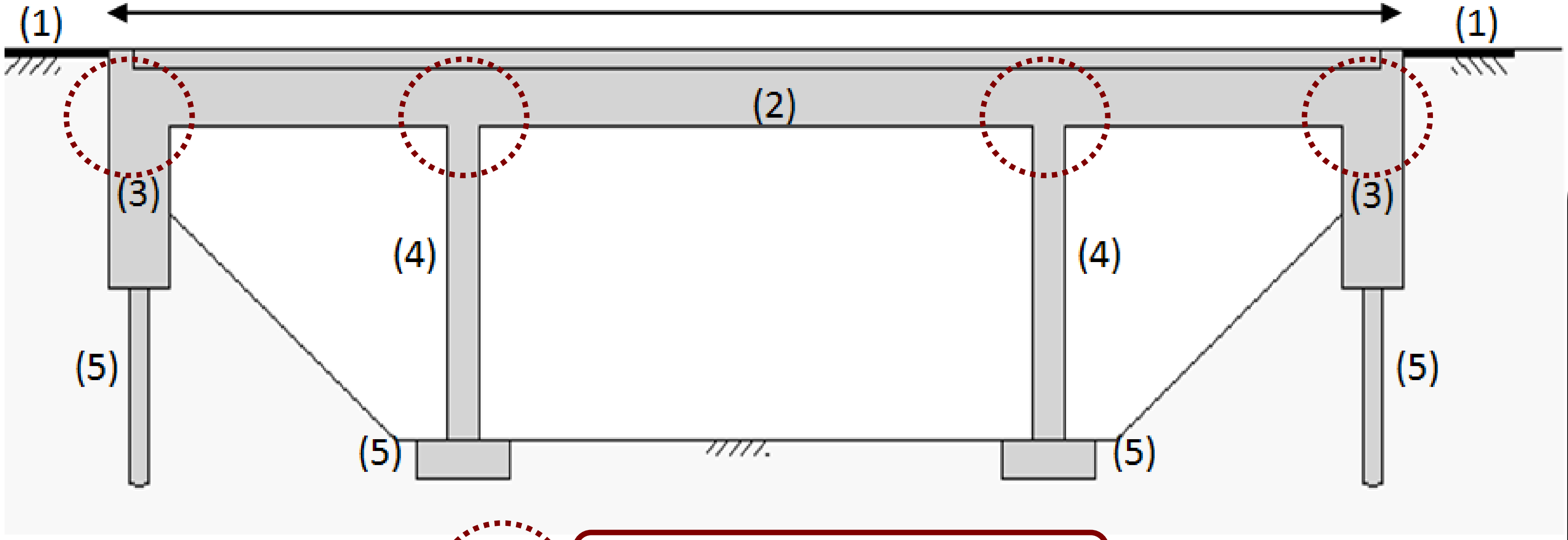
This research was kindly supported by THRACE GROUP
A WORLD OF MATERIALS & SOLUTIONS

Soil-Transition Slab Interaction in Jointless Bridges

Catarina Fartaria[1], Alexandre Pinto[2], David Gama[3]

1. *JET_{SJ}, Geotechnical Engineering, Lda.*
2. *Instituto Superior Técnico, University of Lisbon*
3. *JSJ, Structural Engineering, Lda.*

Time dependent movements principal direction

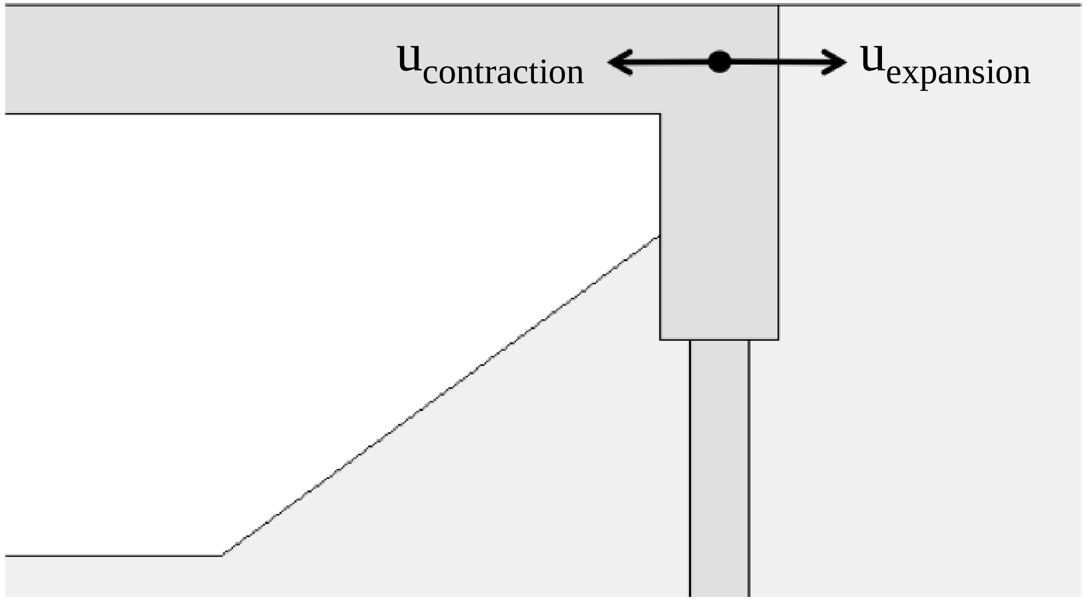


(1) Transition Slab
(2) Bridge Deck
(3) Abutment
(4) Piers
(5) Pile Foundation

Monolithic connection

No need for Bearings or Expansion Joints

INTRODUCTION



$$u_{contraction} = u_{\Delta T(-)} + u_{creep} + u_{\ shrinkage}$$

$$u_{expansion} = u_{\Delta T(+)} - u_{creep} - u_{\ shrinkage}$$

Bridge lenght = 160 m

$\varepsilon_{creep} \approx -0{,}25$ mm/m

$\varepsilon_{shrinkage} \approx -0{,}30$ mm/m

$\varepsilon_{\Delta T} \approx -0{,}20$ mm/m ($\Delta T = -20°C$)

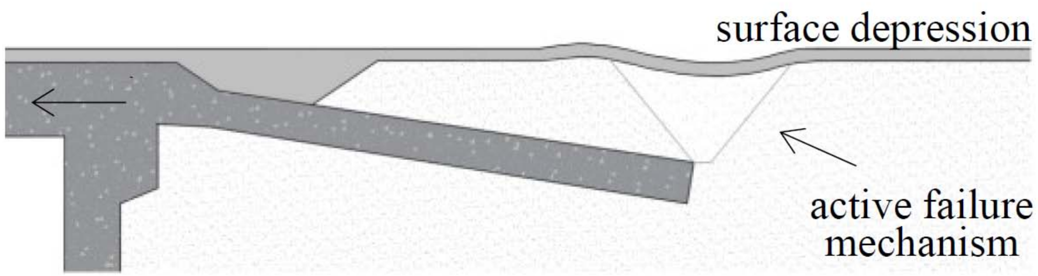
↓

Abutment imposed displacement

u = 60mm

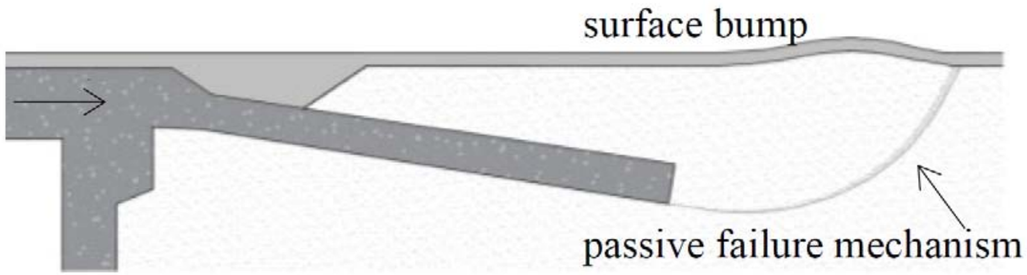
INTRODUCTION

Bridge Contraction



Active failure mechanism
|
Surface Settlement

Bridge Expansion



Passive failure mechanism
|
Surface Bump

INTRODUCTION

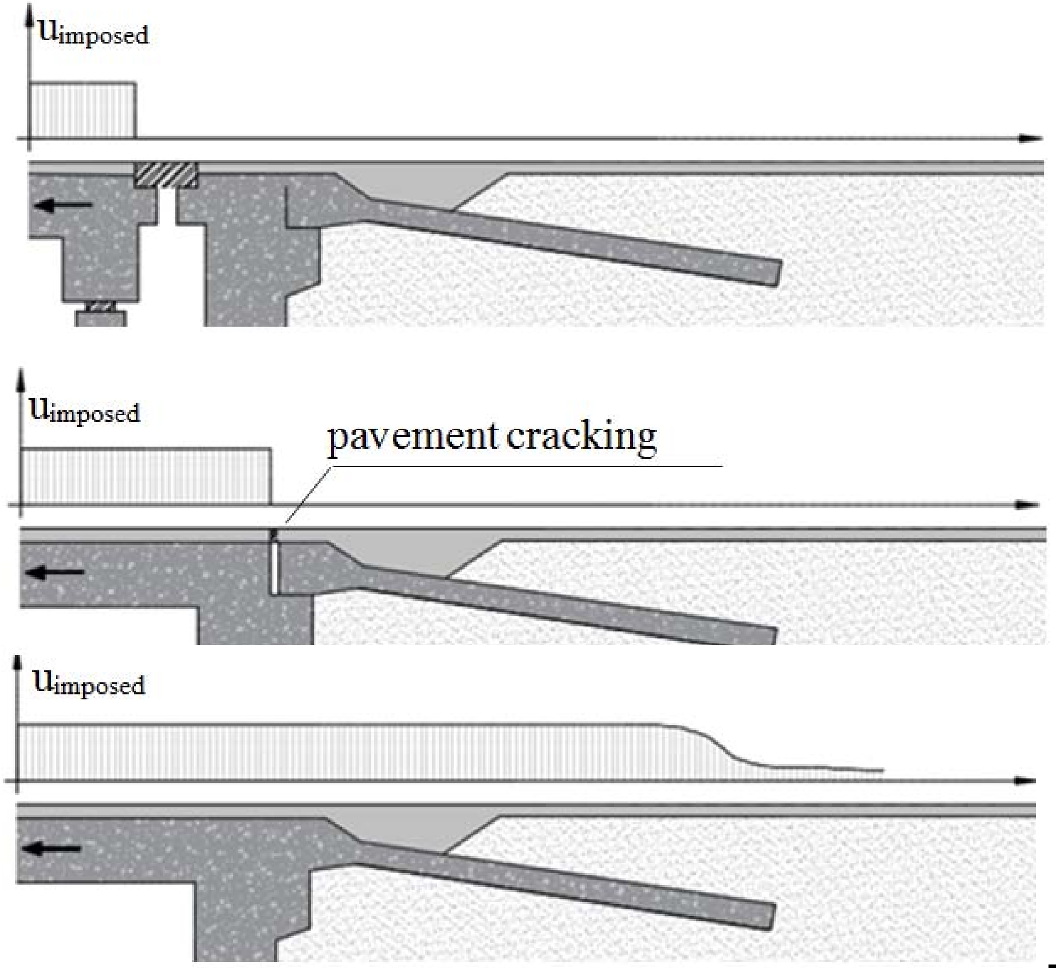
Bridge Contraction

Pavement longitudinal imposed displacements

Expansion Joint

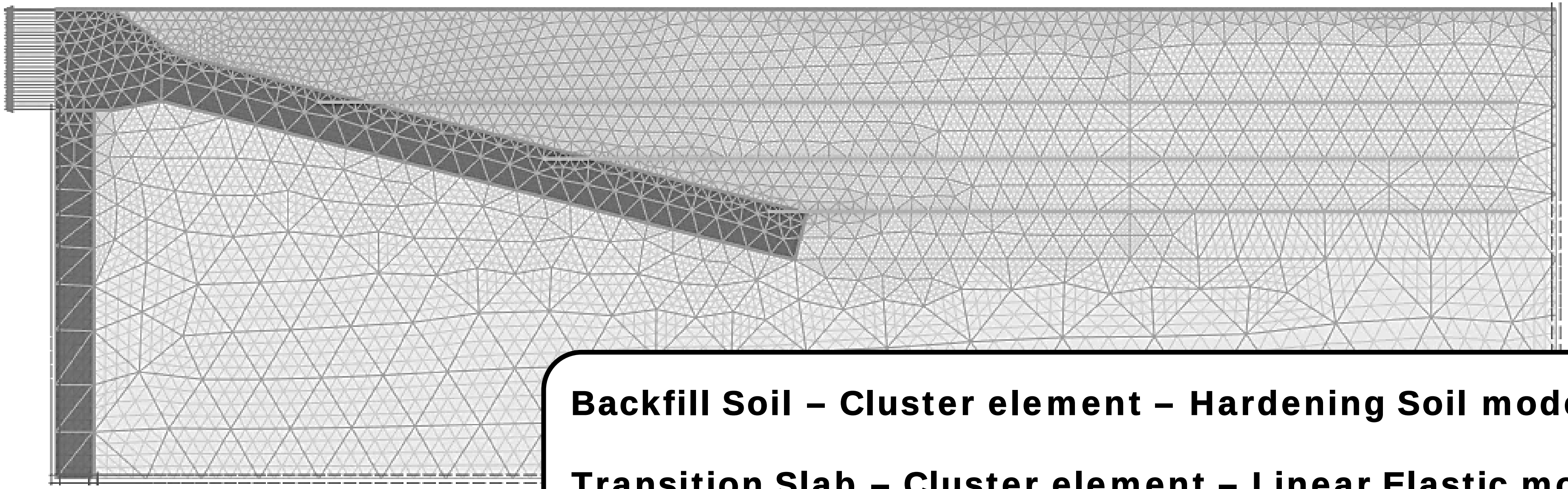
Non-Monolithic Slab

Monolithic Slab



INTRODUCTION

2D Model [PLAXIS]



Backfill Soil – Cluster element – Hardening Soil model

Transition Slab – Cluster element – Linear Elastic model (E=E')

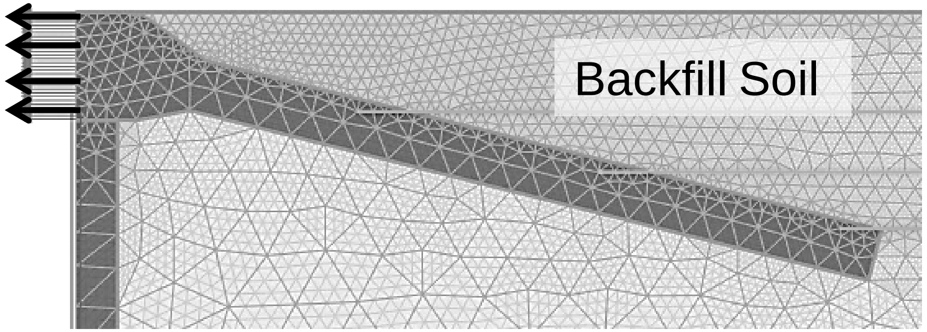
Concrete-Soil interface – Interface elements (Rinter=2/3)

Transition slab movement – Imposed translational displacement

NUMERICAL ANALYSIS

Imposed Displacements

Bridge Contraction ux<0
Bridge Expansion ux>0



Backfill Soil Properties – Hardening Soil Model

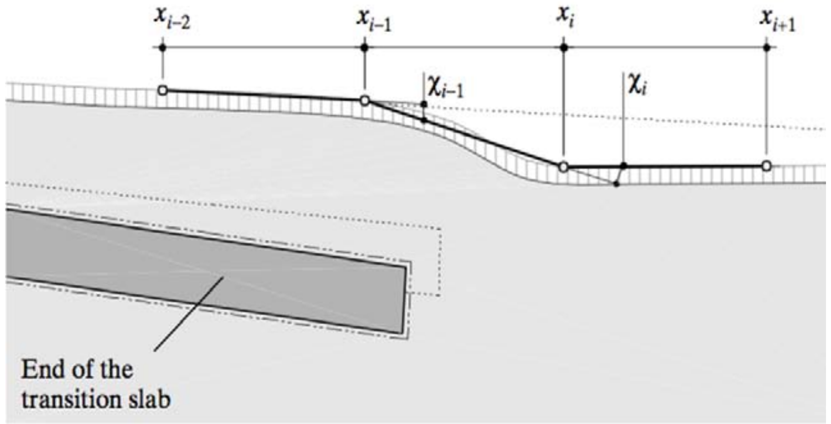
γ	Soil unit weight	18	(KN/m³)
E_{50}	Secant stiffness in standard drained test	80	(MPa)
E_{eod}	Tangent stiffness for primary oedometer loading	80	(MPa)
E_{ur}	Unloading / Reloading stiffness	240	(MPa)
ϕ	Internal friction angle	38	(º)
$c' / \phi / \psi$	Cohesion	1	(kPa)
$c' / \phi / \psi$	Dilatancy angle	7	(º)

NUMERICAL ANALYSIS

Measured Indicators

Absolute Surface Vertical Displacements
[surface settlement / bump]

Absolute Surface Longitudinal Displacements
[imposed pavement strains]

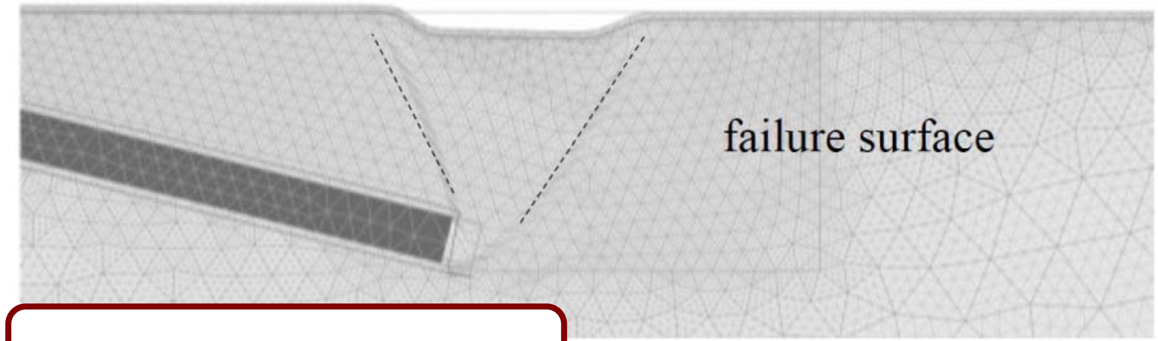


Slope Variation
[surface planirity]

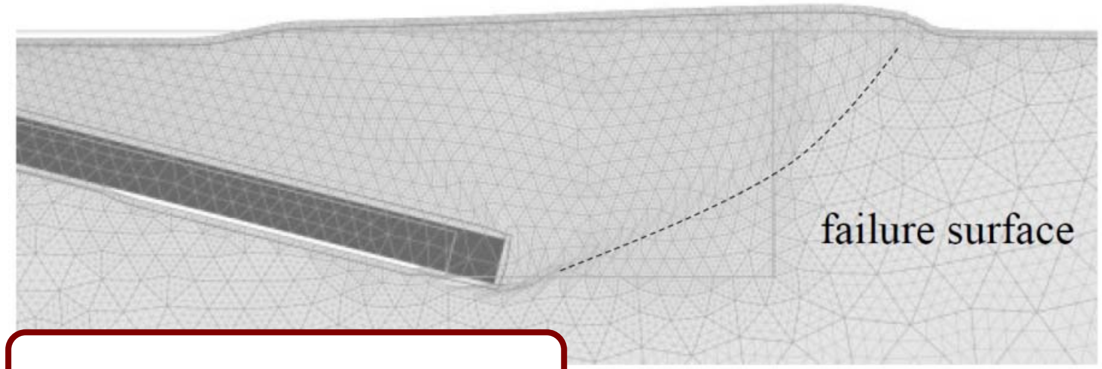
$$\chi(x) = \frac{w(x_j) - w(x_i)}{x_j - x_i} - \frac{w(x_k) - w(x_j)}{x_k - x_j} \leq \chi_{adm}$$

Suiss Code
SN 640 520a / 521c
χ_{adm} = *20‰* Highways

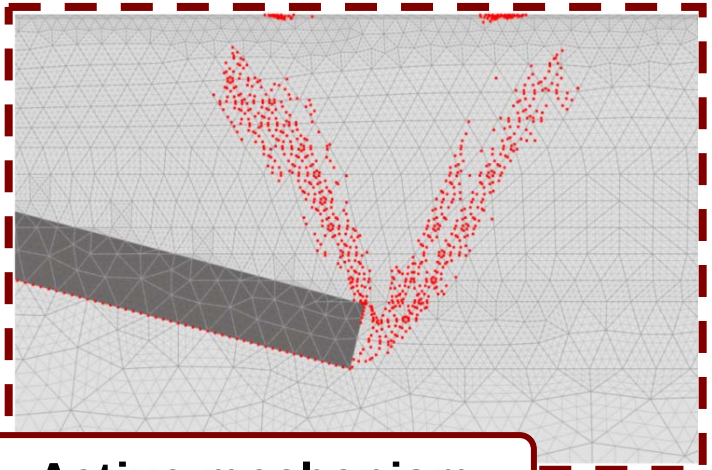
NUMERICAL ANALYSIS



Bridge Contraction

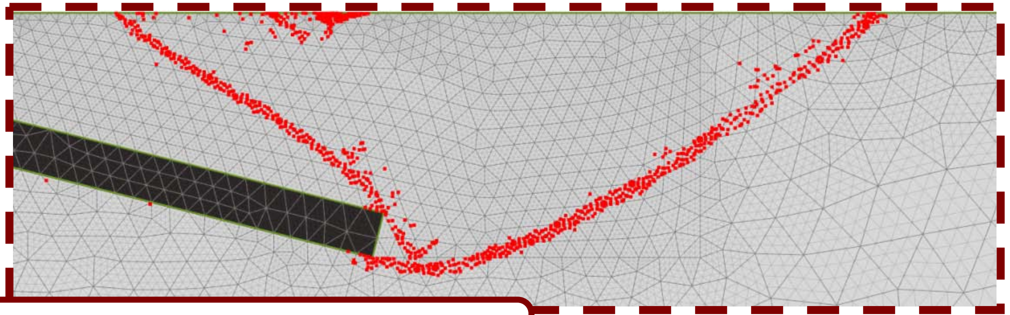


Bridge Expansion



Active mechanism

Mohr-Coulomb failure points

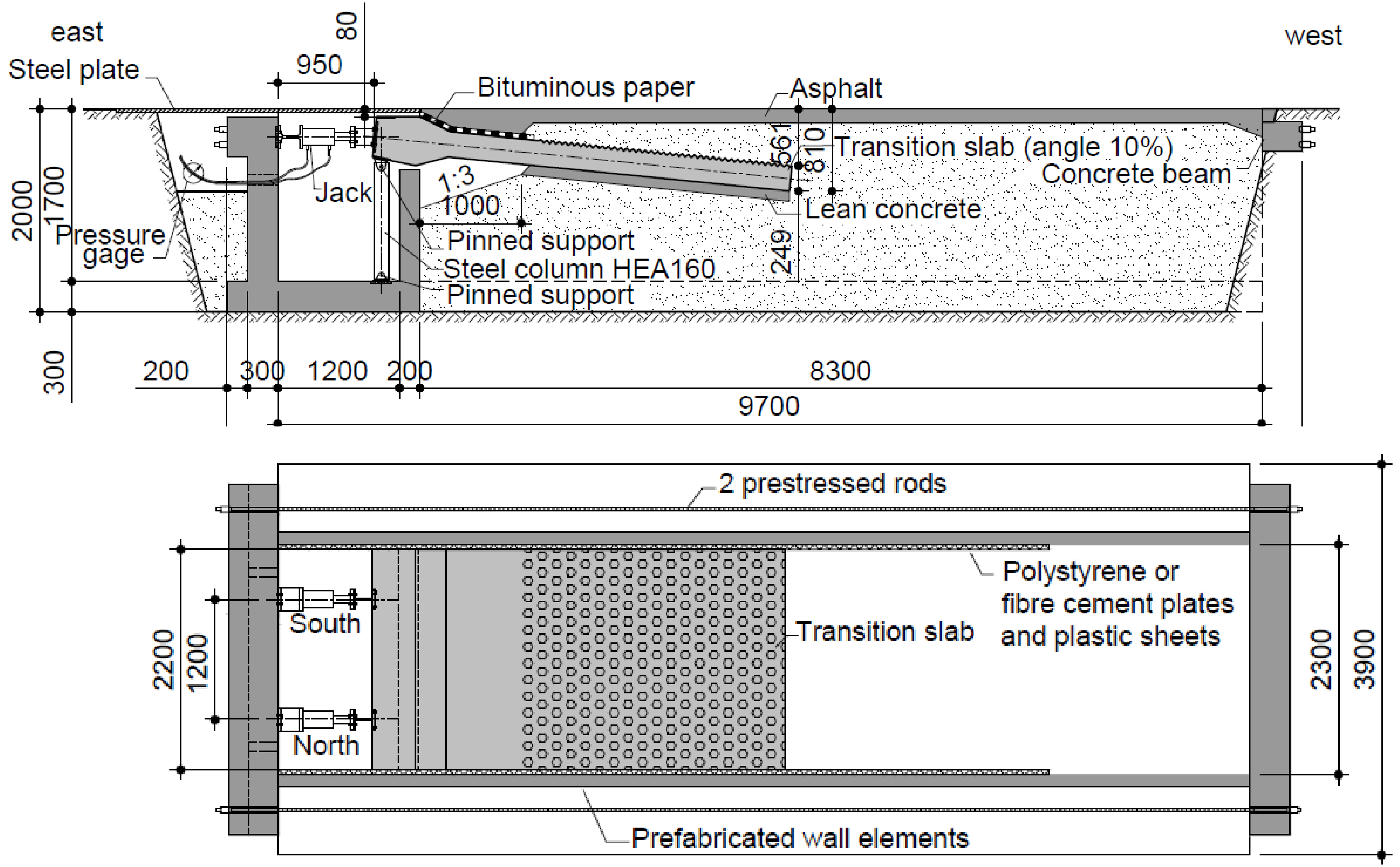


Passive mechanism

NUMERICAL ANALYSIS

Experimental Campaign

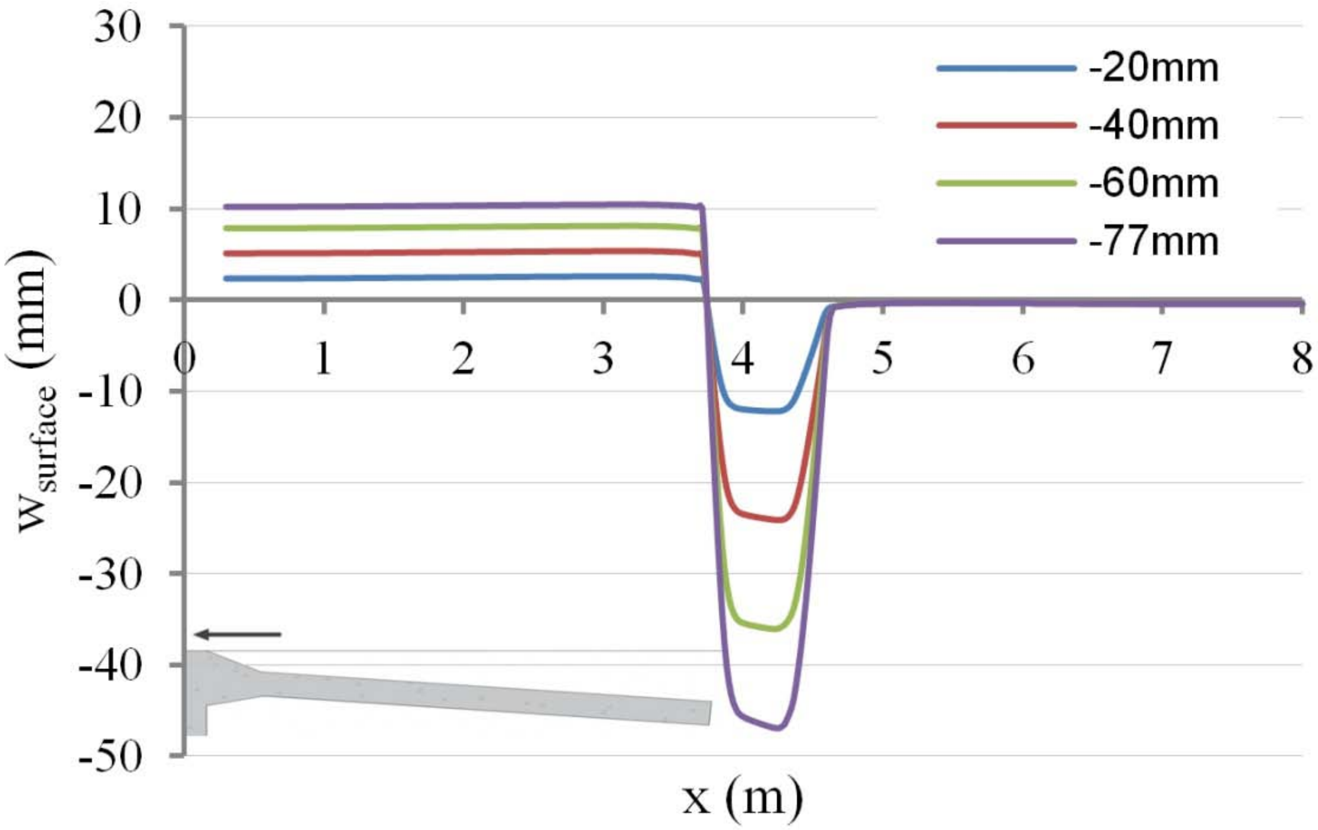
Muttoni *et al*. (2015)

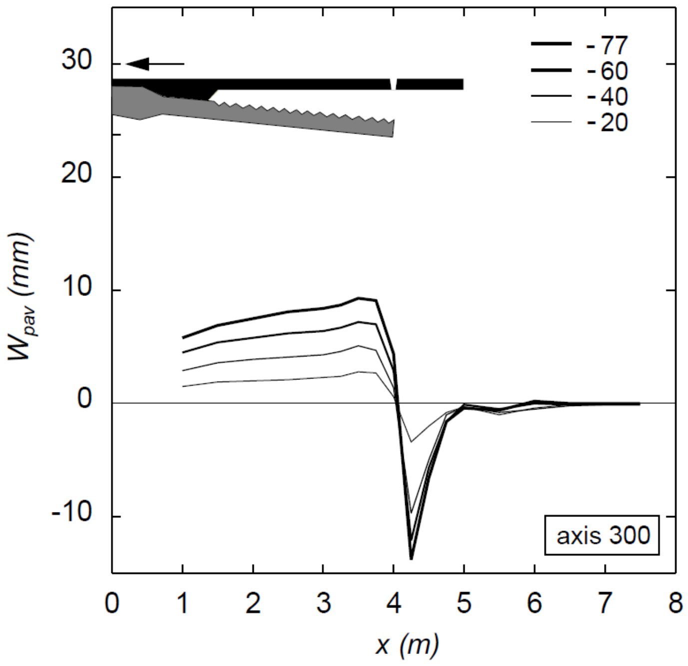


EXPERIMENTAL FULL SCALE MODEL

Bridge Contraction

Vertical Surface Displacements



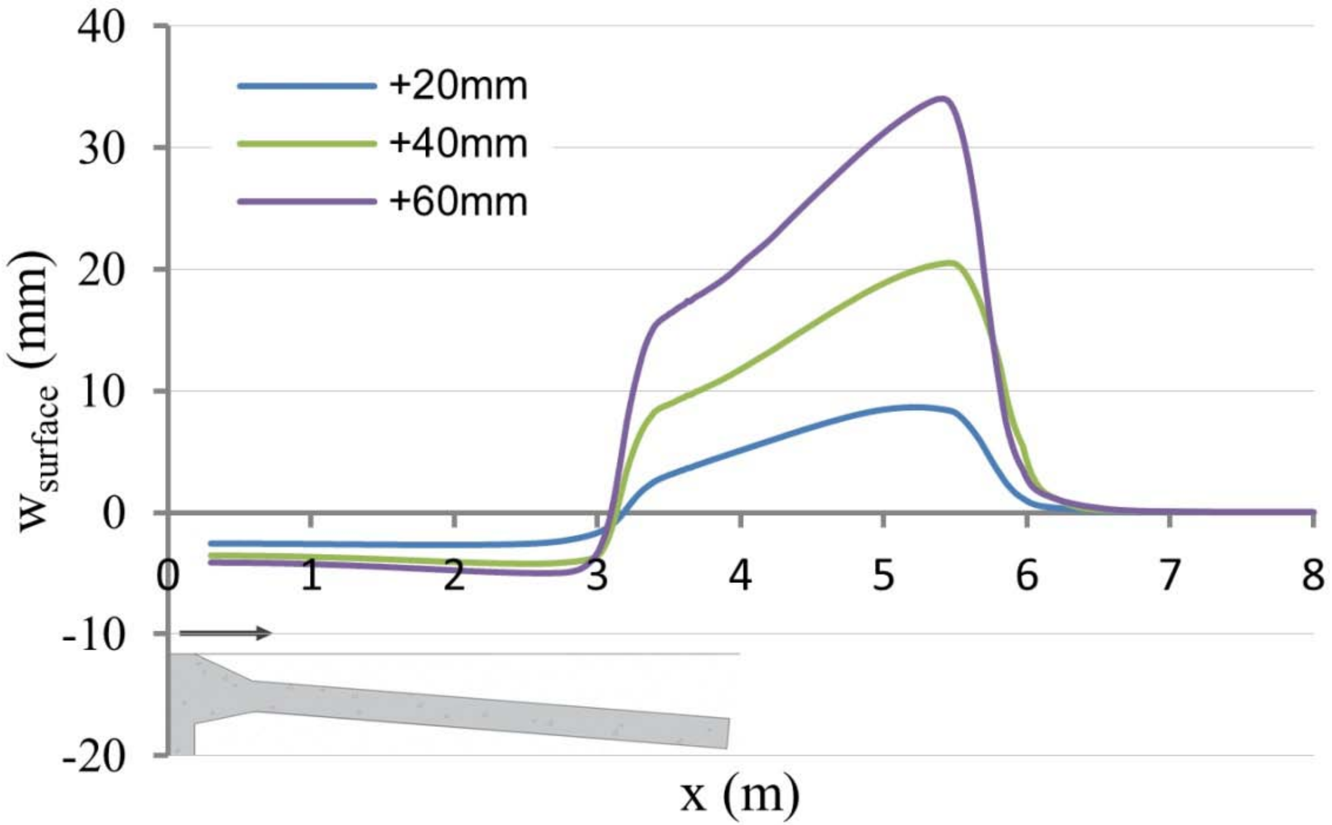


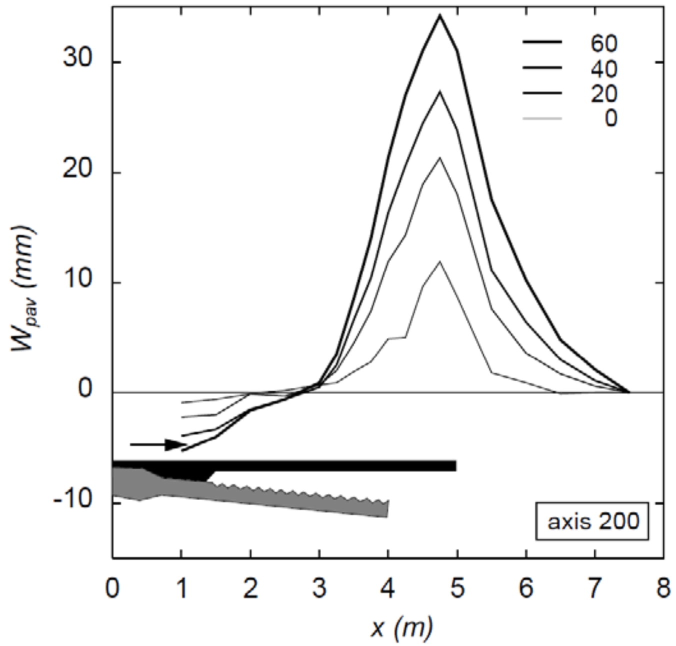
Muttoni *et al*. (2015)

NUMERICAL ANALYSIS

Bridge Expansion

Vertical Surface Displacements



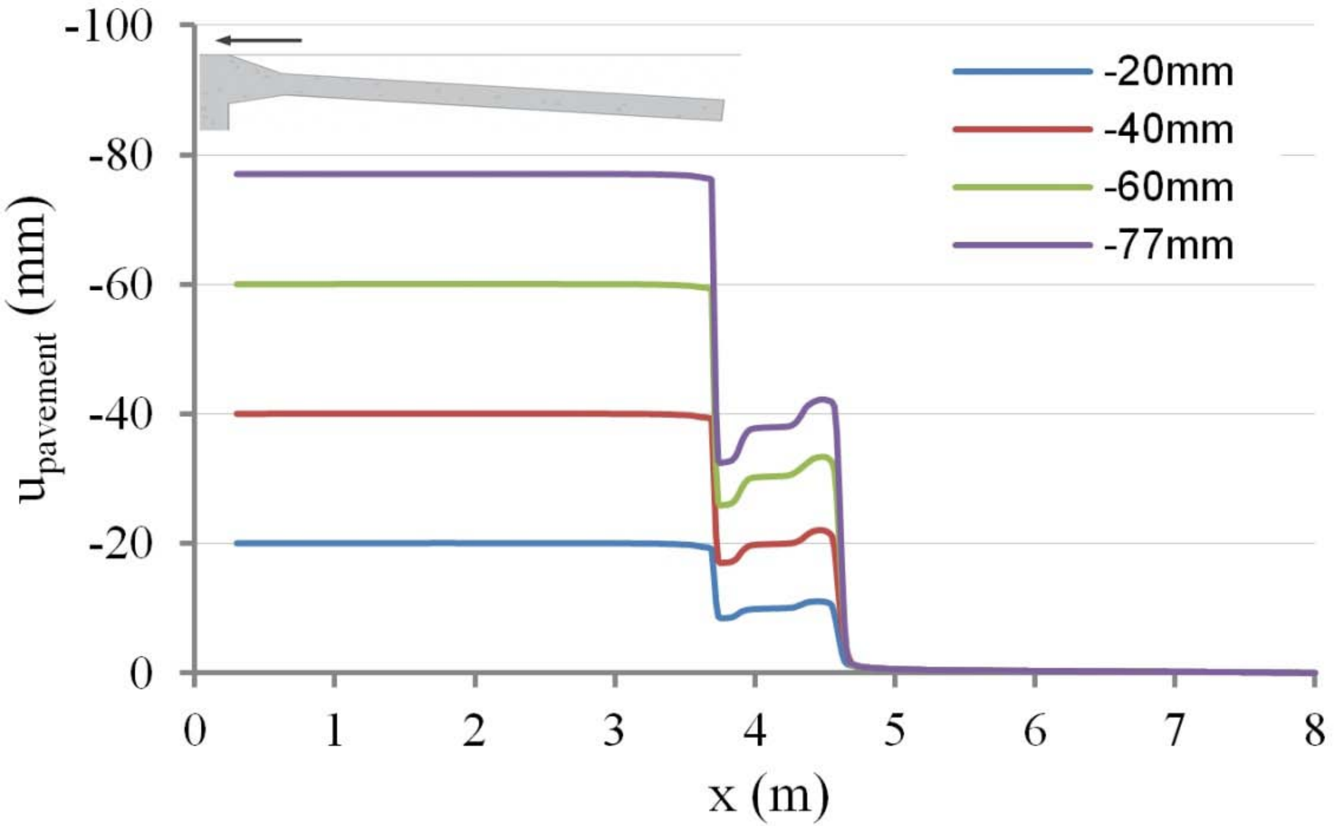


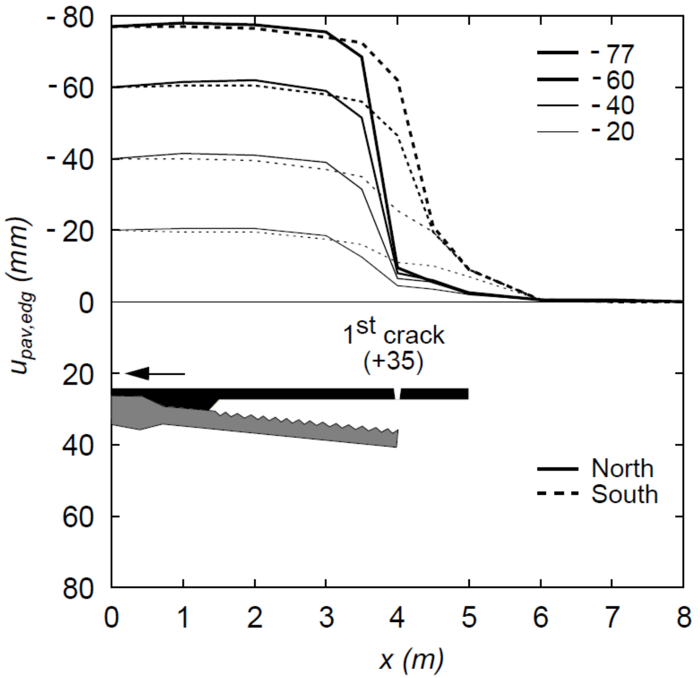
Muttoni *et al*. (2015)

NUMERICAL ANALYSIS

Bridge Contraction

Longitudinal Surface Displacements



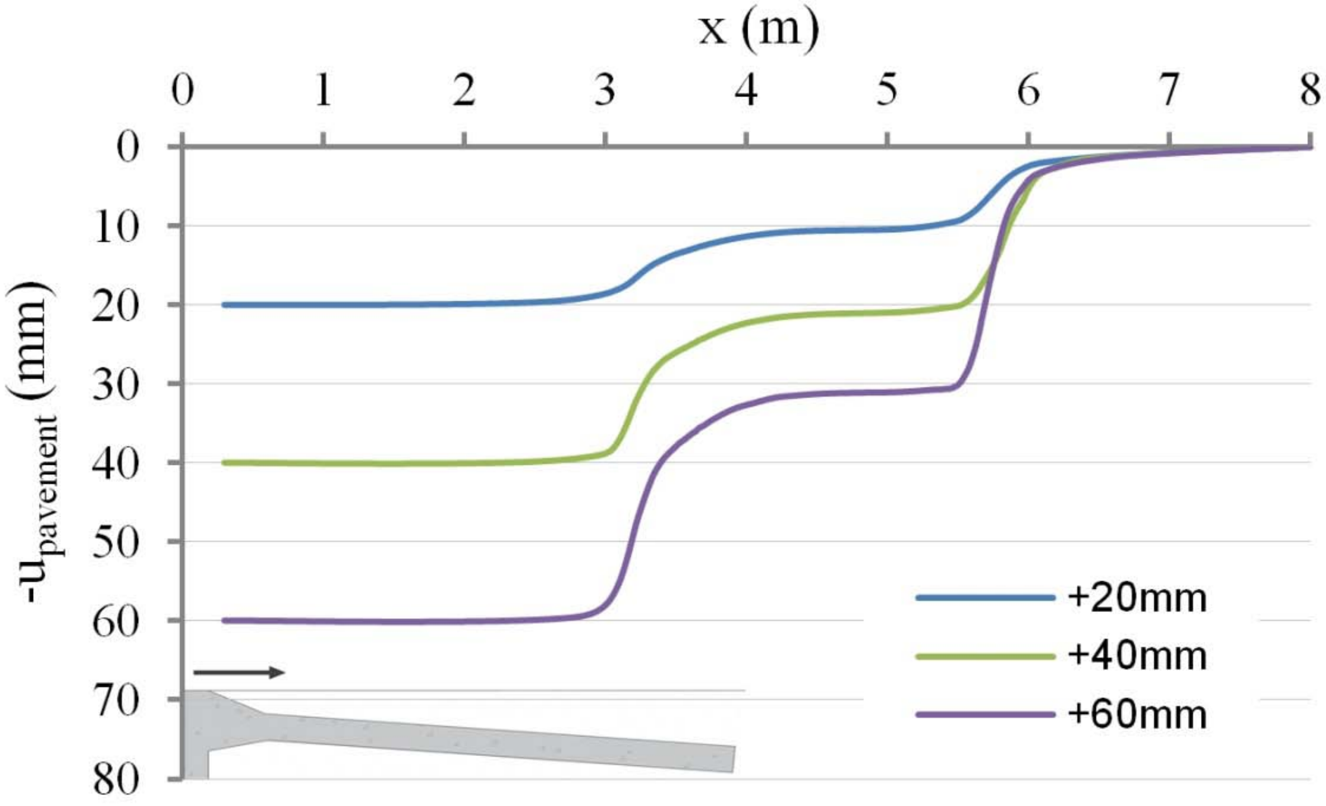


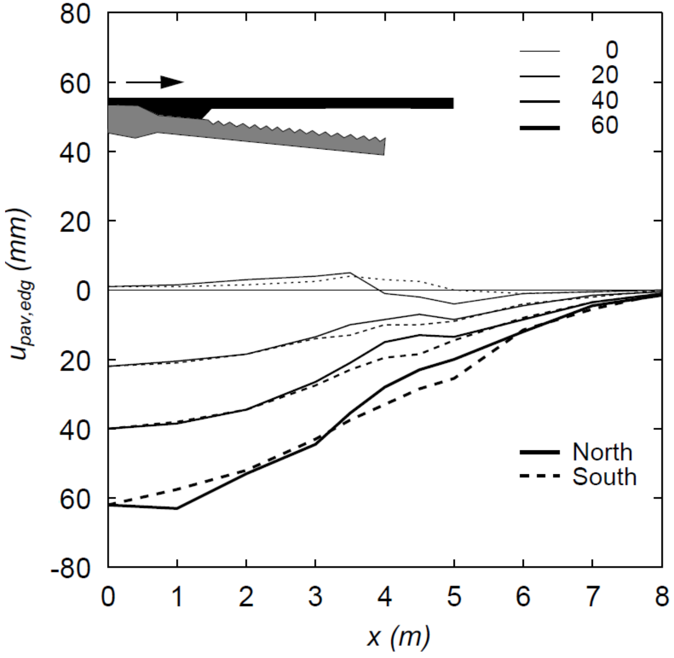
Muttoni *et al*. (2015)

NUMERICAL ANALYSIS

Bridge Expansion

Longitudinal Surface Displacements



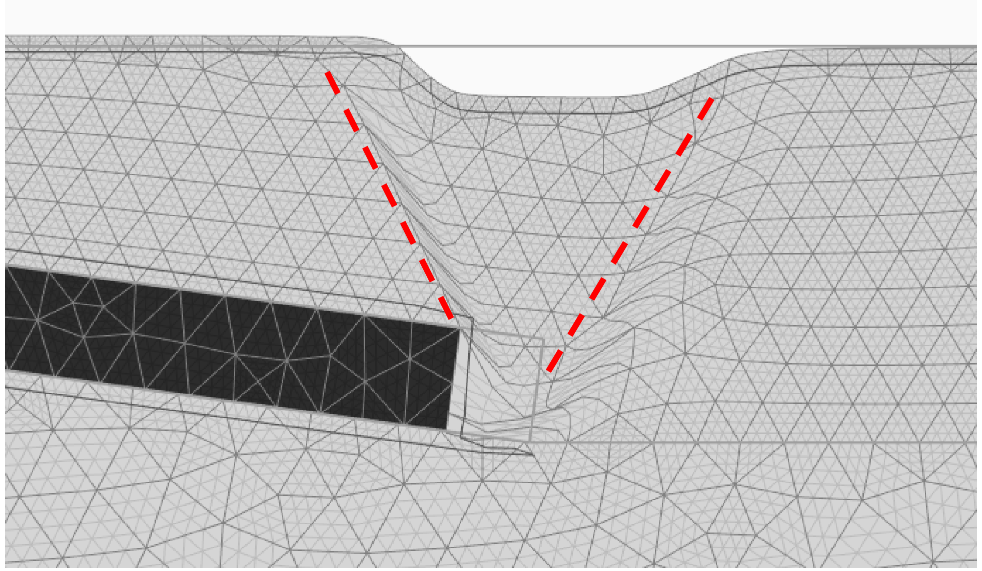


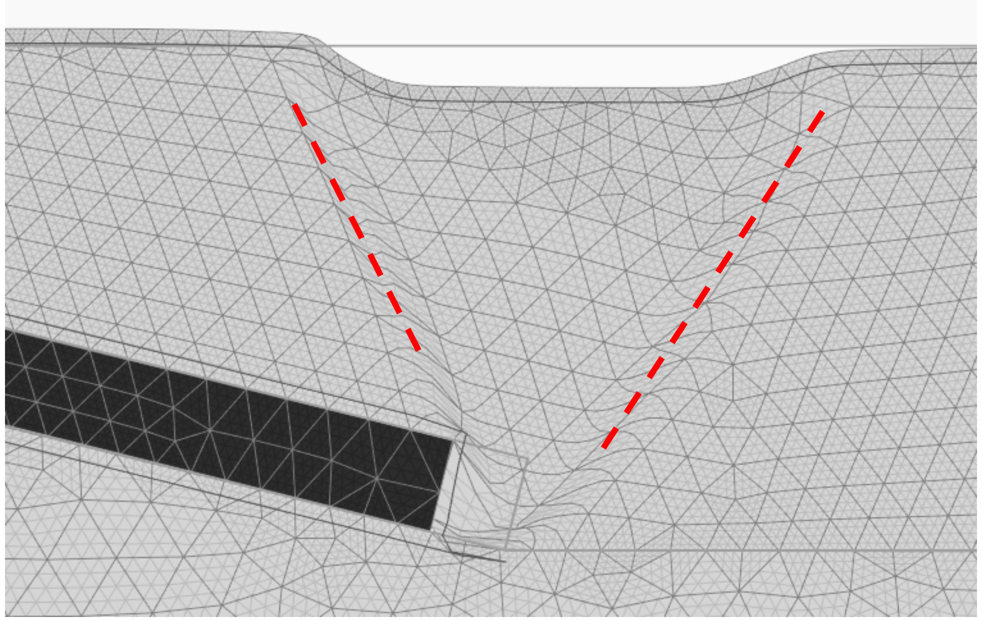
Muttoni *et al*. (2015)

NUMERICAL ANALYSIS

Bridge Contraction

Influence of transition slab buried depth





> Transition Slab End buried depth

Same Active Failure Surface

> Surface Active Zone

< Surface Settlement

MAIN CONCLUSIONS

- The numerical model is representative of physical behavior observed in the experimental campaign

- For short bridges (minor imposed displacements) the transition slab length and its slope can be chosen in order to mitigate soil disturbance at the surface

- For longer bridges a technical solution that address both surface settlement and pavement cracking is required

- The understanding of phenomena here presented and its related kinematics mechanisms is essential to define a technical solution for jointless bridges approach embankments

MAIN CONCLUSIONS

Some effects of fiber addition on the behavior of clean sands under cyclic loadings

Jorge Hernán Flórez Gálvez[1], Lucas Festugato[1]

1. *Universidade Federal do Rio Grande Do Sul, Porto Alegre - Brazil*

Introduction

- Fiber adding for improve the mechanical behavior of soils;
- Characterization of positive effects under static loading conditions;
- Possibility of using this technique for ground improvement in cyclic loading situations:
  - Wind generators;
  - Seismic events;
  - Tidal effects;
- Limited knowledge about the behavior of these material that conditions.

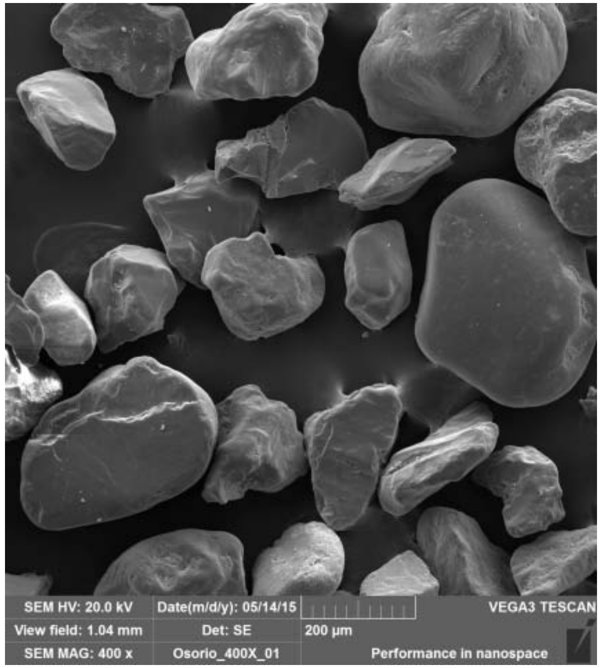
Objective

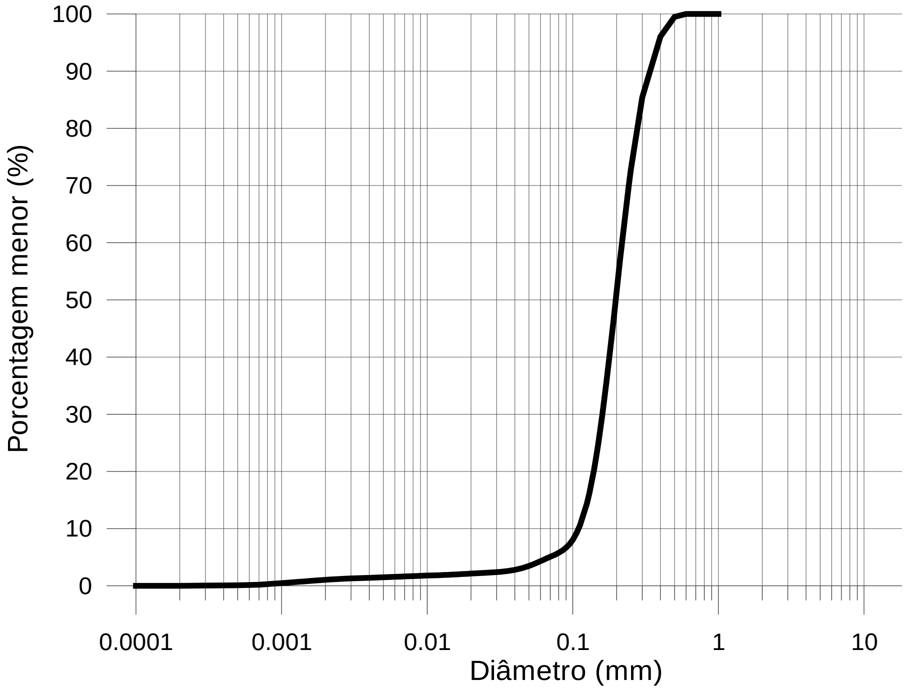
- Evaluate the effect of fiber addition in a sand, when submeted to monotonic and cyclic loading, in two conditions: no fiber and, with 0.5% of fiber in weight. To study the effect of compaction, the sand samples were tested in two different void ratio.

Materials

1. Sand - Source: Osorio, Southern Brazil

Index	Value
g_s	26,2 kN/m³
C_u	2,0
C_c	1,1
D_{10}	0,11 mm
D_{50}	0,20 mm
e_{min}	0,6
e_{max}	0,9





Materials

2. Fiber: Polypropilene

- Diameter: 0,1 mm
- Length: 50 mm
- Density: 0,91
- Secant modulus: 10 GPa
- Tensile Strength: 200 MPa

- Distilled water

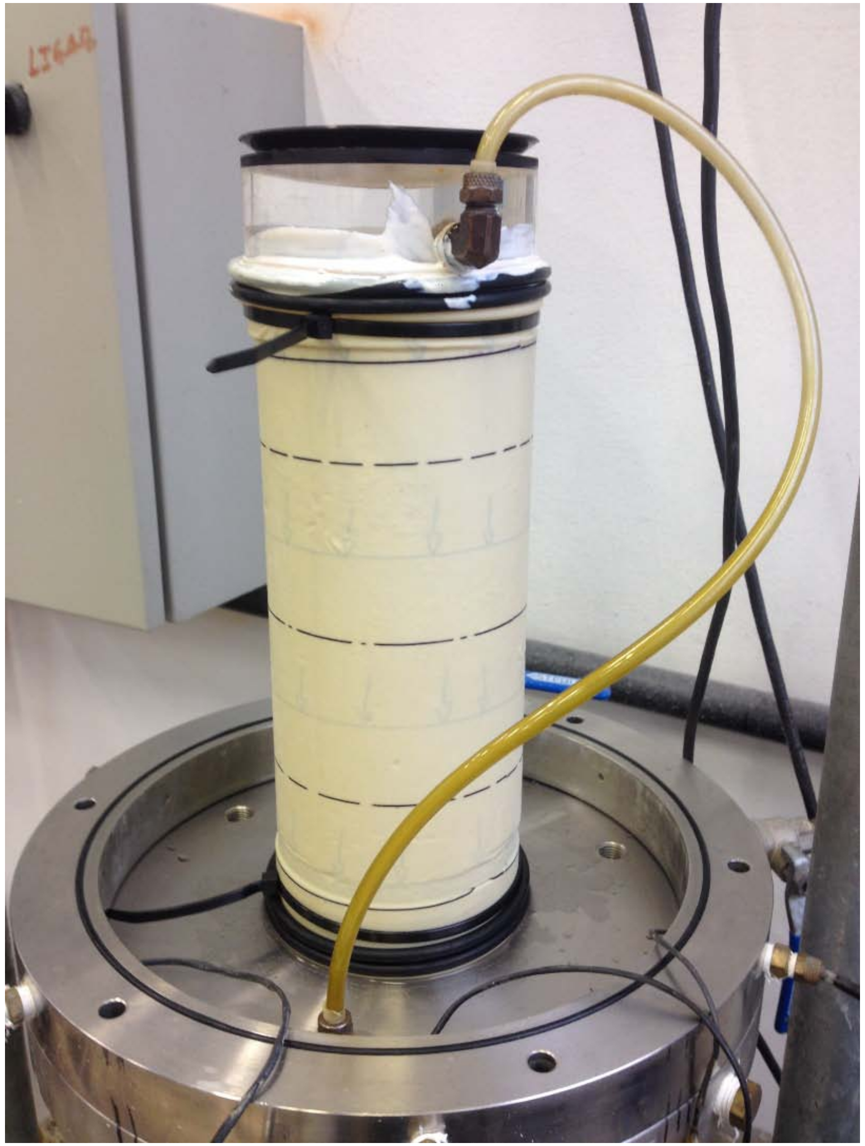
Experimental program

- Monotonic Triaxial tests (CD)
  - Fiber: 0,5 % (constant)
  - Water: 10 % (constant)
  - Effective confining pressures: 20, 100 and 200 kPa
  - Number of tests: 6

- Cyclic Triaxial tests (CU)
  - Fiber: 0,5 % (constant)
  - Water: 10 % (constant)
  - Effective initial confining pressure: 100 kPa
  - Number of tests: 12
  - Frequency: 0.1 Hz
  - Loading path: Sinusoidal
  - Deviatoric stresses: ±20 to ±100 kPa

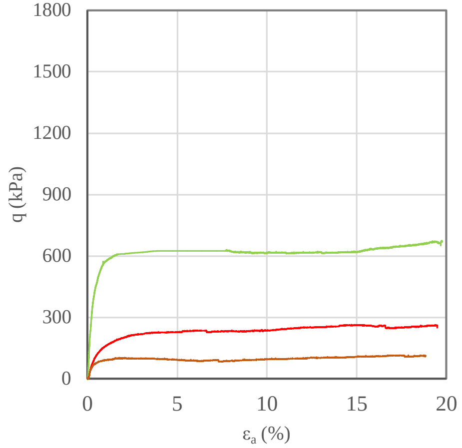
Molding conditions

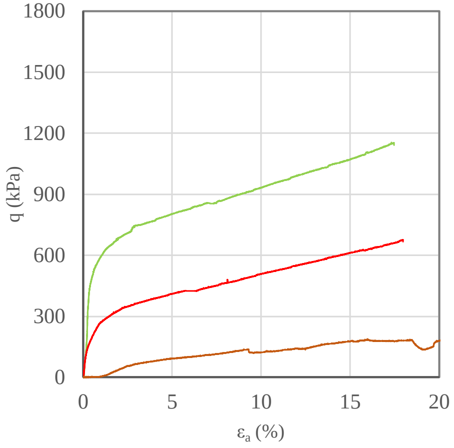
- Sand — Water – Fiber
- Moist tamping (3 layer)
- Sample size:
  - Diameter = 10 cm
  - Height = 20 cm
- Moisture content: 10%



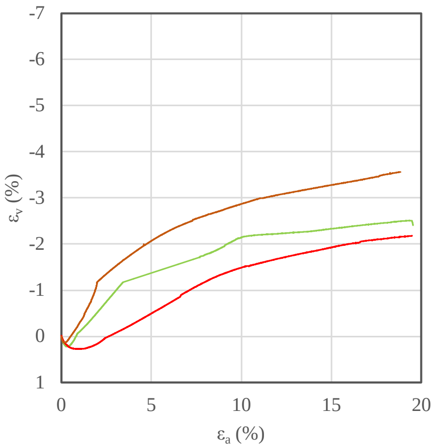
Results – Monotonic triaxial tests

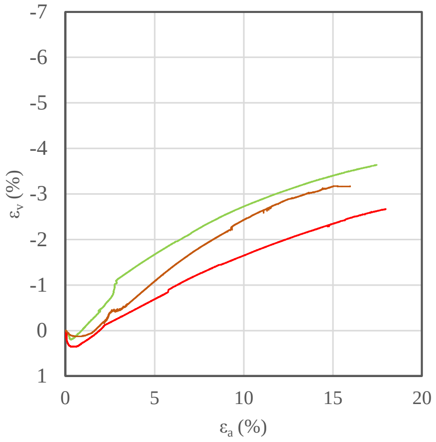
Void ratio: 0,75 **No - fiber** **0,5% fiber**



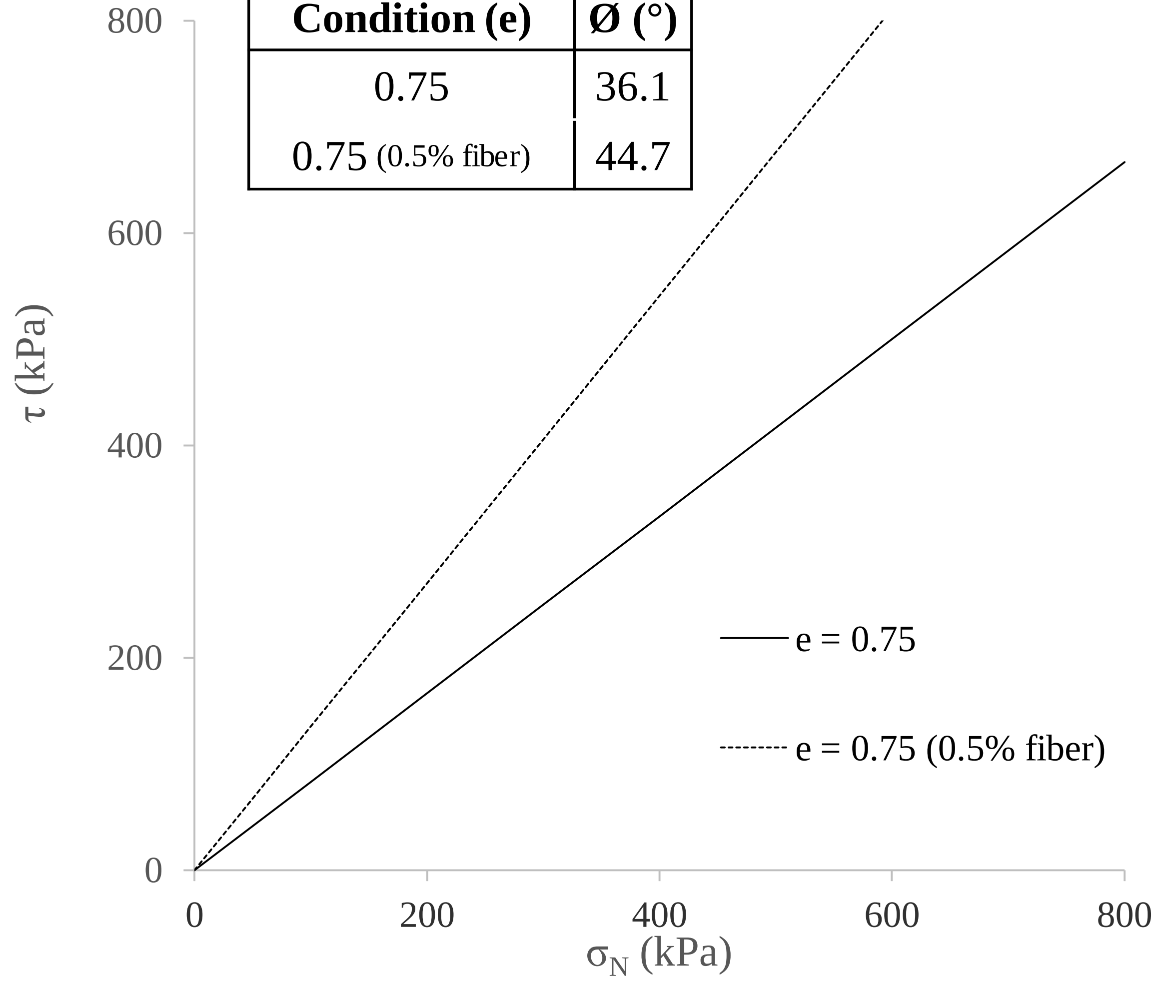


50 kPa
100 kPa
200 kPa





Condition (e)	Ø (°)
0.75	36.1
0.75 (0.5% fiber)	44.7

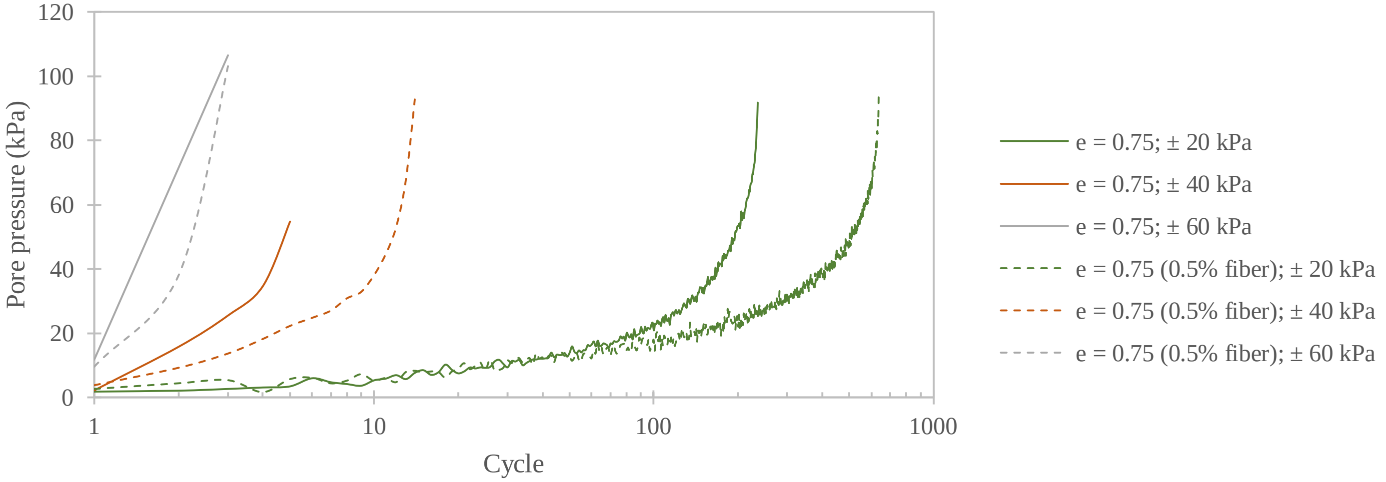


Results – Cyclic triaxial tests

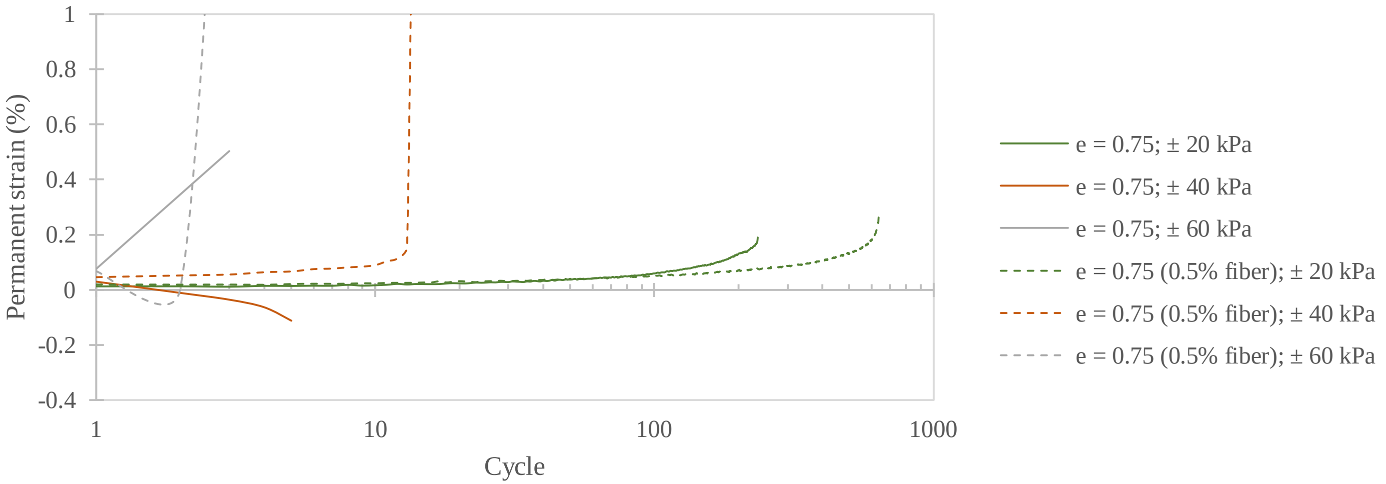
Void ratio	σ_D (kPa)	N_f	
		0,5% fiber	No-fiber
0.75	± 20	635	234
0.75	± 40	14	6
0.75	± 60	3	1

Results – Cyclic triaxial tests

- Evolution of pore pressure

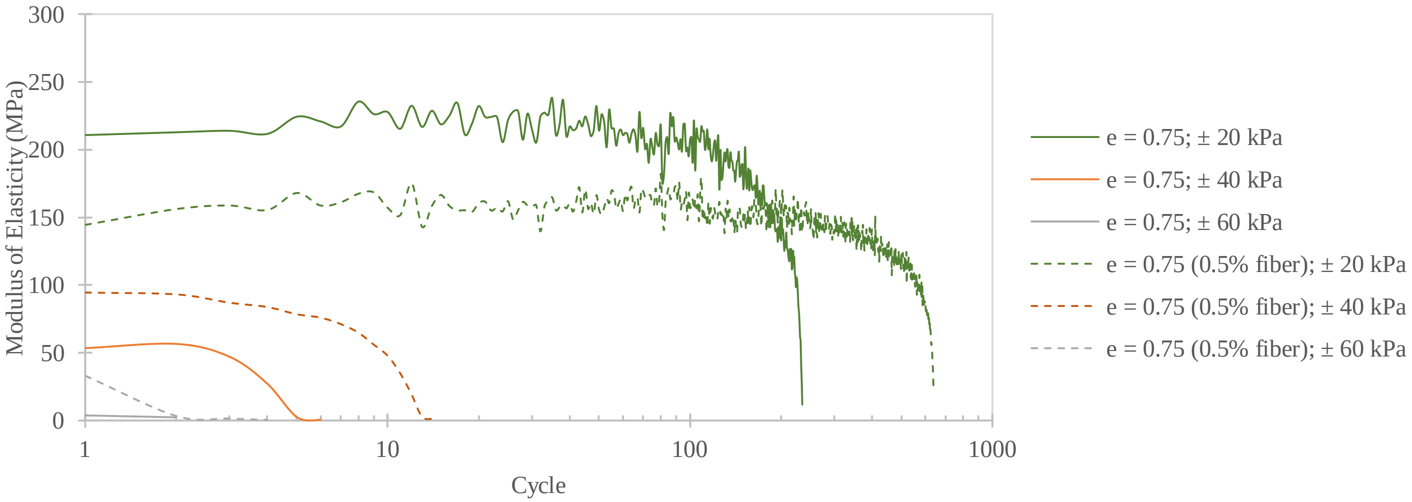


- Accumulation of permanent deformation

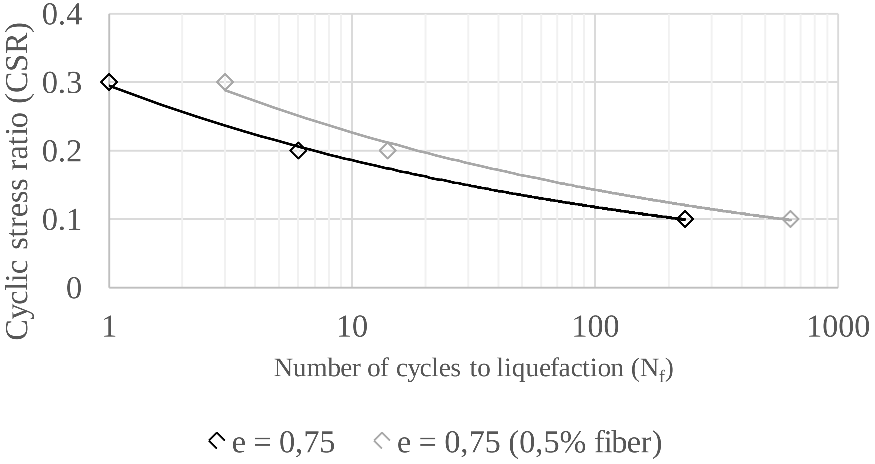


Results – Cyclic triaxial tests

- Degradation of moduli of elasticity



- Cyclic stress ratio



Conclusions

For shear strength parameters, the post-breaking effect in the case with fiber addition, is an increase of strength due to fiber elongation, but this do not have, apparently, any effect in the volumetric strains.

The contribution of fibers is more effective for the higher void ratio, which is the condition with less deformation, delaying the fibers response.

Improvement due to the addition of fibers is not limited to increase in the maximum number of cycles:

Conservation of moduli of elasticity by controlling de accumulation of permanent deformations.

Preservation of test specimens even after liquefaction is reached.

References

Consoli, N. C., Casagrande, M. D. T., & Coop, M. R. (2005). Effect of Fiber Reinforcement on the Isotropic Compression Behavior of a Sand. Journal of Geotechnical and Geoenvironmental Engineering. http://doi.org/10.1061/(ASCE)1090-0241(2005)131:11(1434)

Diambra, A. (2010). Fibre reinforced sands: Experiments and constitutive modelling (Dissertation (Doctor of Philosophy)). University of Bristol, Bristol.

Festugato, L. (2011). Comportamento de hidratação e resposta cisalhante cíclica de resíduo de mineração cimentado feforçado com fibras (Tese (Doutorado em Engenharia)). Programa de Pós-Graduação em Engenharia Civil, Universidade Federal do Rio Grande do Sul, Porto Alegre.

Festugato, L., Consoli, N. C., & Fourie, A. (2015). Cyclic shear behaviour of fibre-reinforced mine tailings. Geosynthetics International, 22(2), 196–206. http://doi.org/10.1680/gein.15.00005

Ladd, R. S. (1978). Preparing Test Specimens Using Undercompaction. Geotechnical Testing Journal, 1(1), 16–23. http://doi.org/10.1520/GTJ10364J

Maher, M. H., & Ho, Y. C. (1993). Behavior of Fiber-Reinforced Cemented Sand Under Static and Cyclic Loads. Geotechnical Testing Journal. http://doi.org/10.1520/GTJ10054J

Maher, M. H., & Woods, R. D. (1990). Dynamic Response of Sand Reinforced with Randomly Distributed Fibers. Journal of Geotechnical Engineering, 116(7), 1116–1131. http://doi.org/10.1061/(ASCE)0733-9410(1990)116:7(1116)

Acknowledgments

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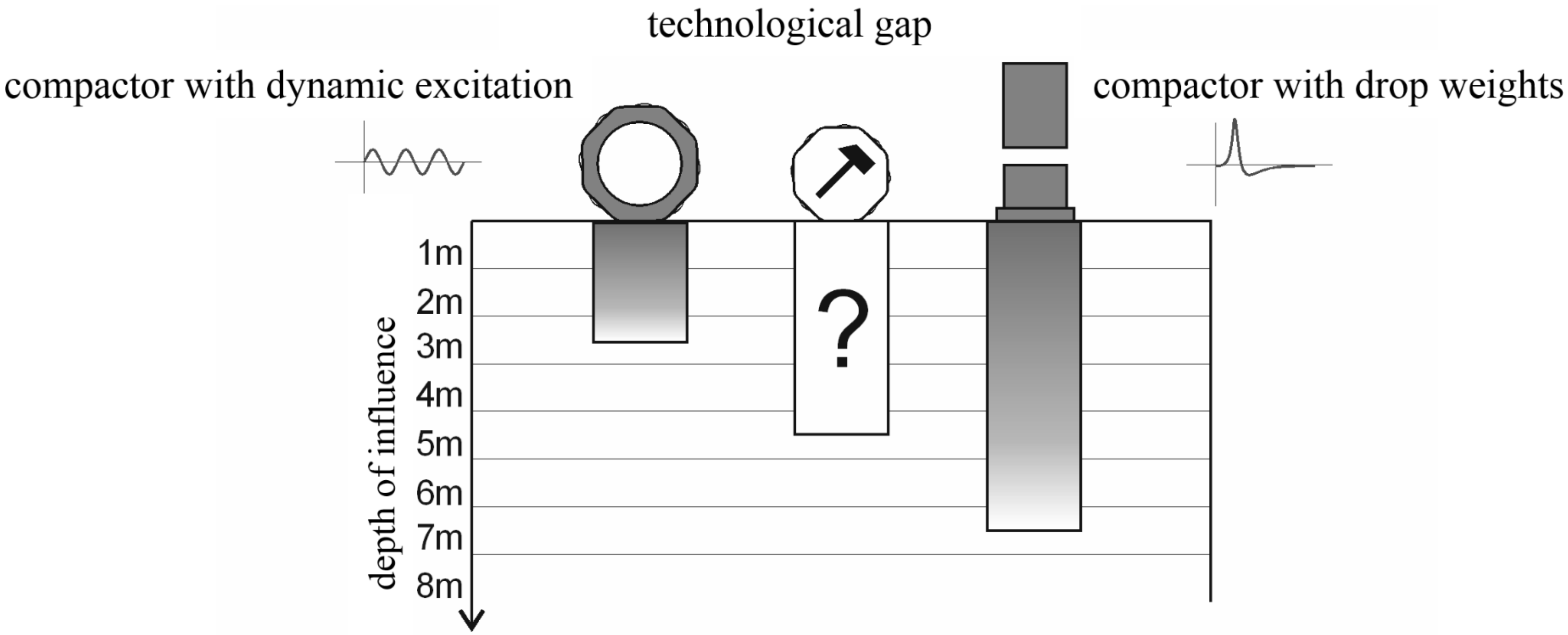
Testing Soil Compaction – High-speed Measurements of scaled Compactors

Holger Pankrath, Rosa Elena Ocaña Atencio, Alexander Knut, Ralf Thiele

Leipzig University of Applied Sciences, G² Group Geotechnics, Germany

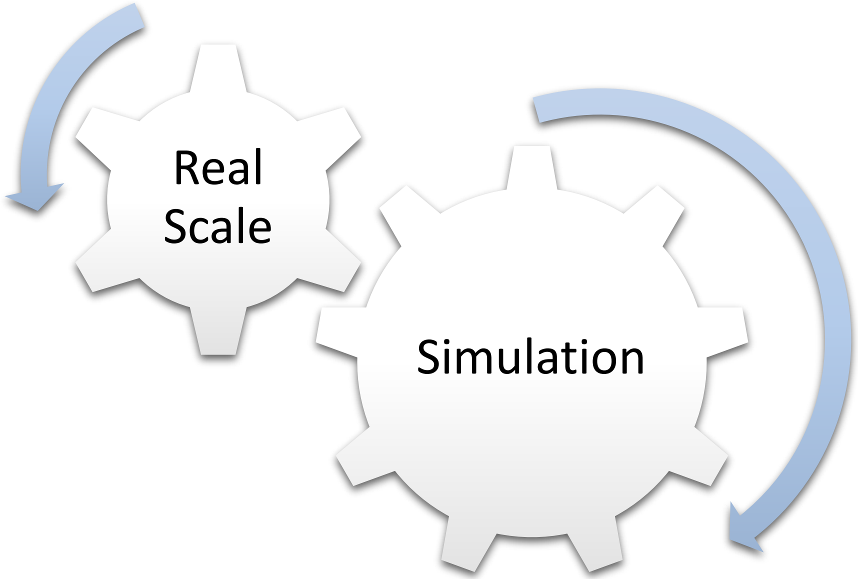
www.g2-gruppegeotechnik.de

Motivation



Procedia Engineering, Volume 125, 2015, Pages 390-396, ISSN 1877-7058

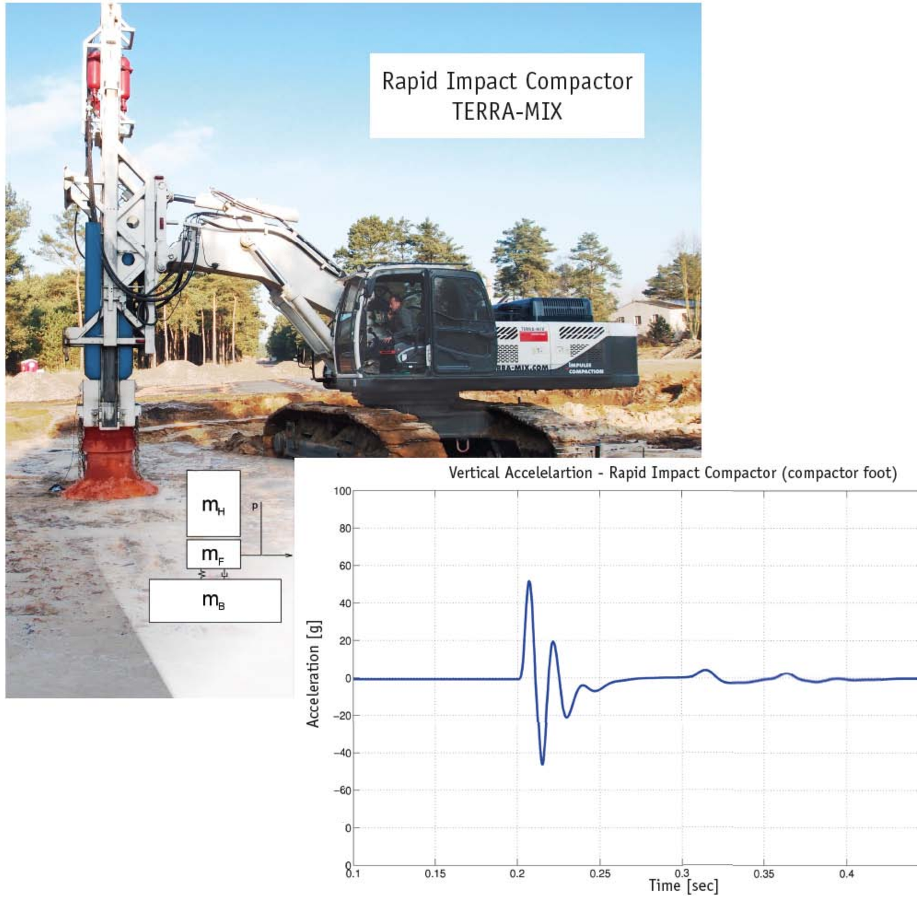
Field tests with
cone penetration tests, layer by layer excavation, …

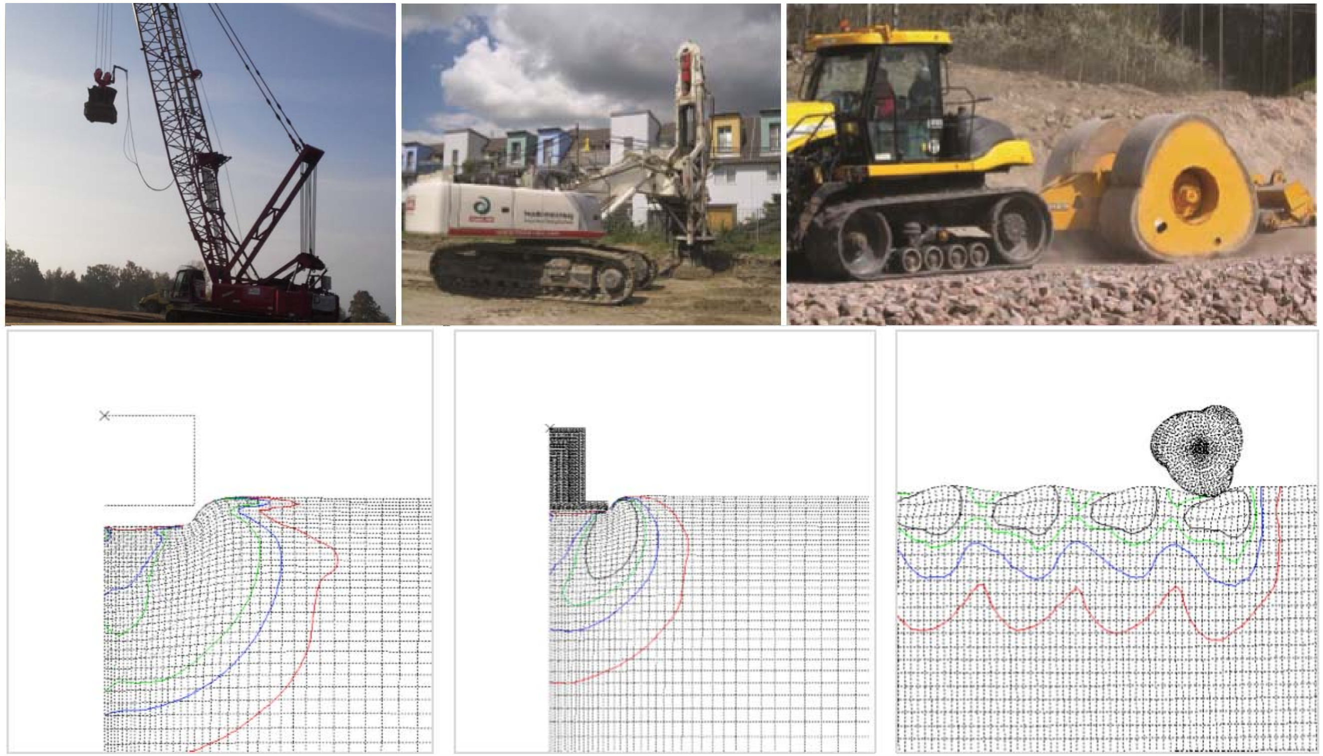


Abaqus Explicit, reducing of element distortion by ALE adaptive meshing and CEL

Modified Drucker-Prager Cap Model

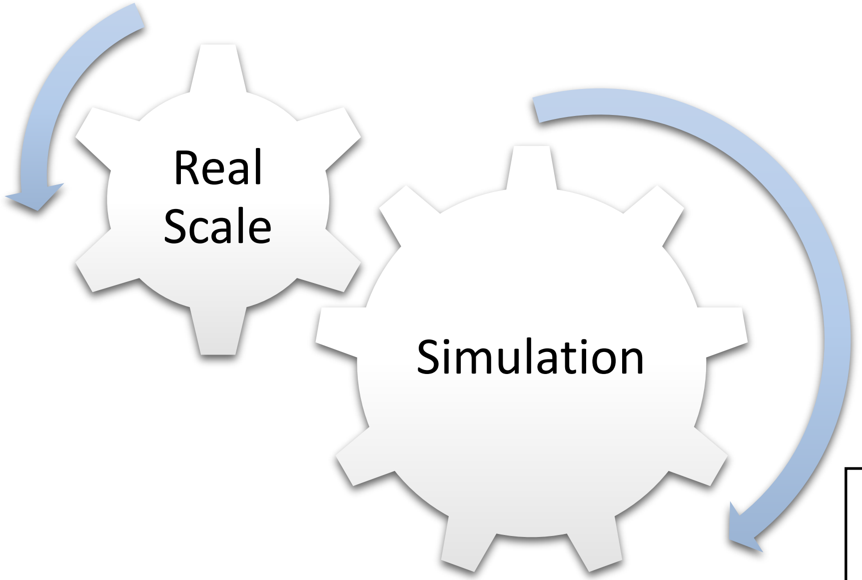
Procedia Engineering, Volume 125, 2015,
Pages 390-396, ISSN 1877-7058

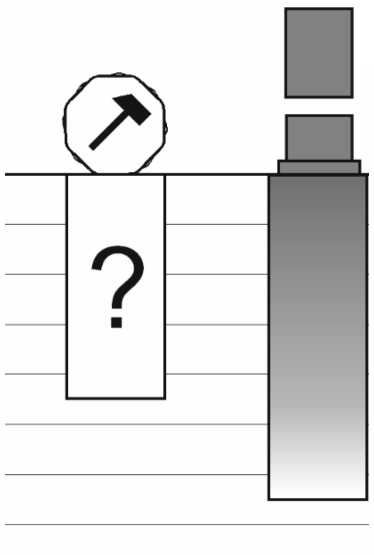




Procedia Engineering, Volume 125, 2015, Pages 390-396, ISSN 1877-7058

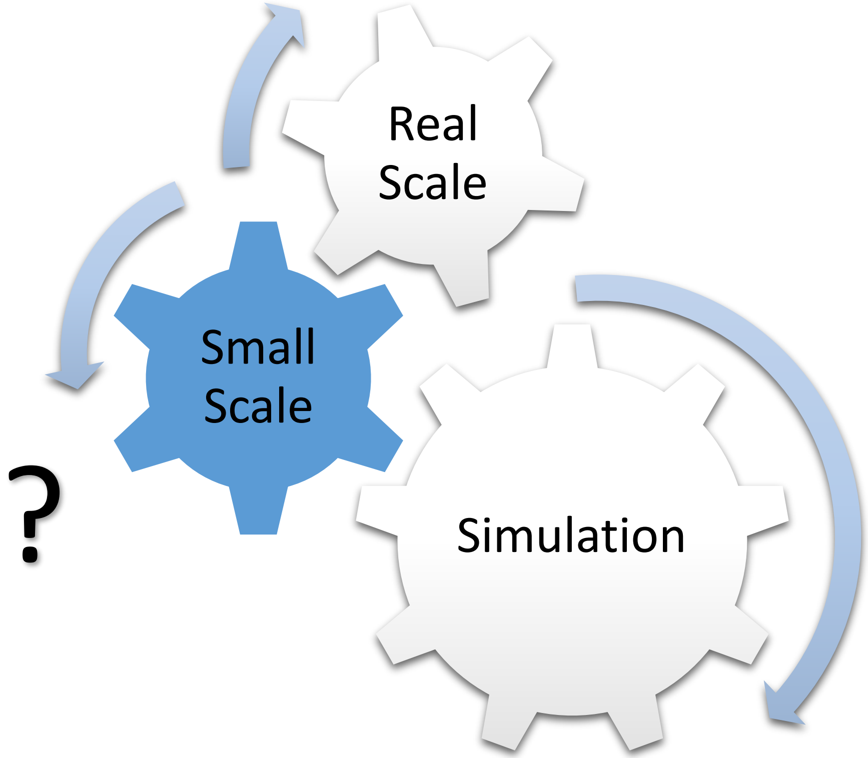
Motivation | Setup/Processes | Test Series | Conclusion

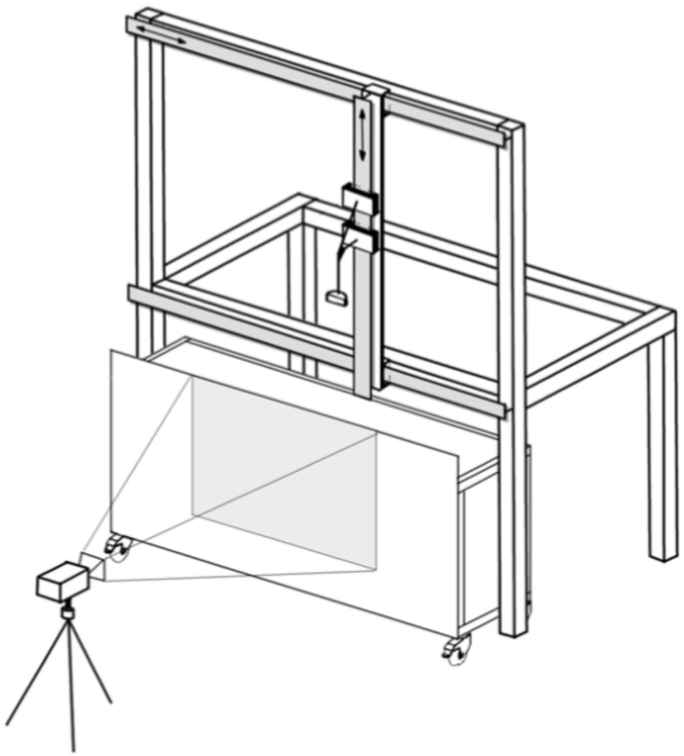




Soil behavior
- during compaction
- below compactor

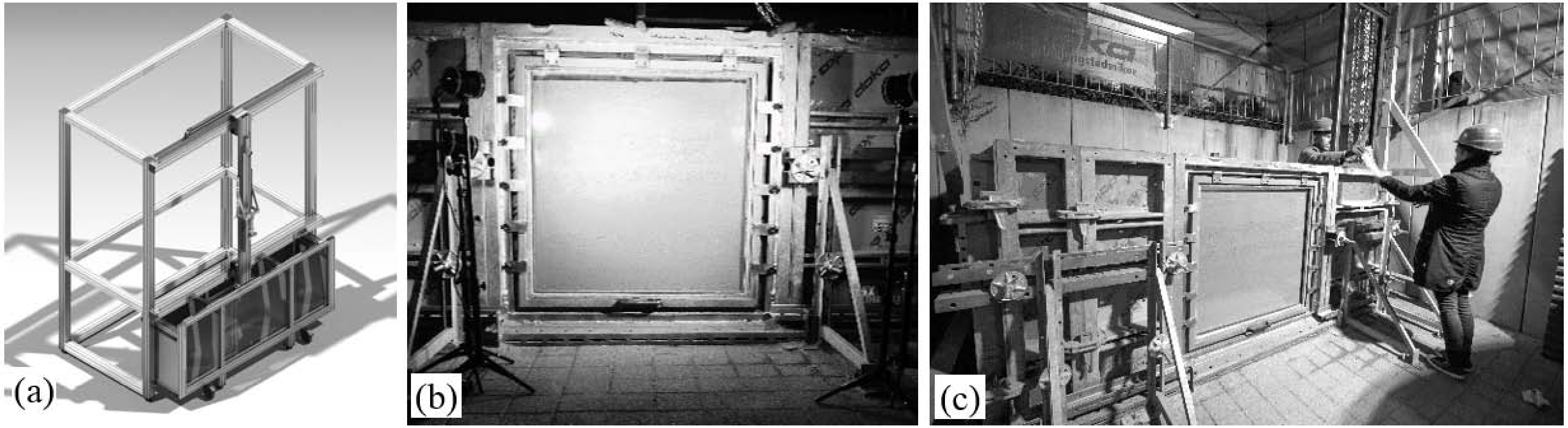
Motivation | Setup/Processes | Test Series | Conclusion





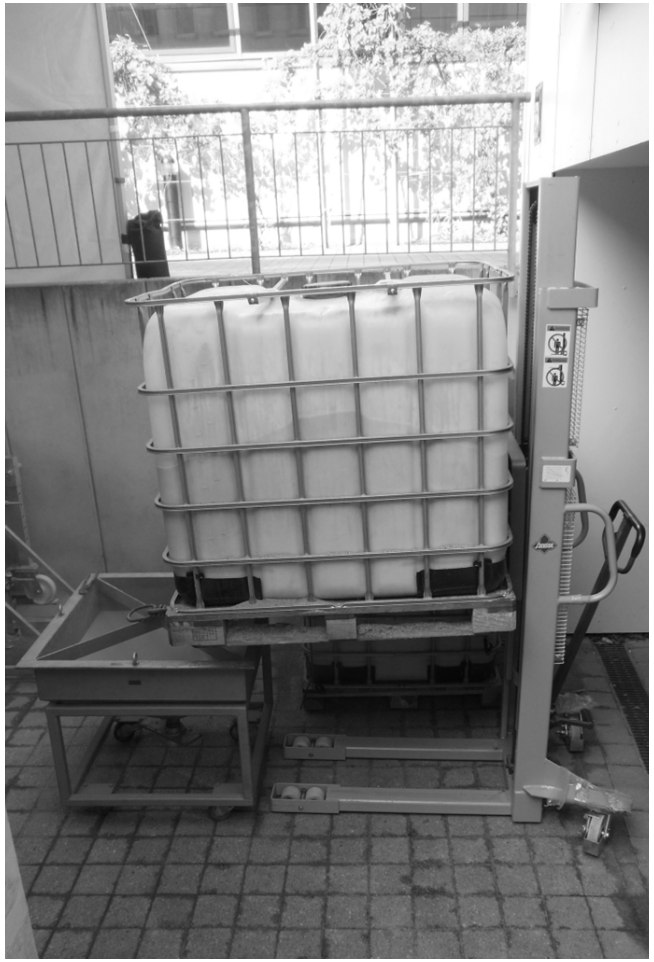
Optical and Physical Measurements
- High Speed Imaging
- DIC/PIV (Digital Image Correlation)
- Acceleration Sensors

Experimental Setup and Processes

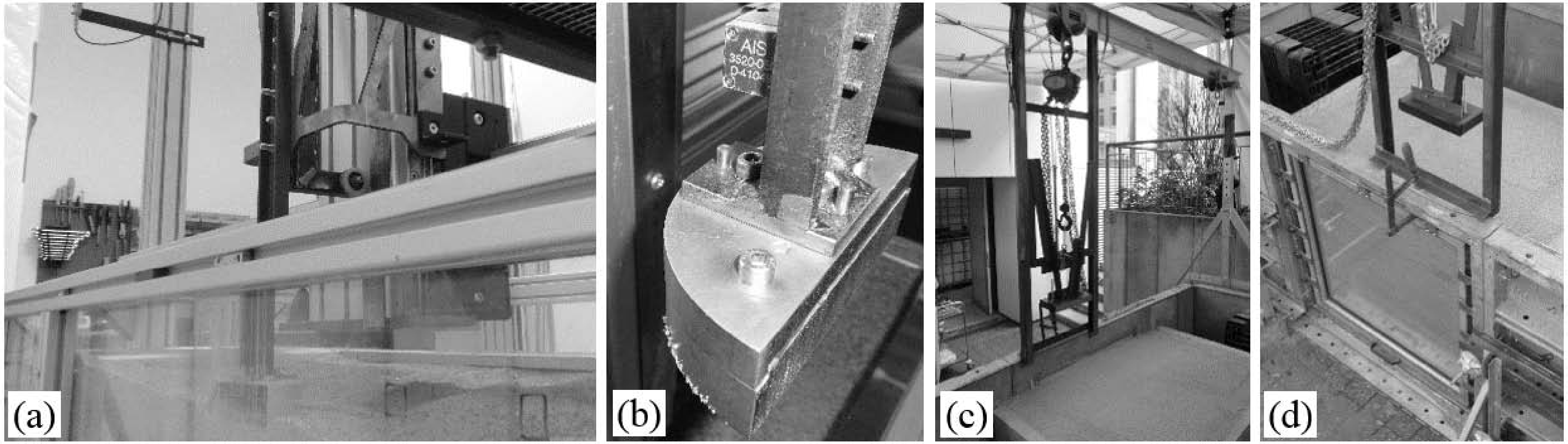


Test setups with transparent section plane for optical measurements with the DIC/PIV method
(a) test station S (small) for a volume of test soil up to 0.4m³ and
(b, c) test station M (medium) for volume of test soil up to 5 m³, laying on natural soil

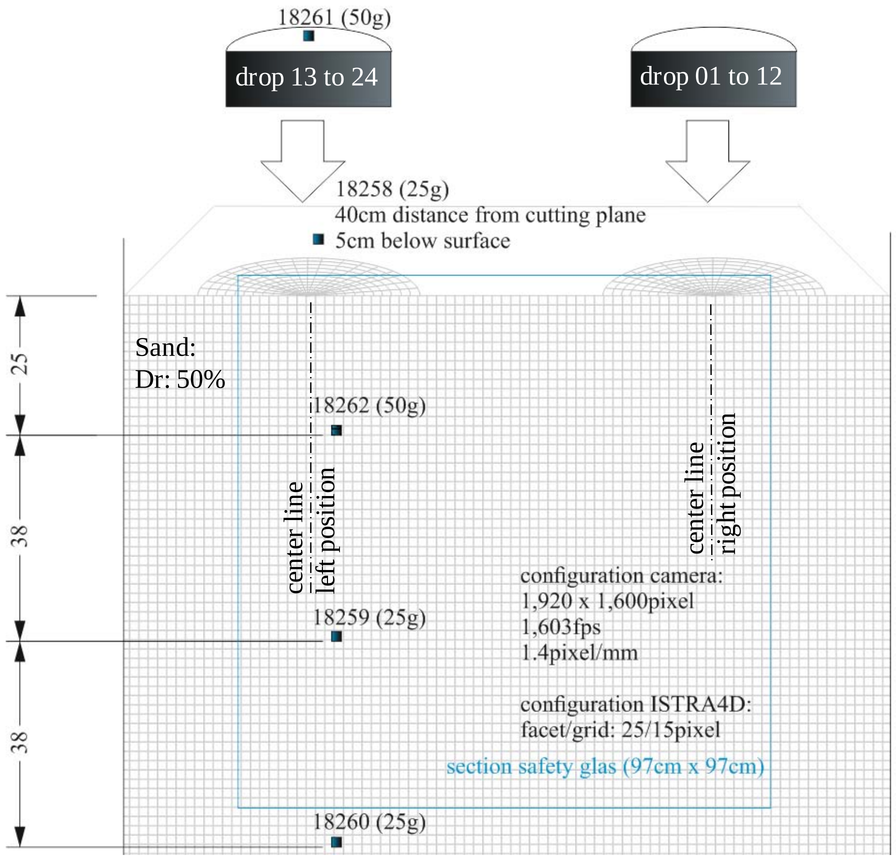
Motivation | Setup/Processes | Test Series | Conclusion



Test Station M

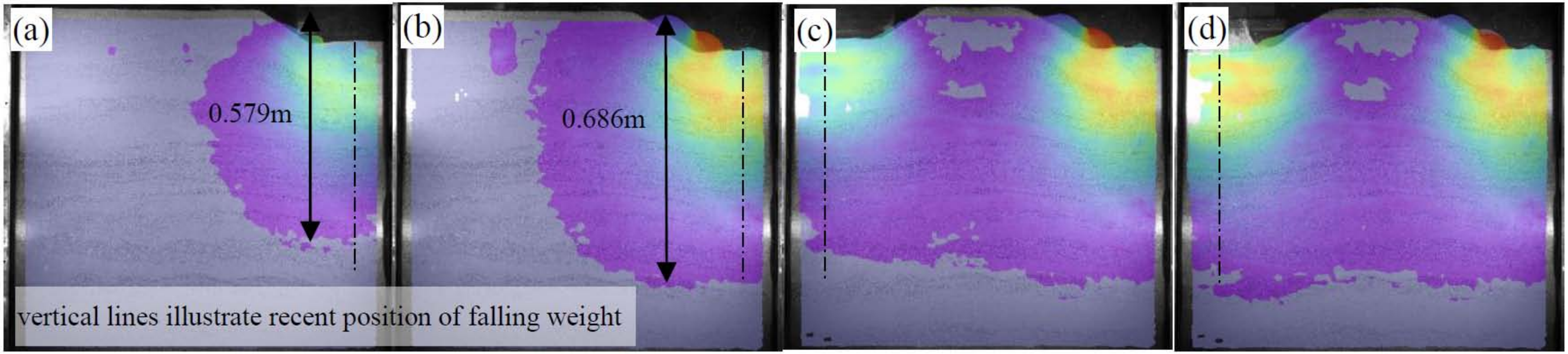


Guided freefall weights with variable basic shapes and falling heights up to 1.2m
(a, b) test station S with weights between 4.5kg and 6.75kg
(c, d) test station M with weights between 26kg and 70kg

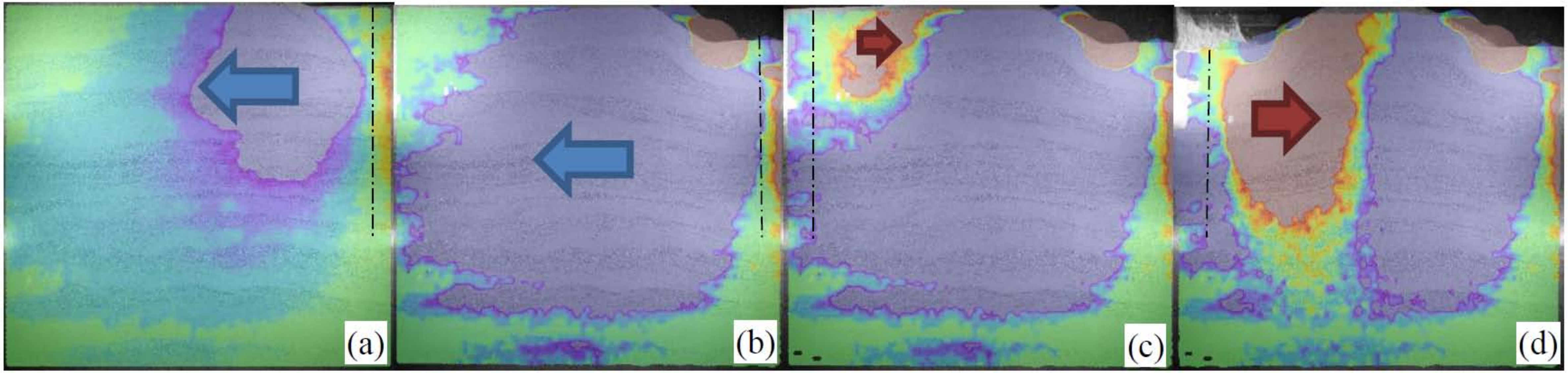


Test station M, configuration for 12 drops on each side with a falling height of 0.34m, a falling weight 47kg and a diameter of 0.3m

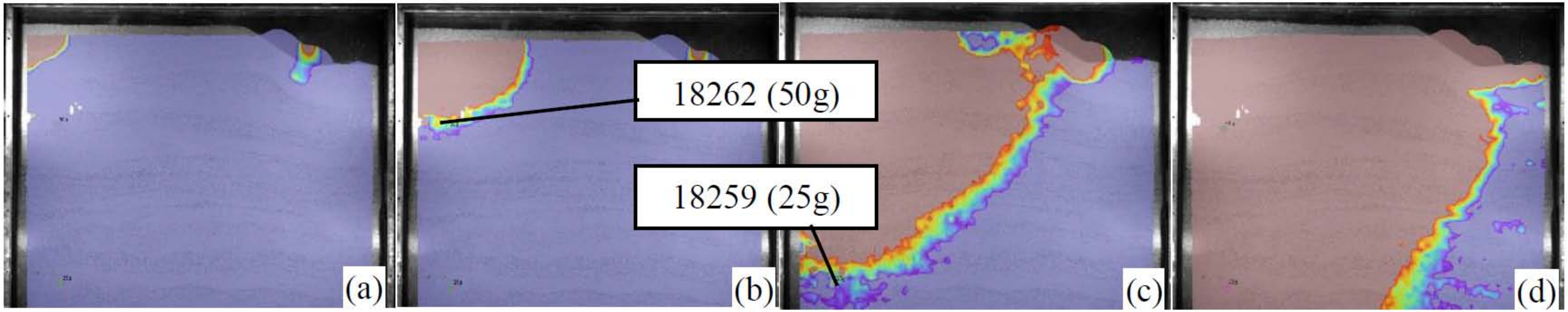
Test Series with scaled Falling Weights



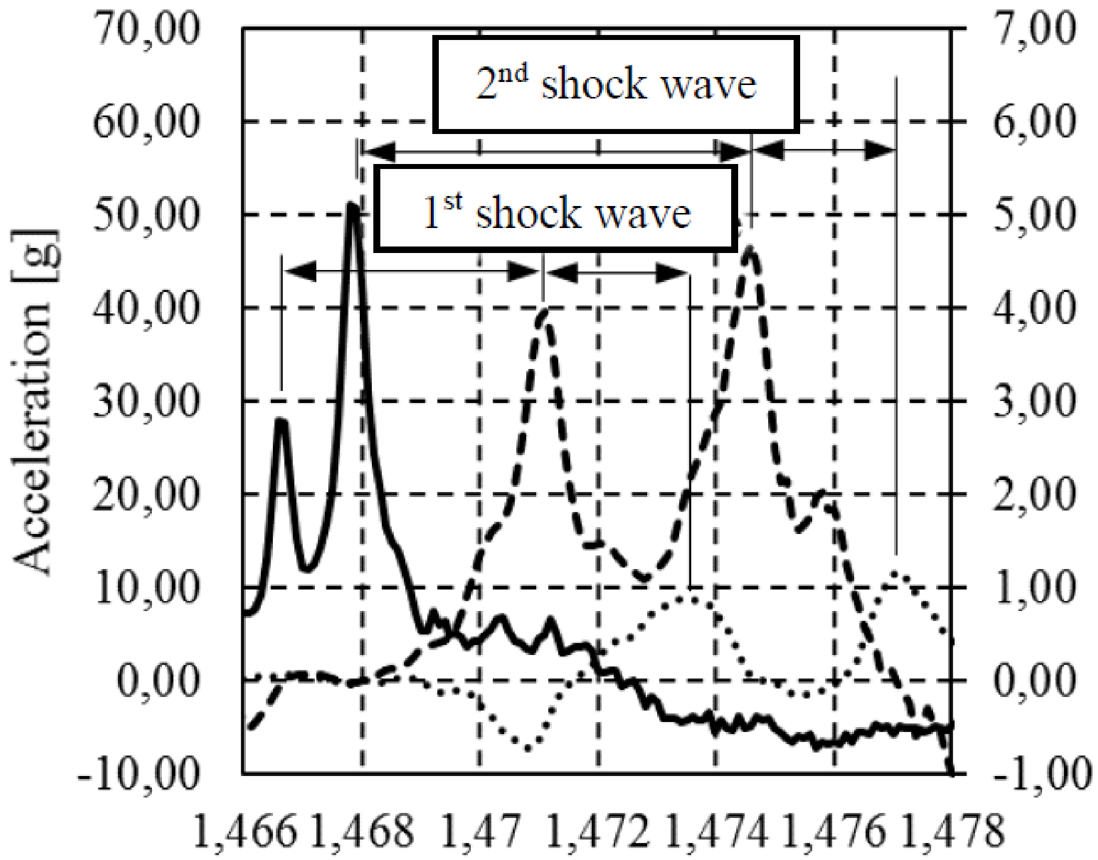
Test station M, evaluation of 12 + 12 drops, total displacements > 10mm,
(a) drop No. 6 right position, (b) drop No. 12 right position, (c) drop No. 6 left position, (d) drop No. 12 left position, compared to situation before compaction

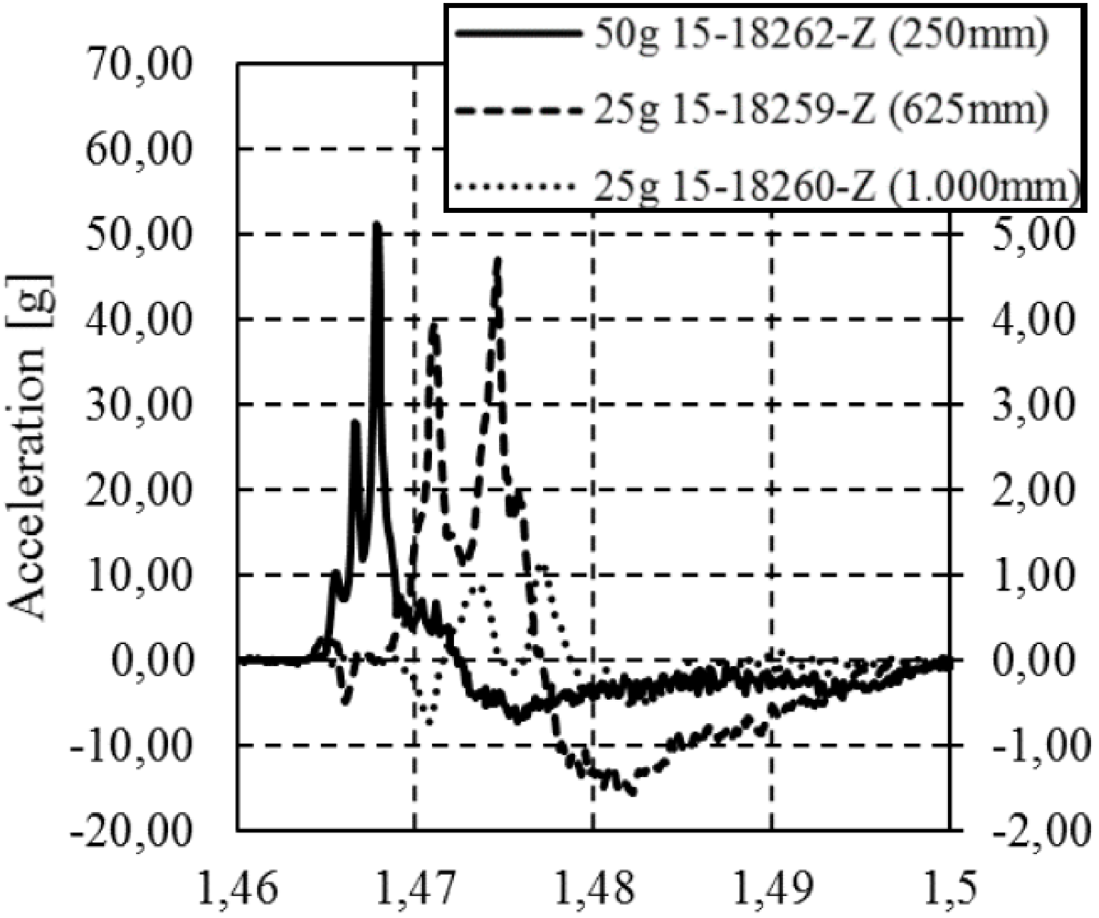


Test station M, evaluation of 12 + 12 drops, horizontal displacements (x) between +/- 2mm,
(a) drop No. 1 right position, (b) drop No. 12 right position, (c) drop No. 1 left position,
(d) drop No. 12 left position, compared to situation before compaction

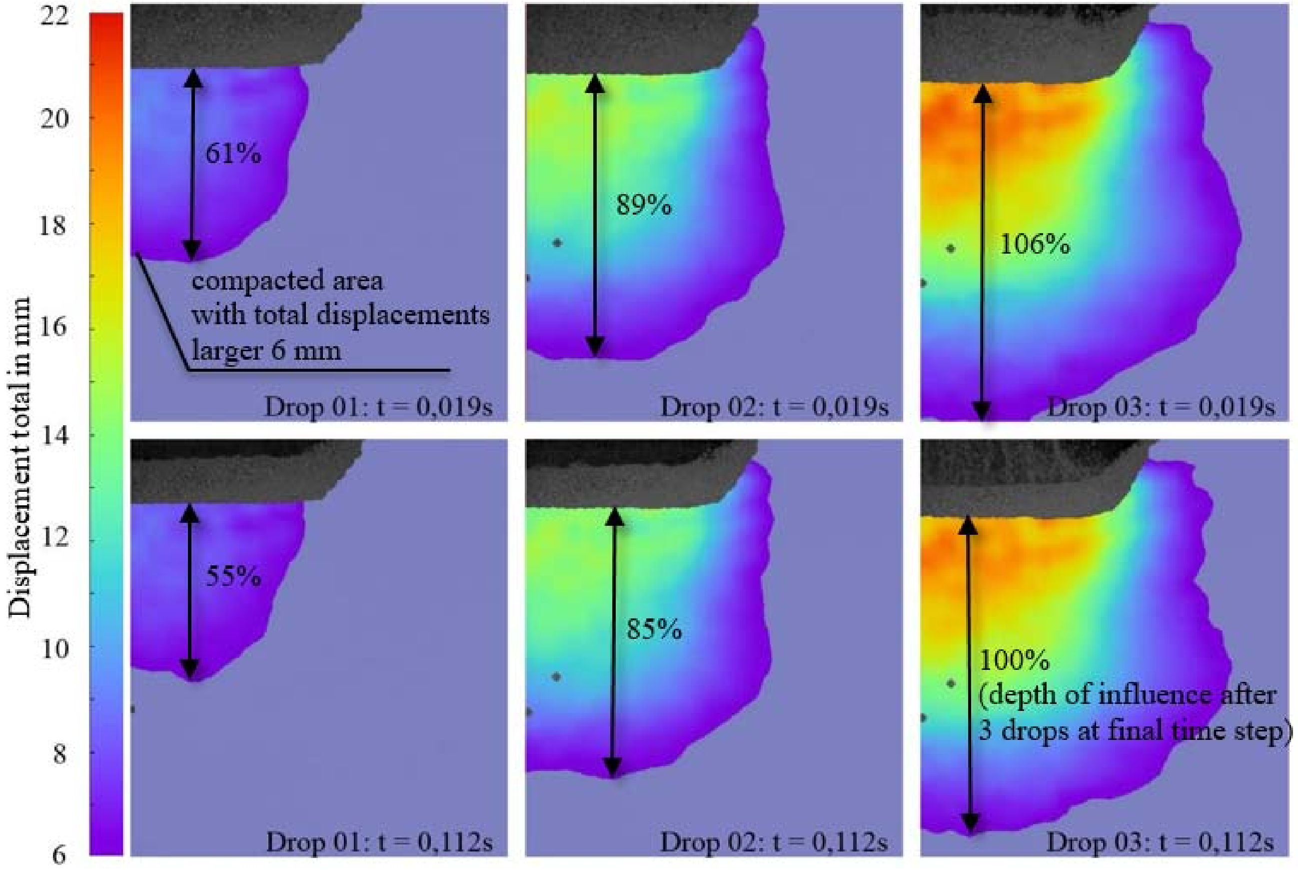


Test station M, evaluation of 1 drop at left position, total displacements between 0.1mm and 0.2mm at, (a) 0.0019sec, (b) 0.0044sec, (c) 0.0094sec and, (d) 0.018sec after impact, with marking the positions of 2 acceleration sensors in the sand

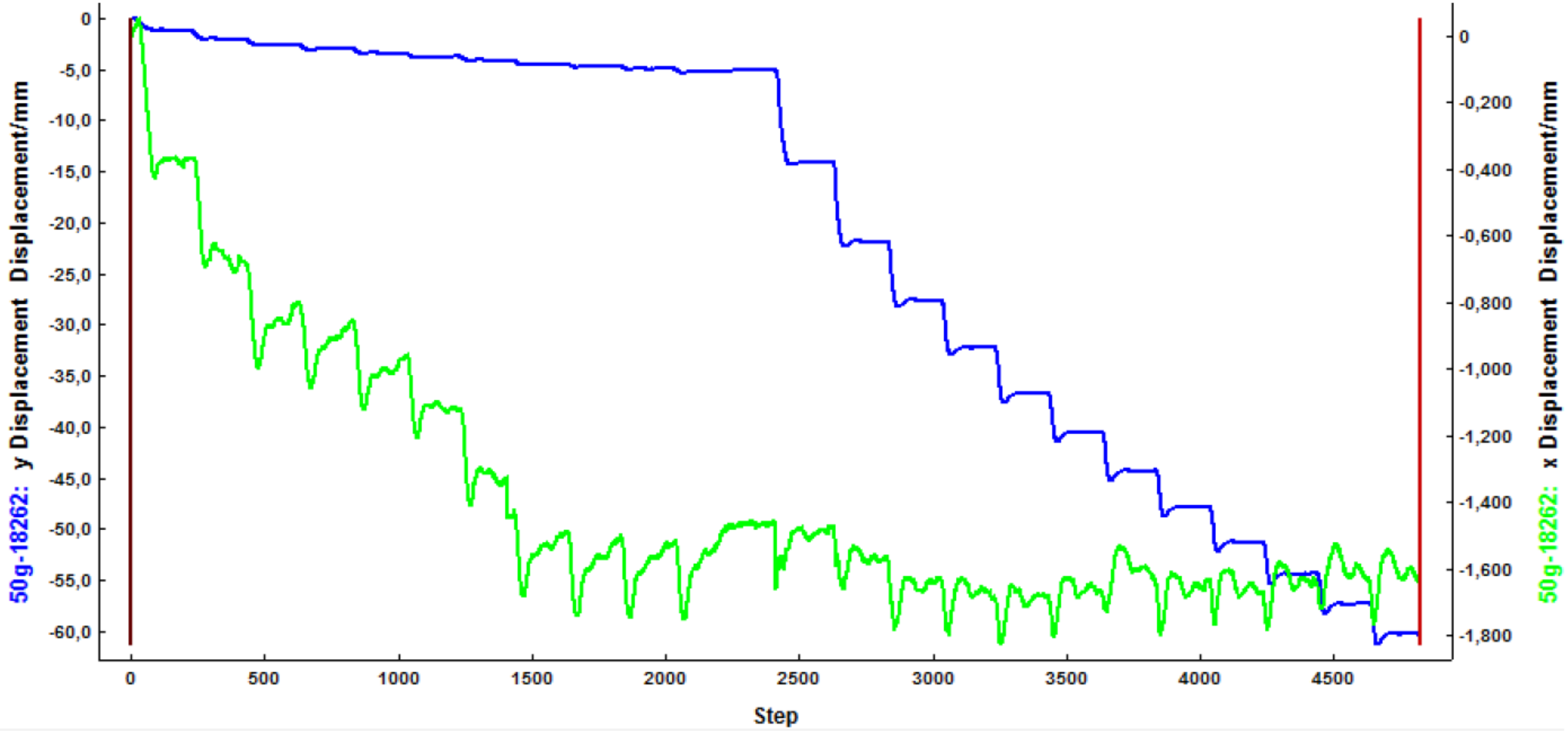




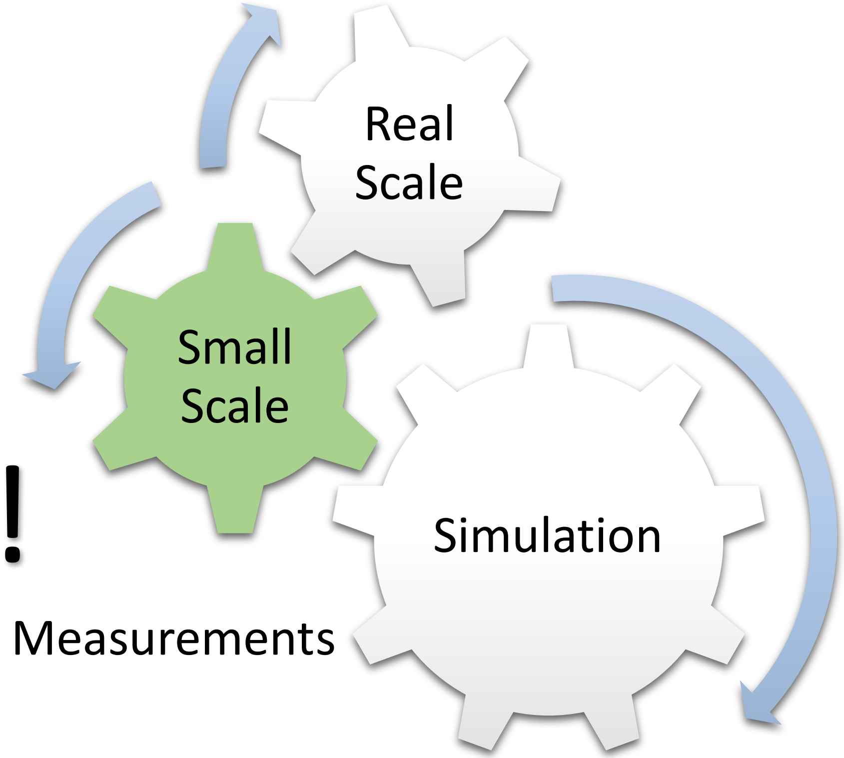
Vertical acceleration in soil, 250mm, 625mm und 1.000mm below surface, medium dense sand (Dr: 50%)



Test station M, evaluation of 3 drops, total displacements > 20mm, measured 0,019s after contact, and 0,112s (final)



Test station M, evaluation of 24 drops, directed displacements of one point 0.25m below initial surface (near sensor 50g 18262)



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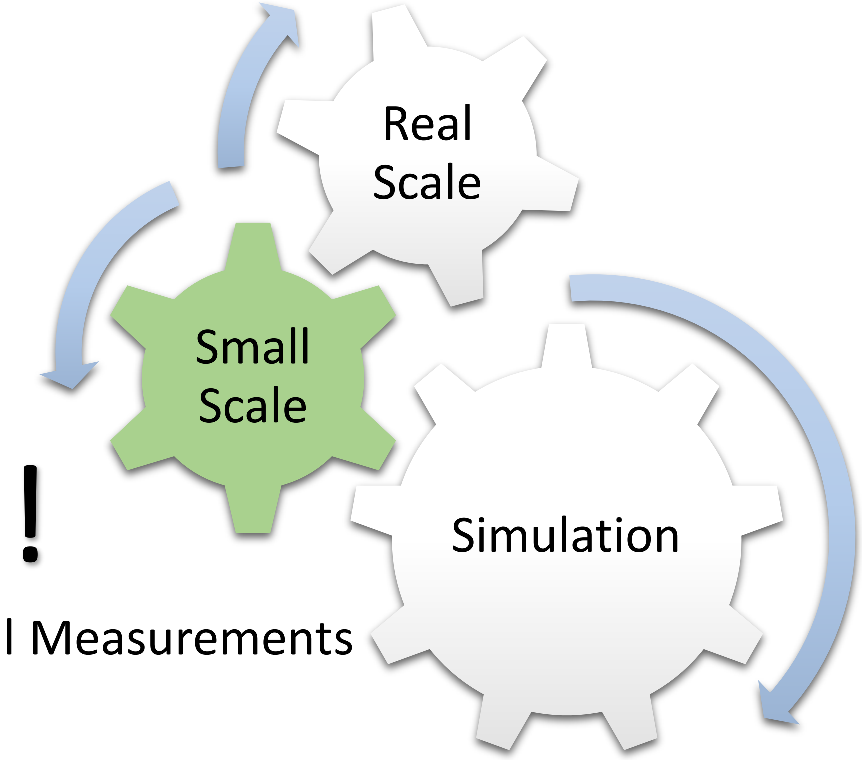
Optical and Physical Measurements

Motivation | Setup/Processes | Test Series | Conclusion



Optical and Physical Measurements

Abaqus Explicit

Hypoplastic model for granular materials von Wolffersdorff [1] (basic model), Niemunis and Herle [2] (small-strain extension)

[1] P. A. von Wolffersdorff.
A hypoplastic relation for granular materials with a predefined limit state surface.
Mechanics of Cohesive-Frictional Materials, 1(3):251-271, 1996.
[2] A. Niemunis and I. Herle.
Hypoplastic model for cohesionless soils with elastic strain range.
Mechanics of Cohesive-Frictional Materials, 2(4):279-299, 1997.

Testing Soil Compaction – High-speed Measurements of scaled Compactors

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The use of seismic wave velocities in the evaluation of stiffness, damping and anisotropy of geomaterials in routine laboratory and field tests

Cláudio Pereira[1], António Gomes Correia[1], Sohel Nazarian[2], Cristiana Ferreira[3]

1. *ISISE, University of Minho, Portugal*
2. *CTIS, University of Texas at El Paso, United States*
3. *CEC, University of Porto, Portugal*

Contents

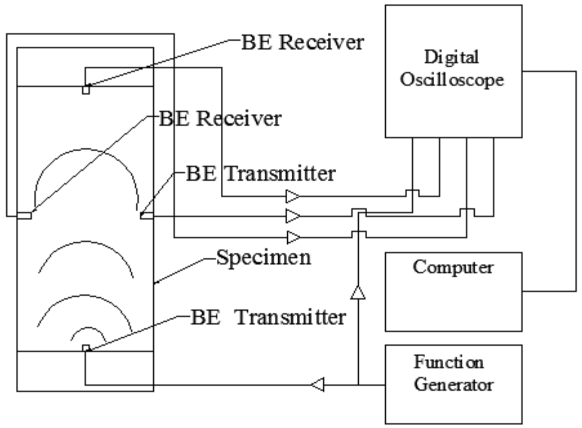
- Introduction
- Materials and Methods
- Results
- Conclusions

Introduction

- Anisotropy of ground materials plays an important role on geotechnical design;
- Materials anisotropy is affected by its geological characteristics, compaction method and stress conditions;
- The present study is based on the use of bender elements (BE), which allow the assessment of shear modulus in different directions;
- BE have become an increasingly common technique for direct and non-destructive measurement of P and S wave velocities;
- With these velocities, elastic stiffness parameters and other relevant features namely anisotropy, sampling quality, liquefaction evaluation, cementation, porosity and damping, can be directly computed;
- This study aims to evaluate inherent and stress-induced anisotropy of a monogranular sand by means of BE measurements in vertical and horizontal directions;
- To improve results consistency, namely in terms of scale effect and BE interpretation:
  - Tests were carried out in two different triaxial chambers with different dimensions; and,
  - Two sets of BE (vertical and horizontal) and accelerometers (AC) were used.

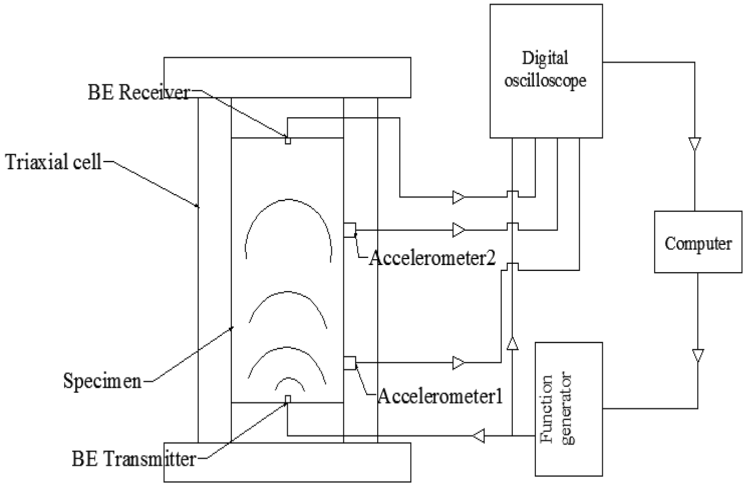
Materials and Methods

- Tests were performed in two distinct triaxial cells using specimens with 100mm and 150mm diameter



a)

b)



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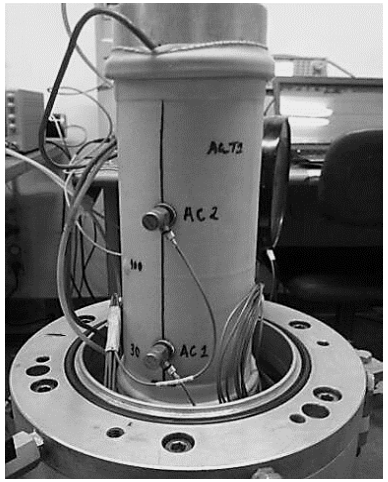


d)

Figure – a) Systematic view of the 150mm triaxial chamber system; b) Detail of the horizontal Bender Elements assemble; c) Systematic view of the 100mm triaxial chamber system; d) b) Detail of the horizontal Accelerometers assemble;

Materials and Methods

- 150mm Triaxial Cell
  - “T-Shaped” bender elements (BE): 11mm wide x 1.8mm total thickness x 2mm cantilever length;
- 100mm Triaxial Cell
  - Two bender elements from GDS Instruments;
  - Accelerometers from Bruel & Kjær (type 4513-001, 100mV/g sensitivity, ±50g measuring range, 1Hz to 10kHz frequency range, 12.7mm in diameter, 15.65mm in height, 9.0g in weight);
  - Its attachment to the specimen is possible by means of threaded head pivots; and,
  - Accelerometer1 (AC1) is placed 30mm from the specimen base and accelerometer2 (AC2) 100mm from AC1.
- Associated Electronic Equipment
  - Function generator from Thurlby Thandar Instruments (TTi TG2511); and,
  - Digital oscilloscope PicoScope model 4424, with 4 channels (1 or 2 channels at a sampling rate of 80MS/s and 3 or 4 channels at 20MS/s, with 12 bits of resolution) for data acquisition.

Figure – Overview of the test setup.

Materials and Methods

- Physical properties of the material tested.
  - D50 = 0.28mm; and,
  - Cu = 1.22.

Table – Physical properties of material tested.

	$\rho_{d\,max}$(g/cm³)	$\rho_{d\,min}$(g/cm³)	e_{max}	e_{min}
LEC_UM	1.589	1.397	0.882	0.655

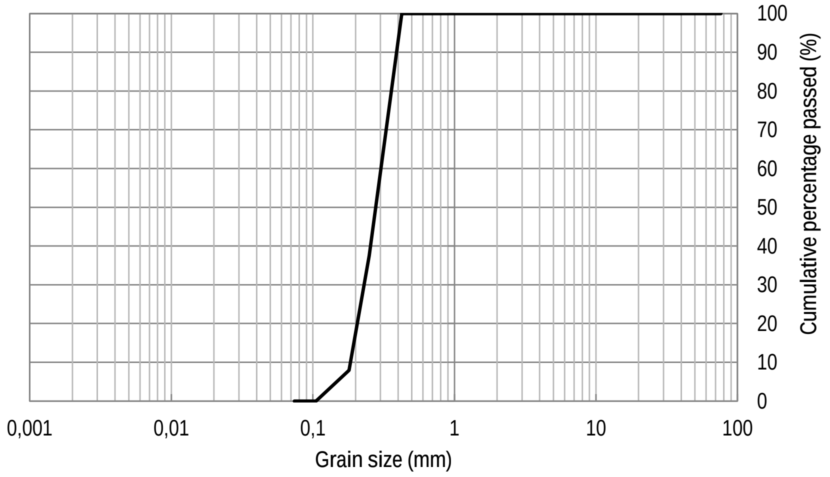


Figure – The particle size distribution obtained according the NP EN 933-1 200.

- The travel time (tt) determination was conducted using time domain methods of signal analyses namely, first direct arrival (t0).

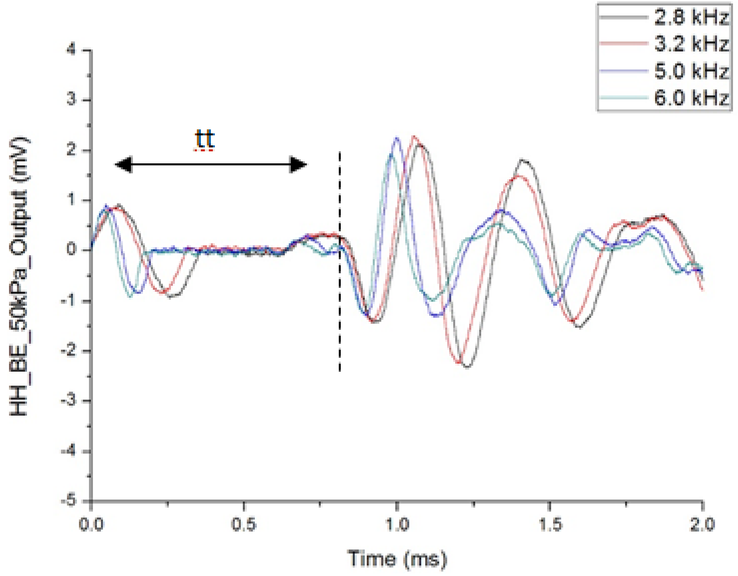


Figure - Example of travel time (tt) determination: First arrival for horizontal Bender Elements for 50 kPa of isotropic effective stress.

Shear Waves Velocity

$$V_S = \frac{tt}{L_{tt}}$$

Shear Modulus

$$G = \rho \times Vs^2$$

Anisotropy Factor

$$a = \frac{G_h}{G_v}$$

Materials and Methods

- Specimens were assembled by the pluviation method;
- In order to assess the inherent and stress-induced anisotropy, a specimen was tested at 3 different stages:
  - Stage 1 - The specimen was submitted to different levels of isotropic stress conditions, with horizontal and vertical BE measurements, for the assessment of the inherent/fabric anisotropy of the sand;
  - Stage 2 - The specimen was submitted to an anisotropic stress state with an effective stress ratio (K=sh/sv) of 0.5 and BE measurements were performed in order to evaluate the anisotropy of the sand under anisotropic stress conditions; and,
  - Stage 3 - The specimen was once again tested under isotropic conditions for the evaluation of the stress-induced anisotropy of the sand.

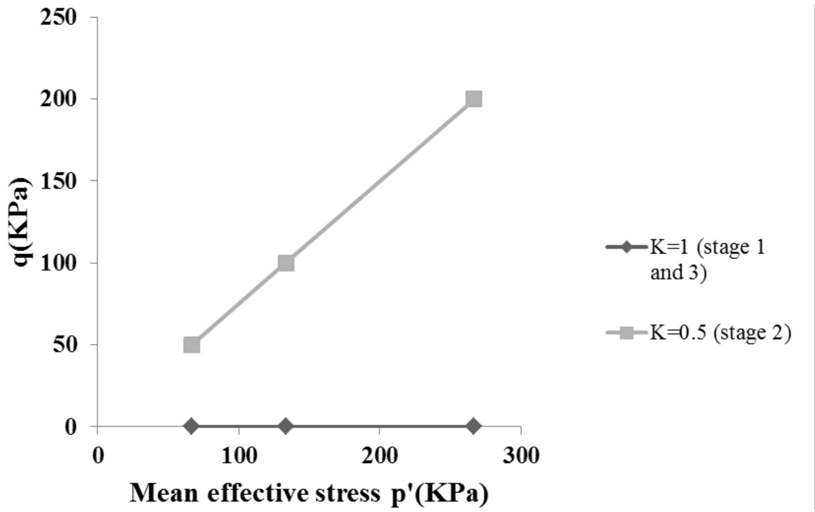


Figure – Stress path for the first specimen.

Materials and Methods

- A secound specimen was assembled in the150mm triaxial chamber through the pluviation method and test sequence followed next steps (numbers represent the order by which the test was carried out):
  - The specimen was submitted to an anisotropic stress level with the BE measurements (points 1,4,7);
  - Unloaded the deviatoric stress (q) for the assessment of the correspondent induced anisotropy (points 2,5,8); and,
  - Return to the previous anisotropic stress level and increase the mean effective stress (anisotropically) to repeat the process (points 3,6).

- The main purpose of this part of the experiment was to evaluate the stress-induced anisotropy at each stress state with cycles of loading and unloading.

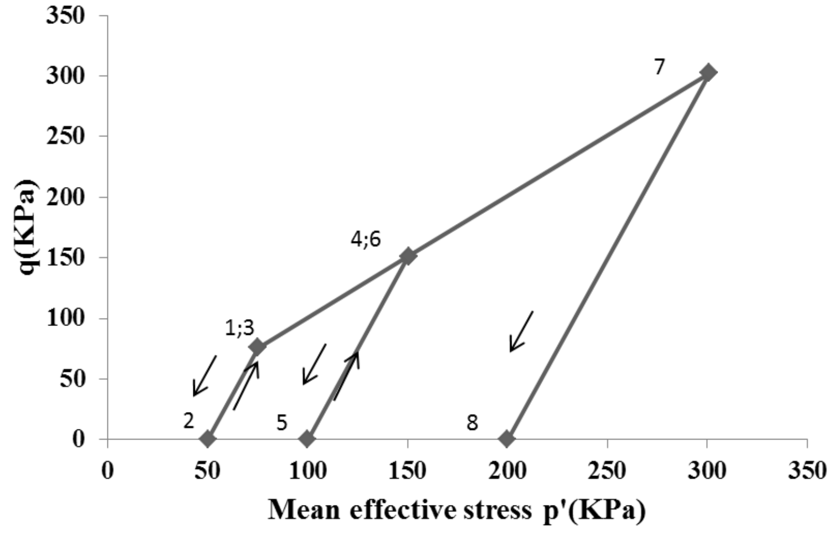


Figure – Stress path for the secound specimen.

Results

- Horizontal shear moduli (Gh) is significantly higher than the vertical shear moduli (Gv);
- Low variation of the anisotropy with the mean stress, raging 1.25-1.27;
- Results similar to those obtained under isotropic stress conditions by Amat (2007) in the Hostun sand and by Kuwano et al. (1999) with the Toyura sand, observing a Gh/Gv of 1.2;
- According to Fioravante (2000), the higher values associated with the Gh when compared to Gv may be caused by the pluviation technique, which results in a slightly oriented structure.

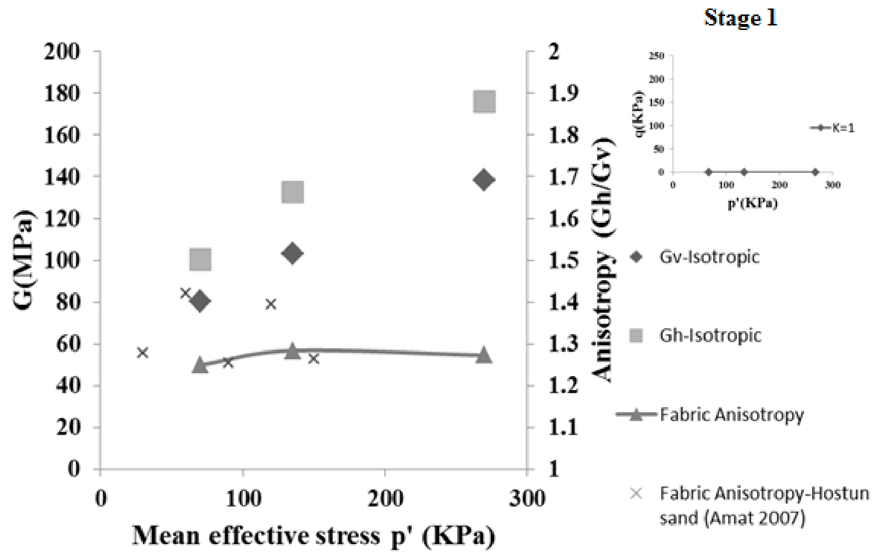


Figure – Shear modulus of the sand under isotropic conditions and fabric anisotropy.

Results

- Anisotropic stress conditions (stage 2) have a significant influence on the sand shear modulus;
- Its possible to observe a reduction of the Gh and an increase of the Gv for the same mean effective stress;
- Anisotropy presented a stress-induced modification, in the range of 1.04-1.06, which are similar to the results obtained by Kuwano et al. (1999) with the Toyura sand (Gh/Gv=1.02), although relatively higher than those obtained by Belloti et al. (1996) with the Tiscino sand ;
- This difference may be partially explained by the differences in the fabric anisotropy, which influences results in a slightly oriented structure.

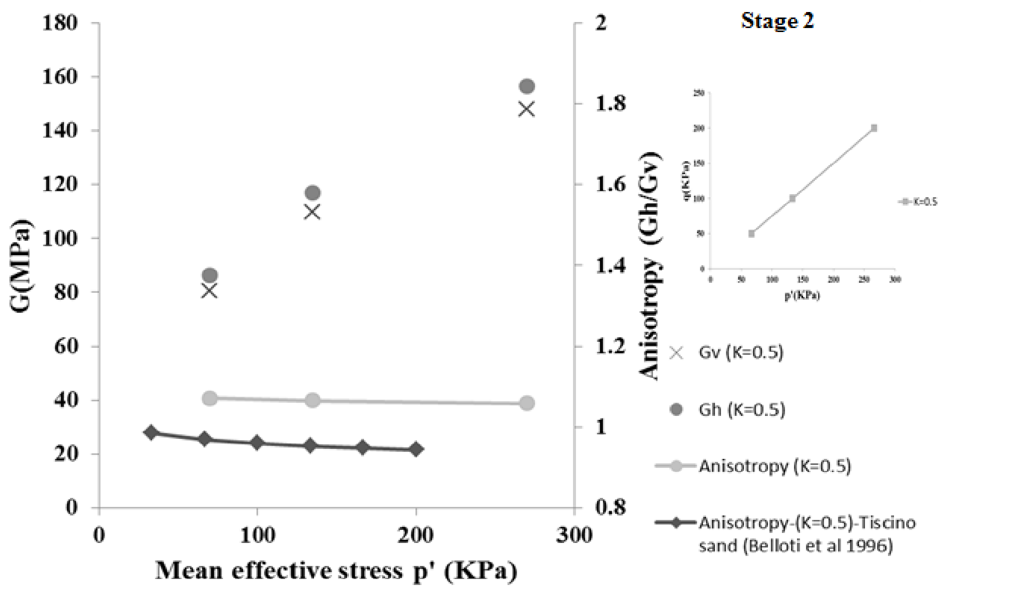


Figure – Shear modulus of the sand under anisotropic conditions and induced anisotropy.

Results

- Anisotropy variation between the 3 stages is clearly evident;
- Anisotropy results in the final stage of the experiment fall between the fabric results (stage 1) and the anisotropic stress results (stage 2);
- The specimen under isotropic conditions (stage 3) recovers some of its initial properties when compared with stage 2, but it does not reach the anisotropy levels of stage 1, due to its stress history.

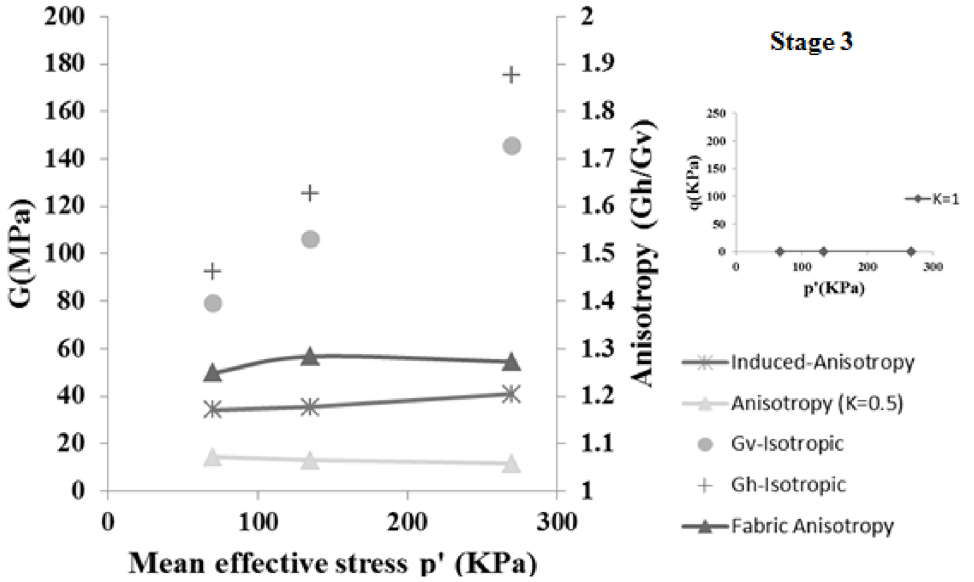


Figure – Shear modulus of the sand under isotropic conditions and comparison of anisotropies.

Results

- The K influence on the anisotropy was reported by several authors (Kuwano et al. 1999; Belloti et al. 1996; Fioravante 2000; Rampelo & Viggiani 2001);
- The results obtained with this sand present a good agreement with results from other authors, particularly in terms of observed tendency;
- Even though this work did not consider tests with stress ratios above 1, it appears that these have a much smaller impact on the anisotropy than stress ratios below 1.

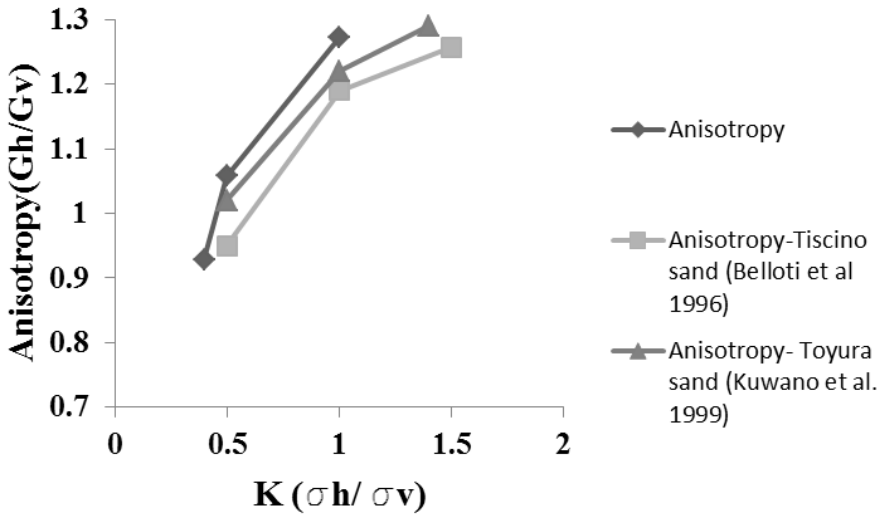


Figure – Anisotropy as function of K.

Results

- The results between chambers are very similar and the scale effect seems to be reduced;
- The tendency for higher shear modulus values in small specimens as reported by Omar & Sadrekarimi (2015) was not found;
- The results obtained in other stress conditions (in terms of comparing triaxial chambers) were similar;
- The use of accelerometers brings robustness to the comparison as it validates the obtained results.

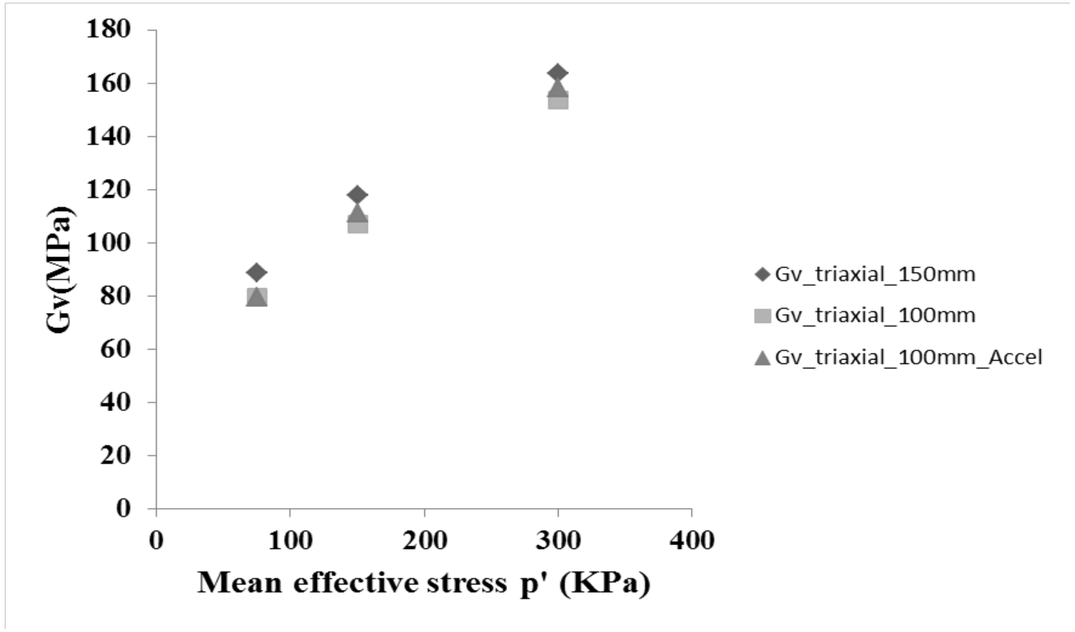


Figure – Vertical shear modulus in different triaxial chambers considering an anisotropic state with a K of 0.4.

Results

- The anisotropy of the sand is lower for lower values of K, emphasizing the importance of the sh/sv relationship on the anisotropy;
- Regarding the trends of the induced anisotropy assessed under different conditions, they seem to have different evolutions (anisotropy increases for K=0.5, and decreases for K=0.4);
- Previous point may be explained by the fact that when the induced test using K=0.5 was performed, the sand had already experienced much higher stress levels;
- In contrast, the K=0.4 experiment was made in reloading and unloading stages ;
- The path of stress level appears to influence the induced anisotropic results.

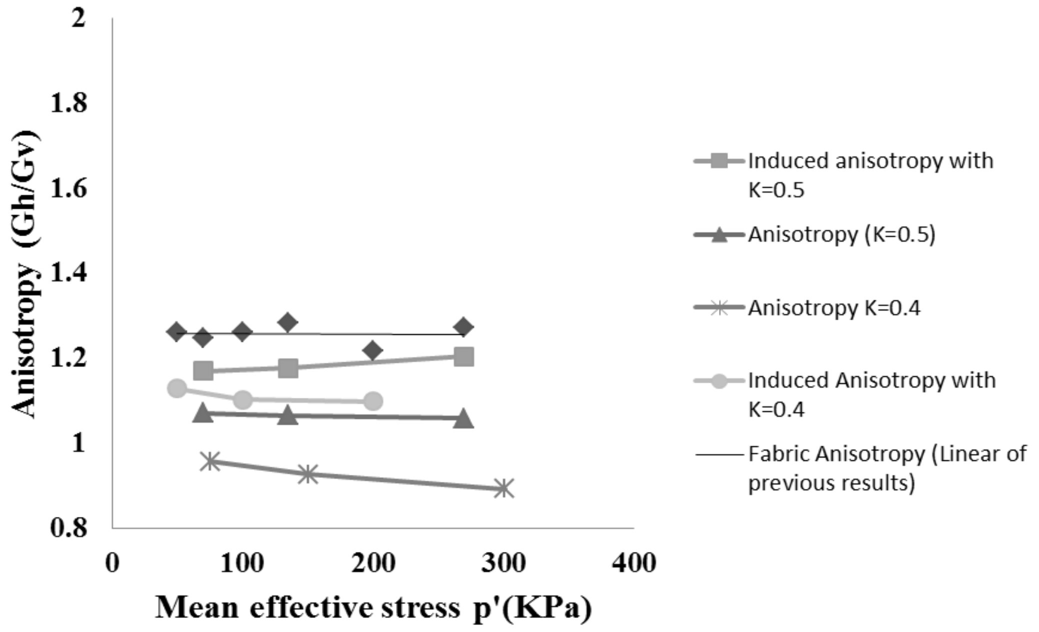


Figure – Effect of the anisotropy stress on the anisotropy of the material.

Conclusions

- The anisotropy of the material was found to be dependent of the fabric of the material (inherent anisotropy), the applied effective stress ratio (induced anisotropy) during testing and the stress paths history;
- The results obtained corroborate other previous research works, showing the predominance of the horizontal modulus over the vertical modulus, which reflects the compaction method, as well as the fabric of the sand ;
- The anisotropic stresses caused an increase of the vertical modulus of the sand over the horizontal modulus;
- After the anisotropic loading, some recovery of inherent anisotropy can be observed under isotropic stresses;
- The scale effects of the tested specimens seams to be not very relevant ;
- Test setup used combining bender elements and accelerometers present considerable reliability and precision.

The use of seismic wave velocities in the evaluation of stiffness, damping and anisotropy of geomaterials in routine laboratory and field tests

Acknowledgments

Financial support provided by FCT (Portuguese Foundation for Science and Technology) in the form of the research project WaveSoil (PTDC/ECM/122751/2010).

Assessment of the short and long term behaviour of the track at a railway transition zone

Cristina Alves Ribeiro[1] e Rui Calçada[1]

1. *University of Porto, Faculty of Engineering, Portugal*

What is a transition zone?

Zones where variation of vertical stiffness of the track occur. Those variations can be abrupt or smoothed by transition structures. Zones that require frequent maintenance operations.

Embankment - bridge

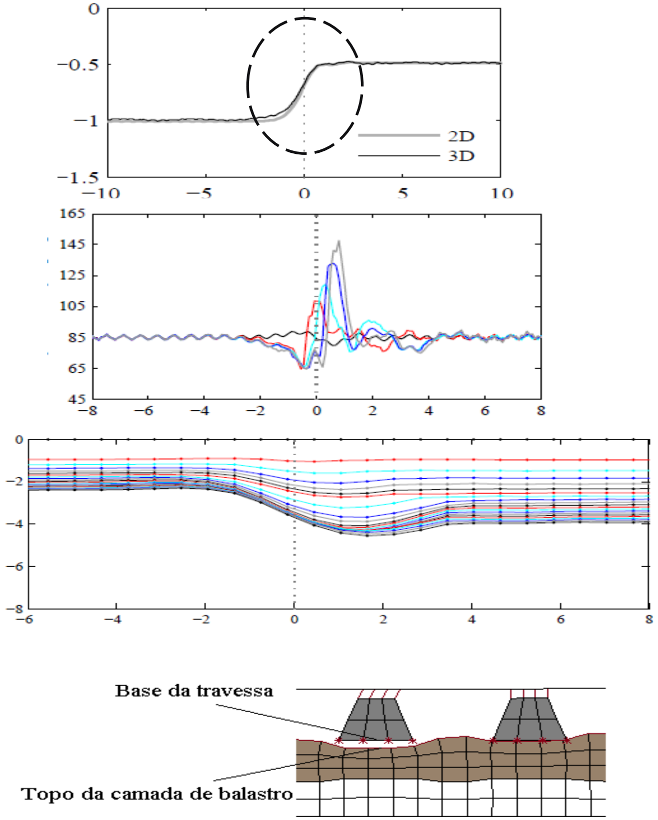
Culvert structures

Embankment - tunnel

Ballast track – slab track

Understand the problematic

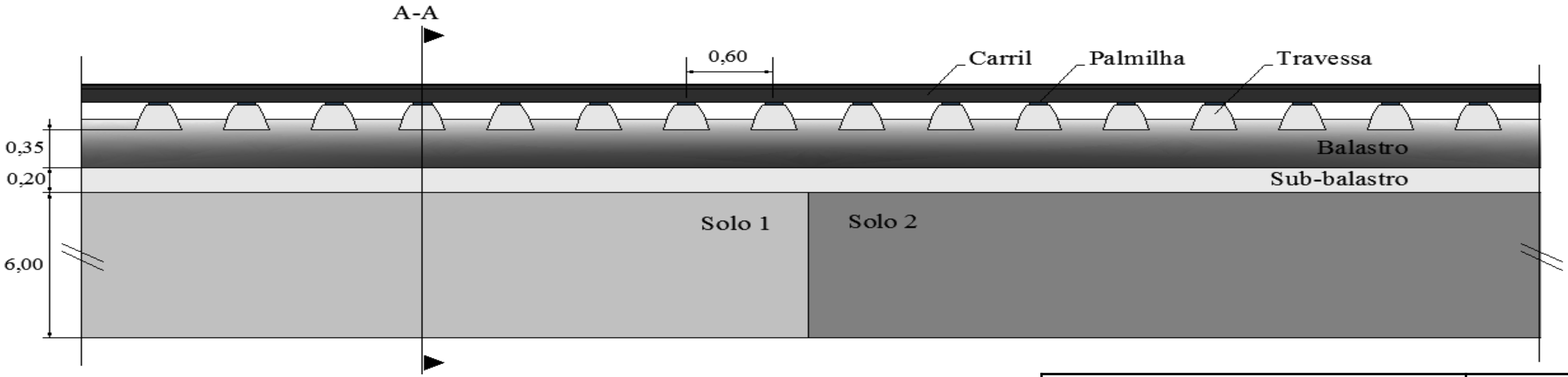
Variation of the vertical stiffness	Assess how the stiffness variation can influences the dynamic behaviour.
Variation of the wheel-rail contact forces	Asses how those forces vary in short and long term.
Differential settlements	Understand the arise of differential settlement due to railway traffic – load repeatedly applied by trains
Unsupported sleepers	Understand the arise of unsupported sleepers: the sleeper is not working properly, there is an overload of the neighbour sleepers



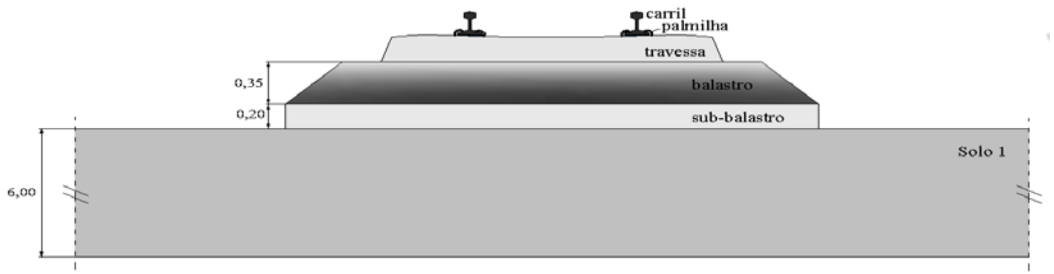
Background:

- Development of numerical models;
- Calibration and validation of the numerical models;
- Validation of the vehicle-track dynamics;

Case study

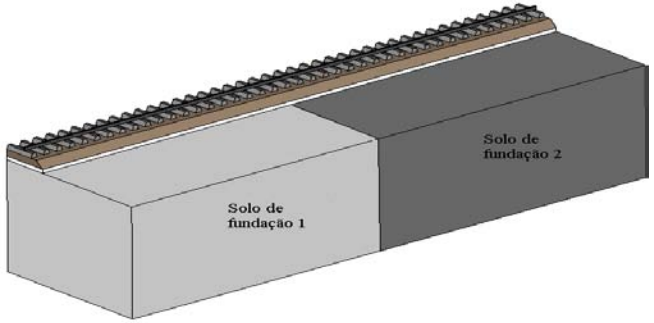


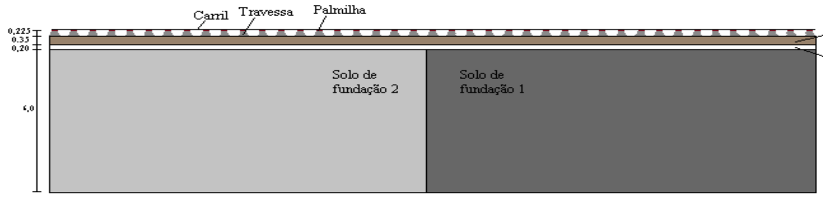
Abrupt stiffness variation:
Soil 1 → Soil 2



Track layer	E (MPa)	ρ (kg/m^3)	ν (-)
Ballast	130	1530	0,20
Sub-ballast	120	1935	0,30
Soil 1	80	2040	0,30
Soil 2	1600	2040	0,30

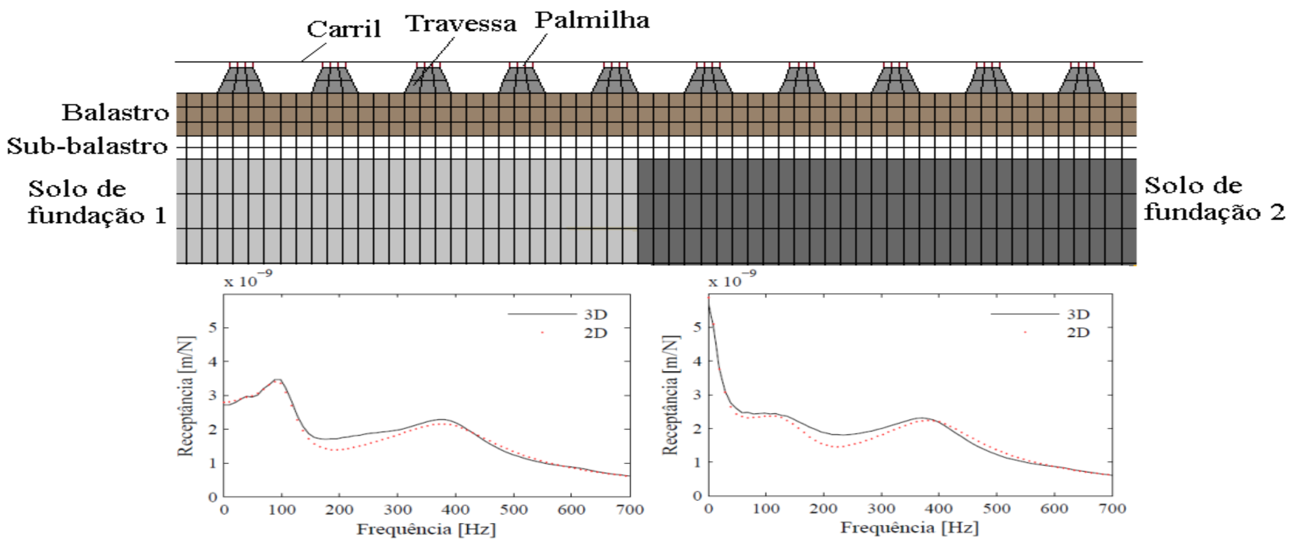
Numerical models:



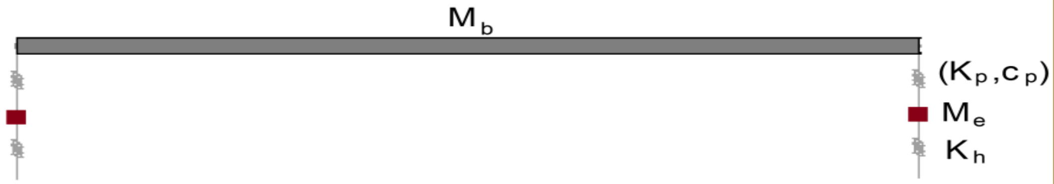


Vehicle-track model

TRACK – TRANSITION ZONE

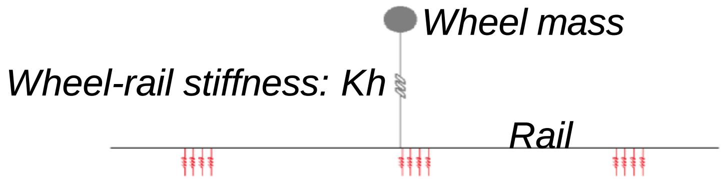


VEHICLE – 1 BOGIE



Vehicle component		Value
Bogies	Mb	2200 kg
Primary suspension	Kp	2,60×10^6 N/m
	cp	1,20×10^4 N/m
Wheels/axle	Me	1700 kg
Wheel – rail stiffness	Kh	1,35×10^9 N/m

VEHICLE-TRACK INTERACTION

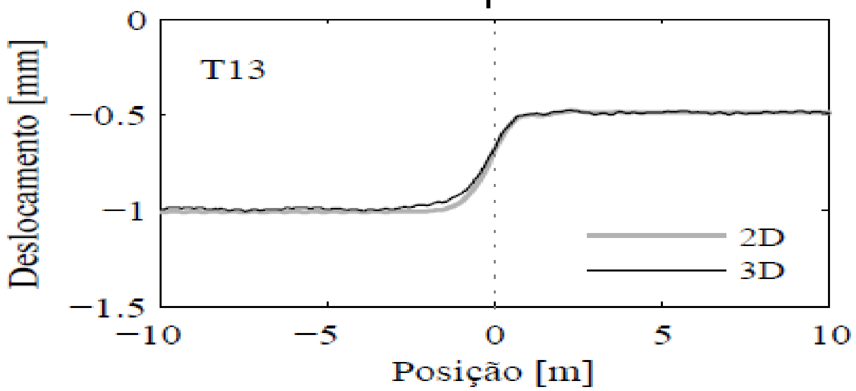


- Point-line contact
- Contact algorithms – ANSYS
- Penalty method

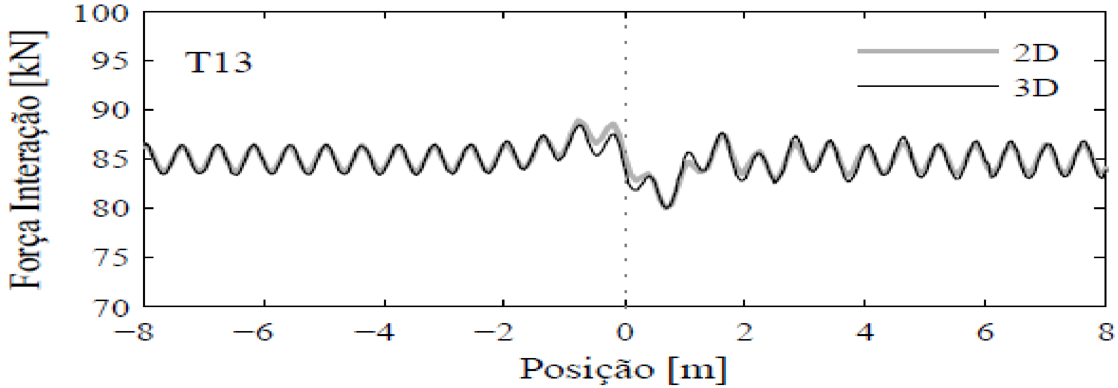
Short term dynamic behaviour

Comparison of the results obtained in both 2D and 3D models

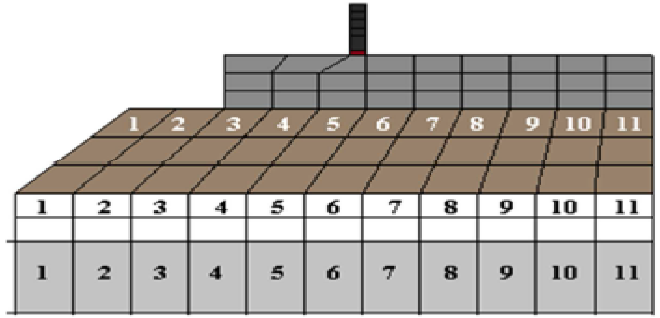
Wheel displacement

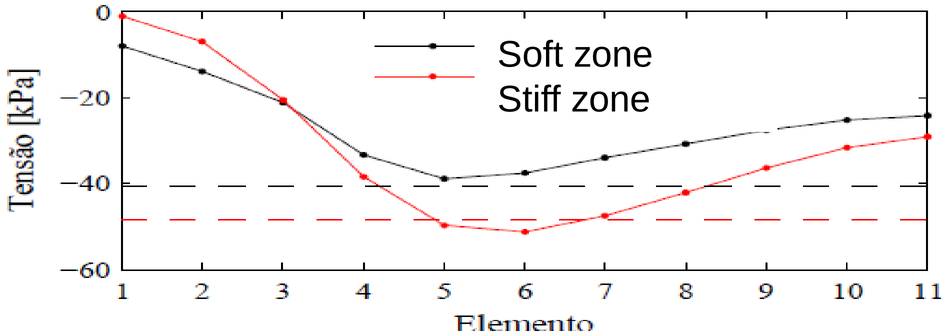


Wheel-rail contact force



Maximum vertical stress (top of sub-ballast layer)





How to simulate long term behaviour?

ANSYS

NUMERICAL MODEL OF THE VEHICLE-TRACK SYSTEM

Track geometry

Finite element model that enables to analyse the stress state induced by the vehicle passage

ANSYS

DYNAMIC ANALYSIS WITH VEHICLE-TRACK INTERACTION

Sleeper-ballast contact

Stresses in track layers (σ)

Simulate the possible separation between the base of the sleeper and the top of the ballast layer

The vertical, horizontal and tangential stresses of the finite elements of the track layers are stored in matrices

MATLAB

DEFORMATION LAW = $f(N,\sigma)$

MATLAB

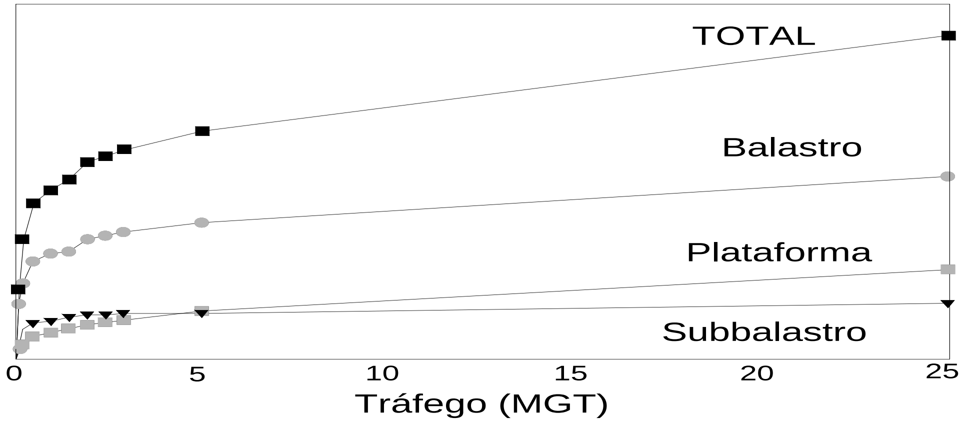
PERMANENT DEFORMATION OF ELEMENTS

$$\varepsilon = \varepsilon(N) + \varepsilon(\Delta N)$$

$$N = N + \Delta N$$

The simulation process is carried out considering sets of cycles (ΔN = 100 000). It is assumed that the stress is constant in each set of cycles.

Deformation laws



Permanent deformation of track layers

- Settlement growth is higher in ballast layer.
- Logarithmic laws.
- Depend on stress state and number of loading cycles

Ballast – ORE (1970) law

$$\varepsilon_N = \varepsilon_1 \left(C \log \left(\frac{N + N_i}{N_i} \right) \right)$$

Do not consider the phase 1 of loading

$$\varepsilon_1 = 0.082 (100 n_p - 38.2)(\sigma_1 - \sigma_3)^2$$

Experimental validated by Ionescu (2004)

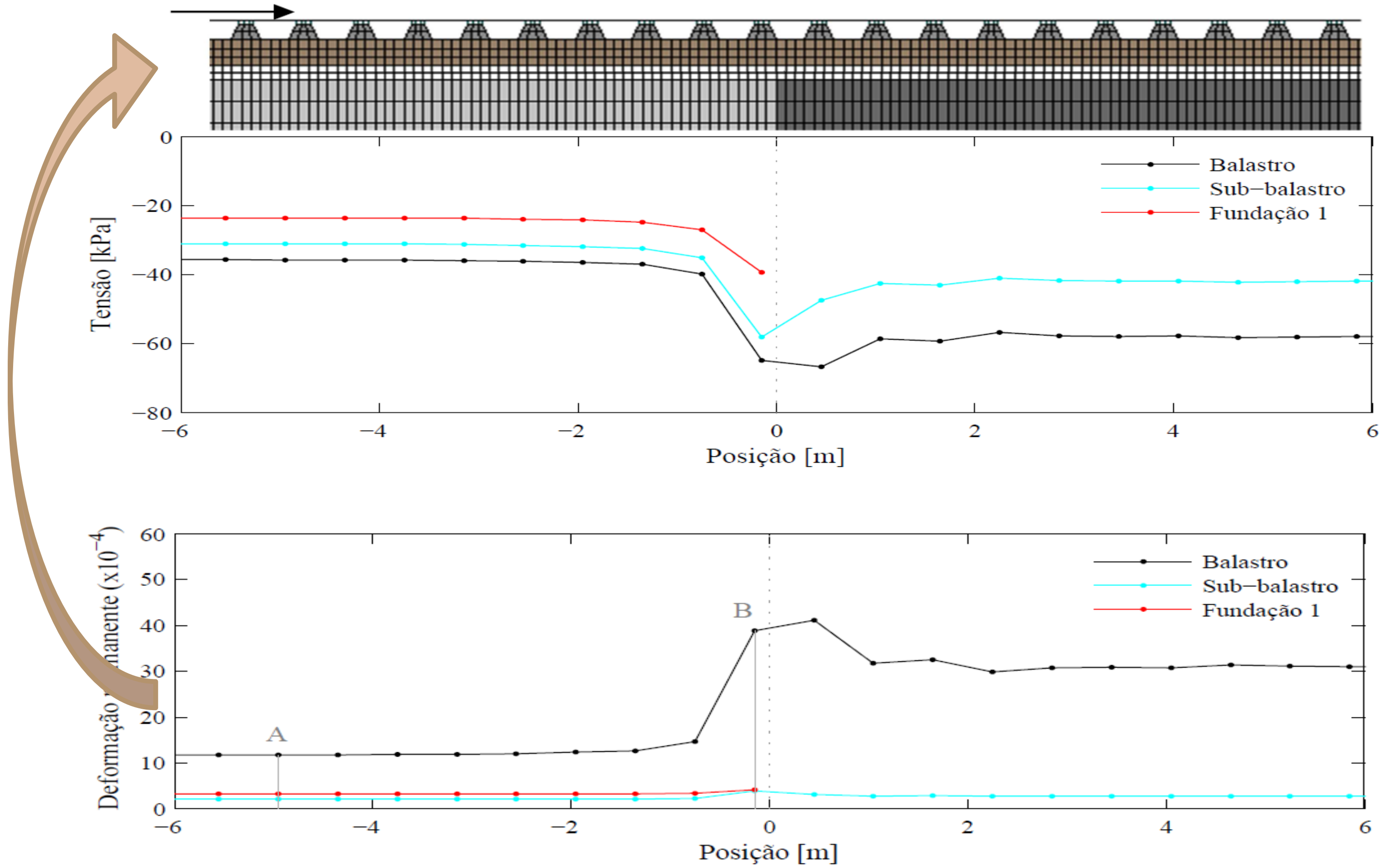
Depends on: N, stress, porosity of layer, constants

Sub-ballast; Foundation – Gidel et al. (2001):

$$\varepsilon_P = f(N) \cdot g(p_{max}, q_{max})$$

depends on: N, stress, constants that depends on the type of material

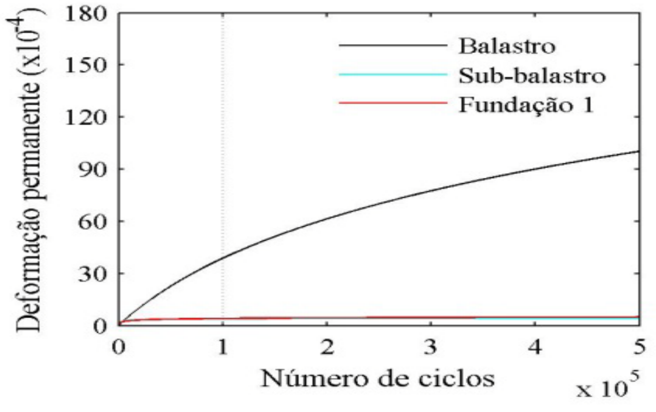
Methodology for long term simulation



Vehicle passage; dynamic analyses with wheel-rail interaction

Assess the stresses of the finite elements

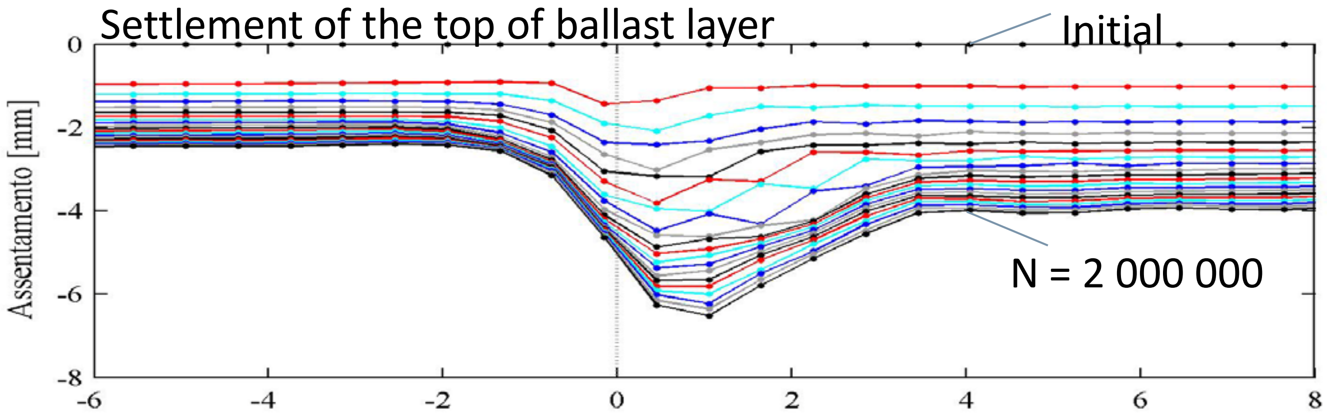
Apply the deformation law of the materials for N cycles

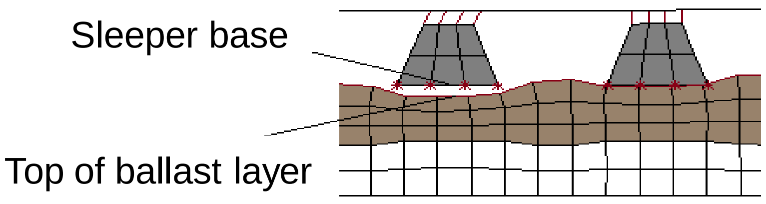


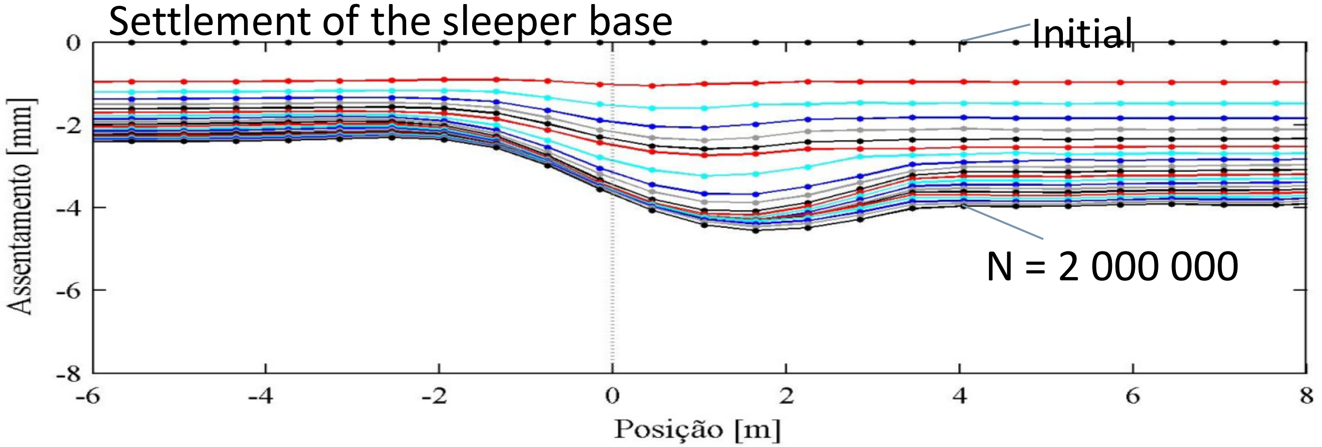
Permanent deformation of the finite elements – update track geometry

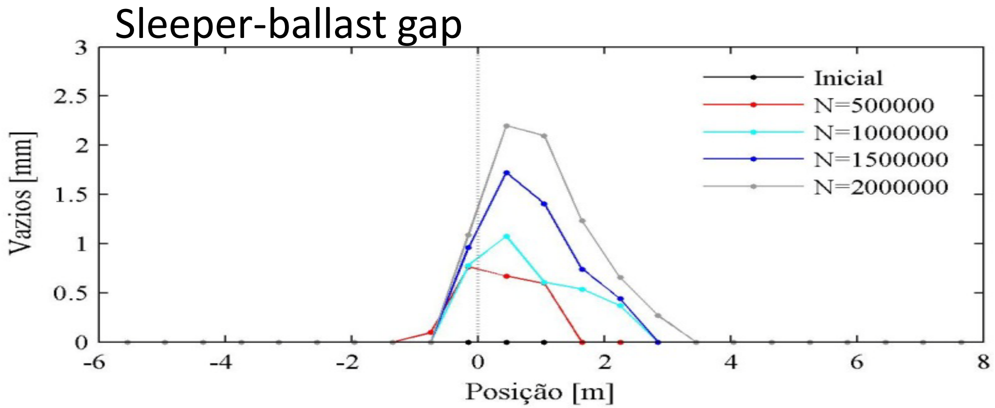
Long term dynamic behaviour

Track settlement



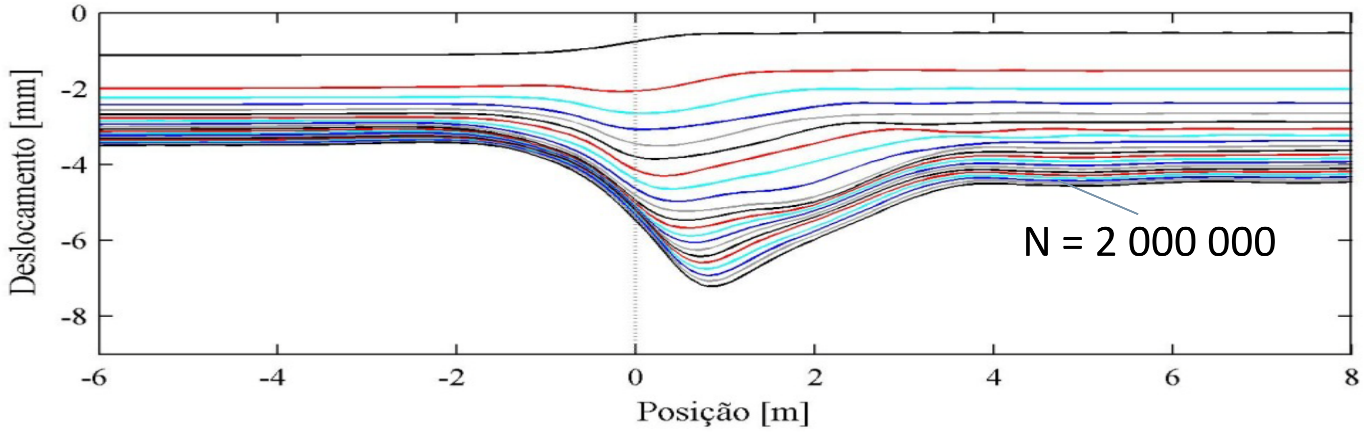




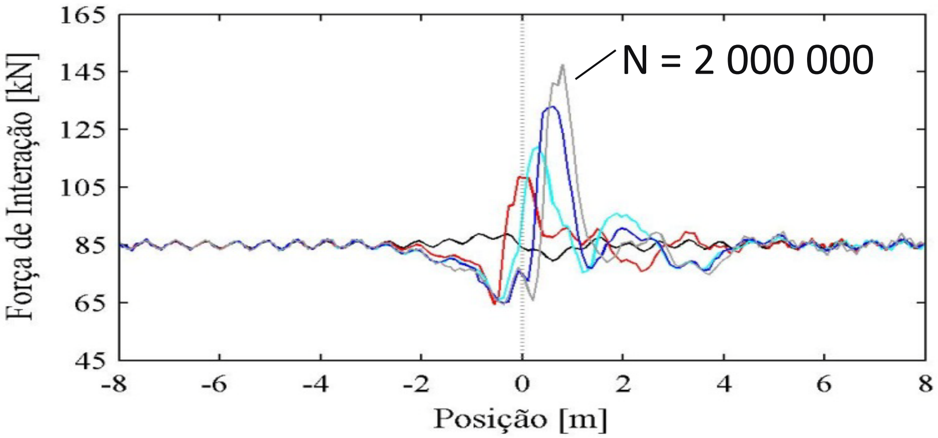


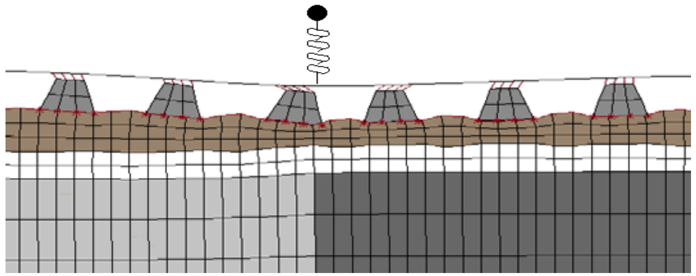
Long term dynamic behaviour

Vertical displacement of the vehicle wheel



Wheel-rail contact force





Maximum amplification: 73,6%

It is very important to consider the dynamic component of the force on the simulation process

600 000 cycles: vertical acceleration of the axle is higher than **30 m/s²**

2 million cycles: vertical acceleration reaches **70 m/s²** (immediate track correction)

Conclusions

I. Permanent deformation is higher when the deviatoric stress of the elements increase;

II. The amplification of the dynamic loads that results from the track deformation, also contributes to its increase;

III. The base of the sleepers do not follow the deformation of the track layers – gap appearance;

IV. The ballast layer permanent deformation dominates the track deformation – both due to the law considered and the stress level installed on this layer;

V. The dynamic effects obtained on the transition zone when permanent deformation is considered are higher than those obtained when there is only the stiffness variation.

VI. This methodology can be applied to predict the long term behaviour of the track in other zones.

Further developments

I. Consider the track irregularities and track defects in the assess of the long term behaviour;

II. Validate the results obtained for the long term behaviour with experimental data;

III. Perform this analysis using different deformation laws;

IV. Apply this methodology to assess the long term behaviour of other zones of the track.

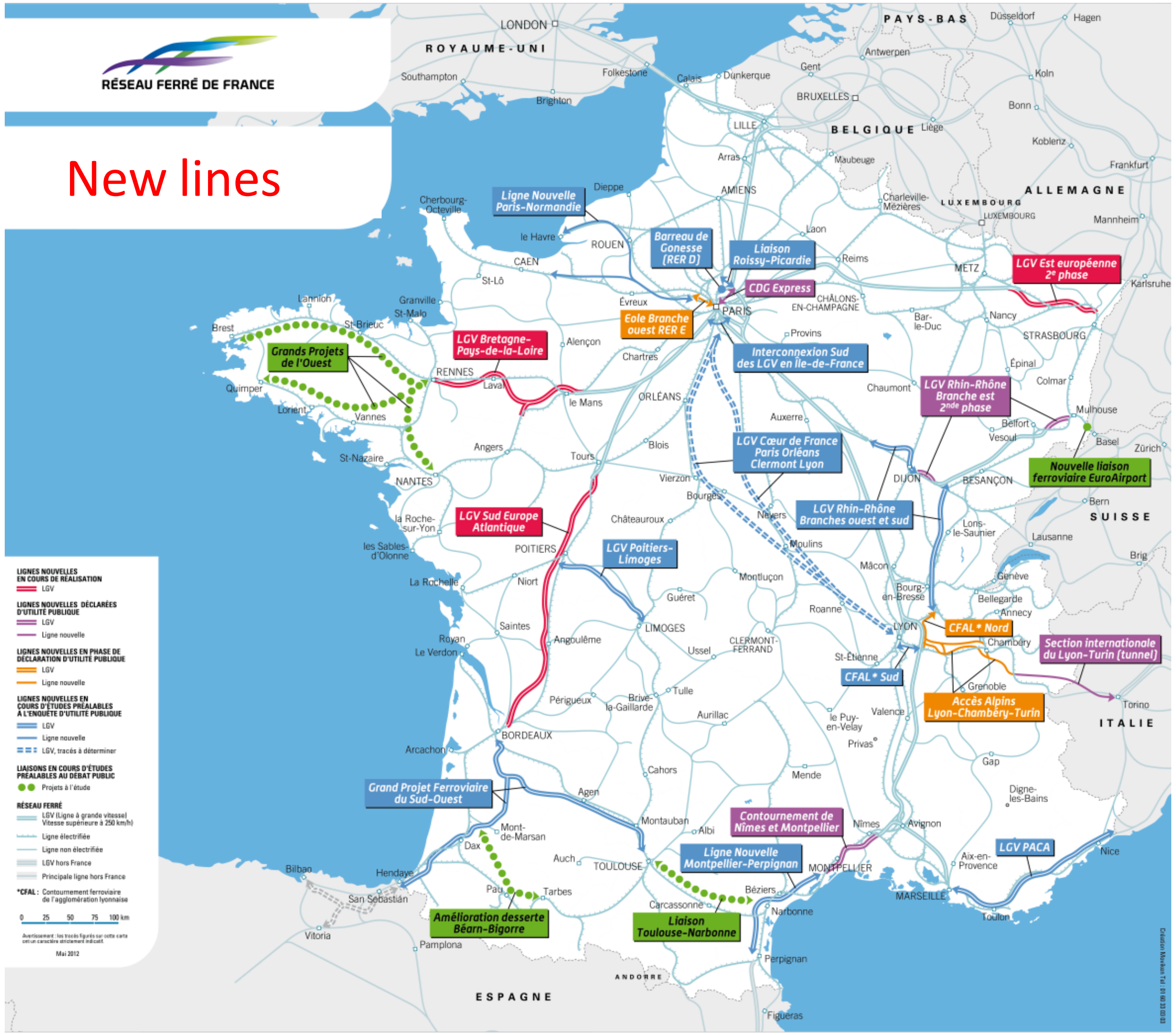
Recently it was created a user-interface platform and a user manual that enables anyone to use this application in models created in ANSYS program.

Biaxial fatigue test for the utilization of stabilized soils in the subgrades of High Speed Rail infrastructures

Mathieu Preteseille[1,2] and Thomas Lenoir[2]

1. *Cerema DTecITM, Sourdun, France*
2. *LUNAM Université, IFSTTAR, Bouguenais, France*

Context



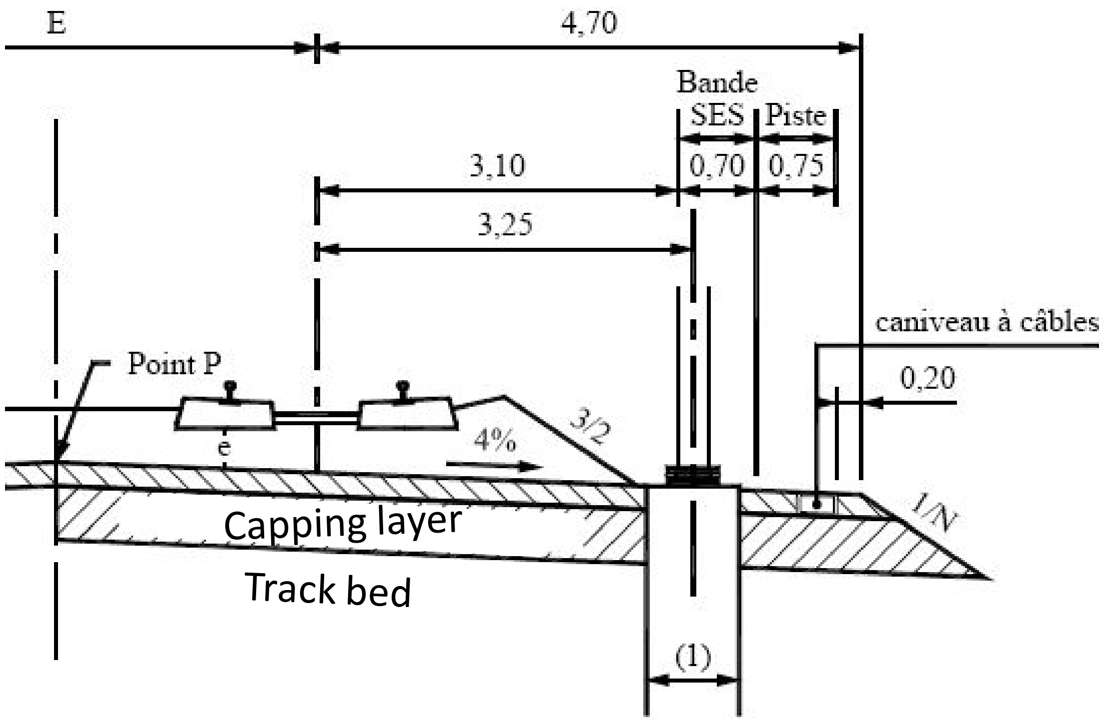
Keywords :
Second European network
30 000 km of lines with
2024 km of high speed lines
800 km of new high speed lines for 2017

Legend :
In red : Lines under construction
Others colours : Projects

Main objective:
Rationalization of the environmental and economical cost of new structures

HSR structures

Aim: Rationalization of the environmental and economical cost of new structures



HSR structure (IN 3278)

For the capping layer

Traditional solution:

Bring granular material from quarry

Advantage:

Design of such structure is well known

Inconvenient:

Not environmental friendly, consumes limited resources

Alternative solution:

Use of the natural soil present in the right of way of the line with an appropriate stabilization

Advantages:

Save granular material

Re-use of soil considered as waste

Inconvenient:

Unknown mechanical behavior especially for the fatigue behavior (100 years of service life)

The fatigue behavior of stabilized soils needs to be studied

Definition of a stabilized soils

In situ soil

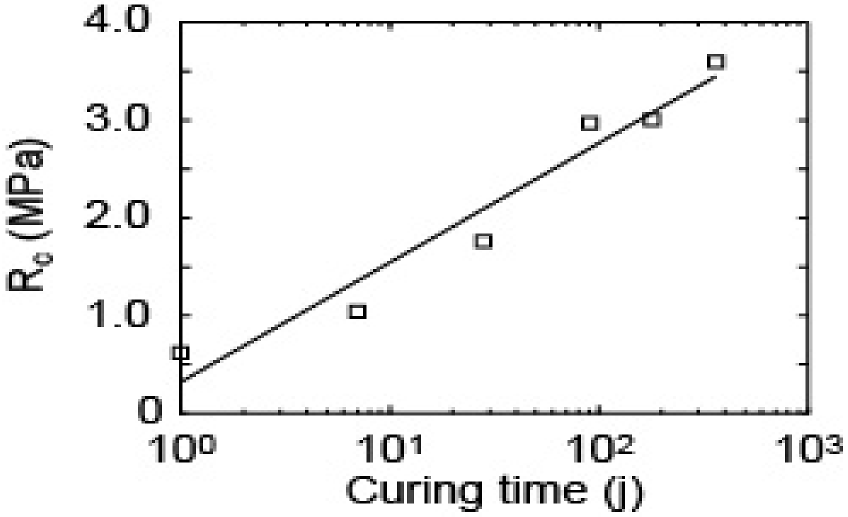
\+

Hydraulic binder (1 to 5%)

=

Stabilized soil

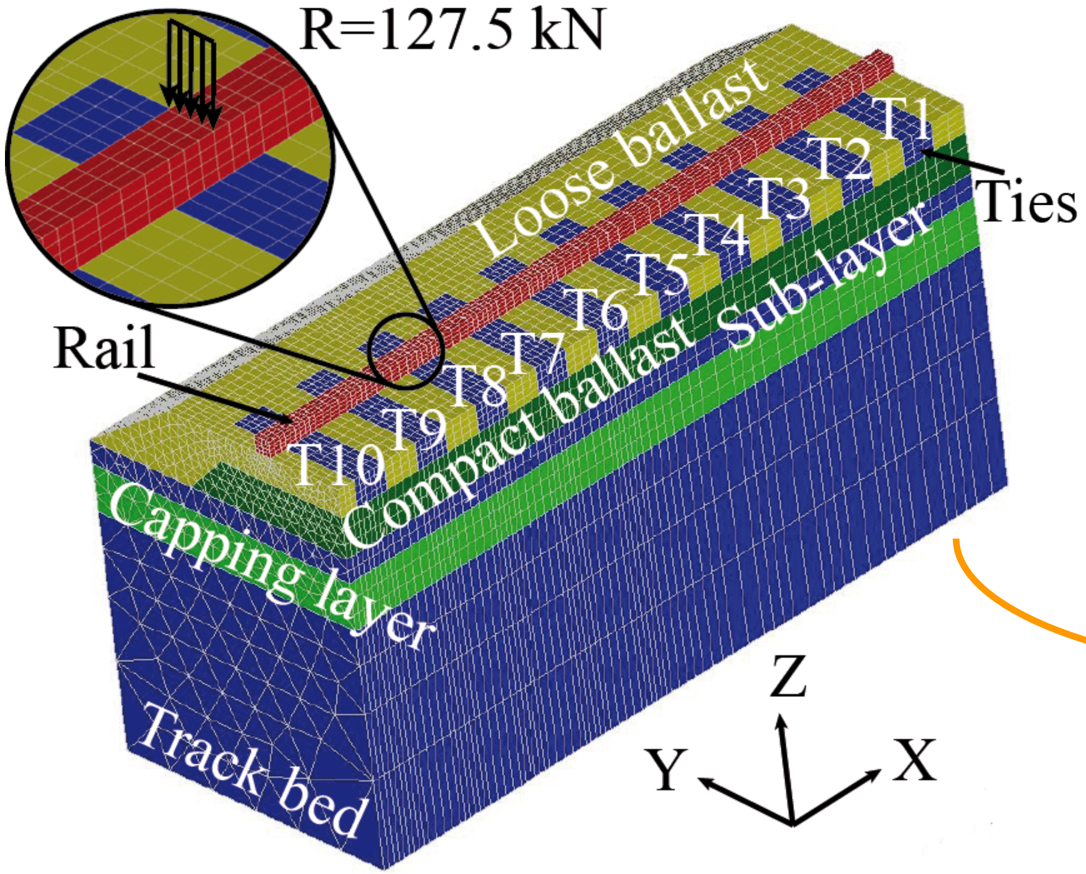
Operation of mixing

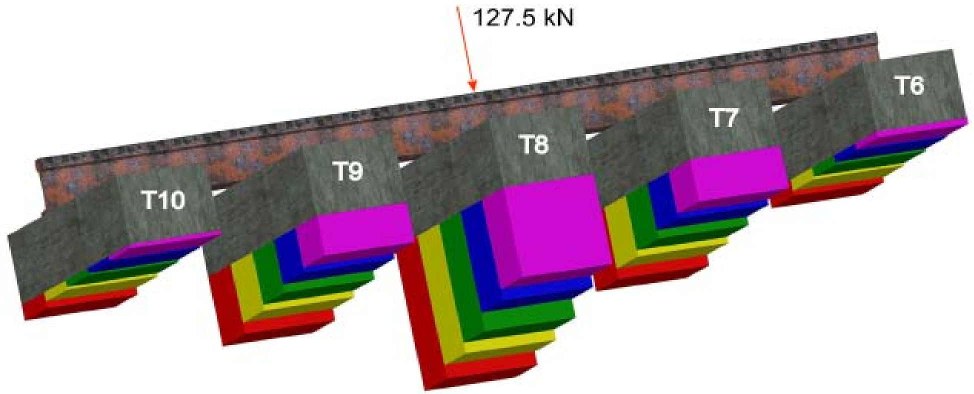


UCS vs time for a regolite of micashiste with 5% of CEM III

Are mechanical performances of stabilized soils compatible with stresses in the capping layer?

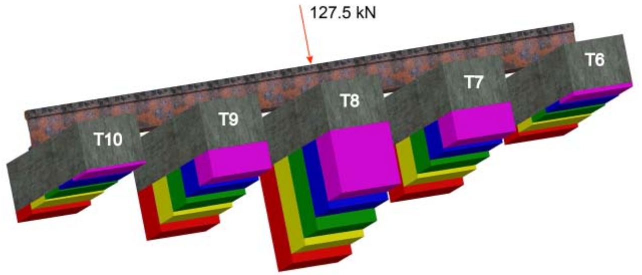
Modeling of the HSR structure (1/2)

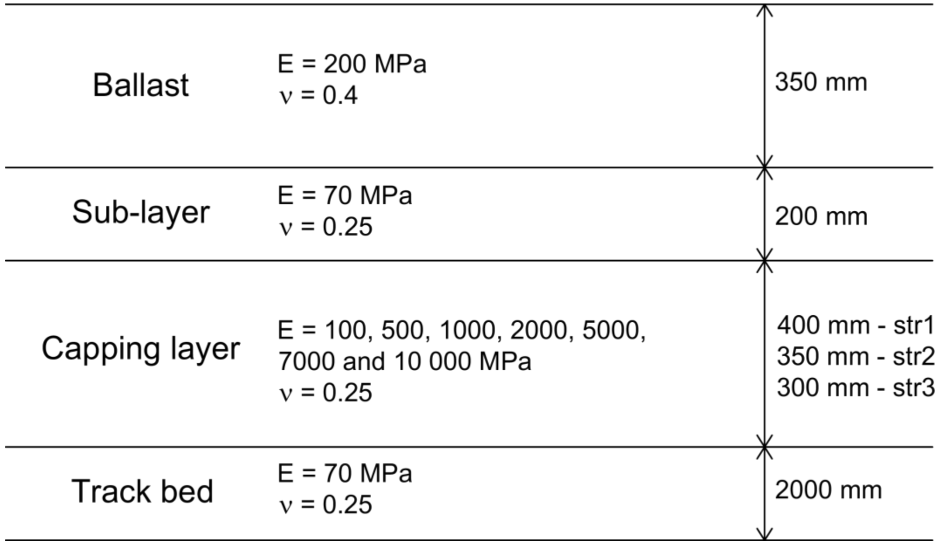




FEM modeling is not well appropriate for sizing studies → Discretization of the loading under the ties

Modeling of the HSR structure (2/2)

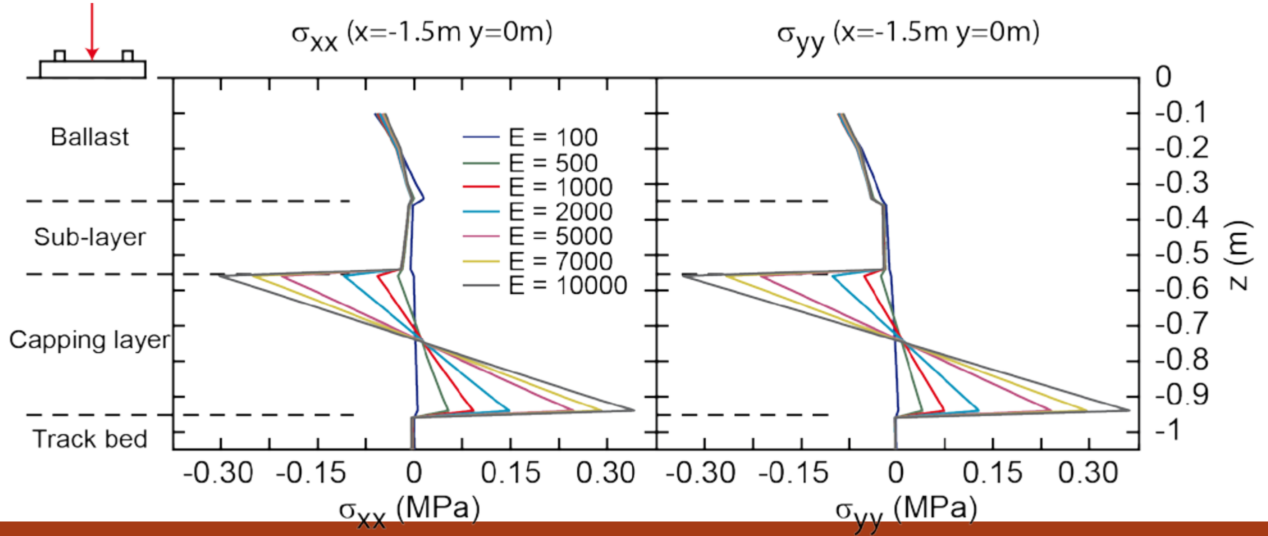




Semi-analytical model

Application of the load under the sleepers previously determined directly on the ballast surface.

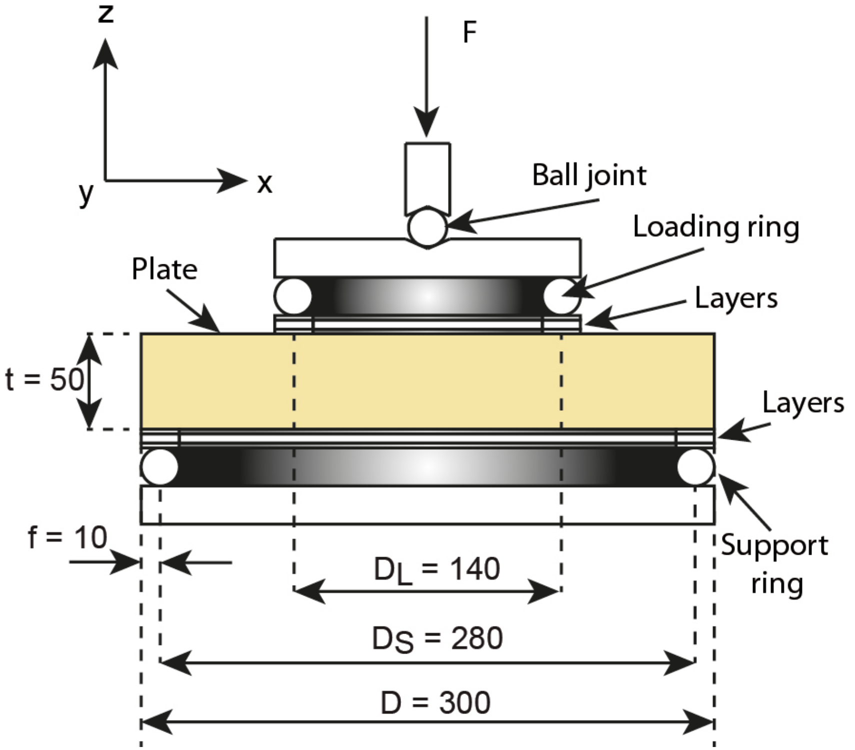
Stresses in the HSR structure



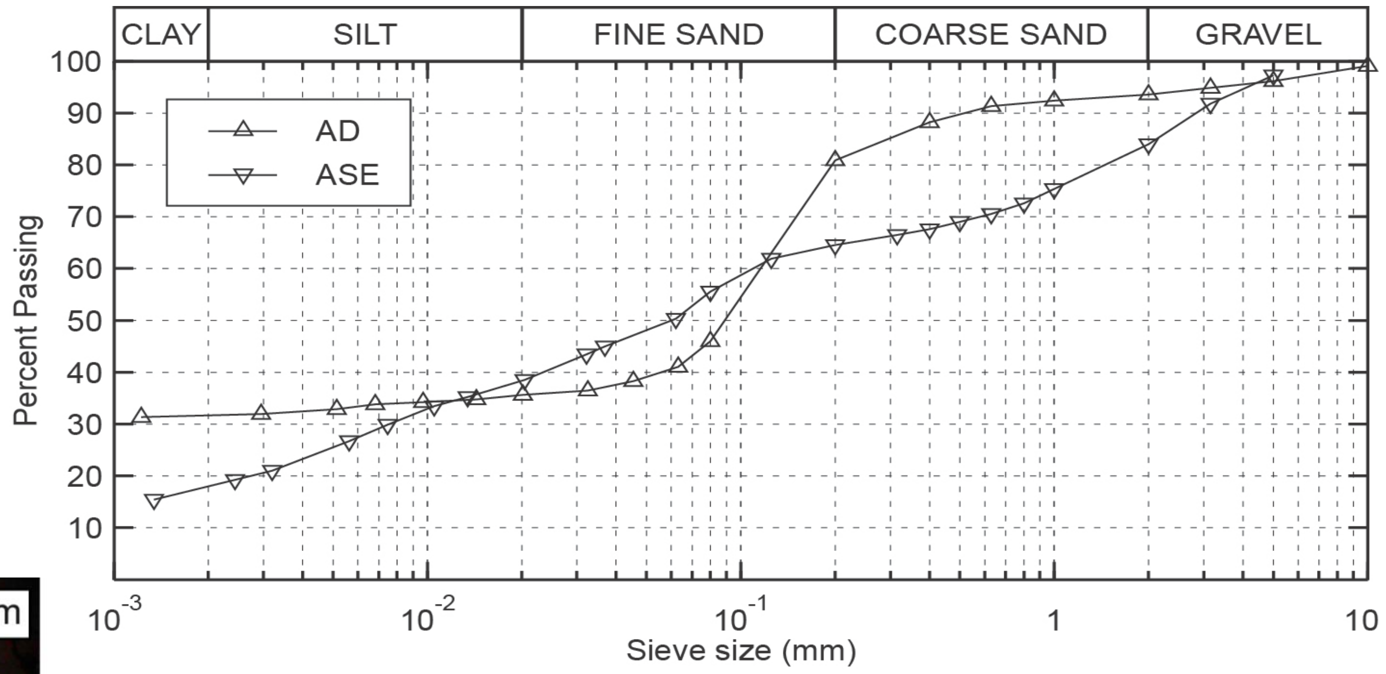
The bottom of the capping layer works in biaxial tension

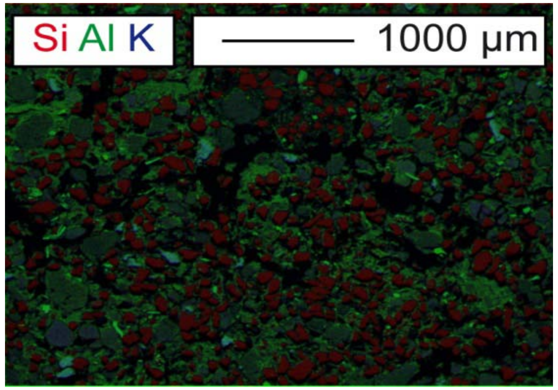
The biaxial flexural test (BFT)

BFT consists in laying a circular plate on a support ring. The load is applied on the upper face through a ring. The test generates a biaxial tension on the lower face delimited by a circle with the same diameter as the loading ring

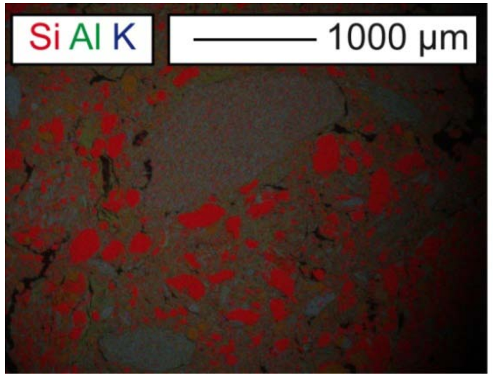


Studied stabilized soils





Stabilized soil AD
VBS = 3.12 g/100g dry soil
Stabilized with 1% of lime and 5% of CEMII
γ = 1.69 g/cm^3 w = 21.5%



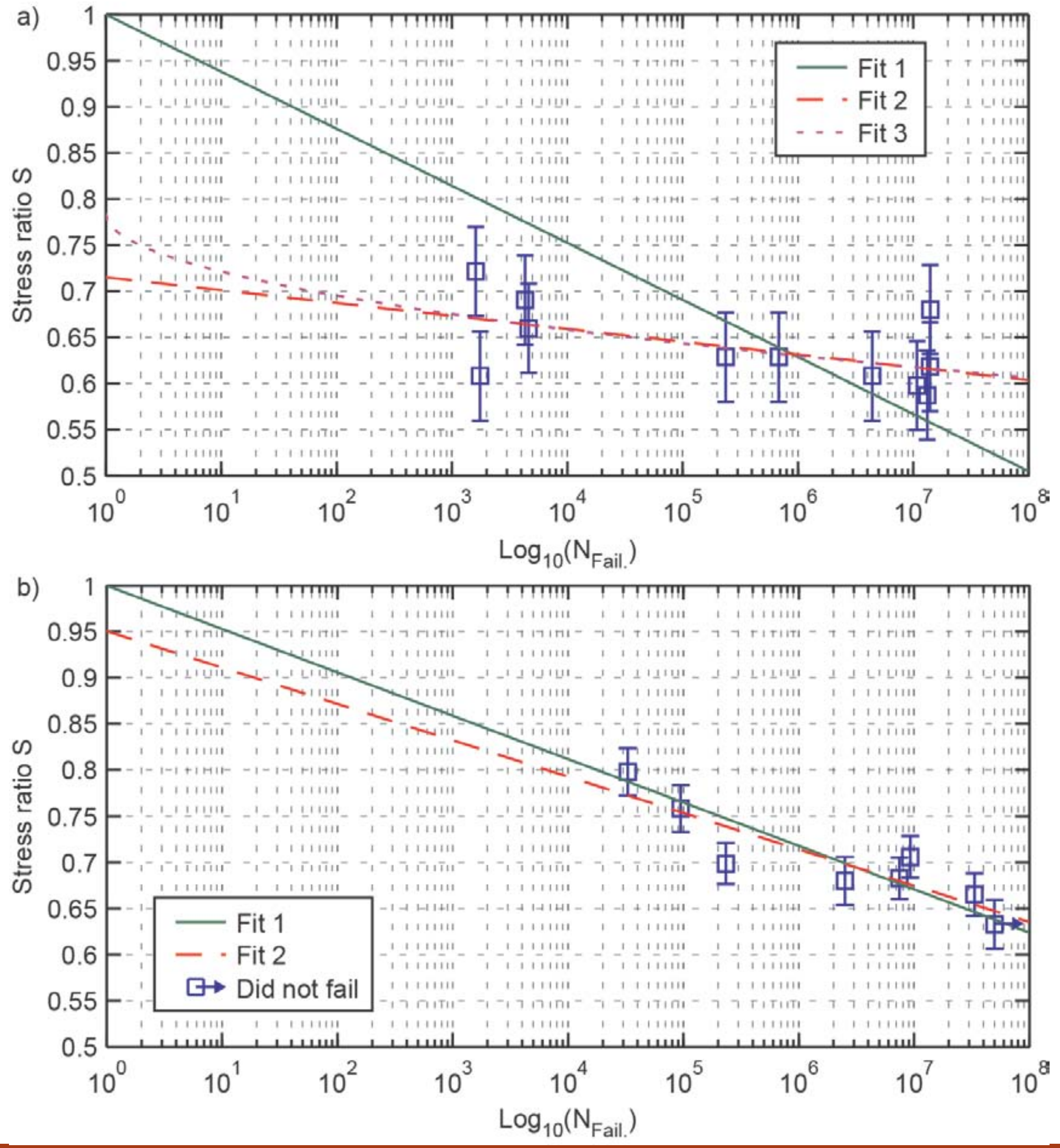
Stabilized soil ASE
VBS = 0.76 g/100g dry soil
Stabilized with 5% of CEMII
γ = 1.88 g/cm^3 w = 14.3%

Fatigue results

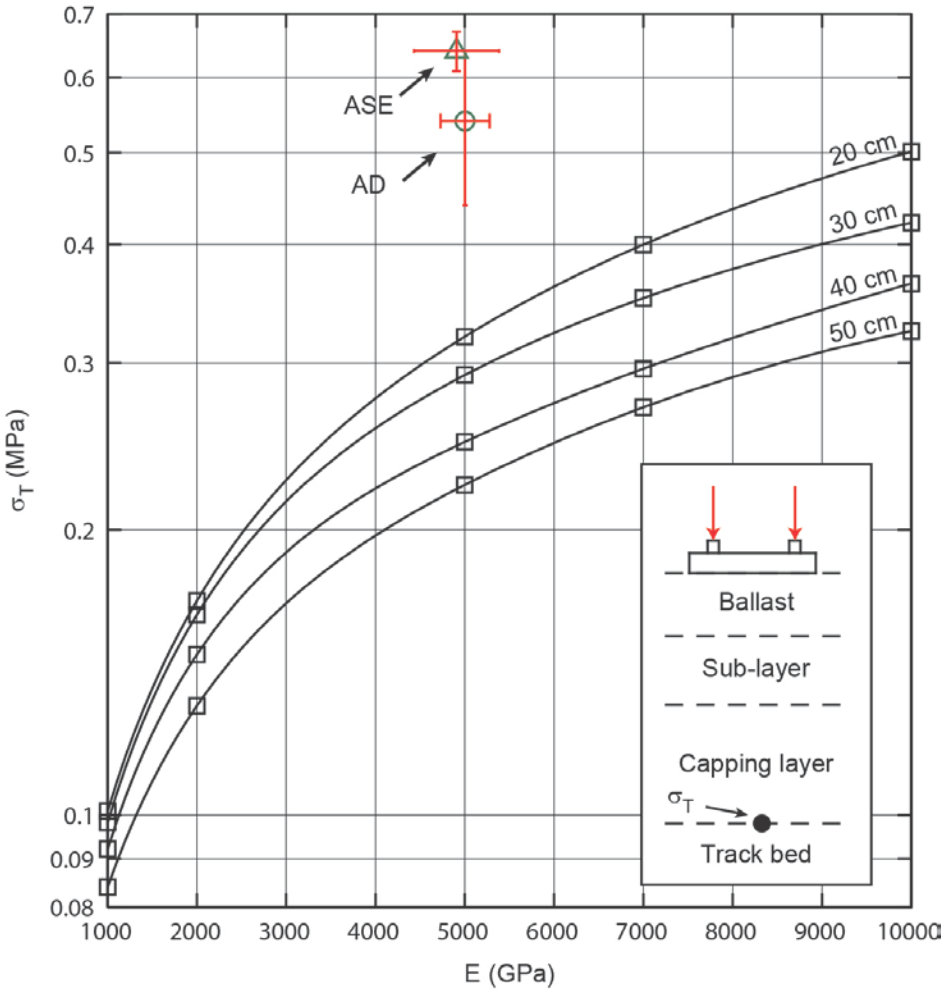
Stabilized soil AD
$\sigma_{f\,BFT}$ = 1.07 MPa
σ_{8} = 0.54 MPa

$\sigma_{f\,BFT}$ corresponds to the biaxial strength
σ_{8} corresponds to the calculated flexural stress that leads to failure after 10^8 cycles

Stabilized soil ASE
$\sigma_{f\,BFT}$ = 1.02 MPa
σ_{8} = 0.64 MPa



Design of the capping layer



Computed stresses at the bottom of the capping layer are presented with a semi-logarithmic scale.
The x-axis is the moduli of the stabilized capping layer and y-axis is the maximum biaxial tensile stress σ_T located at the bottom of this layer.

The mechanical properties of AD and ASE are good enough, i.e. performances better than the ones for a thickness of 20 cm

Conclusions

- The BFT is a relevant procedure to study the mechanical fatigue of stabilized soils used in the capping layers of HSR infrastructures.
- Fatigue performances under biaxial flexion were determined for two stabilized soils. Numerical modeling of the HSR structure confirms that, at the laboratory scale, stabilized soils can be considered for a use in HSR capping layers. Results are very promising even if safety coefficients are used in design procedure. Nevertheless, results should be considered cautiously because they stay at the laboratory scale and real behavior in the field must be studied.
- Several environmental friendly solutions are conceivable to rationalize the costs of the structures, rationalize the global thickness of the structure and the nature of the used materials, consider the use of stabilized soils in other layers of the HSR structure (e.g. sub-layer), optimize the use of hydraulic binders (amount, type,…) and enhance constructive applications (compaction rate, materials…) .

For more information

Lenoir, T., M. Preteseille and S. Ricordel, Contribution of the fiber reinforcement on the fatigue behavior of two cement-modified soils. International Journal of Fatigue, 2016. 93, p.71-81

Preteseille, M. and T. Lenoir, Structural test at the laboratory scale for the utilization of stabilized fine-grained soils in the subgrades of High Speed Rail infrastructures: Experimental aspects. International Journal of Fatigue, 2016. 82, Part 3: p. 505-513.

Preteseille, M. and T. Lenoir, Mechanical fatigue behavior in treated/stabilized soils subjected to a uniaxial flexural test. International Journal of Fatigue, 2015. 77, p. 41-49.

Preteseille, M., et al., Structural test at the laboratory scale for the utilization of stabilized fine-grained soils in the subgrades of High Speed Rail infrastructures: Analytical and numerical aspects. Construction and Building Materials, 2014. 61: p. 164-171.

Preteseille, M., T. Lenoir, and P. Hornych, *Sustainable upgrading of fine-grained soils present in the right-of-way of High Speed Rail projects.* Construction and Building Materials, 2013. **44**: p. 48-53.

Effect of the soil's suction history on the small strain behavior

Ana Heitor, Buddhima Indraratna and Cholachat Rujikiatkamjorn

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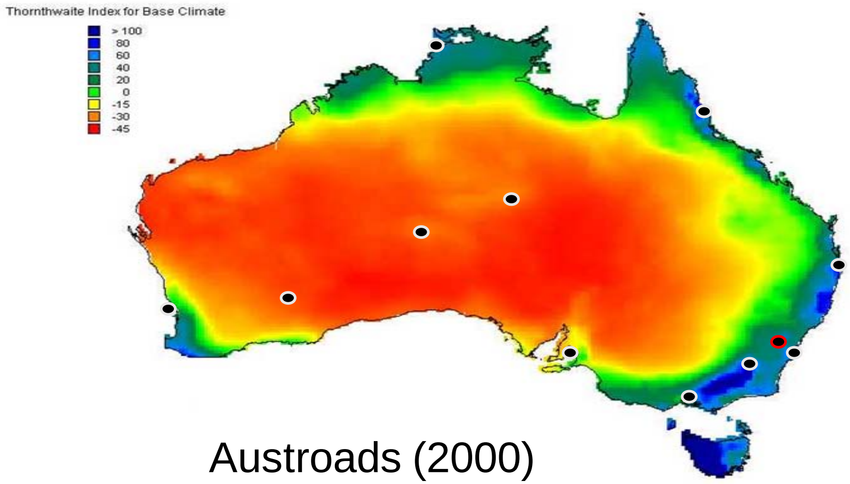
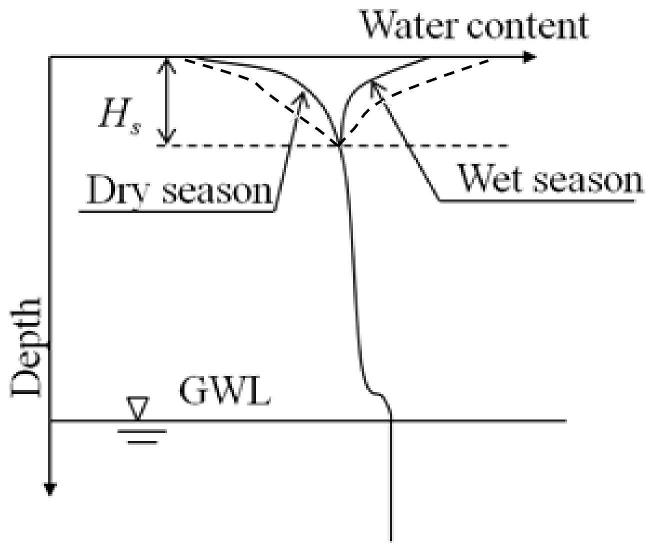
Suction history : wetting and drying

- **Climate change and earth structures**
  - most earth structures experience changes in hydraulic behaviour owing to the climatic changes (i.e. rainfall or extended periods of drought),

Suction history: wetting/drying cycles



Austroads (2000)

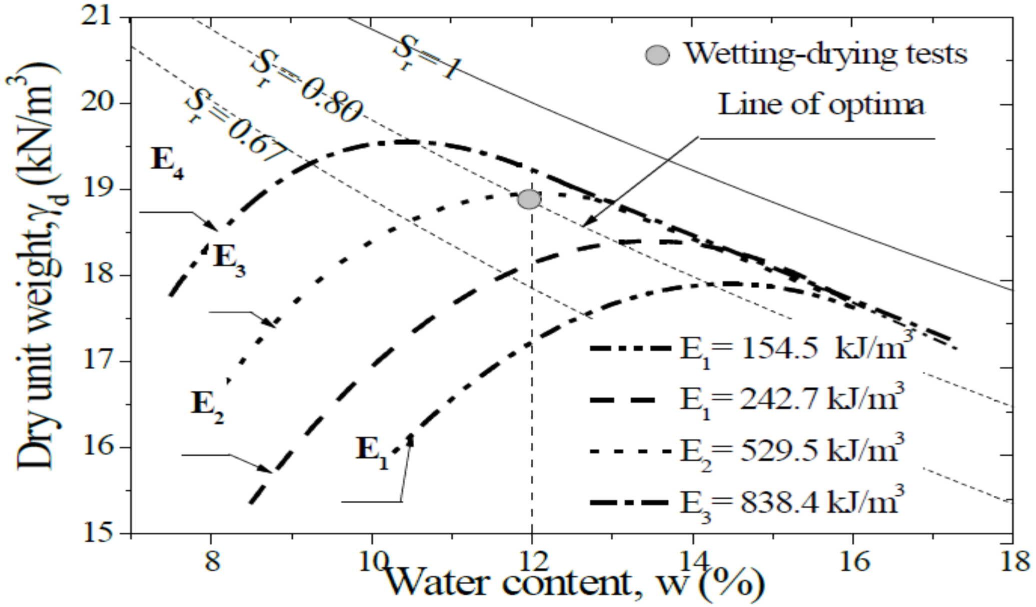


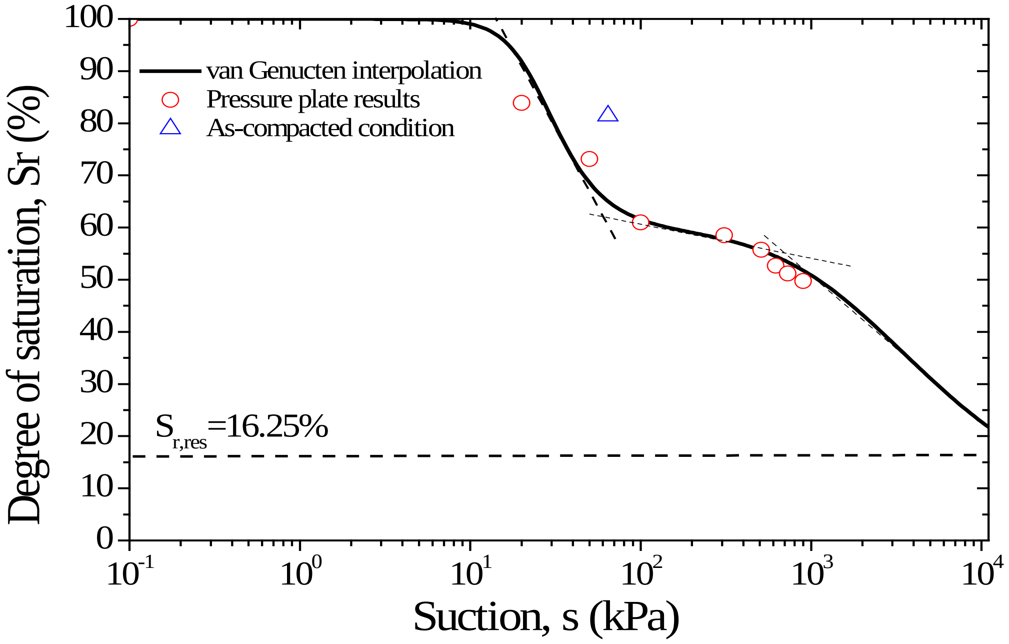
The effect of suction history on G0 (Ng et al., 2012 and Heitor et al., 2014) :

- hydraulic cycles,
- recent suction history
- the current suction ratio (CSR) with $CSR = \frac{s_{max}}{s_{current}}$

Materials

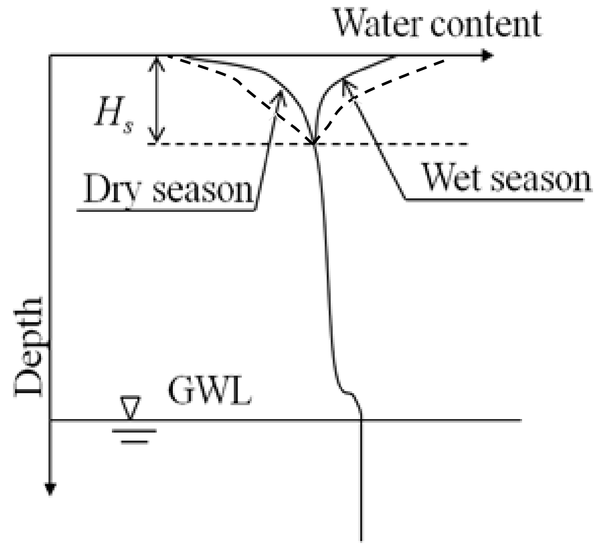
- Silty sand (SP-SC 89% sand and 11% fines)
- LL = 25.5% and PI = 10 and G_s = 2.7
- Specimens compacted ∅50×100mm mould





Heitor, Indraratna and Rujikiatkamjorn (2012) *Aus. Geomech. J.* (47) 2, 79- 86

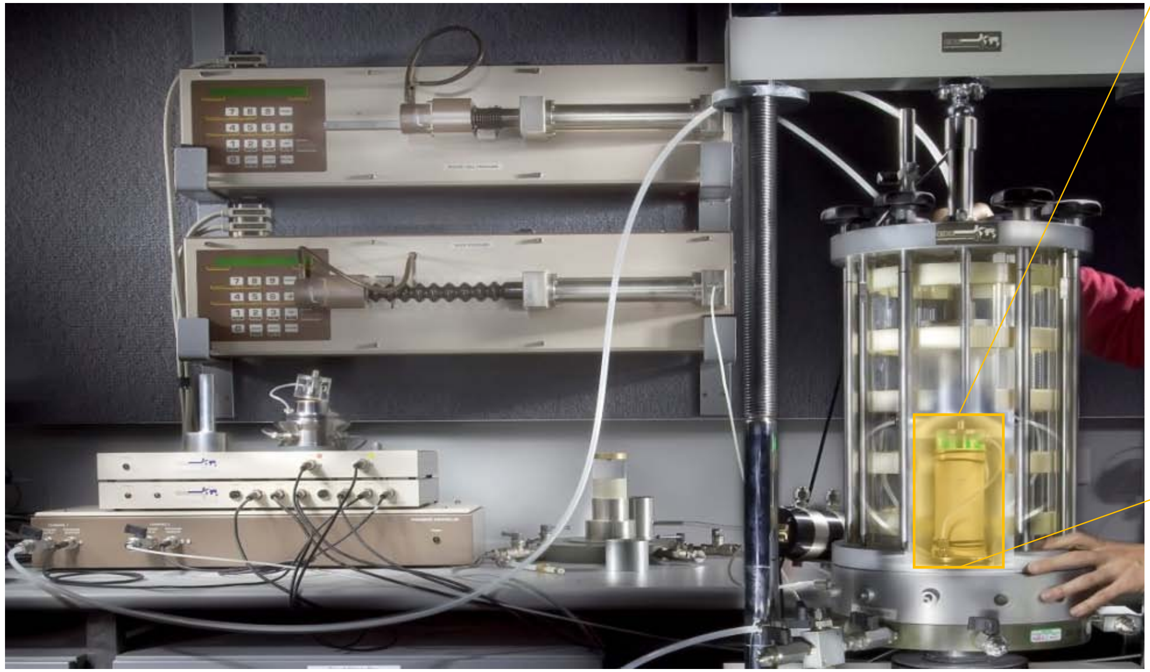
Testing program

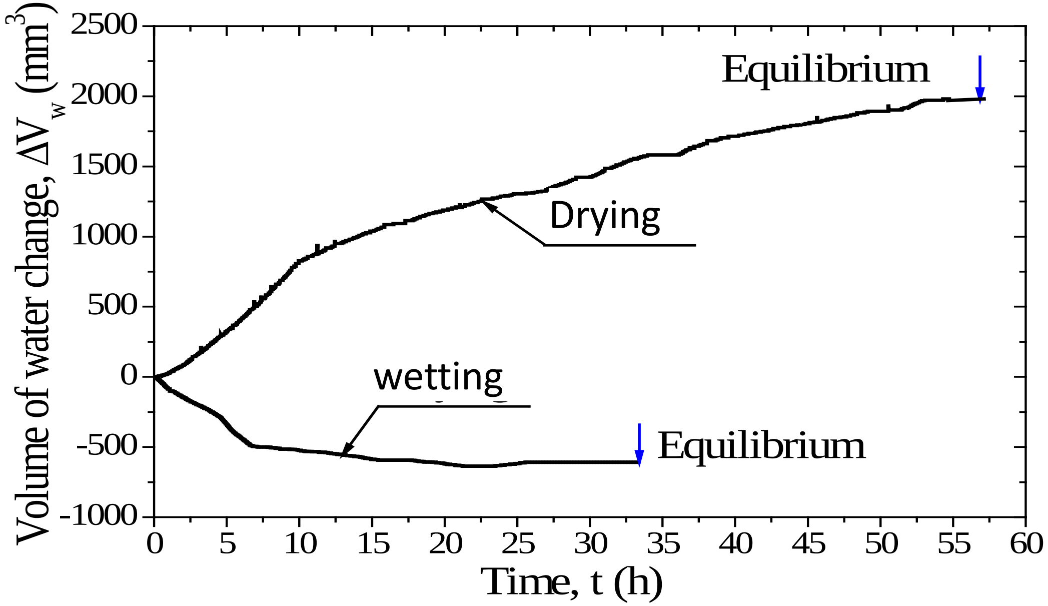


- Effective net stress applied of 50kPa ≈ Hs
- Role of suction history (wetting and drying)
  - 2 specimens (≈ 48-60 hours equilibrium = 2 months)
  - Suction increments of 50kPa (0.16kPa/min)
    - E_2=529.5kJ/m^3 (equivalent to standard Proctor level)
- BE Testing for every suction level at different frequencies (1.4, 2, 3, 5, 10, 20 and 50 kHz) = 230 signals

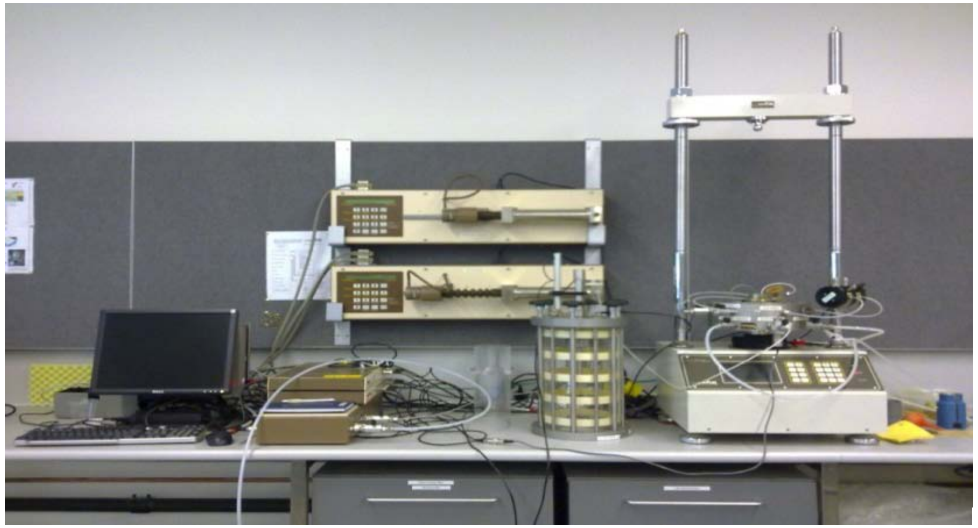
Control of suction : Axis translation technique

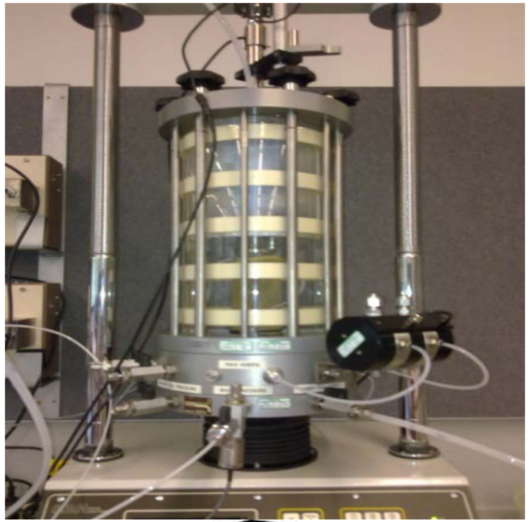
- Suction was incremented in 50kPa interval
- Rate of increase = 0.16kPa/min and kept constant until the end of the equilibration period

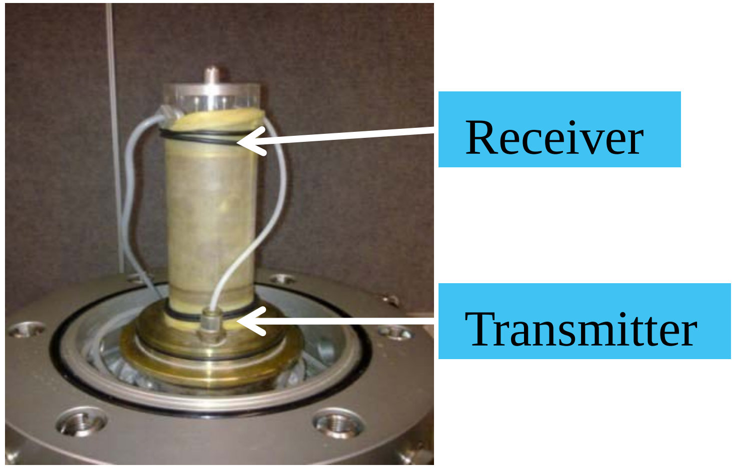


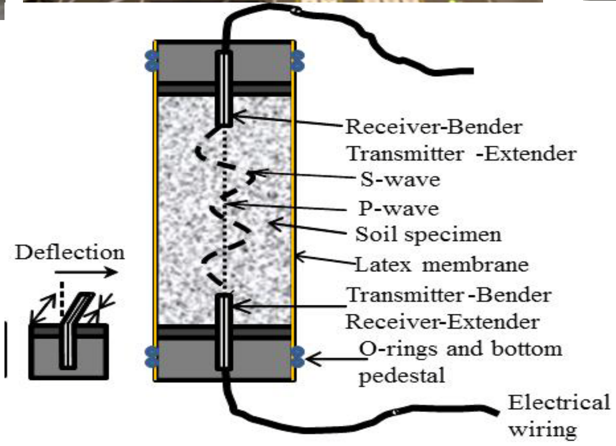


Determination of shear wave velocity : Bender elements







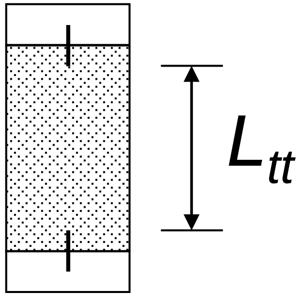


Heitor, Indraratna and Rujikiatkamjorn (2015) *Geotechnique Vol. 65 (9), pp. 717-727*

Wetting and Drying tests

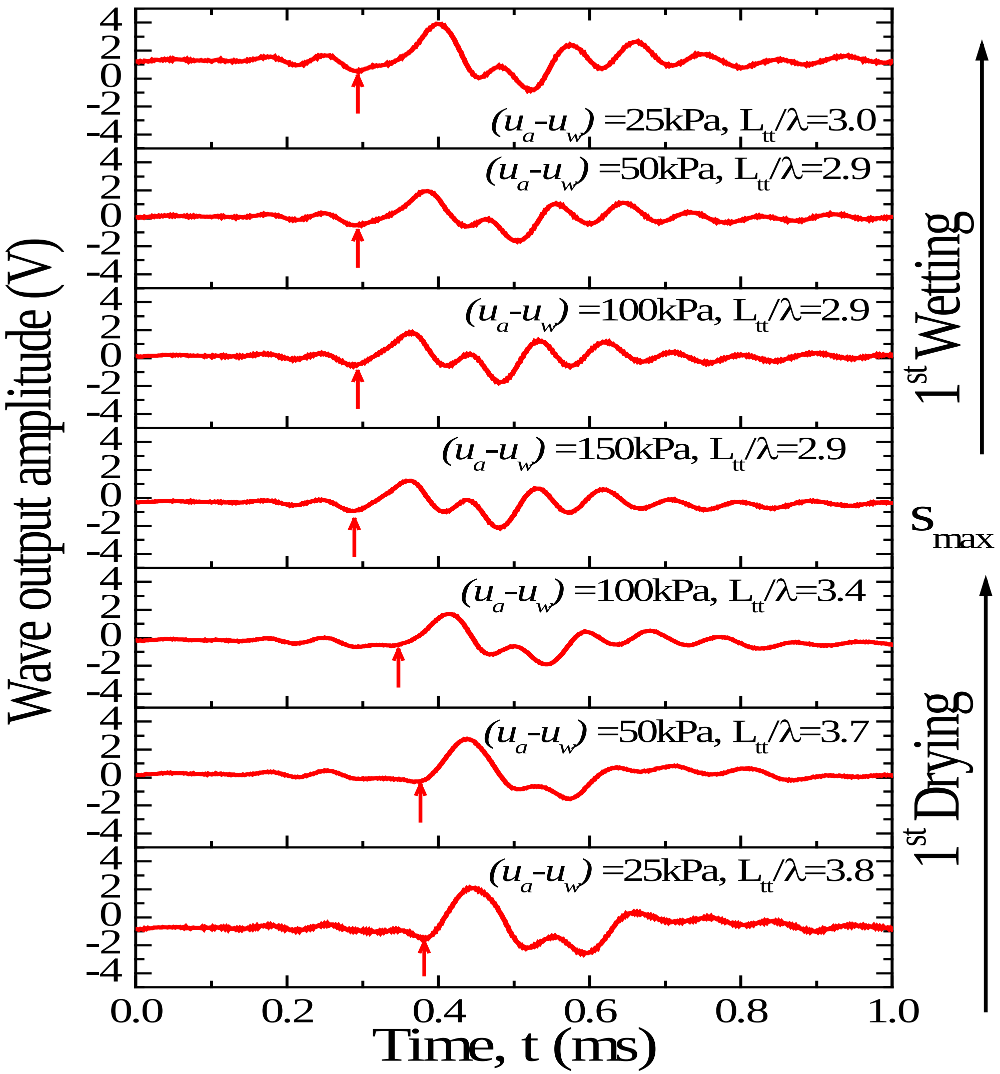
- Travel time evaluation methods:
  - **Time domain :** visual picking
    - 1st bump maximum ($L_{tt} / \lambda > 2$)
    - , 1st arrival, peaks, throughs, multiple reflections

    Frequency domain :
    - Cross-correlation
    - FFT
    - Wavelets
    - π points and phase delay



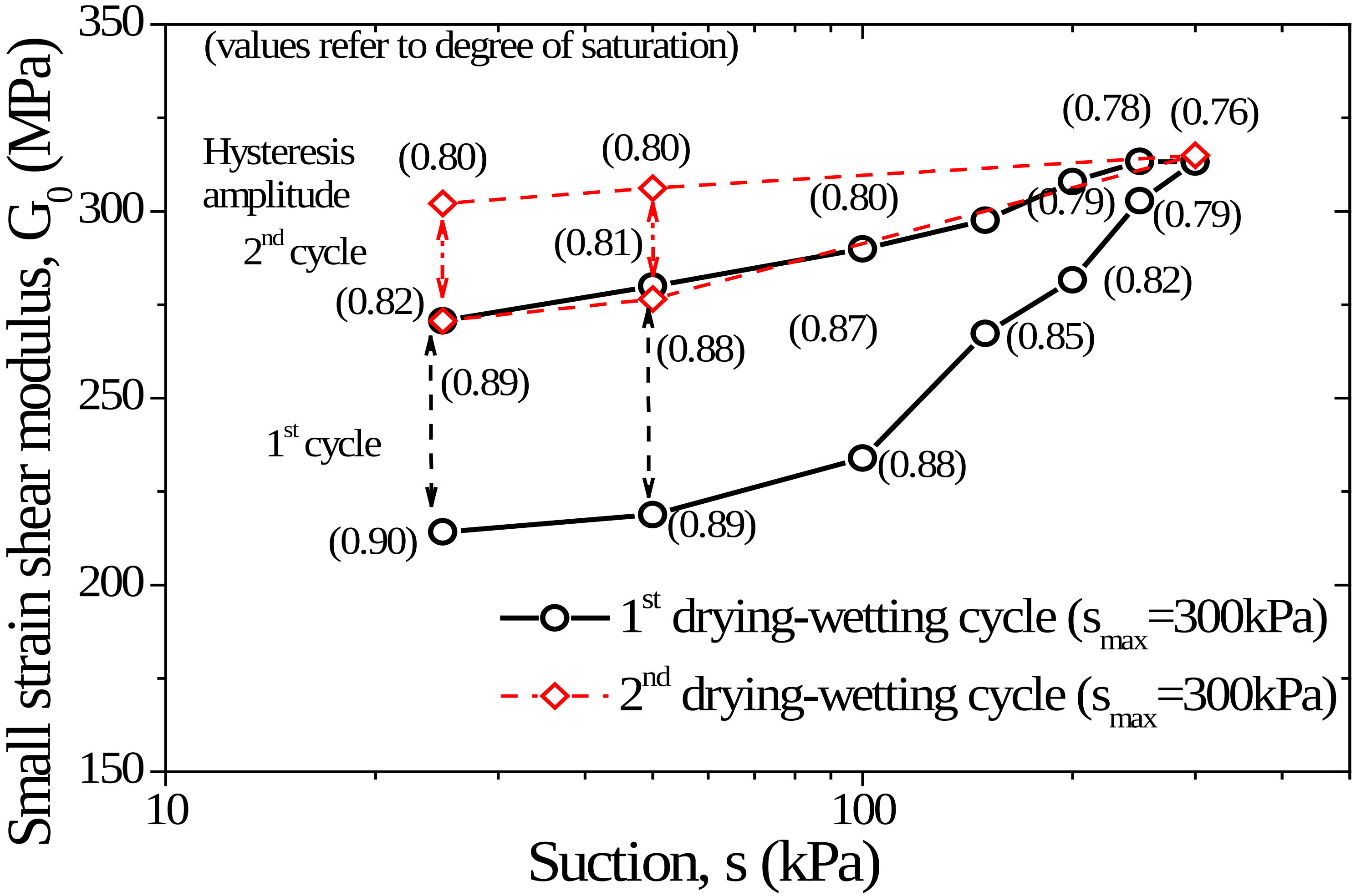
$$\boxed{V_s = \frac{L_{tt}}{t}}$$

Protruding 3mm

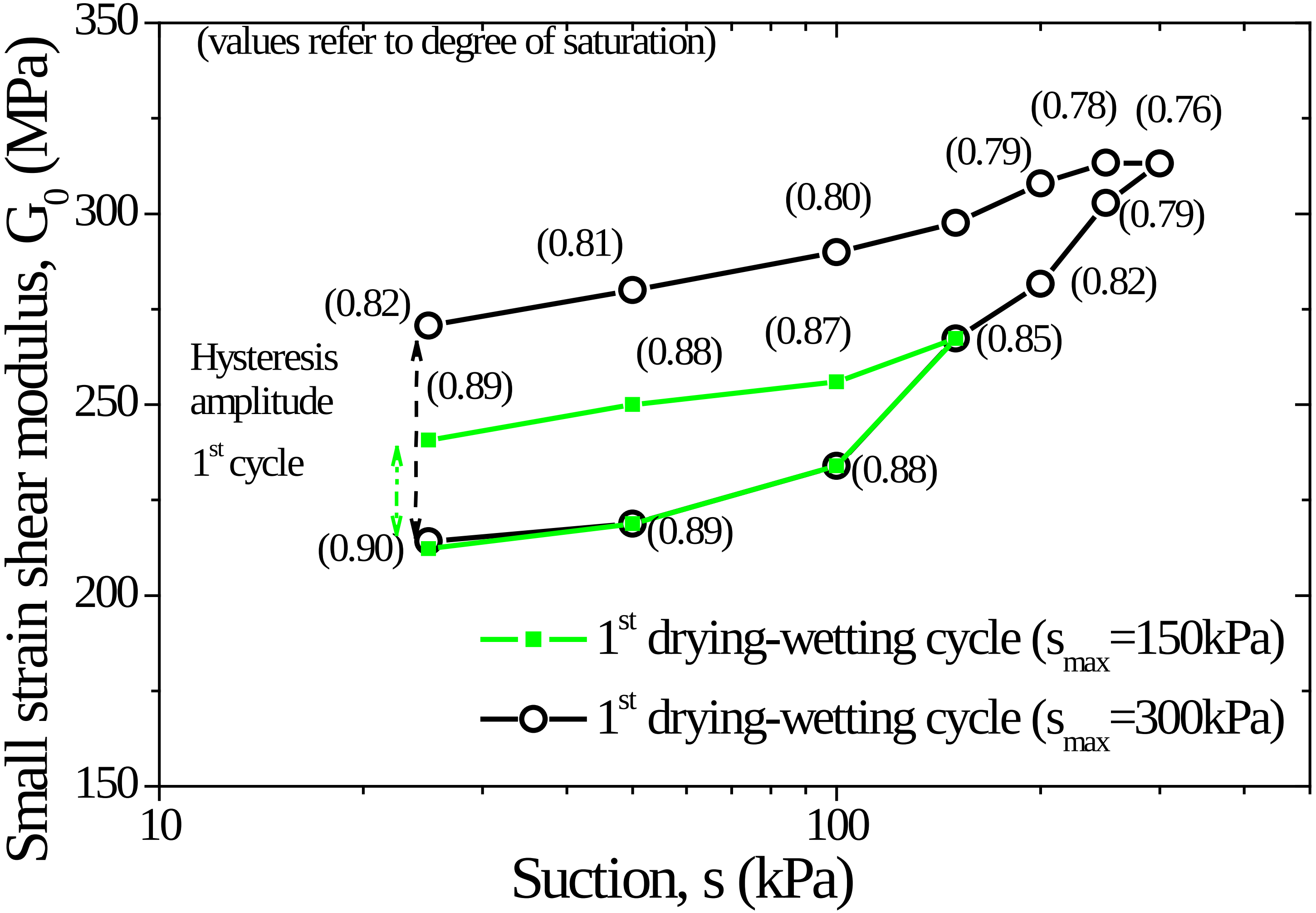


Heitor, Indraratna and Rujikiatkamjorn (2015) *Geotechnique Vol. 65 (9), pp. 717-727*

Hydraulic cycles



Recent suction history



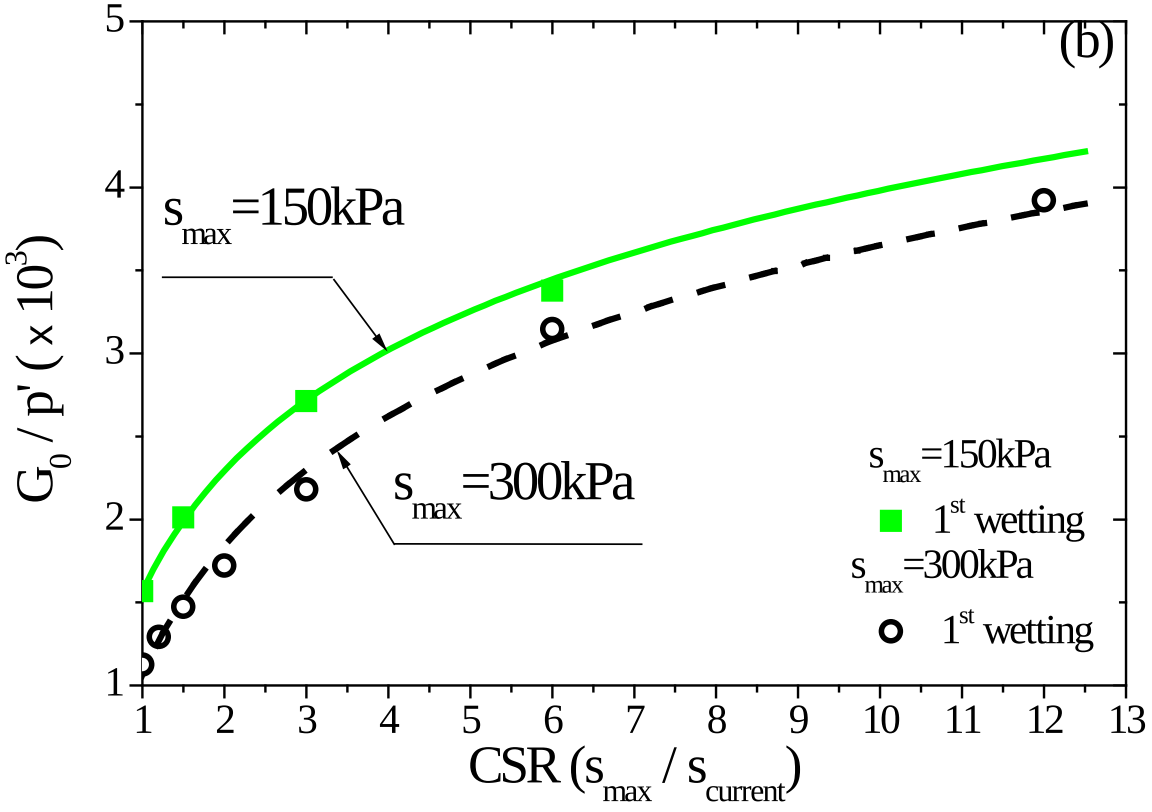
Current stress ratio

- effect of suction stress history at the different CSR's on G_0 the data normalised by the current stress state (p')

$$\frac{G_0}{G_{ref}} = Af(e)\left[\underbrace{\frac{(p-u_a)+(u_a-u_w)S_r}{p_r}}_{\mathbf{p'}}\right]$$

Heitor, Indraratna and Rujikiatkamjorn (2013) *CGJ* 50 (2): 179-188

$$CSR = \frac{s_{\max}}{s_{current}}$$



Heitor, Indraratna and Rujikiatkamjorn (2015) *Geotechnique Vol. 65 (9), pp. 717-727*

Conclusions

- Larger values of G_0 correspond to the wetting paths and this difference was associated with the water retention properties and soil microstructure
- The hydraulic cycles influence on the amplitude of the hysteretic response observed in a cycle of wetting and drying
- The CSR influence however seems to be intimate related to the stress state represented by current suction and degree of saturation
- CSR appears to control the G_0 to some extent but the number of hydraulic cycles contributes to an increase in G_0 for the same CSR

The geomechanical behaviour of earth structures exposed to changes in hydraulic regimes is dynamic and dependent on its suction history

References

- Heitor, A., Indraratna, B., Rujikiatkamjorn (2015) Effect of suction history on the small strain response of a dynamically compacted soil. *Australian Geomechanics* December Issue 50 (4): 61 – 68.
- Heitor, A., Indraratna, B. and Rujikiatkamjorn, C. (2015) The role of compaction energy on the small strain properties of a compacted silty sand subjected to drying-wetting cycles *Géotechnique.* Vol. 65 (9), pp. 717-727 (DOI: http://dx.doi.org/10.1680/geot.14.P.053)
- Heitor, A.; Indraratna, B.; Rujikiatkamjorn, C. (2014) Assessment of the Post-compaction characteristics of a silty sand, *Australian Geomechanics* (49) 4, 121- 131.
- Heitor, A., Indraratna, B. and Rujikiatkamjorn, C. (2013). Laboratory study of small strain behavior of a compacted silty sand. *Canadian Geotechnical Journal*, 50(2), 179-188.

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Australian Government
Australian Research Council

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

PENRITH LAKES

- Laboratory assistance from technical Staff at UOW

Comments / Questions ?

Thank you.

Modeling of lateral sleeper-ballast interaction on rail track

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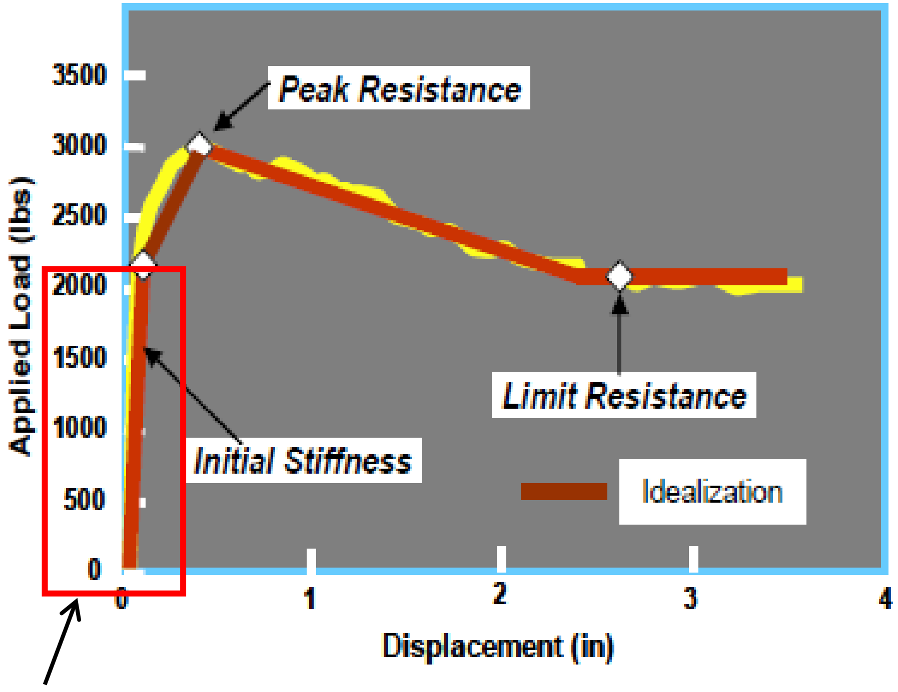
1. Introduction
2. Methods
3. Results
4. Conclusions
5. Further developments

Stiffness and lateral resistance of the track

Fig. 1- Lateral behaviour of the track. Kish (2011)



area under study

Pegasus

Developed by Varandas (2013)

- Matlab program
- Linear (Hook's Law) and non-linear (K-θ) ballast behaviour
- Non-linear contact betwen the sleepers and the ballast (Penalty formulation)

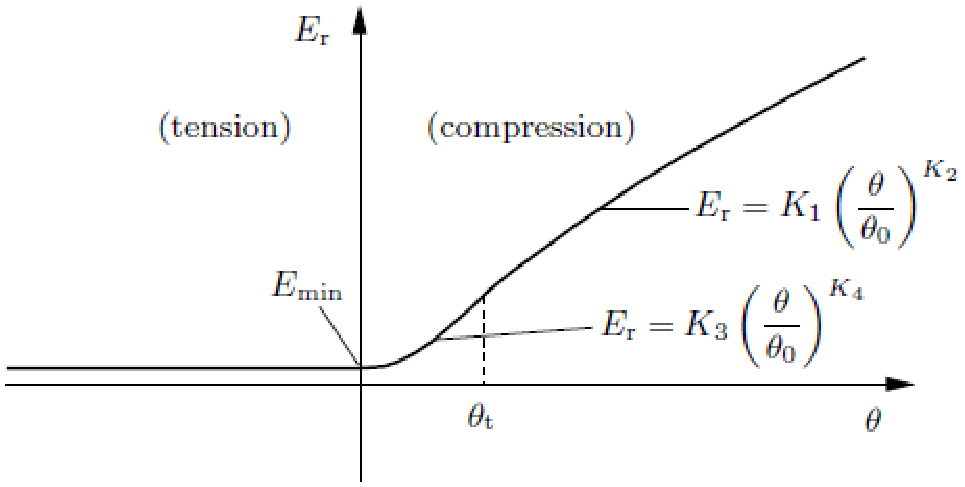


Fig.2 - The E_r-θ relationship . From Varandas (2013)

Model

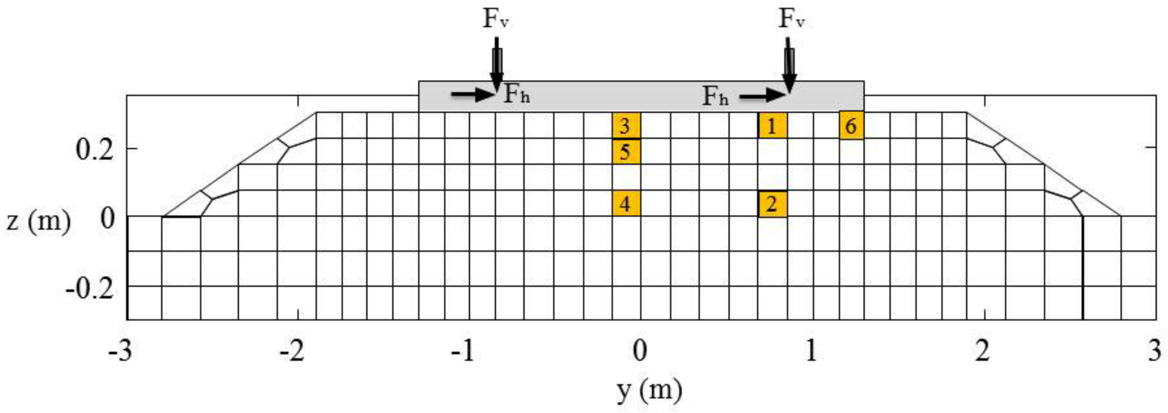


Fig.3 - Elemets in study

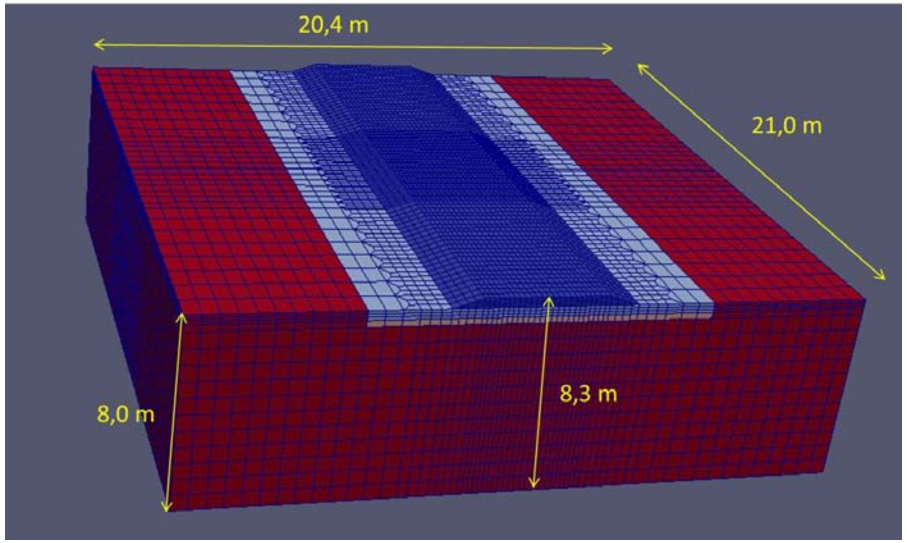


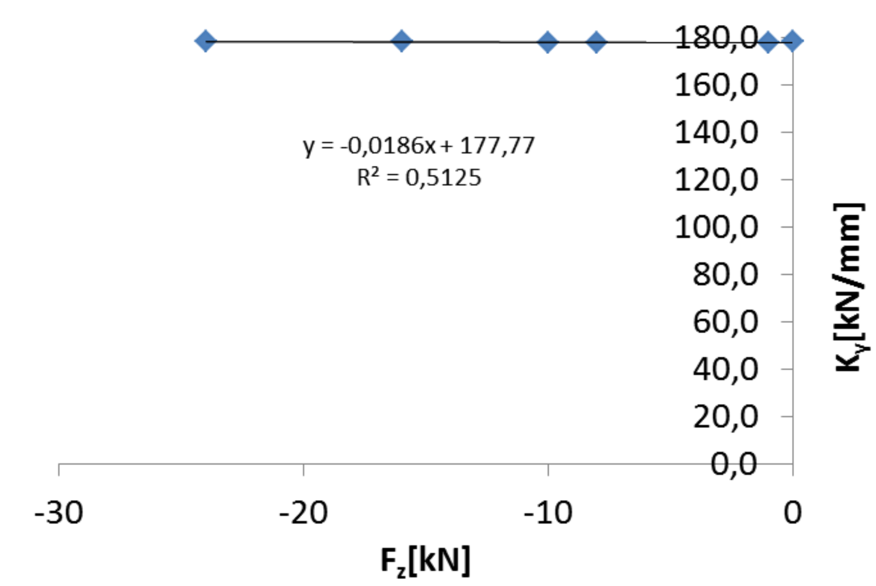
Fig.4- Geometry

Vertical Load influence

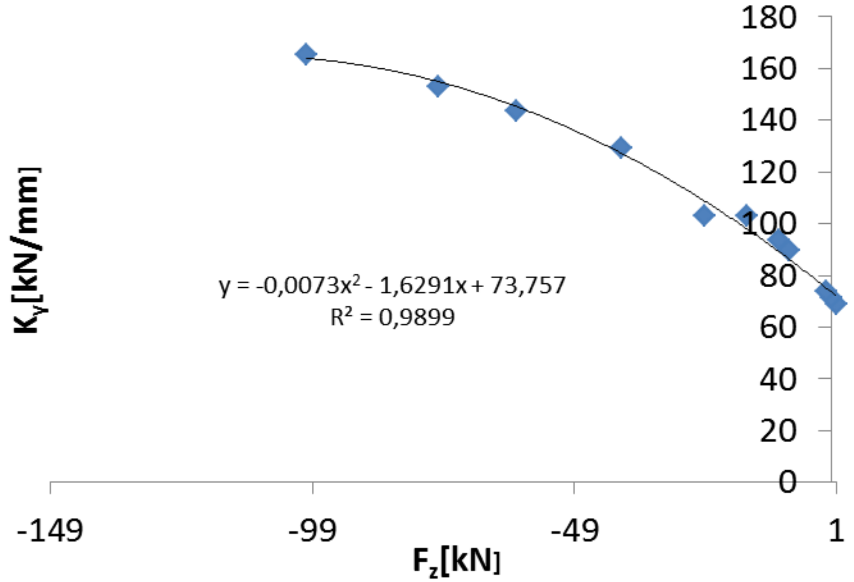
Test	Soil layer 1 : E[mPa] -ν- ρ[t/m^3]	Soil foundation : E[mPa] - ν - ρ[t/m^3]	F_z [kN]	F_y [kN]	F_y/F_z	K_y [kN/mm] Non Linear	K_y [kN/mm] Linear	K_z [kN/mm] Non Linear	K_z [kN/mm] Linear
D1	200 - 0,35 - 1,8	150 - 0,35 - 1,8	1	8	8,00	68,9	-	68,1	-
D2	200 - 0,35 - 1,8	150 - 0,35 - 1,8	0	8	inf	71,4	178,1	0,0	0,0
D3	200 - 0,35 - 1,8	150 - 0,35 - 1,8	-1	8	8,00	74,0	177,6	144,7	222,6
D4	200 - 0,35 - 1,8	150 - 0,35 - 1,8	-8	8	1,00	89,8	177,8	110,3	264,0
D5	200 - 0,35 - 1,8	150 - 0,35 - 1,8	-10	8	0,80	93,5	177,9	111,4	265,4
D6	200 - 0,35 - 1,8	150 - 0,35 - 1,8	-16	8	0,50	103,1	178,1	114,8	267,5
D7	200 - 0,35 - 1,8	150 - 0,35 - 1,8	-24	8	0,33	103,1	178,3	119,1	268,7
D8	200 - 0,35 - 1,8	150 - 0,35 - 1,8	-40	8	0,20	129,1	-	125,7	-
D10	200 - 0,35 - 1,8	150 - 0,35 - 1,8	-60	8	0,13	143,8	-	131,7	-
D11	200 - 0,35 - 1,8	150 - 0,35 - 1,8	-75	8	0,11	152,8	-	135,2	-
D12	200 - 0,35 - 1,8	150 - 0,35 - 1,8	-100	8	0,08	165,5	-	140,0	-

Vertical Load influence – Stifiness : $K_i=2F_i/(u_{i,end}-u_{i,initial})$

Linear

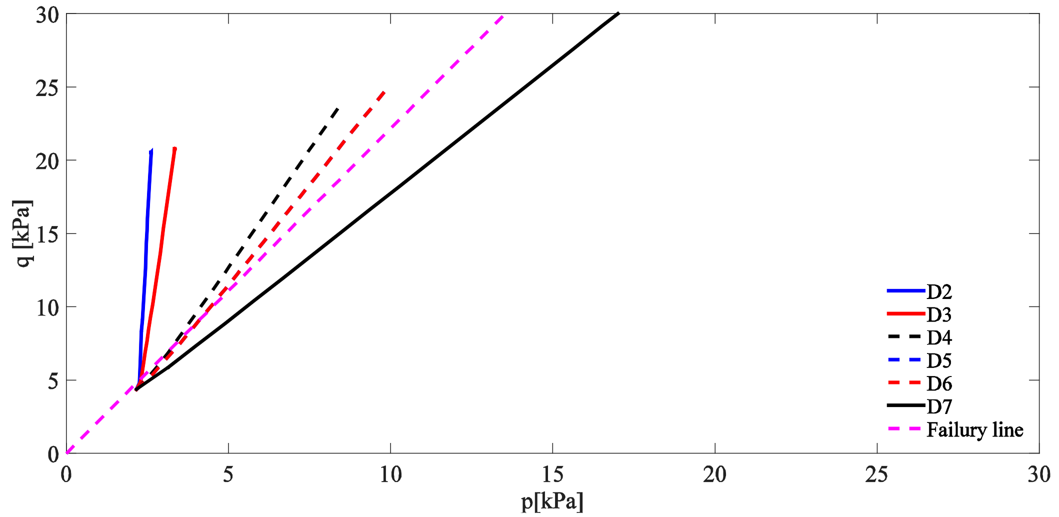


Nonlinear

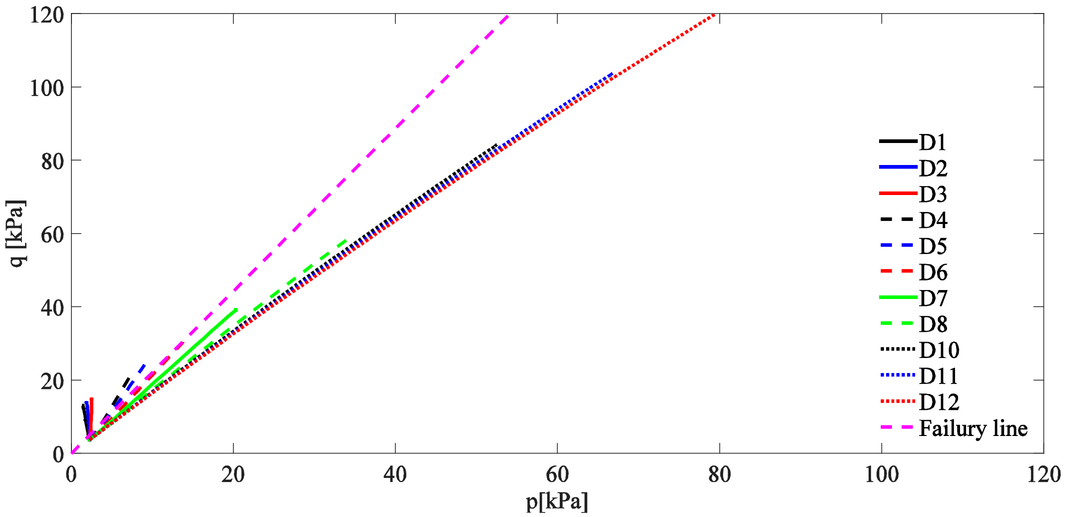


Vertical Load influence : p-q

Linear



Nonlinear

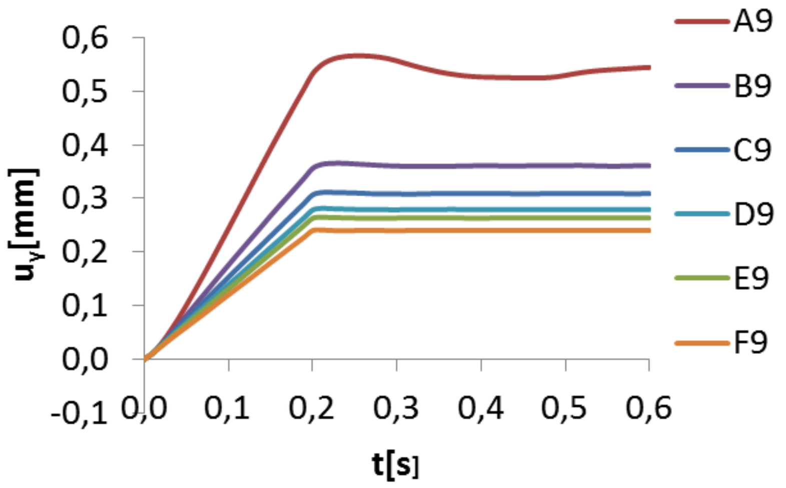


Soil Foudation influence

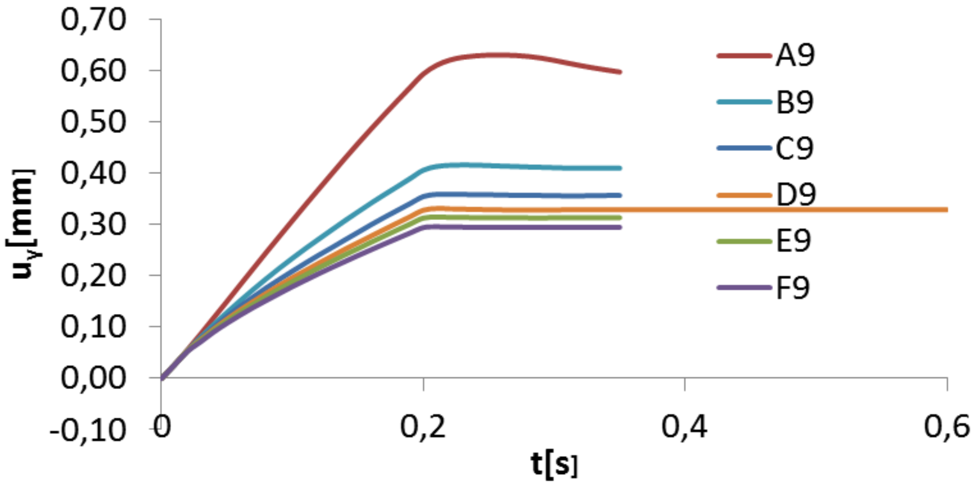
Test	Soil layer 1: E[mPa] - ν - ρ[t/m^3]	Soil foundation : E[mPa] - ν - ρ[t/m^3]	F_z [kN]	F_y [kN]	K_y [kN/mm] Non Linear	K_y [kN/mm] Linear	K_z [kN/mm] Non Linear	K_z [kN/mm] Linear
A9	200 - 0,35 - 1,8	20 -0,45- 2	-75	25	83,6	161,7	110,2	227,2
B9	200 - 0,35 - 1,8	60 - 0,3 - 2	-75	25	121,9	91,8	169,0	105,4
C9	200 - 0,35 - 1,8	100 - 0,3 -1,68	-75	25	140,1	189,7	232,8	292,8
D9	200 - 0,35 - 1,8	150-0,35-1,8	-75	25	152,0	208,2	269,5	341,9
E9	200 - 0,35 - 1,8	200 - 0,35 - 2	-75	25	159,6	138,5	301,4	164,7
F9	200 - 0,35 - 1,8	300-0,3-2,04	-75	25	169,7	178,9	338,2	265,9

Soil Foudation influence : u_y

Linear

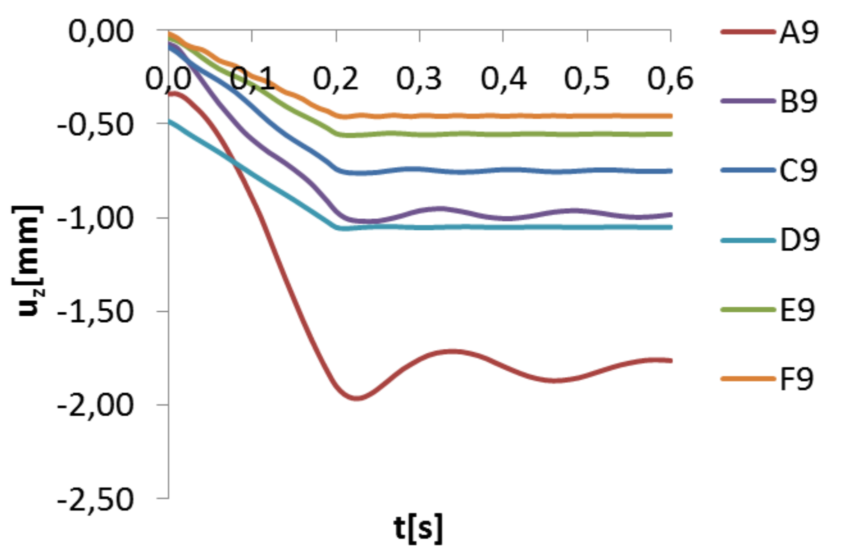


Nonlinear

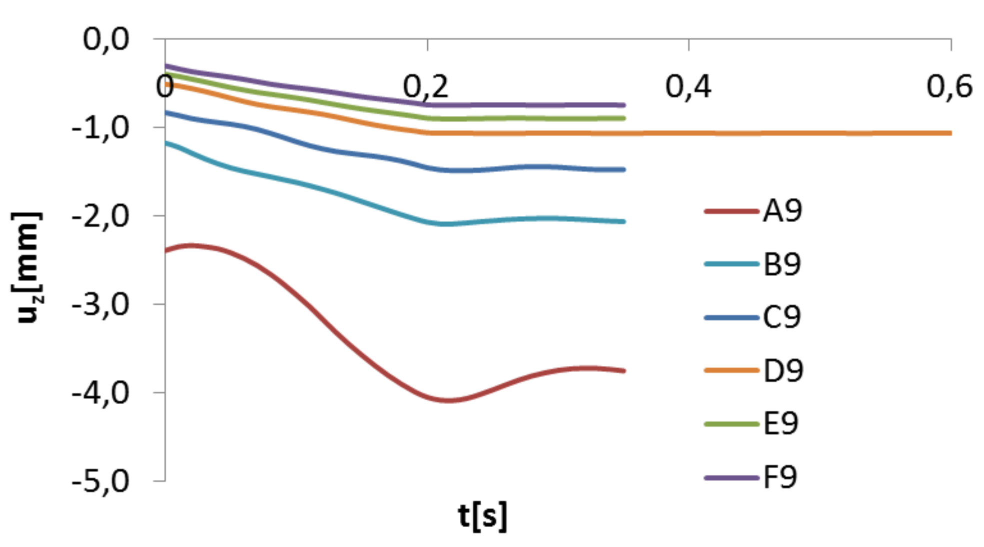


Soil Foudation influence : u_z

Linear

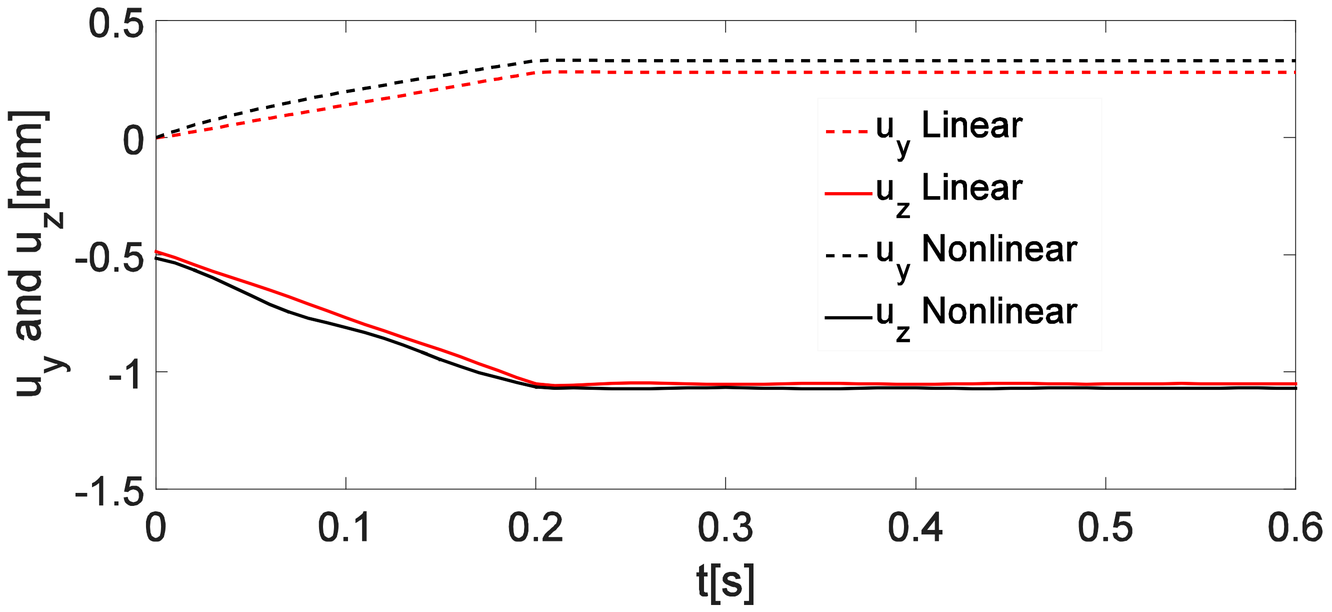


Nonlinear



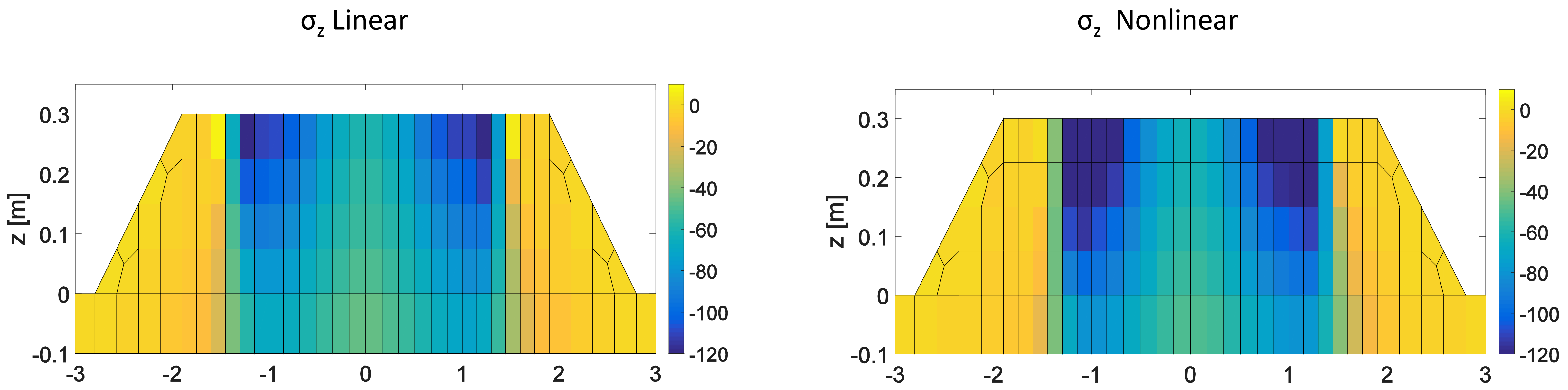
Test D9 – comparison between the linear model and the nonlinear

Displacements



Test D9 – comparison between the linear model and the nonlinear

Stress



Influence of the lateral sleeper-ballast interaction , $K_{c,h}$ on the stress distribution in the ballast

	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7
$K_{c,h}$[kN/m^2]	0	$1x10^2$	$1x10^4$	$1x10^5$	$1x10^6$	$5x10^6$	$1x10^7$
F_z[kN]	-75	-75	-75	-75	-75	-75	-75
F_y[kN]	0	0	0	0	0	0	0
Foudation soil	D	D	D	D	D	D	D

3. Results

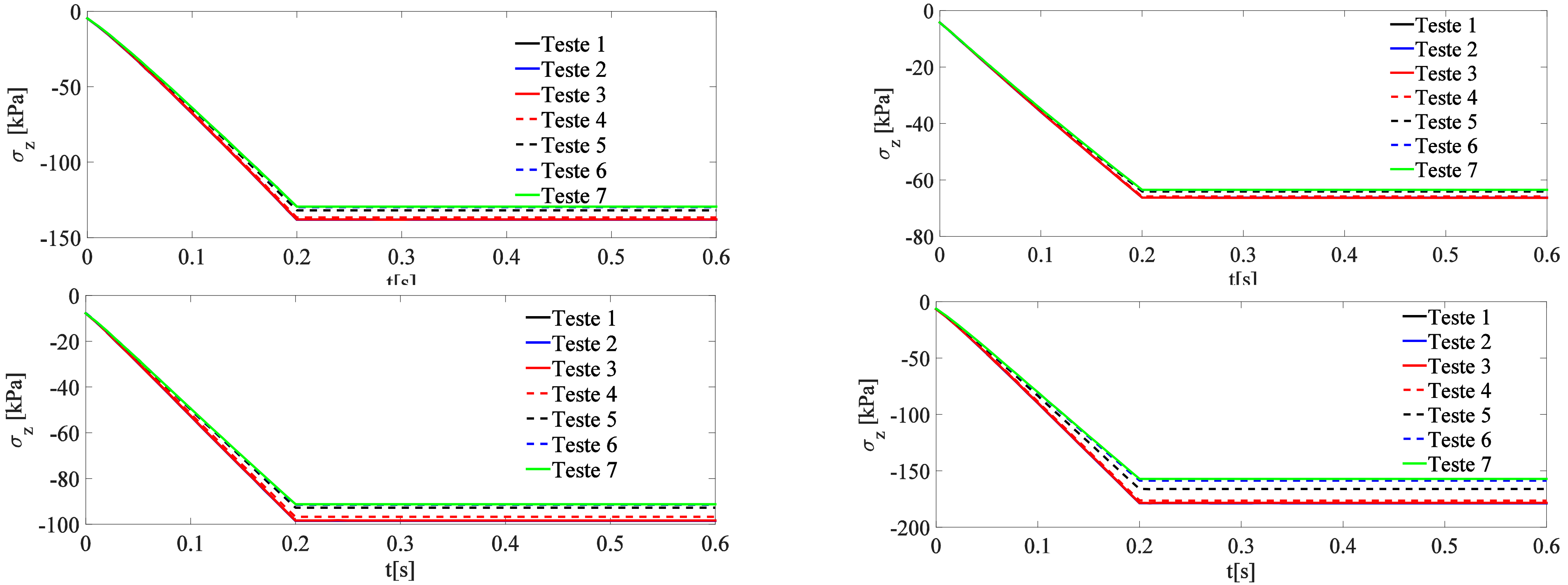
Influence of the lateral sleeper-ballast interaction on the stress distribution in the ballast -σ_z

Elem 1

Elem 3

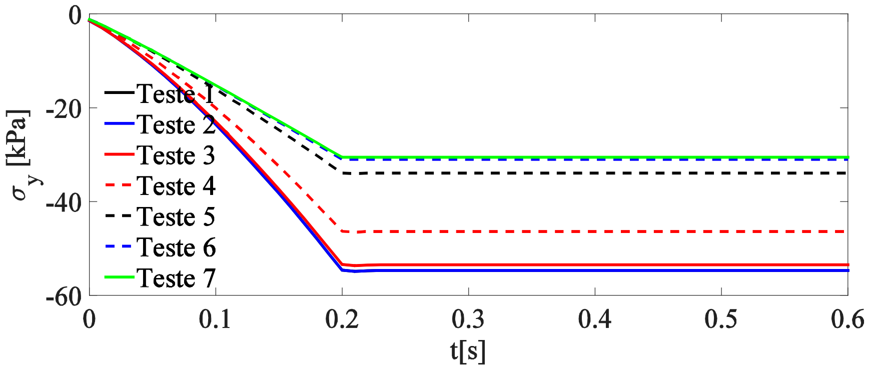
Elem 2

Elem 6

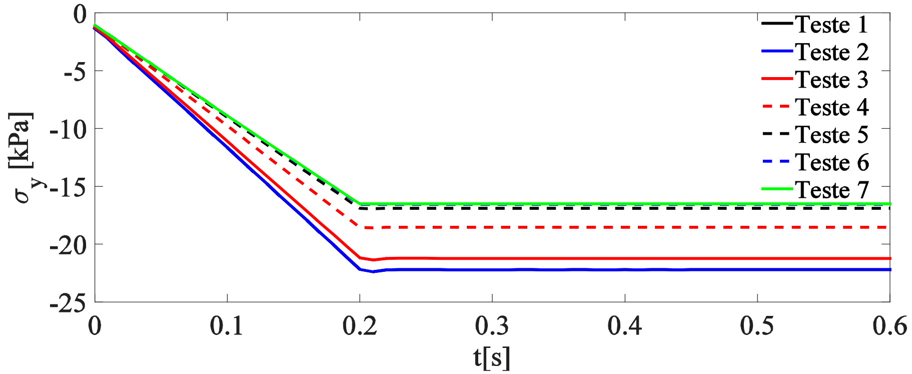


Influence of the lateral sleeper-ballast interaction on the stress distribution in the ballast -σ_y

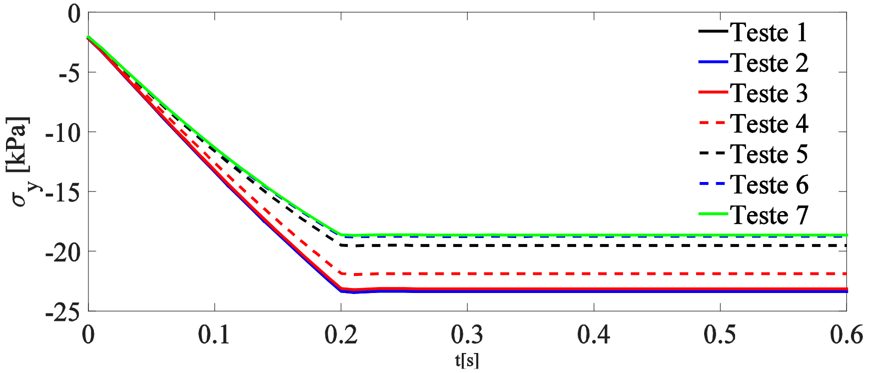
Elem 1



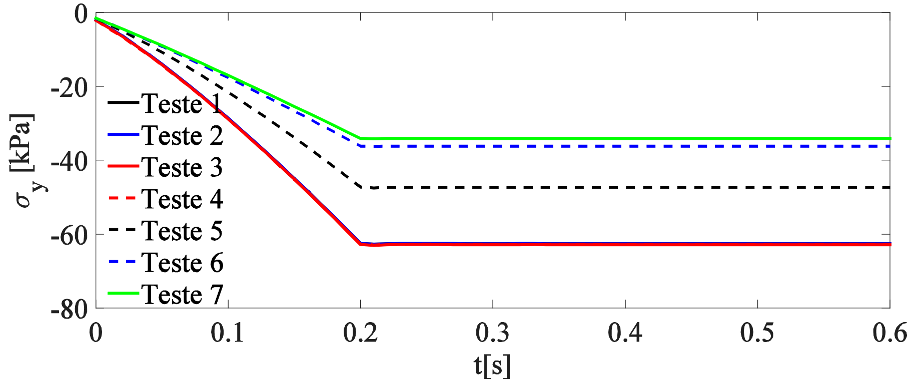
Elem 3



Elem 2



Elem 6



Conclusions

- Load study – It was possible to obtain vertical load (F_z) - lateral stiffness (K_y) relation. For higher F_y/F_z relation, the graph p-q lies above the failure line .
- Soil foundation study – As expected, it was observed that the higher the Young modulus of the soil the higher the lateral stiffness .
- Influence of the lateral sleeper-ballast interaction on the stress distribution in the ballast – It is noted that the parameter $K_{c,h}$ has a non negligible influence on the stresse distribution inside the ballast layer, therefore denoting the importance of a care representation of this friction interface in studies focused on the granular layers of the track .

Thank you for your attention

Universidade Nova de Lisboa-Faculdade de Ciências e Tecnologias, Lisboa, Portugal
Jeniffer costa Barreto - *jc.barreto@campus.fct.unl.pt*
José Varandas - *jnsf@fct.unl.pt*

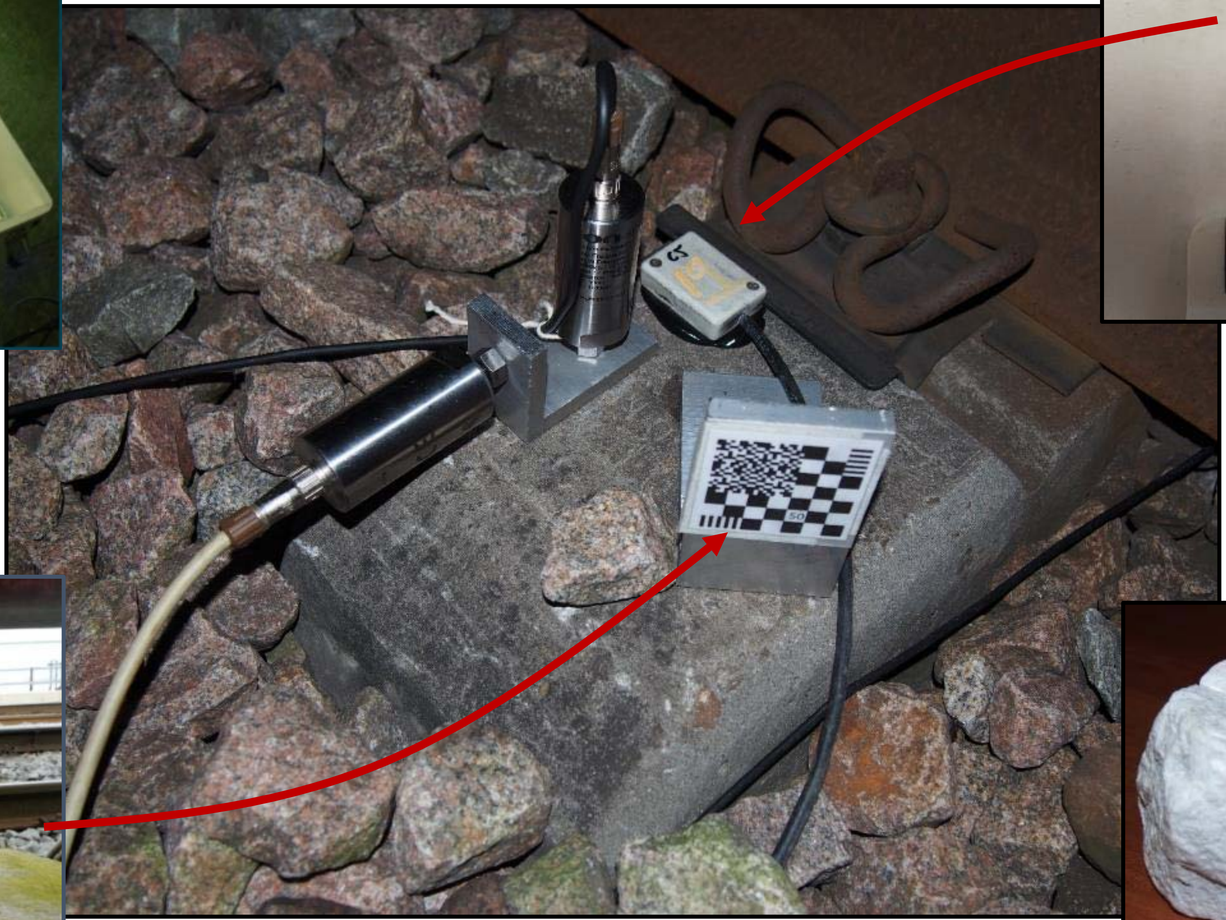
Monitoring track defects in ballasted high speed railways

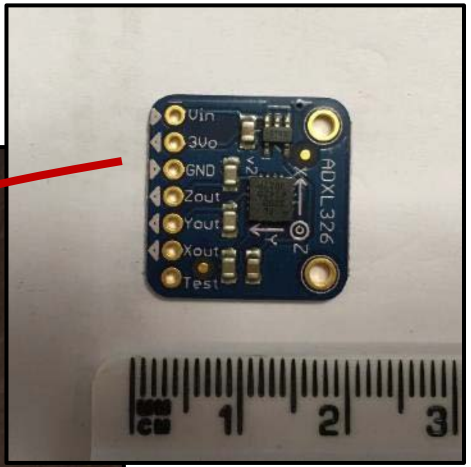
David Milne[1], Louis Le Pen[1] ,David Thompson[1], Willaim Powrie[1]

1. *Faculty of Engineering and the Environment, University of Southampton*

Track Defects

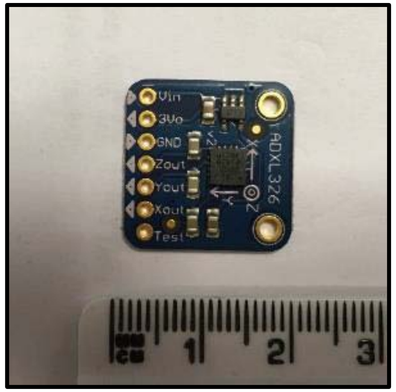
Monitoring Systems

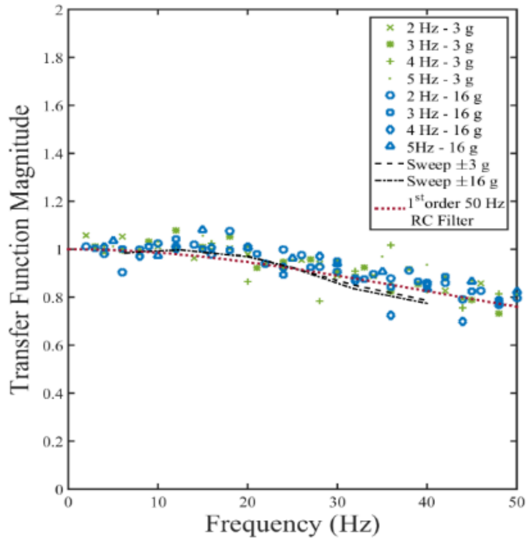


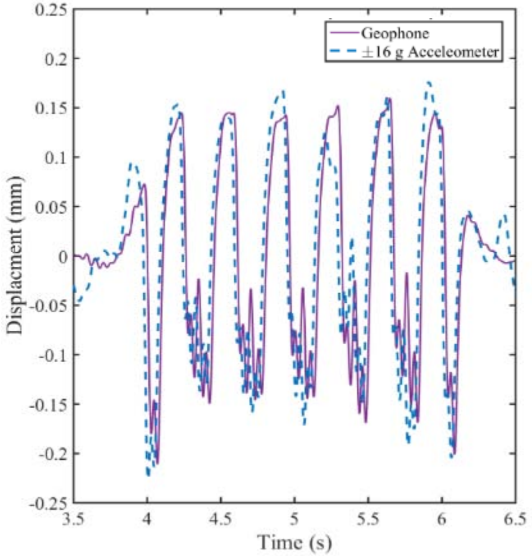


MEMS Accelerometers

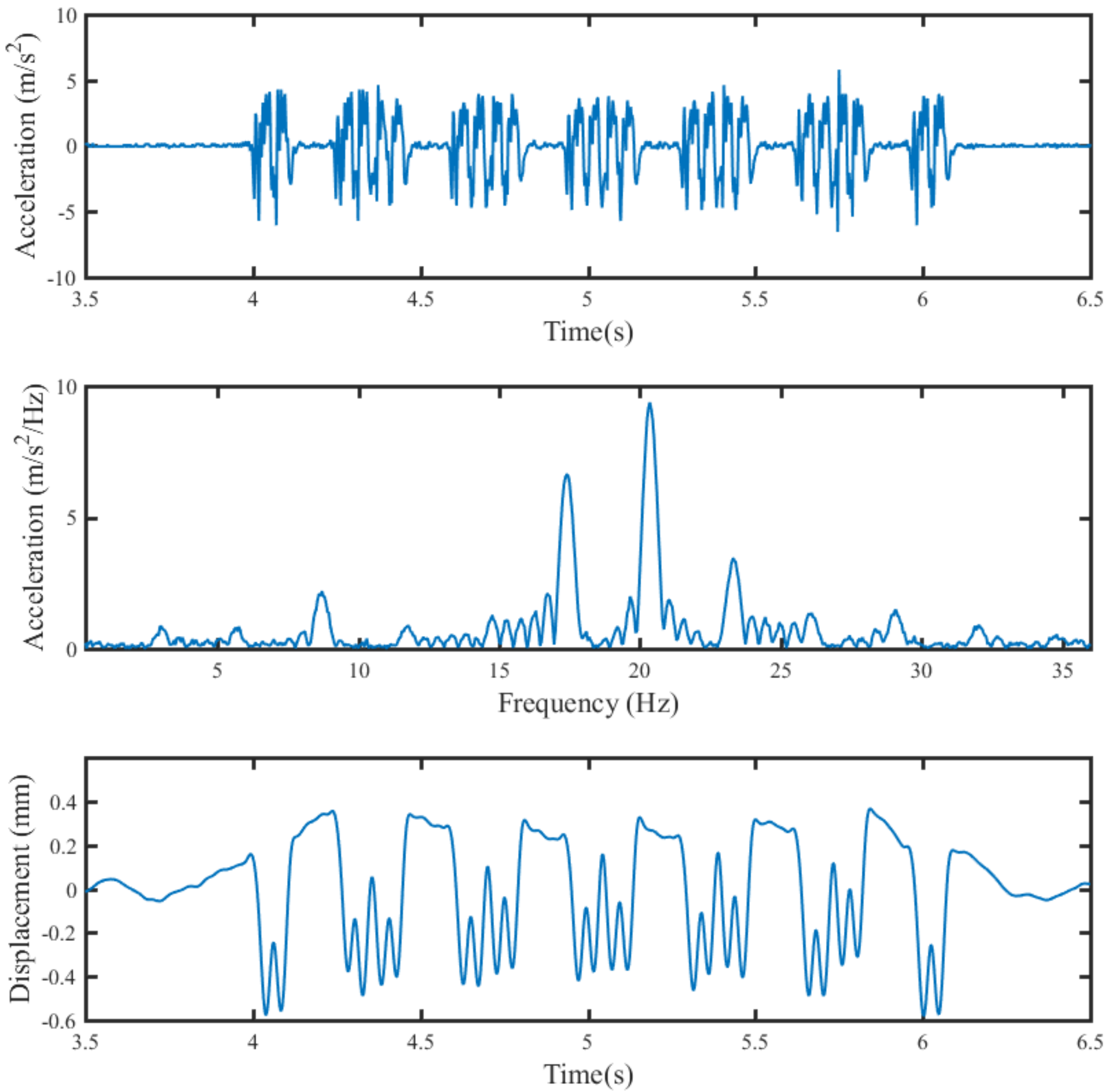
- Very low cost acceleration transducer
- Robust
- Data agrees with geophones
- Enables long term monitoring







Example data

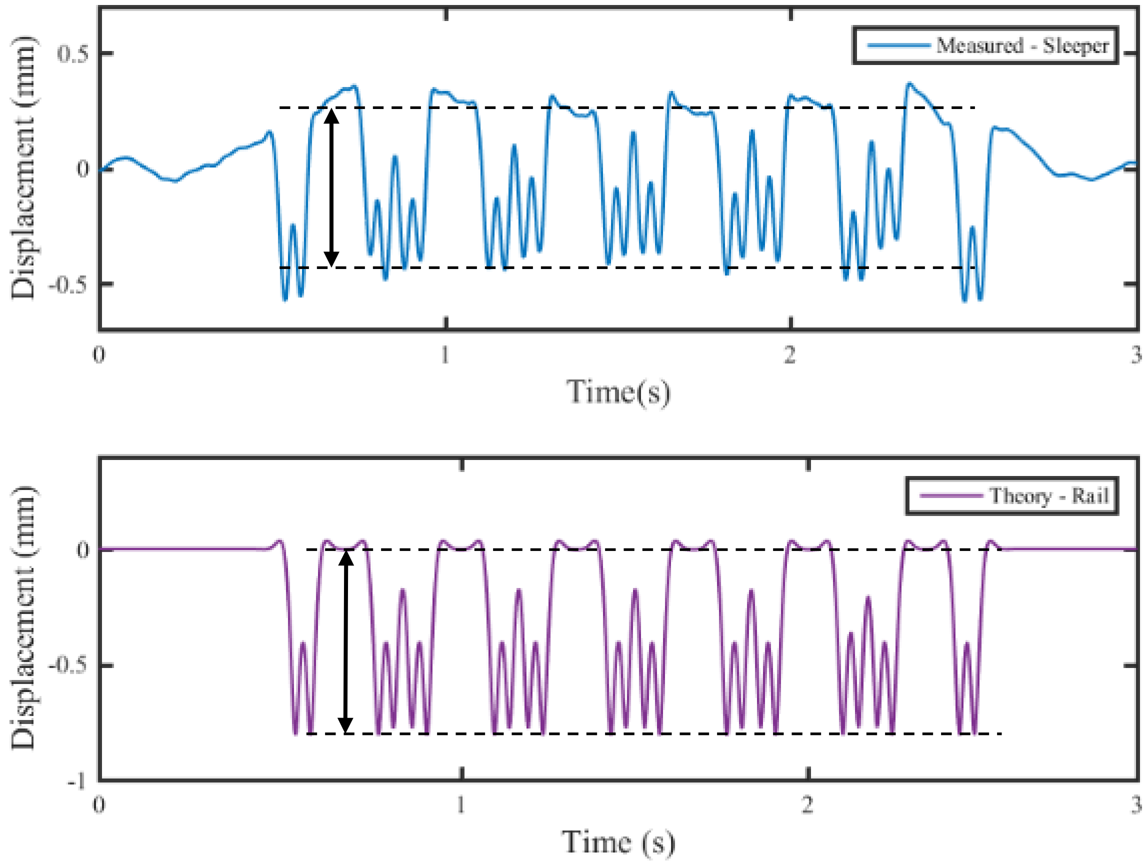


Data interpretation

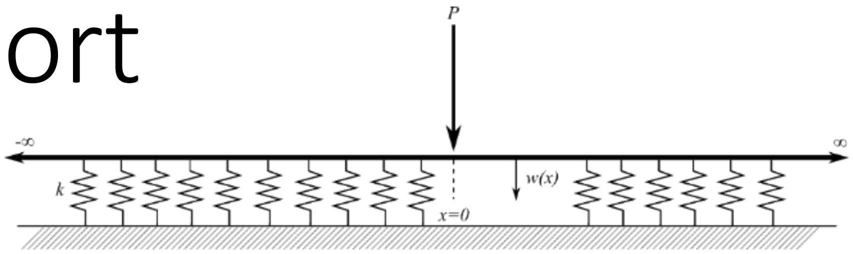
- Long term trackside monitoring produces lots of data
- Not feasible to analyse every time history
- Desirable to characterise each passage automatically
- Displacement and Track modulus
- Can a model help?

Characterising Displacement

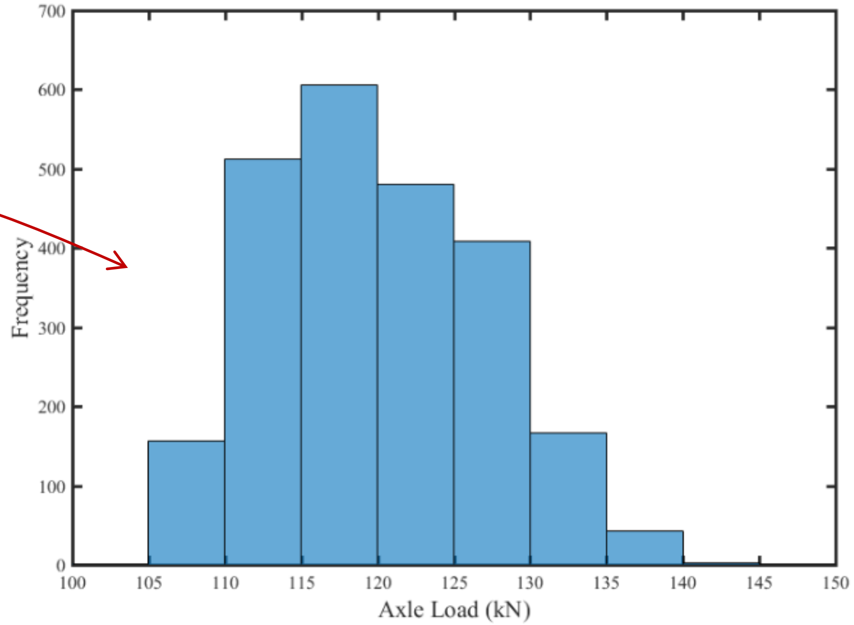
- At rest position lost by filtering data
- Want downwards displacement
- Match analytical model of railway track by inspection or by algorithm



Characterising Support



- Characterise support
  - Track Modulus: Supporting force per unit length of rail
  - Typically calculated using load-deflection relationships
- Load uncertain
  - Capacity
  - Dynamics ?

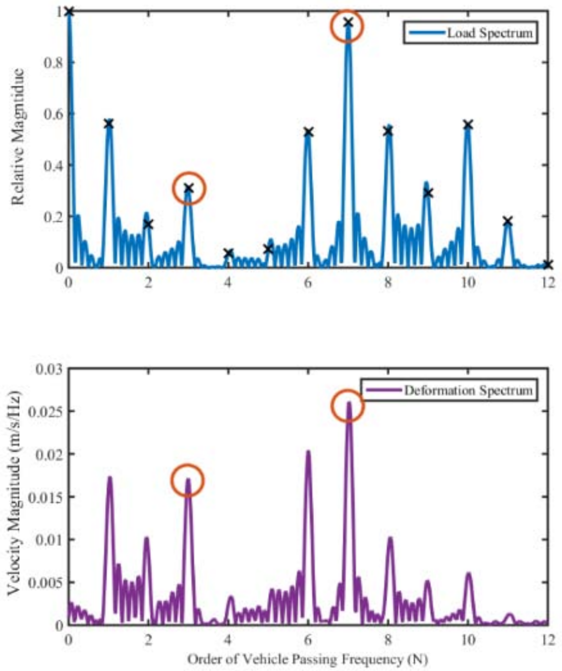


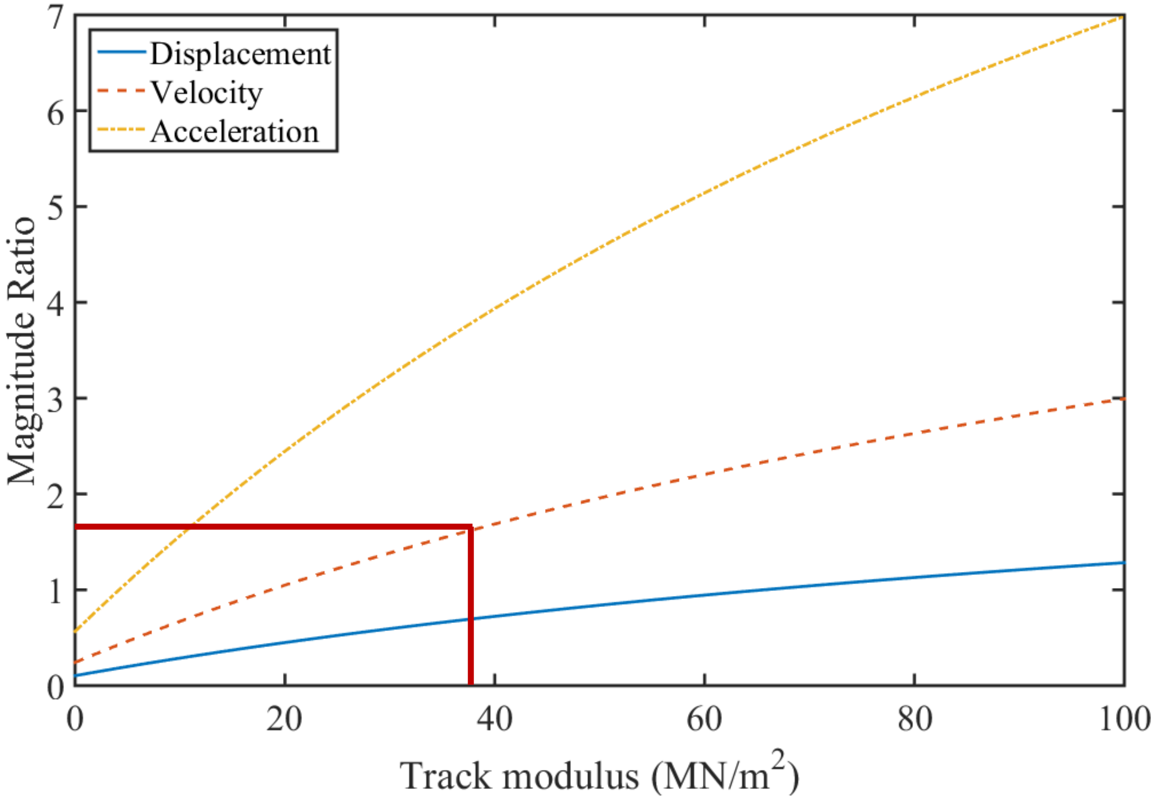
Characterising Support

- A different approach!
- Fit a model of track behaviour in the frequency domain
  - Le Pen, L., Milne, D., Thompson, D. & Powrie, W. (2016) Evaluating railway track support stiffness from trackside measurements in the absence of wheel load data. *Canadian Geotechnical Journal*.
- Utilise properties of the Fourier transform for:
  - lineside measurements (deflection, velocity or acceleration)
  - track model
  - train loads

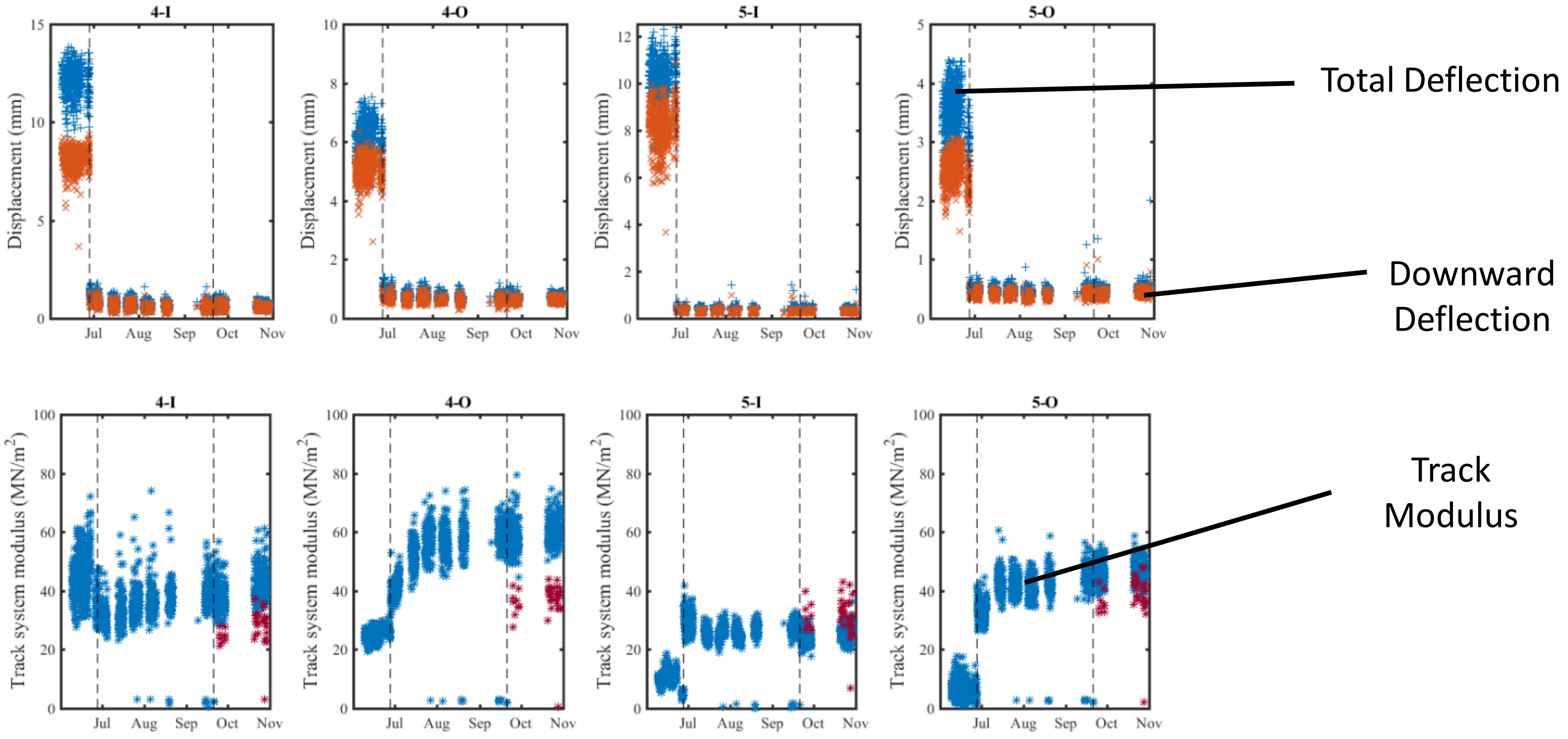
Obtaining track modulus

- $$W\left(\frac{N_a}{N_b}\right) = \frac{kL_v^4+16\pi^4EIN_b{}^4}{kL_v^4+16\pi^4EIN_a{}^4} \cdot \frac{\cos\left(\frac{\pi N_a L_v}{L_b}\right)\cos\left(\frac{\pi N_a L_v}{L_w}\right)}{\cos\left(\frac{\pi N_b L_v}{L_b}\right)\cos\left(\frac{\pi N_b L_v}{L_w}\right)}$$





Monitoring displacement and stiffness



Summary

- Track defects are a problem
  - Want to understand accelerated deterioration and effect of maintenance
- Monitoring provides the necessary type of evidence
  - Larger longer term deployments are possible with low cost instrumentation
- Large quantities of data need to be processed by algorithm
  - Displacement and track support modulus
- Methods allow us to track changes in performance and evaluate track performance

Trend of Research for Transportation Geotechnics in Japan (TC202 Japanese Local Task Force Committee Activity)

Takahisa Nakamura[1]

1. *Railway Technical Research Institute, Tokyo, Japan*

Terms of Reference for TC202

【TC202】
Technical Committee 202 (formerly TC-3) of the ISSMGE

【Goal】
To apply broad engineering to bridge the gap between Pavement/Railway Engineering and Geotechnical Engineering.

【Main task】
To promote co-operation and exchange of information and knowledge about the geotechnical aspects in design, construction, maintenance, monitoring and upgrading of roads, railways and airfields.

【Main members (2013～) 】
TC Chair ： Prof. Erol Tutumluer (USA)
TC Secretary ： Prof. Tatsuya Ishikawa (Japan)
etc.

Research Interest

- Geotechnics for pavement, rail track and airfield
- Geomaterial, including nontraditional materials
- Asphalt mixtures and hydraulically-bound materials
- Earthworks for transportation facilities
- Application of geosynthetics
- Laboratory testing and in-situ testing
- Modeling and numerical simulations

etc.




Papers survey

Survey research items and the number of survey papers

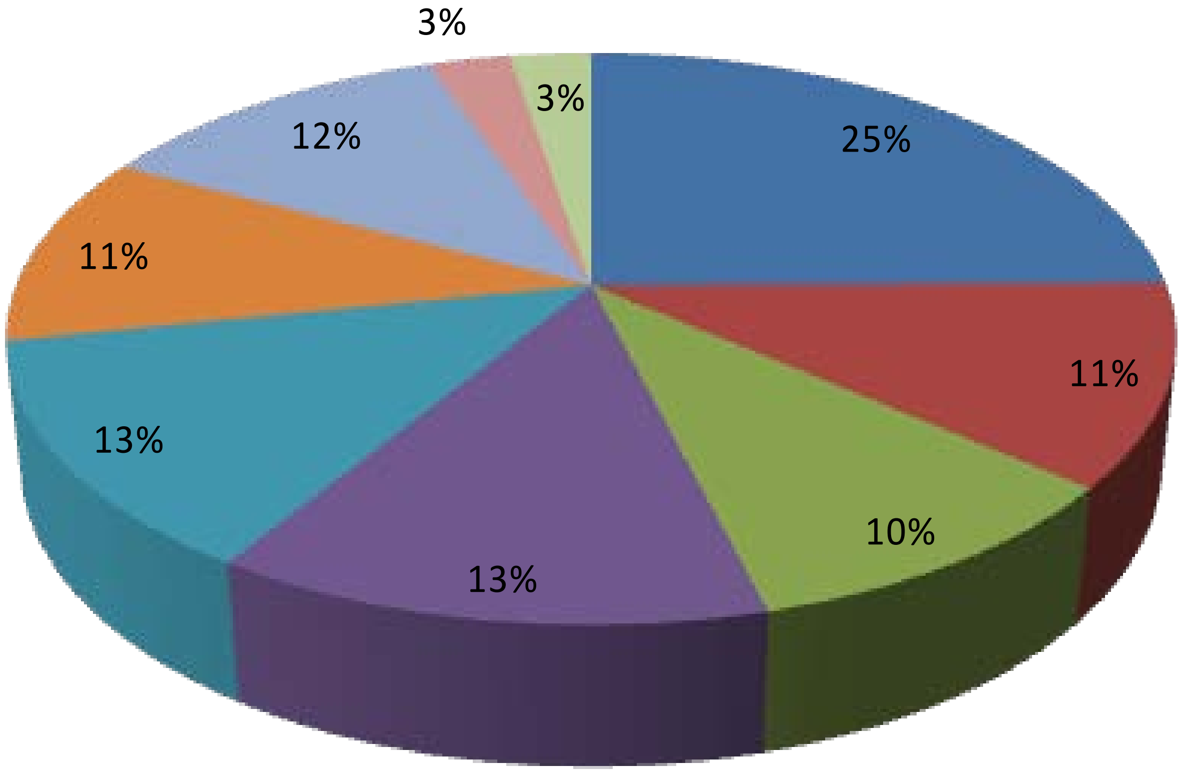
	Subject	The Number	
		Special Document	Keyword
1	Study fot the standardization of the materials properties test method of roadbed and roadbed materials	47	169
2	Evaluation method of soundness and seismic performance for structure of transportation and ground	112	431
3	Preparation of the structure analysis technique to establish the performance based design of the traffic ground structure	43	147

Survey research items and number of survey documents

Title	Year	Total number
Japan National Conference on Geotechnical Engineering	2011-2015	5552
ANNUAL CONFERENCE OF THE JAPAN SOCIETY OF CIVIL ENGINEERS	2011-2015	15666
Journal of Japan Society of Civil Engineers, Ser. C (Geosphere Engineering)	2011-2015	190
Journal of Japan Society of Civil Engineers, Ser. A2 (Applied Mechanics (AM))	2011-2015	452
Journal of Japan Society of Civil Engineers, Ser. E1 (Pavement Engineering)	2011-2015	128
Another Japan Domestic National Conference	-	573
Total		22561

Classification Summary

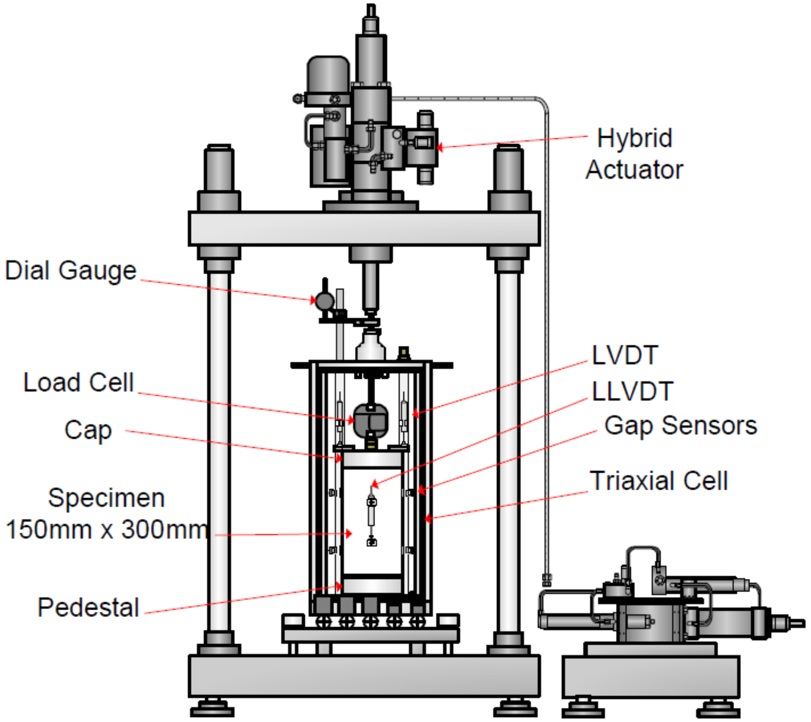
【Subject1】 Studies regarding the standardization of the material property test methods for subgrade and roadbed materials

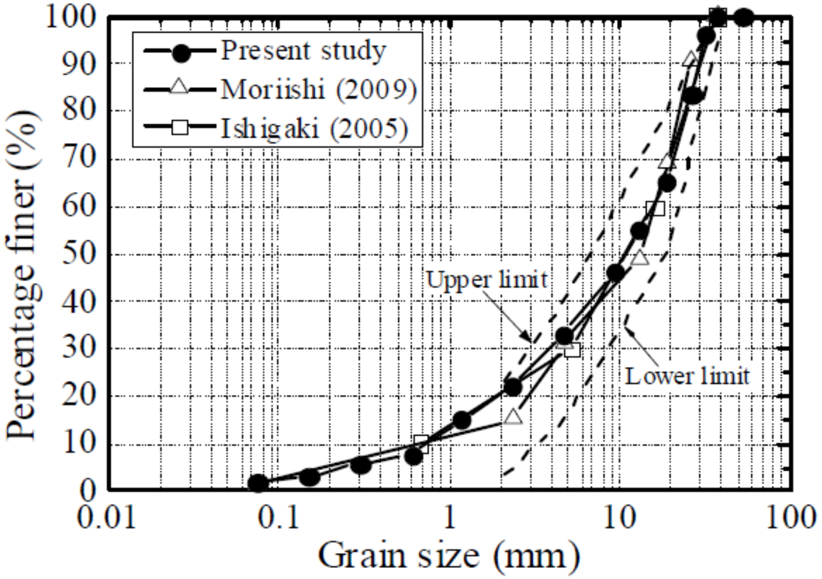


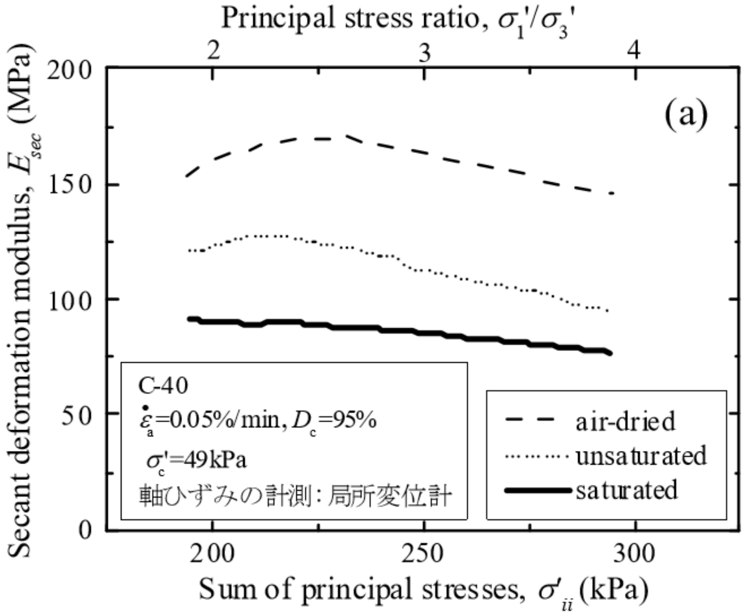
1.Structure/ Material
2.Test types/ Test apparatus
3.Physical characteristic
4.Characteristics of strength and deformation
5.Seepage characteristic
6.Thermal characteristic
7.Modeling/ Analysis
8.Design/ Evalution
9.Etc

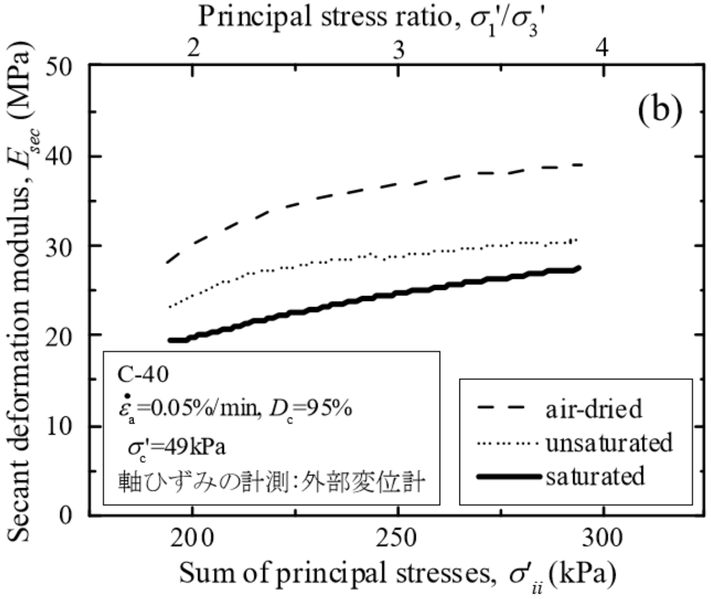
【Major research paper①】

Application of Triaxial Apparatus for Unsaturated Soils to Mechanical Behavior of Granular Base Course Material.



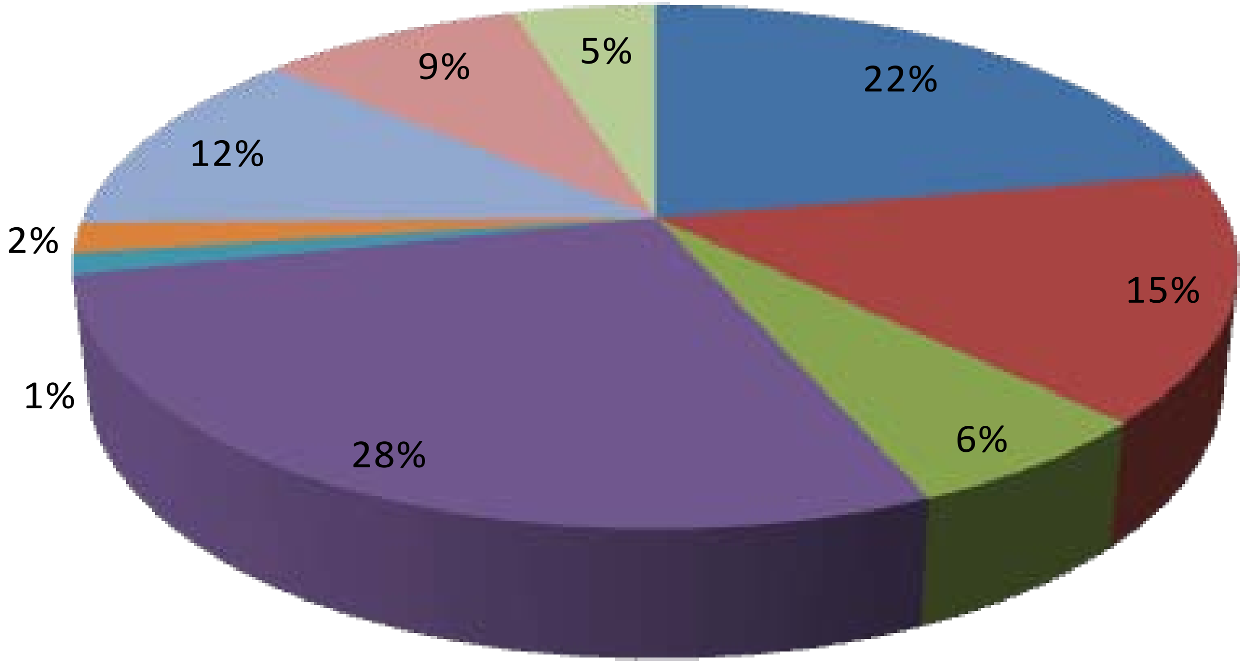






Classification Summary

【Subject2】 Evaluation method of soundness and seismic performance for transportation earth structure

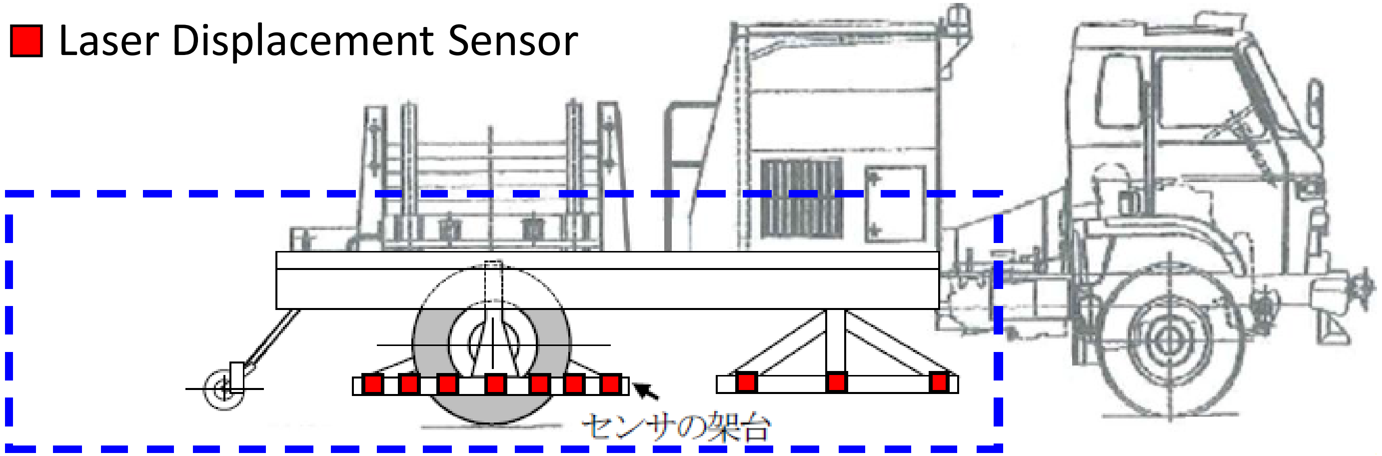


1.Structure/ Material
2.Test types/ Test apparatus
3.Physical characteristic
4.Characteristics of strength and deformation
5.Seepage characteristic
6.Thermal characteristic
7.Modeling/ Analysis
8.Design/ Evalution
9.Etc

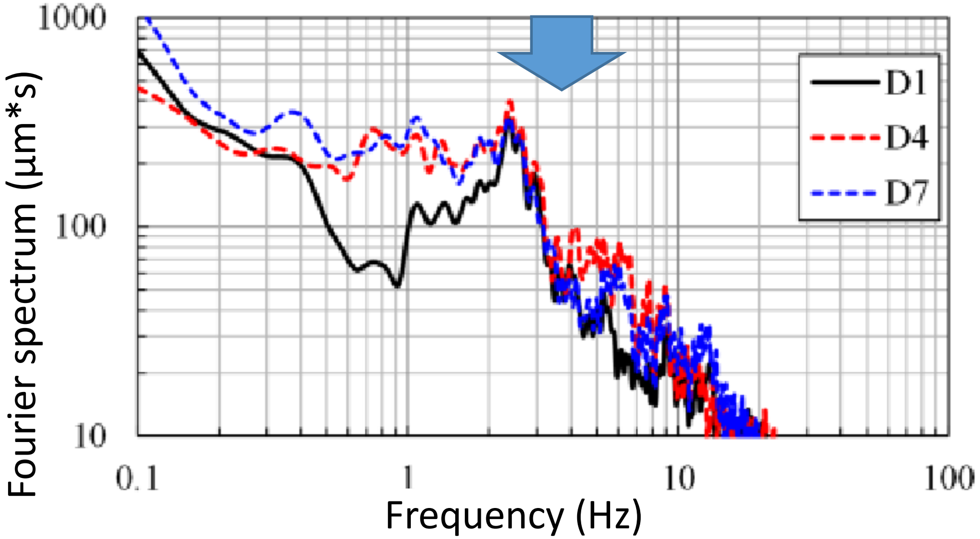
【Major research paper②】 A Study on evaluation of Pavement Soundness Using Mobil Deflection Measuring Device

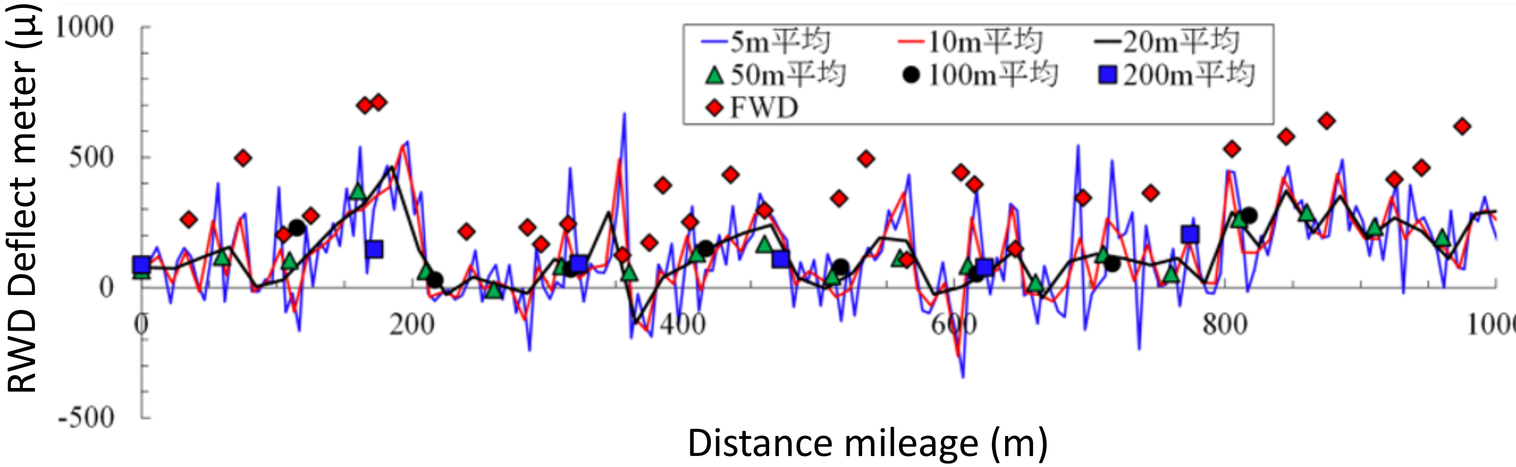
Laser Displacement Sensor

Laser Displacement Sensor



Rolling Weight Deflectmeter (RWD)





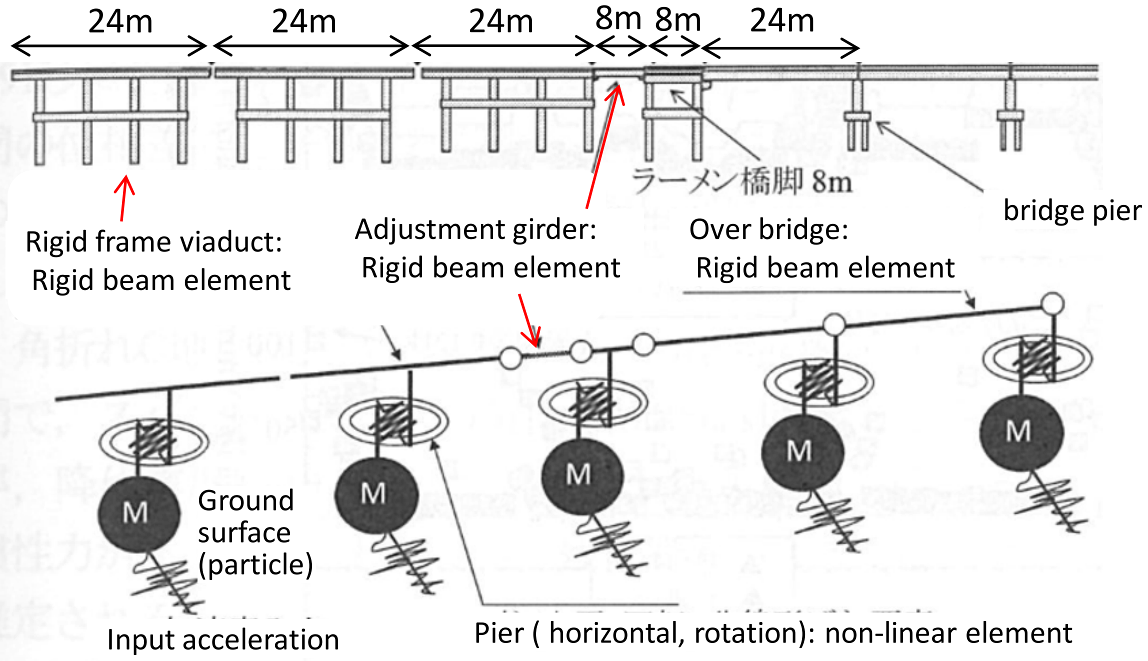
Classification Summary

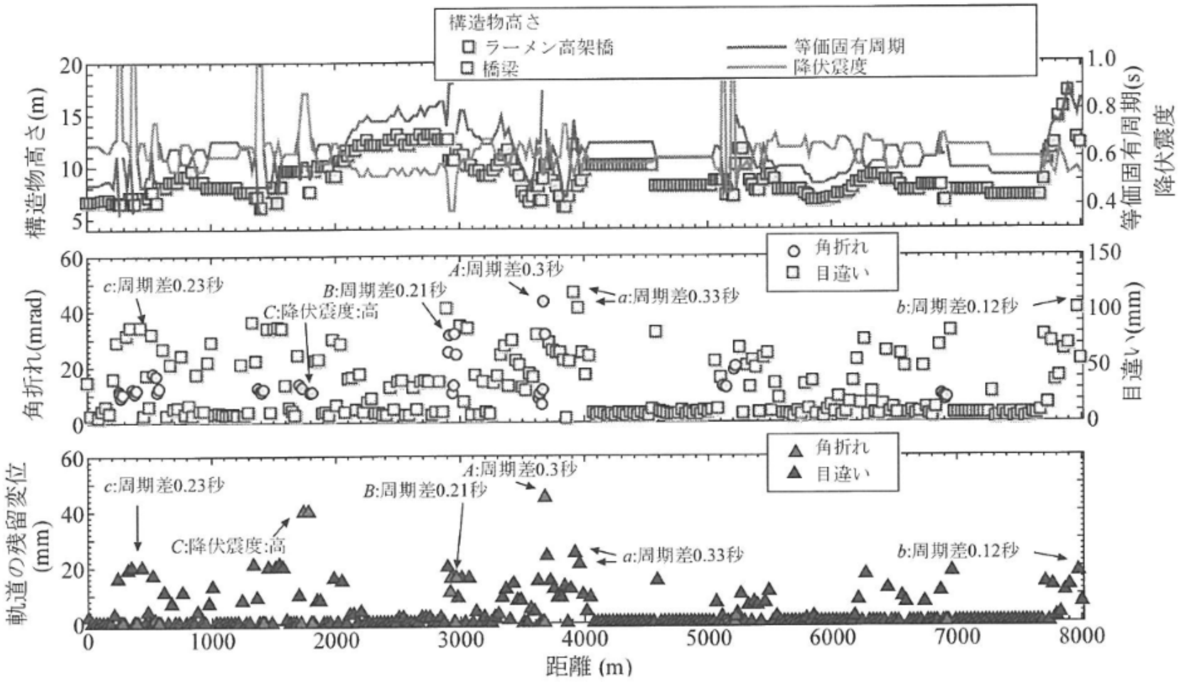
【Subject3】 Structure analysis methods to establish the performance based design method for transportation earth structures

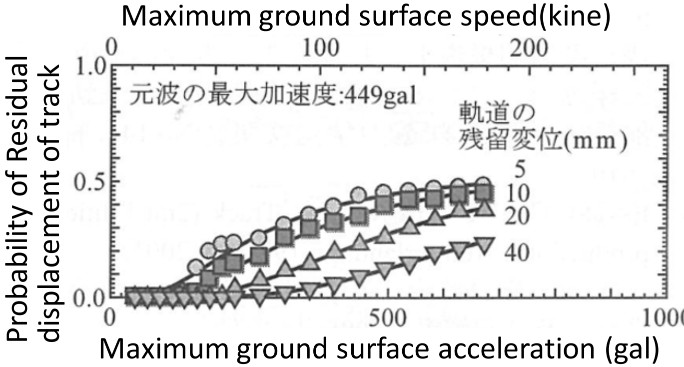
6%
11%
25%
24%
4%
7%
4%
3%
16%

1.Structure/ Material
2.Test types/ Test apparatus
3.Physical characteristic
4.Characteristics of strength and deformation
5.Seepage characteristic
6.Thermal characteristic
7.Modeling/ Analysis
8.Design/ Evalution
9.Etc

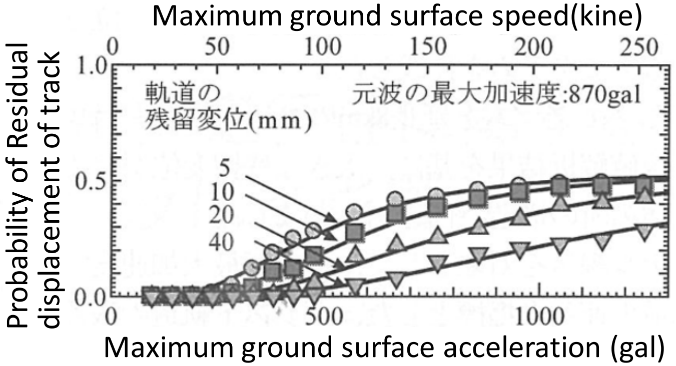
【Major research paper】 Residual Deformation of Ballasted Track laid on The Structure Boundary Area After an earthquake







L2 Earthquake Motion of Spector1



L2 Earthquake Motion of Spector2

Conclusions

- We surveyed the Japanese latest study trend for Transportation Geotechnics based on the papers relating the scientific research subjects of TC202 Japanese Task Force Committee.
- Moreover, we have systematized each keyword and analyzed it to survey the study contents of the papers relating to the respective subjects.
- We will arrange keywords for every classification of each subject and analyze the latest study trend for transportation geotechnics engineering in detail and will create an environment to send the relative information to all the civil engineers concerned.

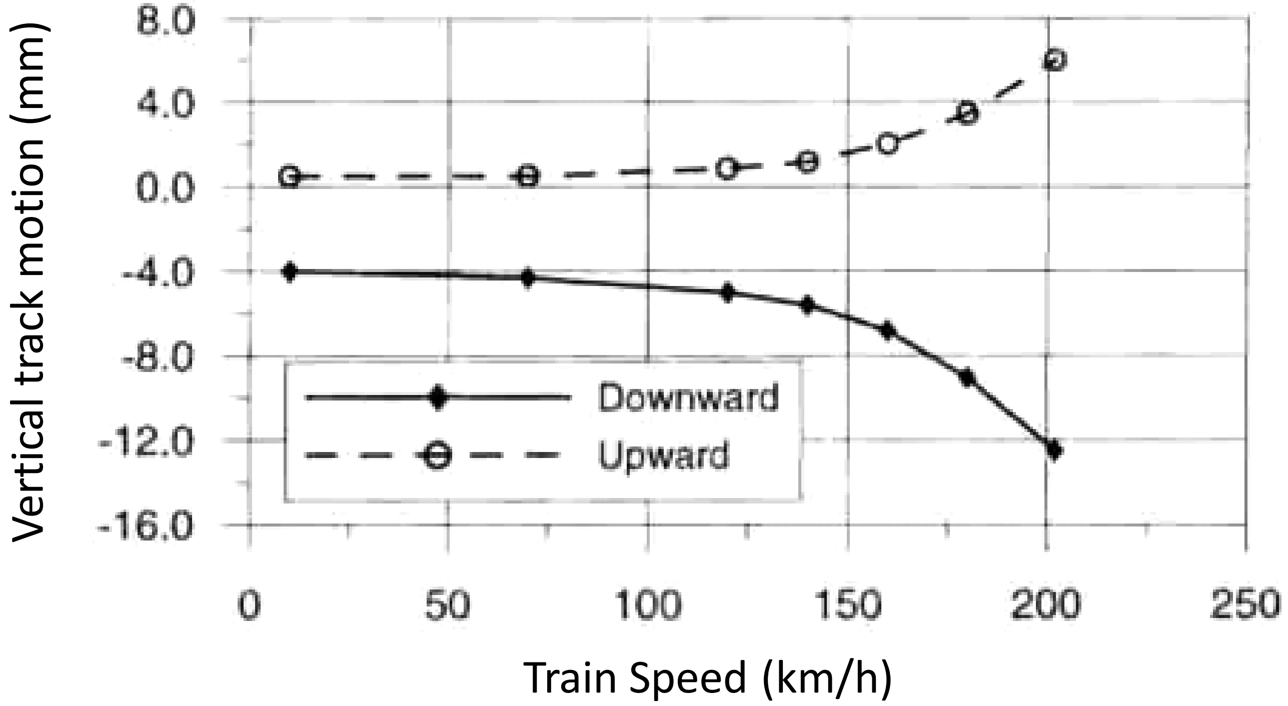
Thank you very much
for your kind attention

Understanding Critical Velocity Effects On High-Speed Railways

Alice Duley[1], William Powrie[1], David Thompson[1], Louis Le Pen[1]

1. University of Southampton, UK

What are critical velocity effects…



Madshus and Kaynia, 2000

- Excessive track and ground movement and vibration beneath train passage
- Speed of onset of extreme movement named 'critical speed/velocity'

Why are they a problem…

- Cause track and substructure damage
- Increased maintenance required
- Train running speeds may have to be lowered
- Bad press

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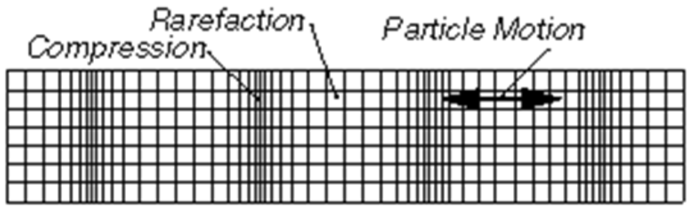
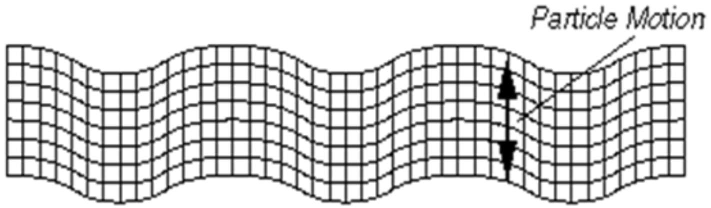
What causes critical velocity effects….



Compressional or P Wave



Shear or S Wave

Rayleigh Wave

Rayleigh = 90 to 95% of Shear

- Effects occur where train speed approaches or exceeds the grounds Rayleigh wave speed
- Rayleigh wave = combination of P and S waves
- Areas of soft material, e.g. peat or organic clay, can have shear wave speeds as low as 30 ms^{-1}, much lower than train speeds.

Project Aims:

- Improved understanding of the influence of various geotechnical parameters on critical velocity effects

- Aid in the improvement of :
  - the identification of potentially problematic locations,
  - simulation of track performance in pre and post-remediated states.

Project Areas:

Lab Testing:

- Standard density, moisture content etc measurements
- RC , BE & CT – stiffness, damping and wavespeeds, inc. variation with stress/strain and frequency

Field Instrumentation

- Ground vibration
- MASW – estimates of wavespeeds and stiffness profiles
- Sleeper movement

Movement and vibration prediction and mitigation design

Models

- WANDS: 2.5D FE/BE
- MOTIV: 2.5D semi-analytic
- More complex 3D models and non-linear models under development

Impact of parameter knowledge:

Very stiff

- no problem

Intermediate stiffness

- borderline problem
- linear modelling likely
- Remediation scoped in or out

Very soft

- obvious problem
- non-linear modelling likely (difficult, time-consuming)
- Remediation guaranteed

Potential for improvement / savings through improved parameter knowledge

Case Study Sites:

Very stiff

Intermediate stiffness

Very soft

Site B

- Ground movement ok at standard speeds
- Soft clays

Site A

- Excessive ground movement at high speed (200 kmh^{-1})
- Peat

Case Study Sites:

Site A

- Train movement measurements
- Very limited seismic measurements
- Boreholes
- Dynamic heavy probe
- Window sampling (2-3 bores, 6m depth). Peat

Site B

- Train movement measurements
- MASW measurements
- Boreholes
- Window sampling (2-3 bores, 6m depth). Soft clay

HS2

- Boreholes
- Future sampling type – unknown – soft clays?
- Possible seismic measurements

Site Monitoring – A:

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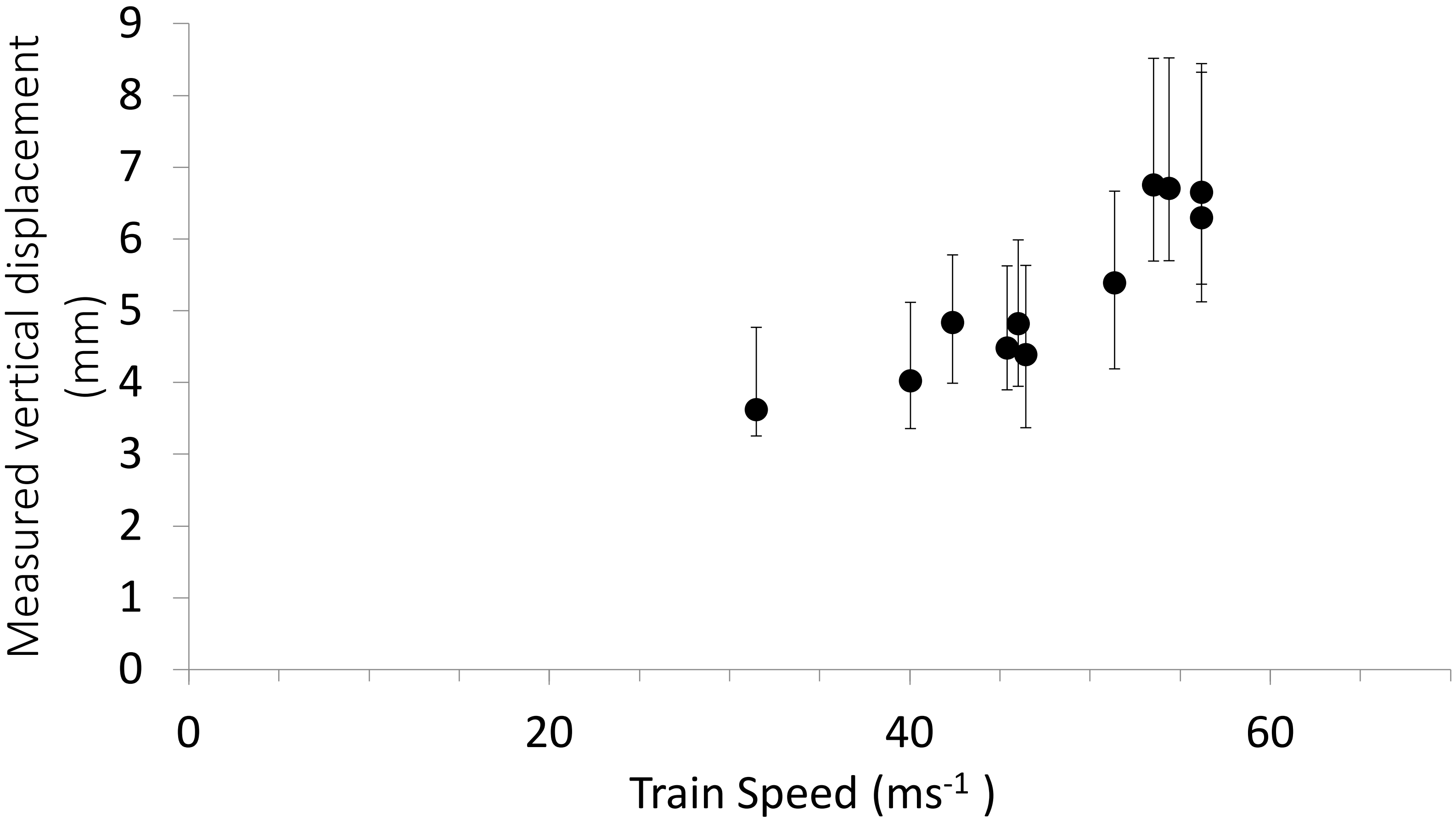


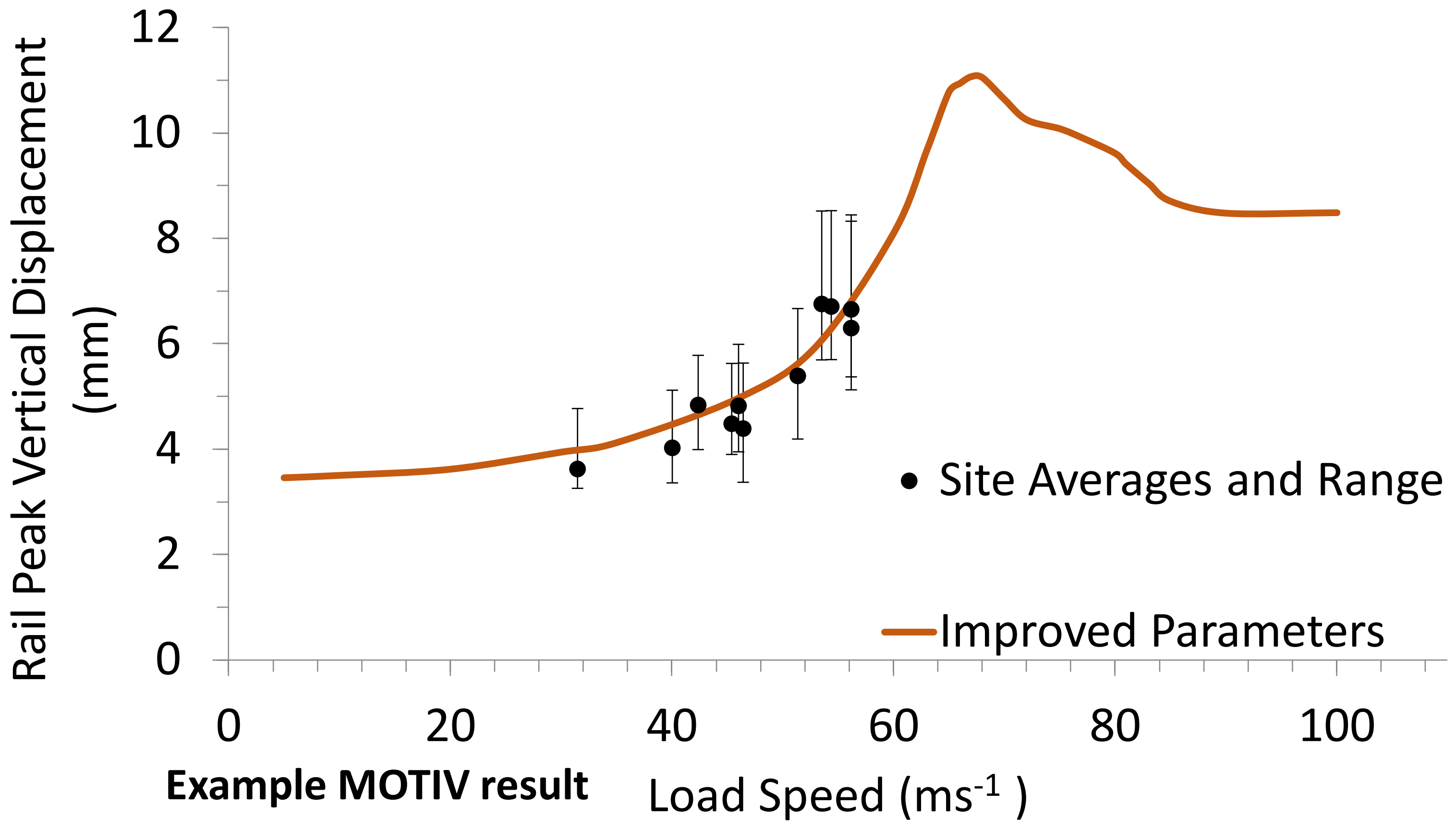
Previous Site Modelling – A:

WANDS:

- 2.5D FE/BE
- Wavenumber domain
- Track: FE ; Ground: BE

MOTIV:

- 2.5D semi-analytical
- Wavenumber domain
- Ground: Layered halfspace



Example MOTIV result

Lab Testing:

- Wavespeeds
- Damping
- Stiffness
- Non-linearity effects

Sample sizes:
38 , 50 or 70 mm diameter, up to 140 mm in height

Resonant Column

Bender Elements

Triaxial

Geotechpedia, 2012

GDS Instruments , 2016

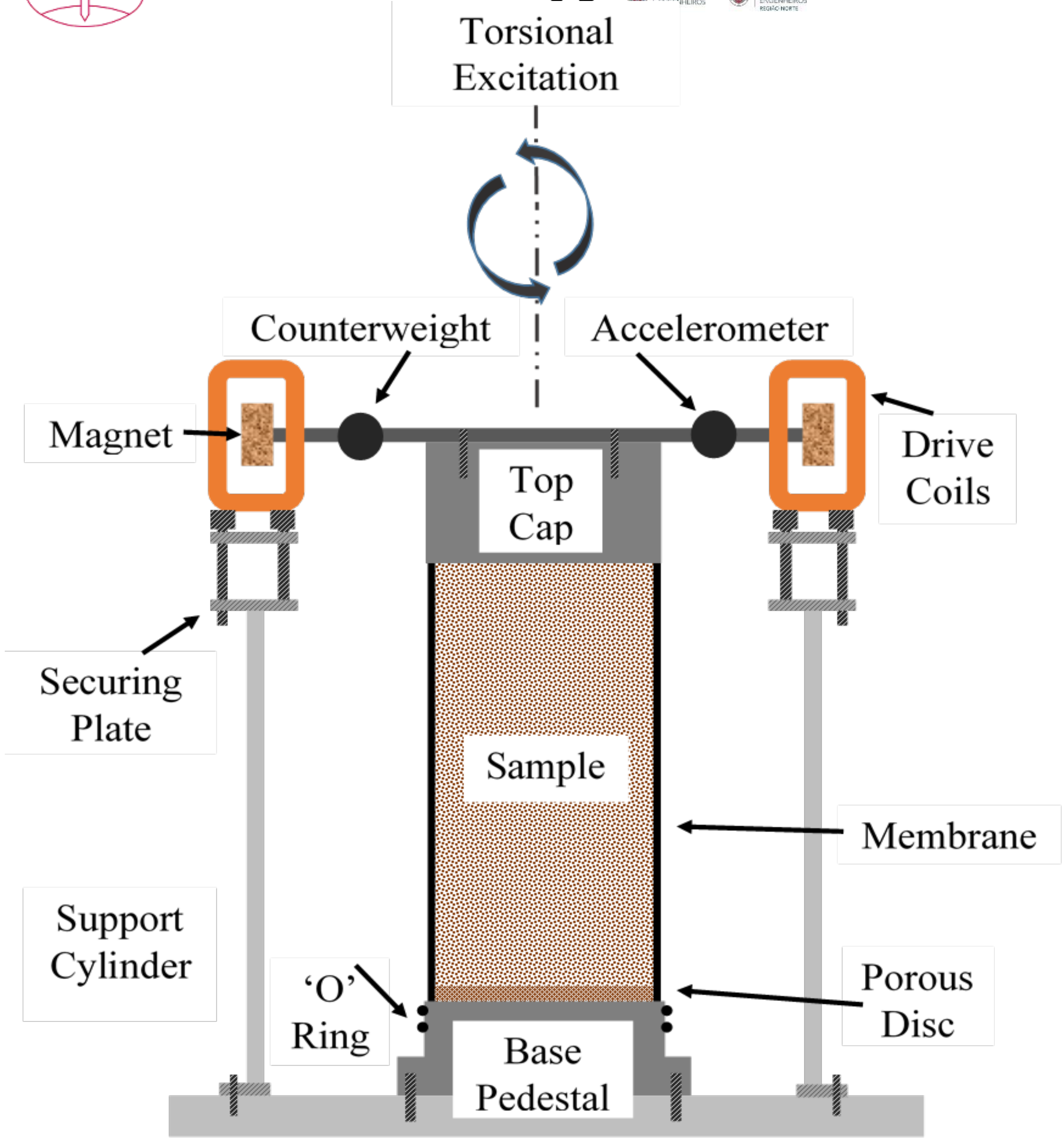
Resonant Column:

Provides key model inputs:

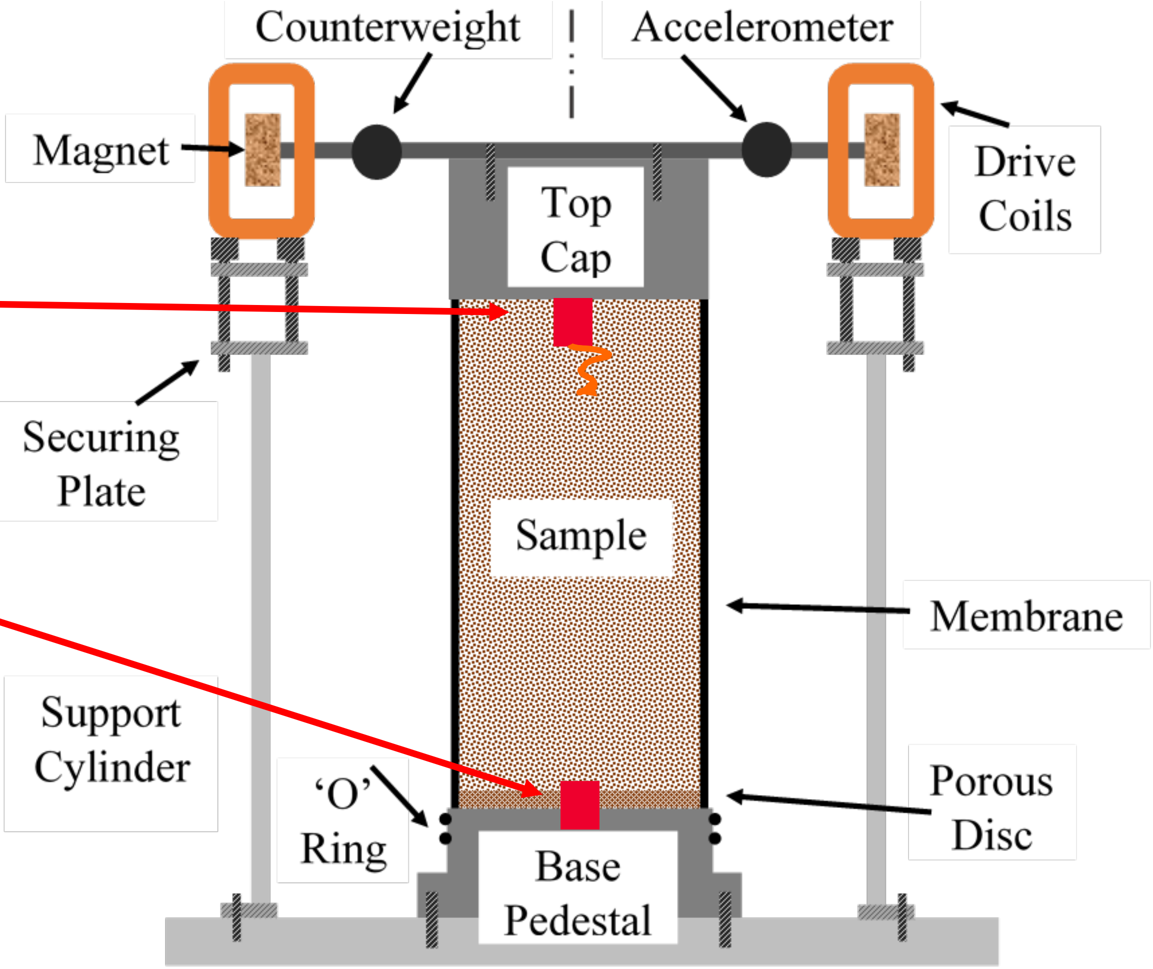
- Shear wave,
- compressional wave ,
- damping.
- (Shear modulus, Young's modulus)

Tests at varied strains -

- Shear modulus degradation curves – Strain dependant stiffness



Bender Elements:



Shear wave (and shear modulus) measurements → Comparison to RC values (at similar frequencies)

Triaxial:

Testing outputs:

- Critical state framework parameters - relatively untested materials
- Shear modulus degradation with strain – complex model inputs, also shows if non-linearity expected at site strains

Conclusions:

- Ground stiffness and shear wave speeds are essential parameters when modelling critical velocity effects.
- Accurate estimation of these parameters is essential when considering possible mitigation measures for marginal sites.
- Laboratory testing on a range of site samples will be carried out, and the resulting impact on model accuracy assessed.
- A combination of case studies, laboratory testing and modelling will provide recommendations for how best measure/predict key parameters for use in relatively ‘simple’ linear elastic models used as scoping tools.

Thankyou for listening!

References

- Geotechpedia (2012). Bender elements.[Image] Available at:http://geotechpedia.com/Images/Equipment/Controls_group_Bender_elements.jpg
- GDS Limited (2016). Triaxial. [Image] Available at:http://www.gdsinstruments.com/gds-products/gds-enterprise-level-dynamic-triaxial-testing-system
- Madshus, C. & Kaynia, A. M. (2000). High-speed railway lines on soft ground: dynamic behaviour at critical train speed. *Journal of Sound and Vibration,* 231,(3), pp. 689-701.

Use of data mining tools for cut soil slope condition state identification

Joaquim Tinoco[1], António Gomes Correia[1], Paulo Cortez[1], David Toll[2]

1. *University of Minho, Guimarães, Portugal*
2. *University of Durham, Durham, UK*

Outline

- Motivation & Goals
- Data characterization
- Metrics
- Methodology
- Results
  - Nominal classification
    - SMOTE
    - OVERSAMPLING
  - Regression approach
    - SMOTE for regression
- Final Remarks

Motivation & Goals

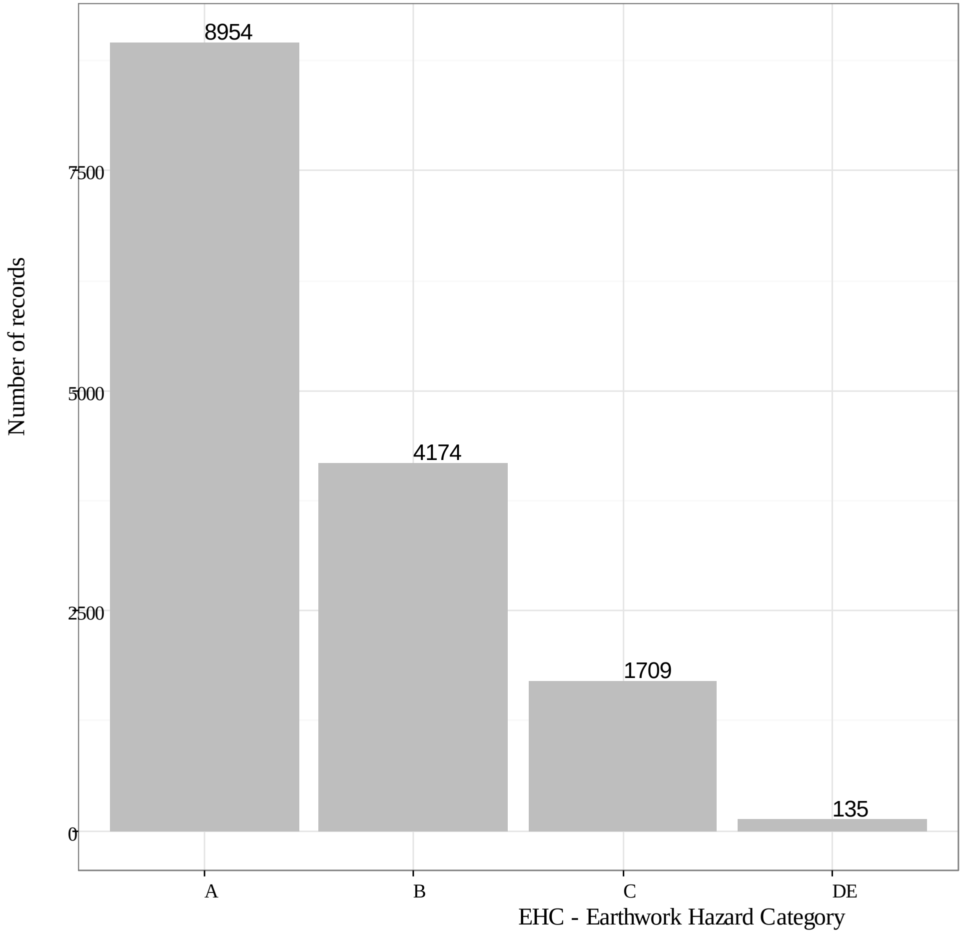
Use of data mining tools for slope condition state identification

Develop a slope classification system

• • •

- ✓ Based on advanced statistical analysis;
- ✓ Use of standard information usually collected during routine inspections;
- ✓ Label each slope into a pre-defined set of classes;
- ✓ Applicable during the slope exploitation phase.

Data characterization



✓ Slope data kindly made available by *UK NetworkRail*;

✓ *Very **unbiased data**! → **60%** of the slopes are classified as **A**;*

✓ More than 100 variables were considered as model inputs:

- Slope geometry;
- Existence of trees;
- Animal activity;
- Ground cover,;
- Number of dangerous trees;
- Root balls locations;
- ....

Metrics (model assessment)

Metrics:

- ✓ **CE** – classification error [0% ; 100%] (lower is better);
- ✓ **Average Utility Score (AUS)** [-Inf ; 1] (higher is better);
- ✓ **Recall** and **Precision** [0 ; 100%] (higher is better);
- ✓ **F1-score** – trade-off between recall and precision [0 ; 100%] (higher is better)

Cost benefits matrix (cbm):

Obs/Pred	A	B	C	DE
A	1	-4	-8	-16
B	-2	1	-4	-8
C	-4	-2	1	-4
DE	-8	-4	-2	1

Methodology

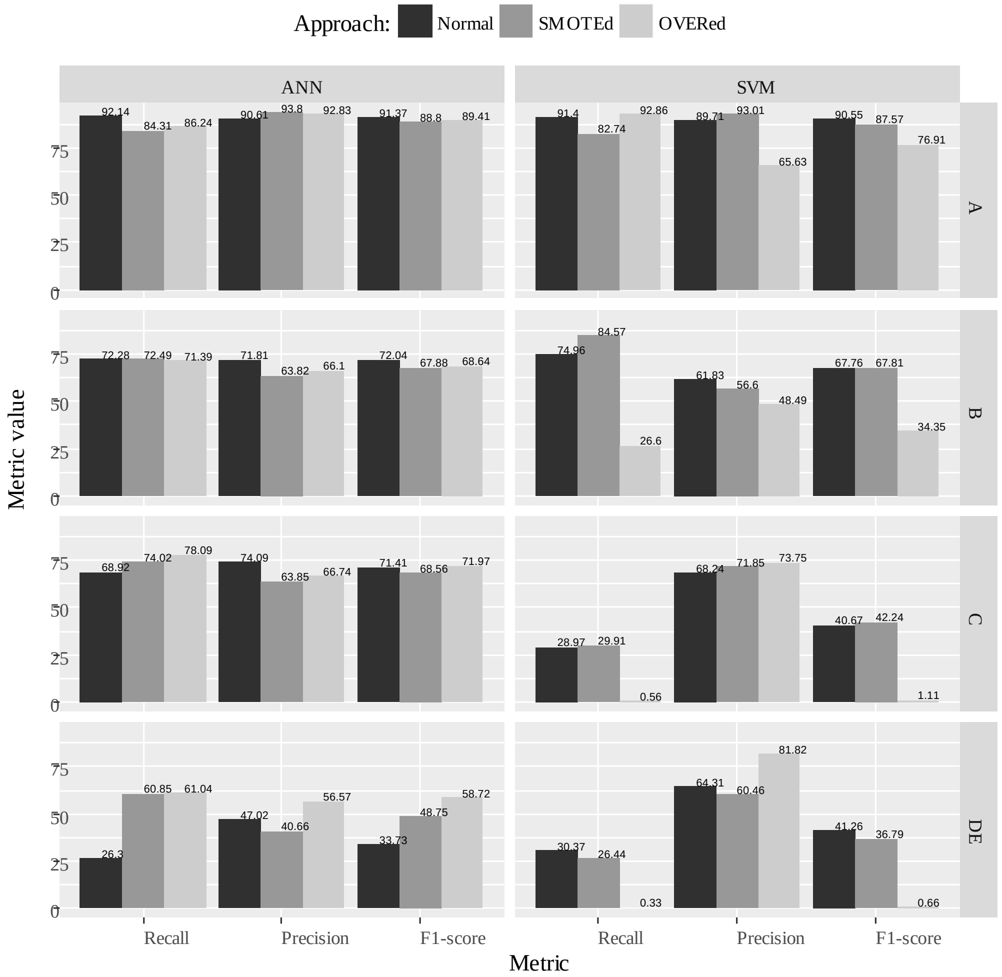
Modeling strategies:

- ✓ Nominal classification;
- ✓ Regression approach;

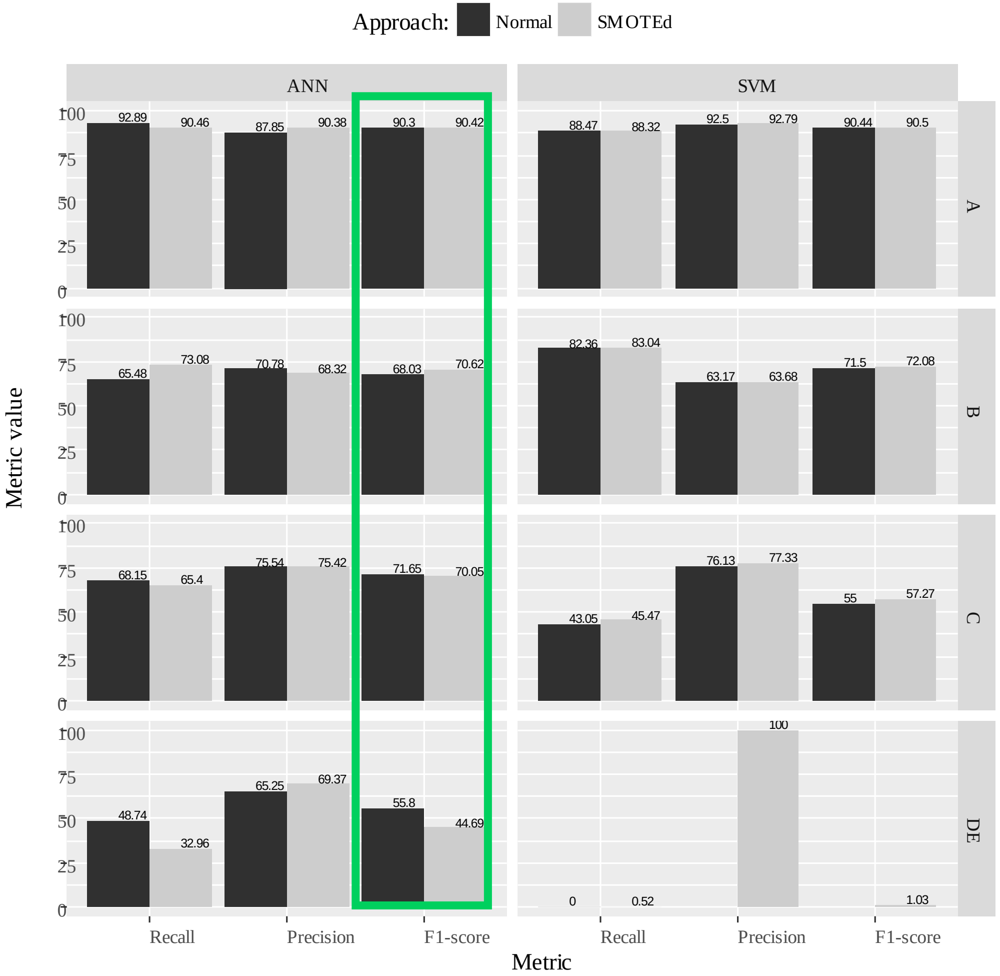
Unbalance data approaches:

- ✓ **SMOTE** – Synthetic Minority Over-sampling Technique : creates 'new data' by looking at nearest neighbors to establish a neighborhood and then sampling from within that neighborhood. It operates on the assumptions that the original data is similar because of proximity;
- ✓ **OVERSAMPLING** – randomly adds samples (with repetition) of the minority classes to the training data, such that the final training set is balanced;

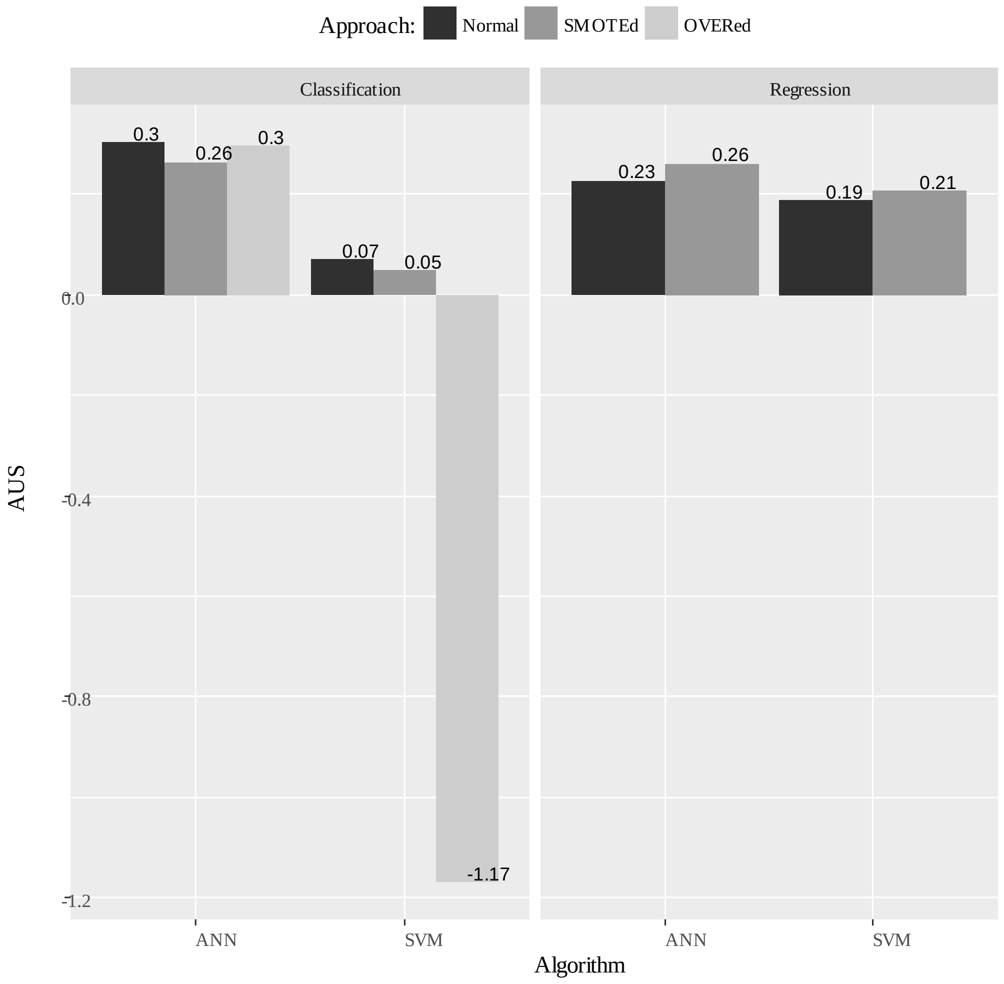
Nominal classification (metrics)



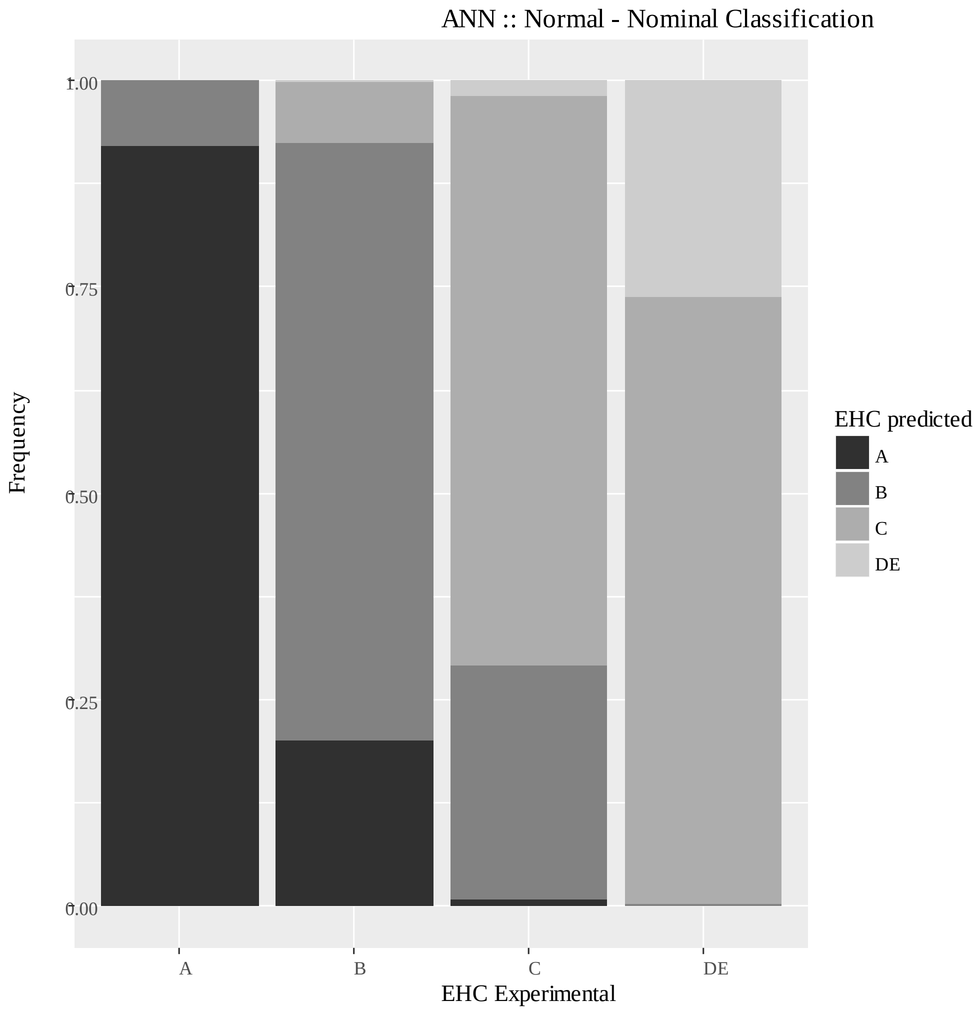
Regression (metrics)

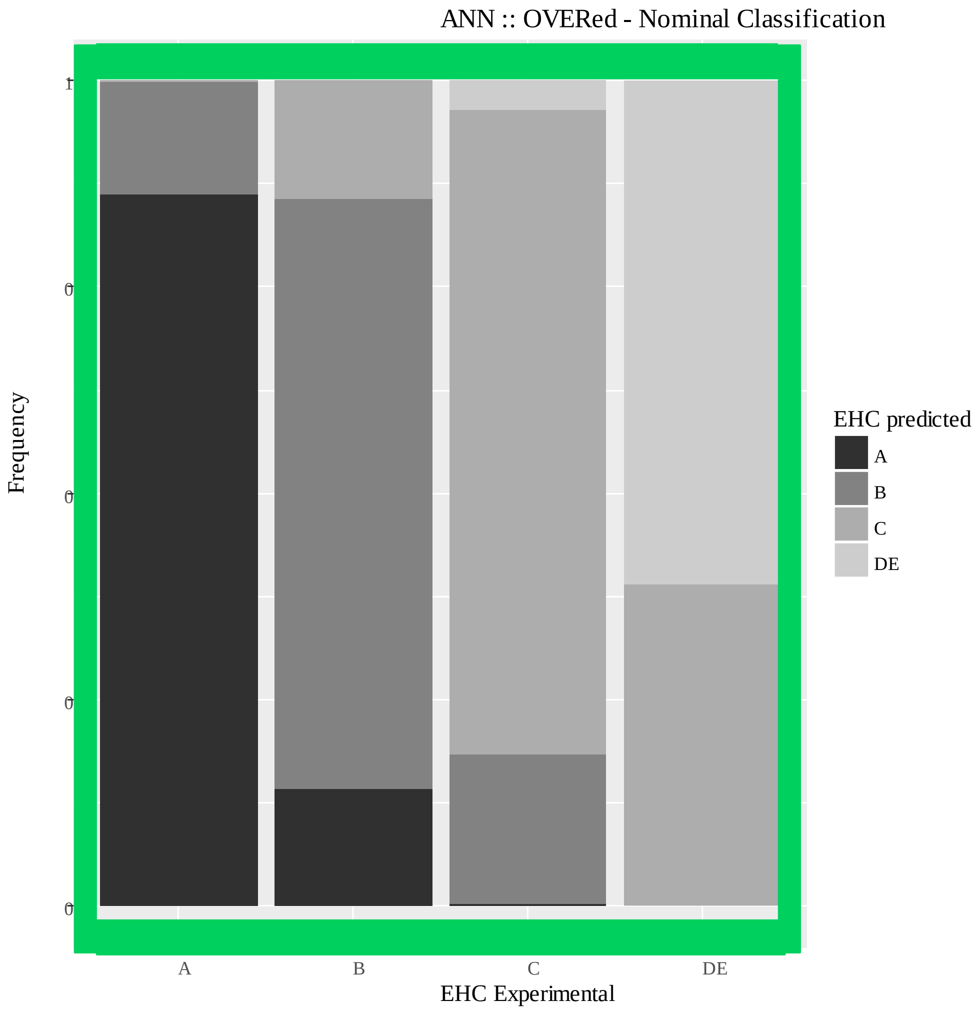


Classification vs Regression (AUS comparison)

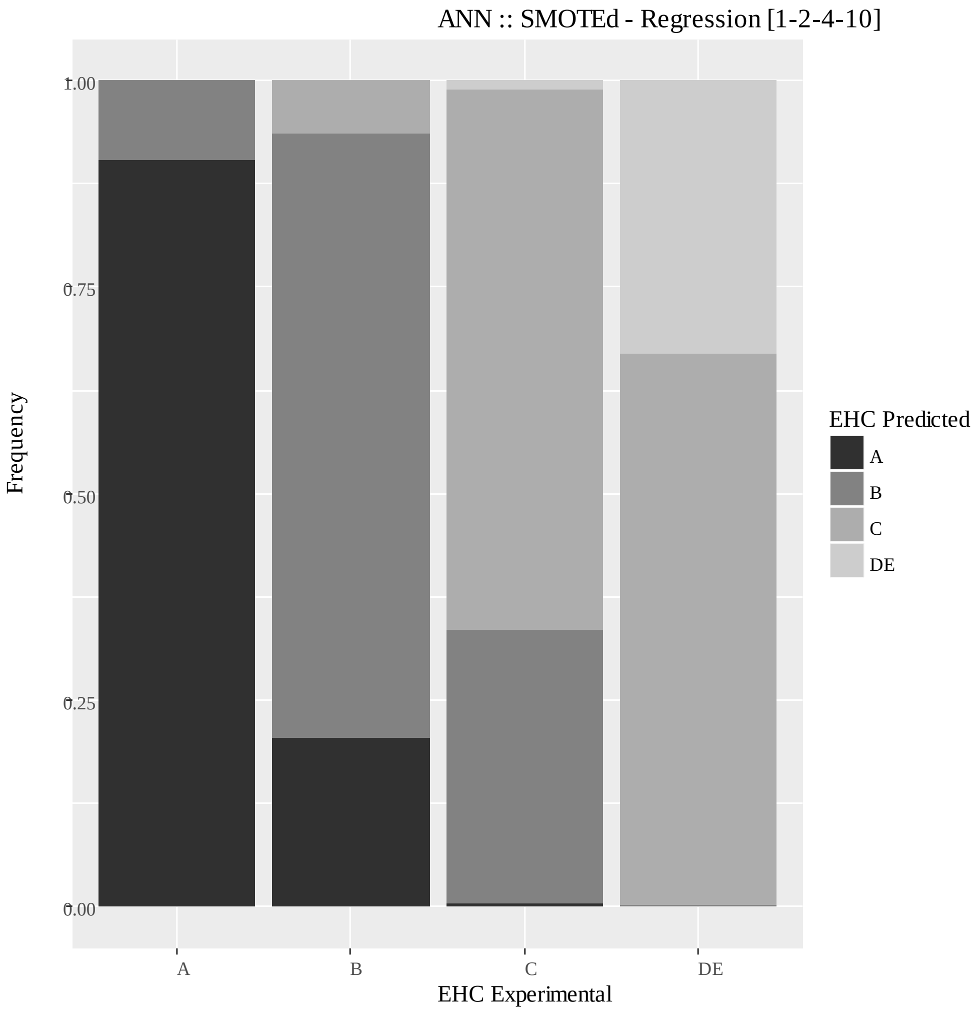


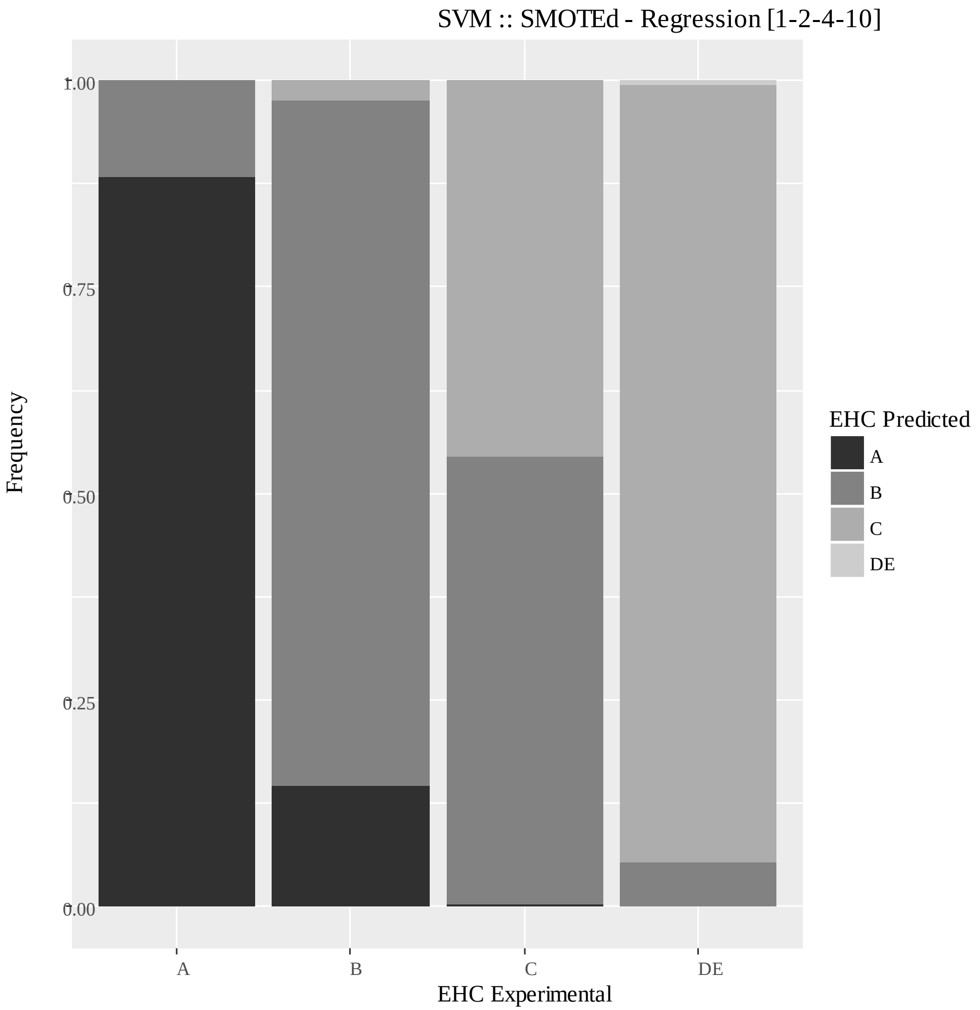
Classification performance





Regression performance





Final Remarks

- ✓ Although some lacks of accuracy, interesting results were achieved;
  - Good prediction for classes A and B;
  - Records of classes C and DE (highest probability of failure) when not correctly predicted are classified as belong to the closest class;
- ✓ It is important to assure that the defined EHC class is realistic → compare failure records database;
- ✓ Work on models accuracy improvement:
  - Feature selection techniques;
  - Optimization techniques.

Thank you for your Attention

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