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Soil Micro Mechanics, Department of Civil Engineering
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Research Interests

- **Bayesian uncertainty quantification** for geomechanical models at micro, meso, and macro scales
- **Coupled particle-continuum** modeling of granular materials in *multi-physical* processes
- **Micro-CT characterization** of multiphase porous materials using *image processing* and *deep learning*
- **Fluid-solid transition** of dense granular flows
- **Soil-water-root** interactions in the vadose zone under

Education

- **Hiroshima University, Japan** **Ph.D.**
2013–2016
Graduate School for International Development and Cooperation
Thesis: Multiscale characterization of geotextile-reinforced granular soil
- **Hiroshima University, Japan** **M.Eng.**
2011–2013
Graduate School for International Development and Cooperation
Thesis: Seismic response of buildings with soilbag-reinforced foundations

Employment

- **University of Twente, The Netherlands** 2020.11–present
Soil Micro Mechanics, Faculty of Engineering Technology, MESA+
Assistant Professor
- **University of Twente, The Netherlands** 2016.11–2020.10
Multi Scale Mechanics, Faculty of Engineering Technology, MESA+
Postdoctoral Researcher

Awards and Honors

- Plenary speaker at the *9th International Conference on Discrete Element Methods*, 2023, 09
- 2021 Top Reviewer Award from *Computers and Geotechnics*, 2023, 02
- Guest Editor of *Acta Mechanica Sinica*, 2022–2023
- Excellent Paper (Junior) from *International Association for Computer Methods and Advances in Geomechanics*, 2022, 08
- Guest Editor of *Computers and Geotechnics*, 2019–2021
- 2018 Top Downloaded Article in *Granular Matter*, 2019, 04
- Best Student Paper at the *7th International Conference on Discrete Element Methods (DEM7)*, 2016, 08
- Japanese Government (Monbukagakusho: MEXT) Scholarship, 2011, 10

Grants

1. **Principal Investigator, Deputy Coordinator** **€ 2.8M (823k)**
2024.03–2026.02
Marie Skłodowska-Curie Actions Doctoral Networks, Horizon Europe, EU
POSEIDON: Improve offshore infrastructure resilience against geohazards towards a changing climate
With Univ. Warwick, Univ. Liverpool, Univ. Kiel, Univ. Bremen, Norwegian Geotech. Inst., and IFREMER

2. **Principal Investigator** € 42.5K
Small-Scale Initiative in Machine Learning, The Netherlands eScience Center, NL 2023.10–present
 U-Net segmentation of 3D micro-CT images of rooted soils using label data from multi-physics simulators
3. **Co-Principal Investigator** € 25K
Crazy Research Call 2022, University of Twente, NL, with F. Anselmucci (University of Twente) 2023.02–present
 Bio-inspired burrowing robot for soil penetration in limited-access sites
4. **Principal Investigator** € 85K
Open eScience Call 2021, The Netherlands eScience Center, NL 2022.03–2023.06
 An artificial brain for interpreting and accelerating physics-based simulations of granular materials
5. **Principal investigator** Start-up package (€263K)
Sectorplan Bèta en Techniek, The Netherlands 2021.07–present
 Towards climate resilience for geomaterials: a multi-disciplinary investigation

Open-Source Research Software Development

Uncertainty Quantification and Machine Learning:	GrainLearning
Granular Solids and Fluids:	YADE, MercuryDPM
Fluid-Coupled Particle Systems:	LB3D
Particle-Continuum Coupling:	MercuryDPM–Oomph-lib, YADE-escript
Machine Learning:	Scikit-learn, Keras/TensorFlow
Image Processing:	ImageJ, OpenCV
Project Management:	DevOps methodologies, CI/CD, GitHub Actions

International Collaborations

- Prof. Jens Harting**
Professor, Helmholtz Institute Erlangen-Nürnberg for Renewable Energy, Germany 2017–present
 Coupled discrete element-lattice Boltzmann method for direct numerical simulations of unsaturated soils
- Dr. Klaus Thoeni**
Associate Professor, University of Newcastle, Australia 2014–present
 Discrete element modeling of deformable wires, fibers, and geosynthetics
- Dr. Takayuki Shuku**
Associate Professor, Okayama University, Japan 2015–present
 Bayesian uncertainty quantification and data assimilation for geomechanical and geotechnical models
- Prof. Jin Ooi**
Professor, University of Edinburgh, UK 2022–present
 Up- and down-scaling of particulate materials via the Arlequin method and coarse-graining
- Dr. Ning Guo**
Assistant Professor, Zhejiang University, China 2016–present
 Hierarchical multi-scale modeling of soil-structure interactions
- Dr. Pamela Tempone**
Geomechanics Specialist, ENI Exploration & Production, Milano, Lombardy, Italy 2016–2018
 Machine learning-based image analysis, wave propagation in reservoir rocks
- Prof. Haruyuki Yamamoto**
Professor, Hiroshima University, Japan 2013–2016
 Multiscale modeling and characterization of geosynthetic-reinforced granular soils

Languages

Chinese:	Mother
English:	Advanced (C1)
Japanese:	Intermediate (N3)
Dutch:	Beginner (A1)
Programming:	C++, Fortran, Python, Matlab

Teaching

University of Twente

2021–present	Smart Cities – Multifunctional Flood Defences, Civil Engineering Bachelor's program, 15EC (1.5EC)	Developed the Geotechnics expert topic and assignment
2020–present	Geo Risk Assessment, Civil Engineering Master's program, 5EC	Redesigned and redeveloped of the entire course
2017–2021	Advanced Programming in Engineering, Mechanical Engineering Master's program, 5EC (0.5EC)	Image analysis lectures and assignment
2017–2022	Granular Matter (201400194), Mechanical Engineering Master's program, (Guest lectures)	Soil constitutive modeling
2017–2018	Multiphase Flows (201400300), Mechanical Master's program	Coordinator

Hiroshima University

2013–2016	Final year project, Civil Engineering Bachelor's program	Supervisor
2013–2016	Geotechnical laboratory tests, Civil Engineering Bachelor's program	Teaching Assistant

Supervision

PhD students (daily supervisor)

2021–present	Retief Lubbe, <i>Continuum-DEM modelling of fluid-solid transition in weakly compacted systems of polydisperse particles of varying shapes</i> , Chair of Soil MicroMechanics, University of Twente
2021–present	Sherrin Joseph, <i>Noise and Vibration in Wet Soil: Micromechanical modelling for smart mitigation strategies</i> , Chair of Soil MicroMechanics, University of Twente
2019–present	Juan Alvarez Naranjo, <i>Multiscale thermo-elasto-plastic modelling of the selective laser sintering process</i> , Multi-Scale Mechanics Group, University of Twente
2019–2020	Fan Jia (visiting PhD), <i>Micromechanical modeling and laboratory testing of soilbags and soilbag-reinforced geostructures</i> , College of Water Conservancy and Hydropower Engineering, Hohai University

Postdocs / Research Engineers (co-supervisor)

2021–present	Floriana Anselmucci, <i>Impact of wetting-drying cycles on the hydro-mechanical behaviour of vegetated soil</i> , Chair of Soil MicroMechanics, University of Twente
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Postdocs / Research Engineers (main supervisor)

2022–2023	Luisa Orozco, <i>Fast and efficient Bayesian parameter estimation for discrete element method simulations using a hybrid data-driven and physics-based framework</i> , Netherlands eScience Center
2022–2023	Aron Jansen, <i>Deep learning surrogates for accelerating particle-scale simulations of granular materials</i> , Netherlands eScience Center

MSc students

2021	Wouter Kampman, <i>The effect of infiltration by wave overtopping on the macro-stability of a dike</i> , Civil Engineering and Management MSc programme, University of Twente
2023	Arjen Zagema, <i>The dike safety assessment for risks of an incorrectly installed vinyl heave screen using bow-tie method</i> , Civil Engineering and Management MSc programme, University of Twente
2014	Shiichi Okano, <i>On the dynamic properties of soilbag assemblies in shaking table experiments</i> , School of Engineering, Hiroshima University
2015	Kazuma Yokura, <i>Crushing characteristics of Toyoura sand under high-pressure true triaxial conditions</i> , School of Engineering, Hiroshima University

BSc students

2023	Niels van Dongen, <i>The effect of fluidizing and predrilling on soil surrounding sheet piles</i> , Civil Engineering BSc programme, University of Twente
2015	Futami, <i>Experimental investigation of soilbag-structure interaction under cyclic loading</i> , School of Engineering, Hiroshima University

Web of Science Profile Summary

Total documents	27
Web of Science Core Collection publications	21
Verified peer reviews	141
Verified editor records	2

Invited Talks

- Plenary lecture, travel expenses and conference registration covered** Erlangen, Germany
1. *Integrating data and modeling with Bayesian statistics for predictive computational granular mechanics* 2023
Invited by International Scientific Committee of the 9th International Conference on Discrete Element Methods
- Invited talk, travel expenses and workshop registration covered** Tokyo, Japan
2. *Uncertainty quantification for multi-scale models of geomaterials: an iterative Bayesian approach* 2019
Invited to Workshop "Recent Developments of Discrete Particle Simulation for Geotechnical Engineering" by the Japanese Geotechnical Society
- Invited talk, travel expenses and scientific visit covered** Okayama, Japan
3. *Direct numerical simulation of wave propagation in dry and saturated granular media* 2019
Invited by Takayuki Shuku of Graduate School of Environment and Technologies, Okayama University
- Invited talk, travel expenses and scientific visit covered** Pisa, Italy
4. *Discrete element method for modeling wave propagation in dry and saturated granular media* 2018
Scientific Visit awarded by Department of Earth Sciences, University of Pisa

Conference/Symposium Organization

- 25th Engineering Mechanics Symposium, EM 2022 Arnheim, The Netherlands
◦ *Co-organizer of Workshop "Trends and Challenges in Machine Learning"* September 2022
with Iuri Rocha (TU Delft), Michael Abdelmalik (TU/e), and Francesco Maresca (University of Groningen)
- 15th World Congress on Computational Mechanics, WCCM 2022 Yokohama, Japan
◦ *Organizer of Mini-Symposium "Computational Granular Mechanics"* July 2022
with Klaus Thoeni (University of Newcastle), Xue Zhang (University of Liverpool), and Vanessa Magnanimo (University of Twente)
- 8th International Conference on Discrete Element Methods Enschede, The Netherlands
◦ *Co-organizer of Mini-Symposium "Open-source development"* July 2019
with A.R. Thornton (University of Twente)

Journal Editor

- Acta Mechanica Sinica Springer
◦ *Guest Editor of Thematic Issue "Computational Mechanics of Granular Materials"* 2022–2023
with Xiaoyan Ye (Lanzhou University)
- Computers and Geotechnics Elsevier
◦ *Guest Editor of Special Issue "Emerging Trends in Discrete-based Modeling and Characterization of Geotechnics"* 2019–2021
with Jidong Zhao (Hong Kong University of Science and Technology) and Catherine O'Sullivan (Imperial College London)

Journal Papers (* Corresponding author)

- Cheng, H.* , Luding, S. , & Weinhart, T. (2023). CG-enriched concurrent multi-scale modeling of dynamic surface interactions between discrete particles and solid continua. *Acta Mechanica Sinica*, 39(1), [722218].
- Cheng, H.* , Thornton, A. R. , Luding, S., Hazel, A. L. , & Weinhart, T. (2023). Concurrent multi-scale modeling of granular materials: Role of coarse-graining in FEM-DEM coupling. *Computer methods in applied mechanics and engineering*, 403(Part A), [115651].
- Ye, X. , & Cheng, H* . (2023). Trending topics in computational mechanics of granular materials: from fundamentals to applications. *Acta Mechanica Sinica*, 39(1), [722903].

4. Lubbe, R., Xu, W. J., Zhou, Q. , & **Cheng, H.** (2022). Bayesian Calibration of GPU-based DEM meso-mechanics Part II: Calibration of the granular meso-structure. *Powder technology*, 407, [117666].
5. Lubbe, R., Xu, W. J., Zhou, Q. , & **Cheng, H.** (2022). Bayesian calibration of GPU-based DEM meso-mechanics Part I: Parallelization of RVEs. *Powder technology*, 407, [117631].
6. Ostanin, I. , **Cheng, H.** , & Magnanimo, V. (2022). Simulation-guided optimization of granular phononic crystal structure using the discrete element method. *Extreme Mechanics Letters*, 55, [101825].
7. **Cheng, H.***, Anselmucci, F. A. R. , Fan, X. , Zeng, Y. , Luding, S. , & Magnanimo, V. (2022). Down to the root of vegetated soil: challenges and the state-of-the-art. *Papers in Physics*, 14, [140014].
8. Hartmann, P. , **Cheng, H.**, & Thoeni, K. (2022). Performance study of iterative Bayesian filtering to develop an efficient calibration framework for DEM. *Computers and Geotechnics*, 141, [104491].
9. Alvarez, J. E., Snijder, H. , Vaneker, T. , **Cheng, H.** , Thornton, A. R. , Luding, S. , & Weinhart, T. (2022). Visco-elastic sintering kinetics in virgin and aged polymer powders. *Powder technology*, 397, [117000].
10. O’Sullivan, C. , **Cheng, H.**, & Zhao, J. (2021). Use of DEM in geomechanics: Special issue associated with the DEM 8 conference. *Computers and Geotechnics*, 137, [104167].
11. Recchia, G. , Magnanimo, V. , **Cheng, H.**, & La Ragione, L. (2020). DEM simulation of anisotropic granular materials: elastic and inelastic behavior. *Granular matter*, 22(4), [85].
12. Weinhart, T., Orefice, L., Post, M., van Schroyen Lantman, M., Denissen, I., Tunuguntla, D., Tsang, JFM., **Cheng, H.**, Shaheen, Y., Shi, H., Rapino, P., Grannonio, E., Losacco, N., Barbosa, J., Jing, L., Alvarez Naranjo, J., Roy, S., den Otter, W., & Thornton A.R. (2020). Fast, flexible particle simulations — An introduction to MercuryDPM. *Computer physics communications*. 249:107129.
13. Wu, Y., Yamamoto H., Cui, J., & **Cheng, H.** (2020). Influence of load mode on particle crushing characteristics of silica sand at high stresses. *International Journal of Geomechanics* 20(3):04019194.
14. **Cheng, H.***, Luding, S., Saitoh, K. & Magnanimo, V. (2020). Elastic wave propagation in dry granular media: effects of probing characteristics and stress history. *International Journal of Solids and Structures*. 187:85–99.
15. Sajeva, A., Capaccioli, S., & **Cheng, H.** (2019). Strain-accumulation mechanisms in sands under isotropic stress. *Journal of Geophysics and Engineering*. 16(6):1139-1150.
16. **Cheng, H.***, Luding, S., Rivas, N., Harting, J. & Magnanimo, V. (2019). Hydro-micromechanical modeling of wave propagation in saturated granular crystals. *International Journal for Numerical and Analytical Methods in Geomechanics*. 43(5): 1115–1139.
17. **Cheng, H.***, Shuku, T., Thoeni, K., Tempone, P., Luding, S. & Magnanimo, V. (2018). An iterative Bayesian filtering framework for fast and automated calibration of DEM models. *Computer Methods in Applied Mechanics and Engineering*. 350:268–294.
18. **Cheng, H.***, Shuku, T., Thoeni, K. & Yamamoto, H. (2018). Probabilistic calibration of discrete element simulations using the sequential quasi-Monte Carlo filter. *Granular Matter* 20(1) 11.
19. **Cheng, H.***, Yamamoto, H., Thoeni, K. & Wu, Y. (2017). An analytical solution for geotextile-wrapped soil based on insights from DEM analysis. *Geotextiles and Geomembranes*. 45(4):361–376.
20. **Cheng, H.***, Yamamoto, H. & Thoeni, K. (2016). Numerical study on stress states and fabric anisotropies in soilbags using the DEM. *Computers and Geotechnics* 76: 170–183.

Book Chapters

1. **Cheng, H.** & Yamamoto, H. (2016). Evaluating the performance of geotextile wrapped/layered soil: a comparative study using the DEM. *Geo-China 2016: Geosynthetic Civil Infrastructure, Disaster Monitoring, and Environmental Geotechnics*: 122–130.
2. **Cheng, H.**, Yamamoto, H., Jin, S. & Okano, S. (2013). Soil reinforcement using soilbags — A preliminary study on its static and dynamic properties. *Geotechnics for Sustainable Development*: 569–578.

Refereed Conference Proceedings

1. Alvarez Naranjo, J. E. , **Cheng, H.**, Snijder, H., Vaneker, T. , Luding, S. , & Weinhart, T. (2021). Neck growth kinetics during polymer sintering for powder-based processes. In *Powders & Grains 2021 – 9th International Conference on Micromechanics on Granular Media* (EPJ Web of Conferences; Vol. 249).

2. **Cheng, H.**, Luding, S., Harting, J. , & Magnanimo, V. (2021). Direct numerical simulation of wave propagation in saturated random granular packings using coupled LBM-DEM. In *Powders & Grains 2021 – 9th International Conference on Micromechanics on Granular Media* [14003] (EPJ Web of Conferences; Vol. 249).
3. **Cheng, H.**, Magnanimo, V., Shuku, T. , Luding, S. , & Weinhart, T. (2021). Bayesian Uncertainty Quantification for Geomechanical Models at Micro and Macro Scales. In M. Barla, A. Di Donna, & D. Sterpi (Eds.), *Challenges and Innovations in Geomechanics: Proceedings of the 16th International Conference of IACMAG - Volume 1* (pp. 837-845). (Lecture Notes in Civil Engineering; Vol. 125). Springer.
4. Jia, F. , **Cheng, H.**, Liu, S. , & Magnanimo, V. (2021). Elastic wave velocity and attenuation in granular material. In *Powders & Grains 2021 – 9th International Conference on Micromechanics on Granular Media* (EPJ Web of Conferences; Vol. 249).
5. Recchia, G. , **Cheng, H.** , Magnanimo, V., & La Ragione, L. (2021). Failure in granular materials based on acoustic tensor: a numerical analysis. In *Powders & Grains 2021 – 9th International Conference on Micromechanics on Granular Media* (EPJ Web of Conferences; Vol. 249).
6. Thornton, A.R., Post, M., Orefice, L., Rapino, P., Roy, S., Polman, H., Shaheen, Y., Alvarez Naranjo, J., **Cheng, H.**, Jing, L., Shi, H., Mbaziira, J., Roeplal, & Weinhart, T. (2019). Faster, more flexible particle simulations: The future of MercuryDPM. In *Proc. 8th International Conference on Discrete Element*. Enschede, The Netherlands.
7. **Cheng, H.**, Shuku, T., Thoeni, K., Tempone, P., Luding, S. & Magnanimo, V. (2018). Grain learning: Bayesian calibration of DEM models and validation against elastic wave propagation. In *China Europe Conference on Geotechnical Engineering*: 132-135. Vienna, Austria.
8. **Cheng, H.**, Shuku, T., Thoeni, K., Tempone, P., Luding, S. & Magnanimo, V. (2018). An iterative sequential Monte Carlo filter for Bayesian calibration of DEM models. In *9th European Conference on Numerical Methods in Geotechnical Engineering*: 381–389. Porto, Portugal.
9. **Cheng, H.**, Pellegrino, A. & Magnanimo, V. (2017). Bayesian calibration of microCT-based DEM simulations for predicting the effective elastic response of granular materials. In *PARTICLE-BASED METHODS V Fundamentals and Applications*. Hanover, Germany.
10. **Cheng, H.**, Shuku, T., Thoeni, K. & Yamamoto, H. (2017). Calibration of micromechanical parameters for DEM simulations by using the particle filter. In *EPJ Web of Conferences*: 140 12011. Montpellier, France.
11. **Cheng, H.**, Yamamoto, H., Guo, N. & Huang, H. (2016). A simple multiscale model for granular soils with geosynthetic inclusion. In *Proceedings of 7th International Conference on Discrete Element Methods (DEM7)*: 445–453. Dalian, China.
12. **Cheng, H.*** & Yamamoto, H. (2016). Modeling microscopic behavior of geotextile-wrapped soil by discrete element method. *Japanese Geotechnical Society Special Publication 2*(65): 2215–2220.
13. **Cheng, H.** & Yamamoto, H. (2015). Discrete modeling of geotextile-wrapped soil under simple shear. In *PARTICLE-BASED METHODS IV Fundamentals and Applications*: 485–496. Barcelona, Spain.
14. Yamamoto, H. & **Cheng, H.** (2012). Development study on device to reduce seismic response by using soil-bags assemblies. In *Research, Development and Practice in Structural Engineering and Construction*: 597–602. Perth, Australia.

Non-refereed papers & talks

1. Rocha, I., Abdelmalik, M. , **Cheng, H.**, & Maresca, F. (2022). Trends and Challenges in "Machine Learning" (Workshop 1). In R. A. M. F. van Oortorst, & A. J. J. T. van Litsenburg (Eds.), *Twenty-fifth Engineering Mechanics Symposium*, October 25-October 26, 2022. Hotel Papendal, Arnhem, Netherlands.
2. Joseph, S. , Luding, S. , Magnanimo, V. , **Cheng, H.**, & Harting, J. (2022). Noise and Vibration in Wet Soil: Micromechanical modelling for smart mitigation strategies. Poster session presented at *25th Engineering Mechanics Symposium, EM 2022*, Arnhem, Netherlands.
3. Lubbe, R. , Magnanimo, V. , Luding, S. , **Cheng, H.**, & Gupta, P. (2022). Continuum-DEM modelling of fluid-solid transition in weakly compacted systems of polydisperse particles of varying shapes. Poster session presented at *25th Engineering Mechanics Symposium, EM 2022*, Arnhem, Netherlands.
4. **Cheng, H.** (2022). On the use of coarse-graining to bridge the discrete and continuum descriptions of granular materials. Abstract from *10th International Conference for Conveying and Handling of Particulate Solids 2022*, Salerno, Italy.
5. Anselmucci, F. A. R. , **Cheng, H.** , Zeng, Y. , & Magnanimo, V. (2022). Quantifying hydro-mechanical properties of vegetated soil. Poster session presented at *25th Engineering Mechanics Symposium, EM 2022*, Arnhem, Netherlands.

6. Anselmucci, F. , **Cheng, H.** , Zeng, Y. , Fan, X. , & Magnanimo, V. (2022). Impact of wetting-drying cycles on the hydro-mechanical behaviour of vegetated soil. Abstract from *EGU General Assembly 2022*, Vienna, Austria.
7. **Cheng, H.**, Shuku, T., Weinhart, T., & Luding, S. (2019). GrainLearning: an efficient Bayesian uncertainty quantification framework for discrete element simulations of granular materials. In *8th International Conference on Discrete Element Methods (DEM8)*. Enschede, Netherlands.
8. **Cheng, H.**, Luding, S., Harting, J., & Magnanimo, V. (2019). Direct simulation of wave propagation in fully saturated granular packings using coupled LBM-DEM. In *8th International Conference on Discrete Element Methods (DEM8)*. Enschede, Netherlands.
9. **Cheng, H.**, Shuku, T., Thoeni, K., Tempone, P., Luding, S. & Magnanimo, V. (2018). A Bayesian calibration toolbox for YADE. In *2nd Yet Another Discrete Element Workshop – Discrete-based modeling of multi-scale coupled problems*: 59–60. Aix-en-Provence, France.
10. **Cheng, H.**, Luding, S., Rivas, N., Harting, J. & Magnanimo, V. (2018). Coupled subpore-scale hydro-mechanical modeling of wave propagation in saturated granular media. In *micro to MACRO mathematical modelling in soil mechanics*. Reggio Calabria, Italy.
11. **Cheng, H.**, Guo, N. & Yamamoto, H. (2017). Multiscale modeling of large deformation in geosynthetic-reinforced granular soils. In *ALERT Geomaterials Workshop 2017*. Aussois, France.
12. **Cheng, H.**, Shuku, T. & Yamamoto, H. (2016). Parameter identification for DEM models of cohesionless granular soil using the particle filter. In *Proceedings of 51th Japanese Geotechnical Engineering Society Annual Meeting*. Okayama, Japan.
13. **Cheng, H.** & Yamamoto, H. (2016). A multiscale approach for modeling soil-geosynthetic interaction. In *Proceedings of Annual Research Meeting Chugoku Chapter, Architectural Institute of Japan*, 39: 365–368.
14. **Cheng, H.** & Yamamoto, H. (2014). Hysteretic behaviors of soil-bag layer under irregular cyclic shear. In *Proceedings of Annual Research Meeting Chugoku Chapter, Architectural Institute of Japan*, 37: 61–64.
15. **Cheng, H.** & Yamamoto, H. (2013). Dynamic analysis of base isolation with soilbags. In *Proceedings of Annual Research Meeting Chugoku Chapter, Architectural Institute of Japan*, 36: 183–186.