

Nguyen, An Danh; Hachemi, Abdelkader; Weichert, Dieter

Application of the interior-point method to shakedown analysis of pavements. (English)

Zbl 1195.74018

Int. J. Numer. Methods Eng. 75, No. 4, 414-439 (2008).

Summary: Based on the lower-bound shakedown theorem by Melan, a method to analyse pavements under cyclic, in particular, rolling contact loading is presented. Repeated sliding/rolling line contact as well as repeated stationary contact is considered. The material is assumed to be rate-independent elastic – plastic. As yield conditions, the rounded Mohr-Coulomb and von Mises yield criteria are used, assuming associated flow rules. The proposed numerical method is based on finite elements, and the inherent optimization problem to determine the shakedown factors is solved using the interior-point method. Several numerical results are presented and compared with the existing results in literatures.

MSC:

74C05 Small-strain, rate-independent theories of plasticity (including rigid-plastic and elasto-plastic materials)

Cited in **9** Documents

74S05 Finite element methods applied to problems in solid mechanics

Keywords:

shakedown; pavements; rolling contact; finite element; nonlinear optimization

Software:

PARDISO; Ipopt

Full Text: [DOI](#)

References:

- [1] Melan, Theorie statisch unbestimmter Systeme aus ideal plastischem Baustoff, Sitzungsberichte der Akademie der Wissenschaften in Wien IIa (145) pp 195– (1936)
- [2] Koiter, A new general theorem on shakedown of elastic–plastic structures, Proceedings of the Koninklijke Nederlandse Akademie van Wetenschappen B59 pp 24– (1956) · [Zbl 0074.40801](#)
- [3] Collins, Geomechanical analysis of unbound pavements based on shakedown theory, Journal of Geotechnical and Geoenvironmental Engineering 126 pp 50– (2000)
- [4] Sharp, Shakedown of pavements under moving surface loads, Journal of Transportation Engineering 110 pp 1– (1984)
- [5] Raad, Stability of multilayer systems under repeated loads, Transportation Research Record 1207 pp 159– (1988)
- [6] Raad, Analysis of full-depth asphalt concrete pavements using shakedown theory, Transportation Research Record 1227 pp 53– (1989)
- [7] Raad, Application of shakedown theory in soil mechanics, Zeitschrift für Angewandte Mathematik und Mechanik 69 pp 482– (1989)
- [8] Boulbibane, Application of shakedown theory to soils with non-associated flow rules, Mechanics Research Communications 24 pp 516– (1997) · [Zbl 0904.73049](#)
- [9] Yu, Lower bound shakedown analysis of layered pavements using discontinuous stress fields, Computer Methods in Applied Mechanics and Engineering 167 pp 209– (1998) · [Zbl 0946.74069](#)
- [10] Shiau, Load and displacement prediction for shakedown analysis of layered pavements, Transportation Research Record 1730 pp 117– (2000)
- [11] Shiau, Proceedings of the John Booker Memorial Symposium 2000 pp 643– (2000)
- [12] Shiau SH, Yu HS. Numerical methods for shakedown analysis of pavements. Ph.D. Thesis, The University of Newcastle, Australia, 2001.
- [13] Radovsky, Shakedown of subgrade soil under repeated loading, Transportation Research Record 1547 pp 82– (1996)
- [14] Yu, Three dimensional analytical solutions for shakedown of cohesive-frictional materials under moving surface loads, Proceedings of the Royal Society of London Series A, 461 pp 1951– (2005) · [Zbl 1186.74083](#)
- [15] Ponter, Application of the kinematical shakedown theorem to rolling and sliding point contacts, Journal of the Mechanics

and Physics of Solids 33 pp 339– (1985) · [Zbl 0572.73045](#)

- [16] Melan, Zur Plastizität des räumlichen Kontinuums, *Ingenieur Archiv* 9 pp 116– (1938)
- [17] Weichert, Numerical application of shakedown theory to non-linear transportation support systems, *Zeitschrift für Angewandte Mathematik und Mechanik* 69 pp 485– (1989)
- [18] Weichert, Inelastic Behaviour of Structures Under Variable Repeated Loads: Direct Analysis Methods pp 203– (2002) · [Zbl 1030.00039](#) · [doi:10.1007/978-3-7091-2558-8_10](#)
- [19] Weichert, Inelastic Behaviour of Structures Under Variable Repeated Loads: Direct Analysis Methods pp 239– (2002) · [doi:10.1007/978-3-7091-2558-8_12](#)
- [20] Hachemi, Numerical Methods for Limit and Shakedown Analysis 15 pp 57– (2002) · [Zbl 1019.74034](#)
- [21] Hachemi, Modelling, Computation and Optimisation in Information Systems and Management Sciences pp 299– (2004)
- [22] Hachemi, Progress in shakedown analysis with applications to composites, *Archive of Applied Mechanics* 74 pp 762– (2005)
- [23] Wächter A, Biegler LT. Global and local convergence of line search filter methods for non-linear programming. Technical Report CAPD B-01-09, 1998.
- [24] Wächter A, Biegler LT. Global and local convergence of a reduced space quasi-Newton barrier algorithm for large-scale non-linear programming. CAPD Technical Report B-00-06, Carnegie Mellon University, 2000.
- [25] Wächter A, Biegler LT. On the implementation of a primal–dual interior point filter line search algorithm for large-scale non-linear programming. IBM Research Report RC 23149 IBM T. J. Watson Research Center, March 12, 2004; Yorktown Heights, NY, U.S.A., 2004; 1–28.
- [26] Pastor, Solving limit analysis problems: an interior-point method, *Communications in Numerical Methods in Engineering* 21 pp 631– (2005) · [Zbl 1121.65329](#)
- [27] Christiansen, Computation of collapse states with von Mises type yield condition, *International Journal for Numerical Methods in Engineering* 46 pp 1185– (1999) · [Zbl 0951.74060](#)
- [28] Aboudi, A smooth hyperbolic approximation to the Mohr–Coulomb yield criterion, *Computers and Structures* 54 pp 427– (1995)
- [29] Johnson, The application of shakedown principles in rolling and sliding contact, *European Journal of Mechanics A–Solids* 11 pp 155– (1992)
- [30] Ponter, Shakedown analyses for rolling and sliding contact problems, *International Journal of Solids and Structures* 43 pp 4201– (2006) · [Zbl 1120.74668](#)
- [31] Hamilton, Explicit equations for the stresses beneath a sliding spherical contact, *Proceedings of the Institution of Mechanical Engineers* 197C pp 53– (1983)
- [32] Johnson, *Contact Mechanics* (1985) · [Zbl 0599.73108](#) · [doi:10.1017/CBO9781139171731](#)
- [33] König, On a new method of shakedown analysis, *Bulletin de l’Academie Polonaise des Sciences, Serie des Sciences Techniques* 4 pp 165– (1978)
- [34] Schenk, Solving unsymmetric sparse systems of linear equations with PARDISO, *Journal of Future Generation Computer Systems* 20 (3) pp 475– (2004) · [Zbl 1062.65035](#)
- [35] Schenk, On fast factorization pivoting methods for symmetric indefinite systems, *Electronic Transactions on Numerical Analysis* 23 pp 158– (2006) · [Zbl 1112.65022](#)
- [36] Zienkiewicz OC, Taylor RL, Zhu JZ. A finite element program: personal version (FEAPpv), University of California, Berkeley, 2006. (Available from: <http://www.ce.berkeley.edu/rlt/feappv/>.)
- [37] Fiacco, *Non-linear Programming Sequential Unconstrained Minimisation Techniques* (1968) · [Zbl 0193.18805](#)

This reference list is based on information provided by the publisher or from digital mathematics libraries. Its items are heuristically matched to zbMATH identifiers and may contain data conversion errors. It attempts to reflect the references listed in the original paper as accurately as possible without claiming the completeness or perfect precision of the matching.