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**A constitutive model for granular materials with grain crushing and its application to a pyroclastic soil.** (English) [Zbl 1026.74020](#)  
*Int. J. Numer. Anal. Methods Geomech.* 26, No. 15, 1531-1560 (2002).

Summary: A constitutive model for granular materials is developed within the framework of strain-hardening elastoplasticity, aiming at describing some of the macroscopic effects of the degradation processes associated with grain crushing. The central assumption of the paper is that, upon loading, the frictional properties of the material are modified as a consequence of changes in grain size distribution. The effects of these irreversible microscopic processes are described macroscopically as accumulated plastic strain. Plastic strain drives the evolution of internal variables which model phenomenologically the changes of mechanical properties induced by grain crushing by controlling the geometry of yield locus and the direction of plastic flow.

An application of the model to Pozzolana Nera is presented. The stress-dilatancy relationship observed for this material is used as a guidance for the formulation of hardening laws. One of the salient features of the proposed model is its capability of reproducing the stress-dilatancy behaviour observed in Pozzolana Nera, for which the minimum value of dilatancy always follows the maximum stress ratio experienced by the material.

**MSC:**

74E20 Granularity

74L10 Soil and rock mechanics

**Keywords:**

pyroclastic soils; soft rocks; fabric/structure of soils; grain crushing; plasticity

**Full Text:** [DOI Link](#)

**References:**

- [1] Mechanical behaviour of soft rock: some remarks. In: *Experimental Characterisation and Modelling of Soils and Soft Rocks*. CUEN: Napoli, Italy, 1991; 191-223.
- [2] Cecconi, *International Journal for Numerical and Analytical Methods in Geomechanics* 25 pp 1525– (2001)
- [3] The influence of particle breakage and state on the behaviour of sands. In: *International Workshop on Soil Crushability, IWSC'99*, Yamaguchi, Japan, 2000. Japan Geotechnical Society.
- [4] Shear behaviour and stiffness of naturally cemented sands. PhD Thesis, City University of London, 1995.
- [5] Lagioia, *Géotechnique* 45 pp 633– (1995)
- [6] Fukumoto, *Soils and Foundations* 30 pp 27– (1990). doi:10.3208/sandf1972.30.27
- [7] The mechanical behaviour of compacted decomposed granite. PhD Thesis, City University of London, 1991.
- [8] Nova, *European Journal of Mechanics A/Solids* 11 pp 135– (1992)
- [9] Conceptual bases for a constitutive model for bonded soils and weak rocks. In: *Hard Soils-Soft Rocks*, et al. (eds.) Balkema: Rotterdam, Athens, Greece, 1993.
- [10] On the mechanical behaviour of bonded soils. In *COMETT Seminar on Large Excavations*, 1994.
- [11] Kinematic hardening model for structured soil. In: *NUMOG V*, (eds.) Balkema: Rotterdam, 1995; p. 83-88.
- [12] Rouainia, *Géotechnique* 50 pp 153– (2000)
- [13] Gajo, *International Journal for Numerical and Analytical Methods in Geomechanics* 25 pp 207– (2001)
- [14] Elliott, *Géotechnique* 35 pp 413– (1985)
- [15] Airey, *Journal of Geotechnical Engineering, ASCE* 119 pp 1379– (1993)
- [16] Aversa, *Rock Mechanics and Rock Engineering* 31 pp 25– (1998)
- [17] Laboratory studies of a weakly bonded artificial soil. PhD Thesis. Imperial College of Science Technology and Medicine, University of London, 1987.
- [18] Leroueil, *Géotechnique* 40 pp 467– (1990)
- [19] Cotecchia, *Géotechnique* 47 pp 523– (1990)

- [20] Herle, *Mechanics of Cohesive-Frictional Materials* 4 pp 461– (1999)
- [21] Miura, *Soils and Foundations* 37 pp 89– (1997) · doi:10.3208/sandf.37.289
- [22] Li, *Géotechnique* 50 pp 449– (2000)
- [23] Miura, *Soils and Foundations* 19 pp 1– (1979) · doi:10.3208/sandf1972.19.31
- [24] Hardin, *Journal of Geotechnical Engineering, ASCE* 111 pp 1177– (1985)
- [25] Hagerty, *Journal of Geotechnical Engineering, ASCE* 119 pp 1– (1993)
- [26] Lade, *Journal of Geotechnical Engineering, ASCE* 122 pp 309– (1996)
- [27] Nakata, *Soils and Foundations* 41 pp 69– (2001) · doi:10.3208/sandf.41.69
- [28] Nakata, *Soils and Foundations* 41 pp 39– (2001) · doi:10.3208/sandf.41.239
- [29] McDowell, *Géotechnique* 48 pp 667– (1998)
- [30] McDowell, *Soils and Foundations* 40 pp 133– (2000)
- [31] *Computational Inelasticity*. Springer Verlag: New York, 1997.
- [32] Houslyby, *Computers and Geotechnics* 1 pp 3– (1985)
- [33] Lagioia, *Computers and Geotechnics* 19 pp 171– (1996)
- [34] van Eekelen, *International Journal for Numerical and Analytical Methods in Geomechanics* 4 pp 89– (1980)
- [35] Sinfonietta classica: an exercise on classical soil modelling. In: *Constitutive Equations for Granular Non-Cohesive Soils*, (eds.), Balkema: Rotterdam, Cleveland, 1988.
- [36] Sture, *Ingenieur-Archiv* 59 pp 253– (1989)
- [37] Runesson, *International Journal for Numerical and Analytical Methods in Geomechanics* 11 pp 315– (1987)
- [38] Alawaji, *International Journal for Numerical and Analytical Methods in Geomechanics* 16 pp 737– (1992)
- [39] Nova, *International Journal for Numerical and Analytical Methods in Geomechanics* 3 pp 255– (1979)
- [40] Nova, *Archiwum Mechaniki Stosowanej* 29 pp 445– (1977)
- [41] Fuller, *Transactions on ASCE* 59 pp 67– (1907)
- [42] Bardet, *International Journal for Numerical and Analytical Methods in Geomechanics* 15 pp 1– (1991)
- [43] *Fundamentals of Soil Mechanics*. Wiley: New York, 1948.
- [44] Rowe, *Proceedings of the Royal Society of London A* 269 pp 500– (1962) · doi:10.1098/rspa.1962.0193
- [45] Caratteristiche strutturali e proprietà meccaniche di una piroclastite: la Pozzolana Nera dell'area romana. PhD Thesis, Università di Roma ?Tor Vergata?, 1999 (in Italian).
- [46] Stability of subvertical cuts in pyroclastic deposits. In *Proceedings Geoeng 2000*, Melbourne, Australia, 2000.
- [47] *Introduction to Numerical Analysis* (2nd edn). Springer Verlag: New York, 1992.
- [48] Nova, *Journal of Mechanical Behaviour of Materials* 5 pp 193– (1994) · doi:10.1515/JMBM.1994.5.2.193

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