Limit Analysis of 3D Reinforced Concrete Beam Elements

A new finite-element framework for lower-bound limit analysis of reinforced concrete beams, subjected to loading in three dimensions, is presented. The method circumvents the need for a direct formulation of a complex section-force-based yield criterion by creating a discrete representation of the internal stress-state in the beam. The yield criteria are formulated and applied on a stress-state level. The stress-state is decomposed to concrete and reinforcement stresses, and separate yield criteria are applied to each component. Simple limits are used on the reinforcement stresses, and a modified Coulomb criterion is applied to the concrete stresses. The modified Coulomb criterion is approximated using second-order cone programming for improved performance over implementations using semidefinite programming. The element is verified by comparing the numerical results with analytical solutions.

General information
State: Published
Organisations: Department of Civil Engineering, Section for Structural Engineering, Ramboll Group AS
Contributors: Larsen, K. P., Nielsen, L. O., Poulsen, P. N.
Pages: 286-296
Publication date: 2012
Peer-reviewed: Yes

Publication information
Journal: Journal of Engineering Mechanics
Volume: 138
Issue number: 3
ISSN (Print): 0733-9399
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 2.08 SJR 0.779 SNIP 1.324
Web of Science (2017): Impact factor 1.799
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 1.62 SJR 0.682 SNIP 1.262
Web of Science (2016): Impact factor 1.764
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 1.42 SJR 0.74 SNIP 1.171
Web of Science (2015): Impact factor 1.346
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 1.42 SJR 0.894 SNIP 1.493
Web of Science (2014): Impact factor 1.294
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 1.45 SJR 0.945 SNIP 1.63
Web of Science (2013): Impact factor 1.173
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 1.35 SJR 0.981 SNIP 1.833
Web of Science (2012): Impact factor 1.116
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 1.16 SJR 0.809 SNIP 1.422
Web of Science (2011): Impact factor 0.99
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 0.983 SNIP 1.518
Web of Science (2010): Impact factor 0.956
BFI (2009): BFI-level 2
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Scopus rating (2000): SJR 1 SNIP 1.358
Scopus rating (1999): SJR 1.04 SNIP 1.16

Original language: English

DOI: 10.1061/(ASCE)EM.1943-7889.0000326
Source: dtu
Source-ID: n:oai:DTIC-ART:compendex/370926391::24942
Research output: Research - peer-review | Journal article – Annual report year: 2012