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A MODIFIED NODE-TO-SEGMENT ALGORITHM PASSING THE CONTACT PATCH TEST

G. Zavarise[1], *L. De Lorenzis[2]

[1] University of Salento
via per Monteroni, 73100 Lecce (ITALY)
giorgio.zavarise@unile.it

[2] University of Salento
via per Monteroni, 73100 Lecce (ITALY)
laura.delorenzis@unile.it

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ABSTRACT

Several investigations have shown that the classical one-pass node-to-segment algorithms for the enforcement of contact constraints do not pass the contact patch test [1-3]. This implies that the algorithms may introduce solution errors at the contacting surfaces, and these errors do not necessarily decrease with mesh refinement. These researches have mainly focused on the Lagrange multiplier method to exactly enforce the contact geometry conditions. The situation is even worse with the penalty method, due to its inherent approximation which yields a solution affected by a non-zero penetration.

The aim of this study is to analyze and improve the contact patch-test behavior of the one-pass node-to-segment algorithm used in conjunction with the penalty method. For this purpose, several sequential modifications of the basic formulation have been considered, which yield incremental improvements in results of the contact patch test. The final proposed formulation is a modified one-pass node-to-segment algorithm which is able to pass the contact patch test also if used in conjunction with the penalty method. In other words, this algorithm is able to correctly reproduce the transfer of a constant contact pressure, with a constant proportional penetration.

Two distinct ideal steps are involved in the transfer of a uniform contact pressure between two discretized contacting bodies. The first step is the transformation of a uniform contact pressure over the slave surface into concentrated contact forces acting at the slave nodes. The second step is the transformation of the concentrated forces at the slave nodes into a uniform contact pressure acting over the master surface. In order for the patch test to be passed, perfect equivalence of forces and moments between the concentrated forces and the uniform contact pressure must hold at each contact element during both the above steps. The problems arising during each step and preventing the patch test from being passed by the usual node-to-segment formulation are outlined in the paper. Solutions to such problems are also proposed, and their effectiveness is demonstrated with suitable examples. Small deformation linear isoparametric quadrilateral elements in plane strain have been used throughout the analyses. All computations have been performed with the finite element program FEAP (courtesy of Prof. R.L. Taylor).

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