A Review of latest methods for embedding predefined interfaces in finite elements structures design

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Abstract

A latest method design for embedding predefined interfaces within the arbitrary finite elements meshing is proposed and demonstrated. Within a given finite element, the initiation of fracture or slippage may occur simultaneously along a predefined interface and in the bulk of the element. In order to determine which surface is critical, we feature a criterion which aids in determining the correct surface upon which all further slippage due to fracture will occur. The algorithm for generating these predefined surfaces is detailed and subsequently applied to, but by no means limited to, masonry problems to demonstrate its efficacy. This interface method is cast in the framework of an enhanced strain finite element which is capable of capturing softening along an embedded strongdiscontinuity.

Keywords

Strongdiscontinuity,demonstrate, Enhanced strain, finite element Pre-existinginterface, Localized deformation.

1. *INTRODUCTION*

The presence of weak interfaces within materials may hold significant ramifications for their overall performance. These interfaces often introduce orthotropic or anisotropic characteristics intostructures and critically reduce their load-carrying capacity. Many methods have been implemented within a finite element context, as this has arguably been the most popular method in solid mechanics. Techniques include the use of interface or cohesive elements, finite elementswithembeddeddiscontinuities,discontinuousGalerkinNetsch's method, and phase-fieldmethods.

Interfaceorcohesiveelementsmodelthesurfaceexplicitly within the mesh. These elements are inserted between continuum elements at the interface, leading to a very sharp resolution and dis- tinct boundary between the two sides of the fracture. Usually, two sets of nodes are used which connect to each element that it is between, and a force-displacement or traction-displacement relationship is used todeterminethedisplacementbetweenthesetsofnodes.This approach is quite useful for composite materials and simulating delamination, and many other cases where the fracture or delamination is known to occur along the interface.

The paper is about the presence of weak interfaces within materials may hold significant ramifications for their overall performance.Techniques include the use of interface or cohesive elements, finite elementswithembeddeddiscontinuities,discontinuousmethod, and fieldmethods. Another approach is to embed the discontinuity within the continuum finite elements, using extra degrees of freedom to enrich the element. Several formulations exist with respect to inserting the discontinuity and how the extra degrees of freedom are applied.

2. *LITERATURE REVIEW*

Paola Antonietti (2019), The important method based on galerkin approximation method this method in work we have introduced a new way to handle fluid-structure interaction problems with immersed structures featuring large displacements. . It naturally accommodates high order discretizations, by using modal basis functions built on the physical mesh element. In the computational practice, for high order and/or 3D computations numerical integration should be treated with care, as classical sub tessellation method (considered here for the sake of simplicity) become unfeasible due to the complexity and CPU time burden.

Durand, R., Pantoja-Rosero, B. G., & Oliveira, V. (2019) ,A general mesh smoothing method for finite elements. The method deals with two and three dimensional meshes with virtually any type of element. To evaluate the quality of different element types, the paper also introduces a broad quality function. The proposed method works by solving a standard deformation analysis where nodal forces aim to deform each element into an optimally placed reference element. A detailed algorithm of the proposed smoothing method is presented which is suitable for a straightforward computer implementation.

Timothy J. Truster ,ArifMasud (2017), The DG formulation is applied to solve numerical problems for domains containing interfaces that progressively soften. All results were obtained using trilinear hexahedral displacement elements, although the method does not impose any restrictions against tetrahedral or higher-order elements. Eight-point Gauss quadrature was employed for all domain integrals, and four-point quadrature was used along the interfaces. Discontinuous Galerkin method for modeling the progressive failure of interfacial bonding between constituents of a composite material. In this initial study, cracking and separation along the interface is treated as the sole damaging process. The cohesive energy at the interface is incorporated into the governing energetic potential through an auxiliary field, the so-called residual gap, that plays the role of inelastic interface deformations.

John Dolbow (2009),A stabilized finite element method based on the Nitsche technique for enforcing constraints leads to an efficient computational procedure for embedded interface problems. We consider cases in which the jump of a field across the interface is given, as well as cases in which the primary field on the interface is given. The finite element mesh need not be aligned with the interface geometry.

3. CONCLUSIONS

The interface technology in this paper is represented by the reviews for the latest methods for embedding predefined interfaces in finite elements structures design surfaceinserted into a continuum constant strain element. The conceptof the strong discontinuity is utilized as well as an enhanced strainfinite element. A methodology for propagating user-defined interfaceswithin a finite element mesh has been outlined. This method is particularly suited for structures such as periodic masonry, where interfaces between brick and mortar occur at regular intervals. The placement ofthese periodic interfaces can be easily systematized in order to insertthem at the desired locations. The deformation patterns of the masonryin this study show good agreement with prior studies which showcasedthese examples. A potential application for this methodology would beto validate experimental masonry results, featuring three-point bendingtests and shear walls, which incorporate the use of brick and mortar.Experimental results do exist for masonry walls, constructed fromearthen materials, subjected to flexure. These are the focus of anupcoming study for the authors.

Eigenmode analyses of the element stiffness matrices have been used to assess the impact of the applied integration scheme on the stress predictions of two- and three-dimensional plane interface elements. It is demonstrated that large stress gradients over the element and coupling of the individual node-sets of the interface element may result in an oscillatory type of response. For line elements and linear plane interface elements the performance can be improved by using either a nodal lumping scheme or Newton-Cotes or Lobatto integration schemes instead of the more traditional Gauss scheme. For quadratic interface elements the same holds true except for a nodal lumping scheme.

4. REFERENCES

I. Carol, P. Prat, C. Lopez, Normal/shear cracking model: application to discrete crack analysis, J. Eng. Mech. 123 (8) (1997) 765–773.

II. Arnold DN (1982) An interior penalty finite element method withdiscontinuous elements. SIAM J Numer Anal 19:742–760.

III. Arnold DN, Brezzi F, Cockburn B, Marini LD (2002) Unifiedanalysis of discontinuous Galerkin methods for elliptic problems.SIAM J Numer Anal 93:1749–1779

IV. Durand, R., Pantoja-Rosero, B. G., & Oliveira, V. (2019). A general mesh smoothing method for finite elements. Finite Elements in Analysis and Design, 158, 17–30. doi:10.1016/j.finel.2019.01.010

V. Antonietti, P., Verani, M., Vergara, C., &Zonca, S. (2019). Numerical solution of fluid-structure interaction problems by means of a high order Discontinuous Galerkin method on polygonal grids. Finite Elements in Analysis and Design, 159, 1–14. doi:10.1016/j.finel.2019.02.002

VI. Dolbow, J., & Harari, I. (2009). An efficient finite element method for embedded interface problems. International Journal for Numerical Methods in Engineering, 78(2), 229–252. doi:10.1002/nme.2486