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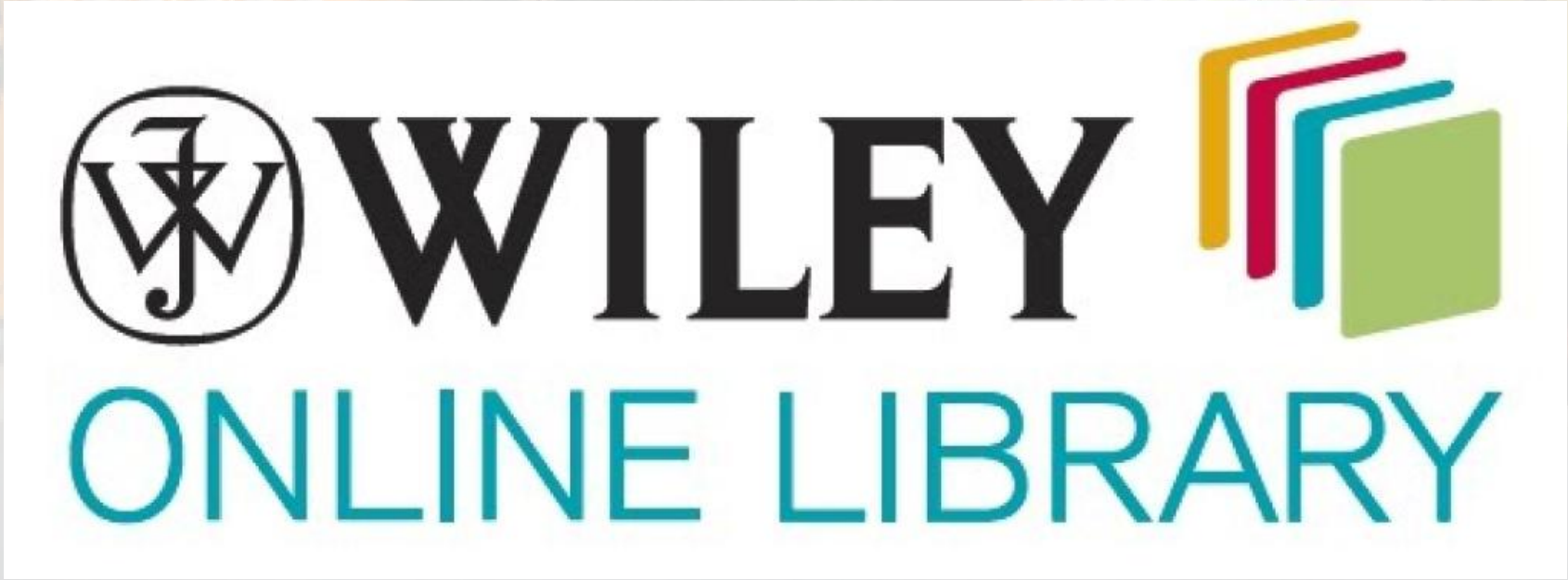

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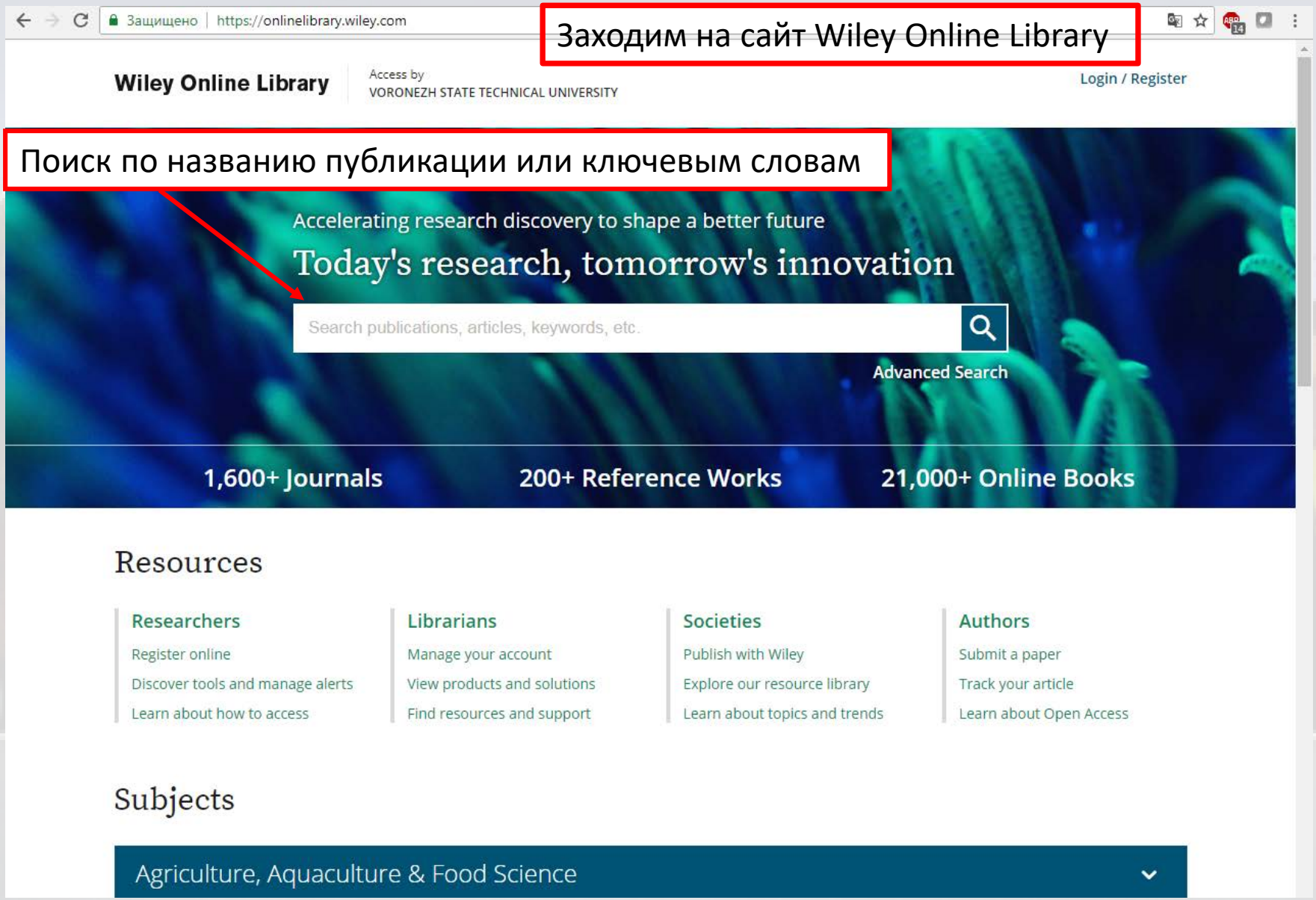

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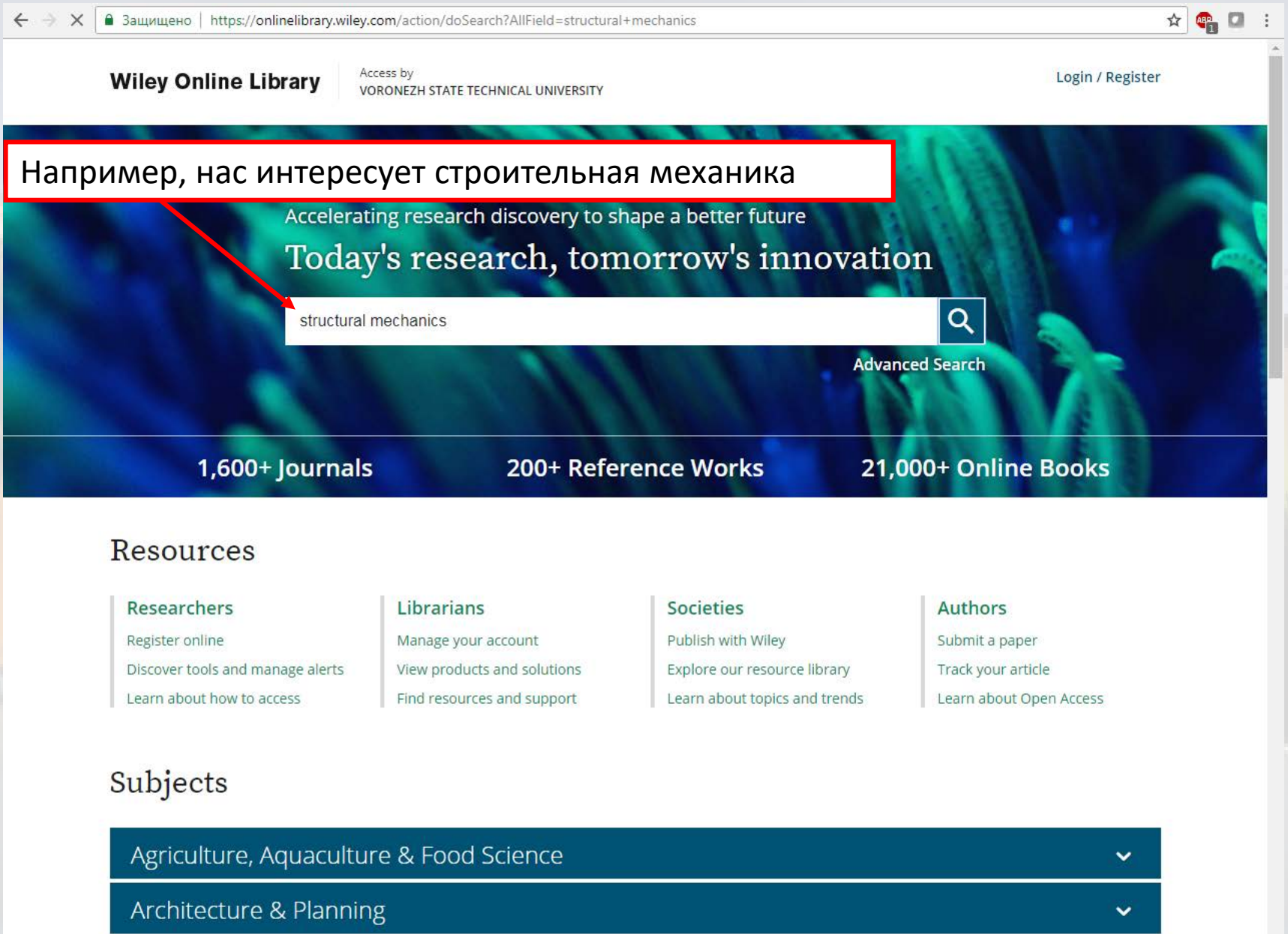

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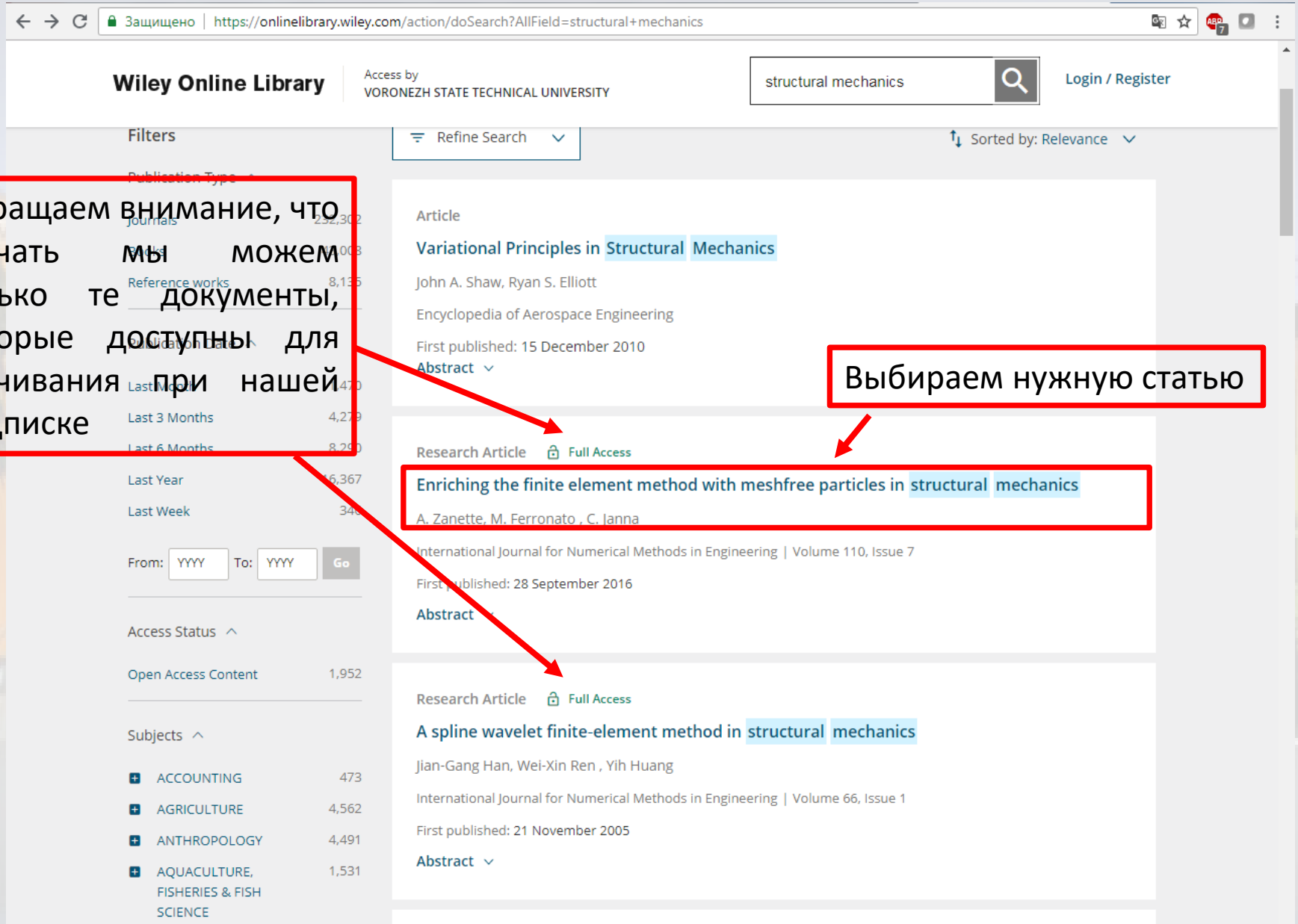

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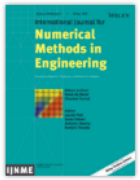

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Enriching the finite element method with meshfree particles in structural mechanics

A. Zanette, M. Ferronato, C. Janna

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Summary

The automatic generation of meshes for the finite element (FE) method can be an expensive computational burden, especially in structural problems with localized stress peaks. The use of meshless methods can address such an issue, as these techniques do not require the existence of an underlying connection among the particles selected in a general domain. This study advances a numerical strategy that blends the FE method with the meshless local Petrov–Galerkin technique in structural mechanics, with the aim at exploiting the most attractive features of each procedure. The idea relies on the use of FEs to compute a background solution that is locally improved by enriching the approximation space with the basis functions associated to a few meshless points, thus taking advantage of the flexibility ensured by the use of particles disconnected from an underlying grid. Adding the meshless particles only where needed avoids the cost of mesh refining, or even of remeshing, without the prohibitive computational cost of a thoroughly meshfree approach. In the present implementation, an efficient integration strategy for the computation of the coefficients taking into account the mutual FE–meshless local Petrov–Galerkin interactions is introduced. Moreover, essential boundary conditions are enforced separately on both FEs and meshless particles, thus allowing for an overall accuracy improvement also when the enriched region is close to the domain

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Enriching the finite element method with meshfree particles in structural mechanics

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SUMMARY

The automatic generation of meshes for the finite element (FE) method can be an expensive computational burden, especially in structural problems with localized stress peaks. The use of meshless methods can address such an issue, as these techniques do not require the existence of an underlying connection among the particles selected in a general domain. This study advances a numerical strategy that blends the FE method with the meshless local Petrov–Galerkin technique in structural mechanics, with the aim at exploiting the most attractive features of each procedure. The idea relies on the use of FEs to compute a background solution that is locally improved by enriching the approximation space with the basis functions associated to a few meshless points, thus taking advantage of the flexibility ensured by the use of particles disconnected from an underlying grid. Adding the meshless particles only where needed avoids the cost of mesh refining, or even of remeshing, without the prohibitive computational cost of a thoroughly meshfree approach. In the present implementation, an efficient integration strategy for the computation of the coefficients taking into account the mutual FE–meshless local Petrov–Galerkin interactions is introduced. Moreover, essential boundary conditions are enforced separately on both FEs and meshless particles, thus allowing for an overall accuracy improvement also when the enriched region is close to the domain boundary. Numerical examples in structural problems show that the proposed approach can significantly improve the solution accuracy at a local level, with no remeshing effort, and at a low computational cost.

Received 27 November 2015; Accepted 23 September 2016

KEY WORDS: enrichment; meshless method; finite elements; structural mechanics

1. INTRODUCTION

The finite element (FE) method is currently the method of choice in structural mechanics, because

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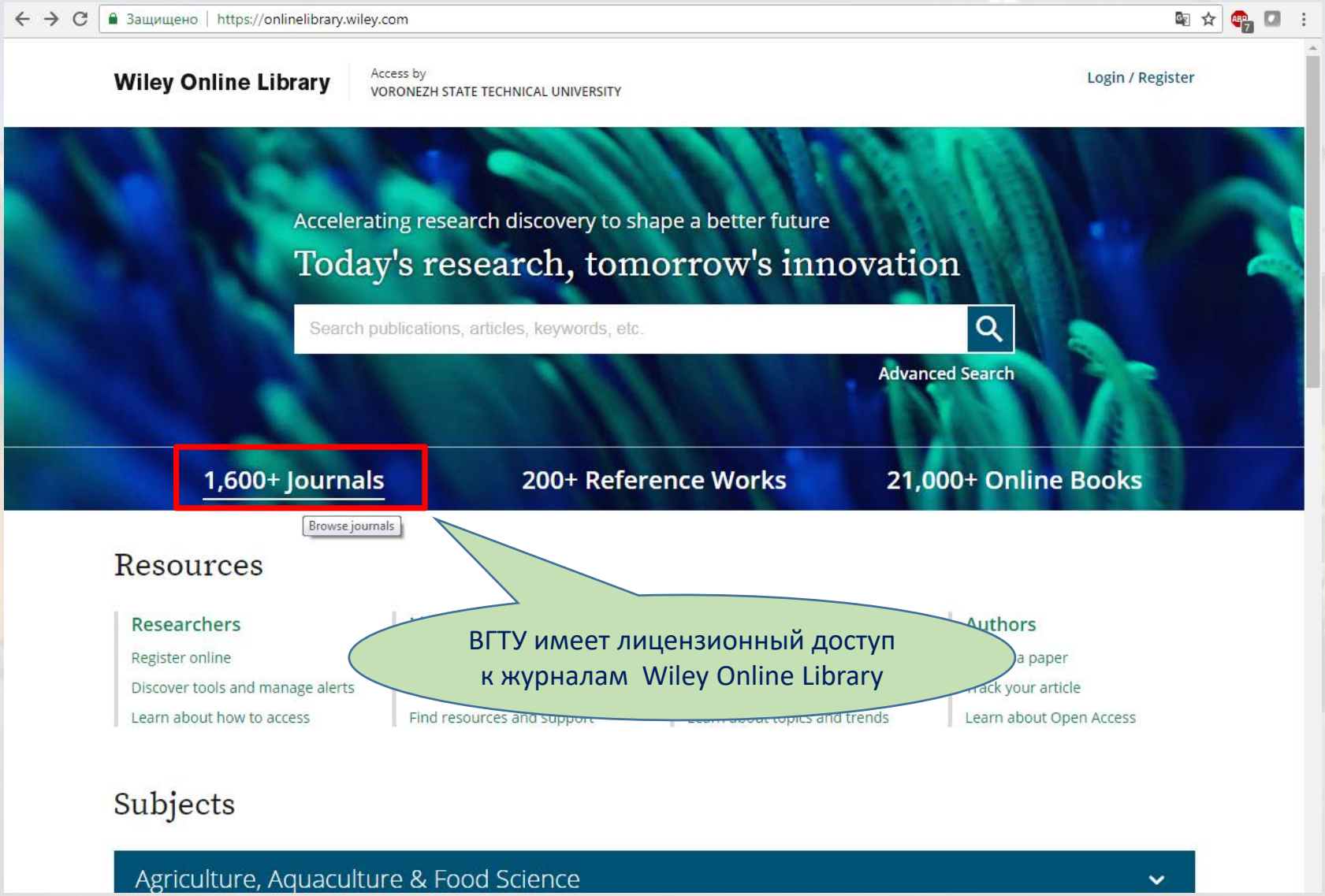

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