Lecture Notes in Civil Engineering

Magd Abdel Wahab *Editor*

Proceedings of the 5th International Conference on Numerical Modelling in Engineering

Volume 1: Numerical Modelling in Civil Engineering, NME 2022, 23–24 August, Ghent University, Belgium

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Preface

This volume contains the proceedings of the 5th International Conference on Numerical Modelling in Engineering: Volume 1 Numerical Modelling in Civil Engineering. Numerical Modelling in Engineering NME 2022 is the 5th NME conference and is held Online via MS Teams, during the period 23–24 August 2022. Previous NME conferences were celebrated in Ghent, Belgium (2018), Beijing, China (2019) and Ghent, Belgium (2020–2021).

The overall objective of the conference is to bring together international scientists and engineers in academia and industry in fields related to advanced numerical techniques, such as FEM, BEM, IGA, etc., and their applications to a wide range of engineering disciplines. The conference covers industrial engineering applications of numerical simulations to Civil Engineering, Aerospace Engineering, Materials Engineering, Mechanical Engineering, Biomedical Engineering, etc. The presentations of NME 2022 are divided into two main sessions, namely (1) Civil Engineering and (2) Mechanical and Materials Engineering. This volume is concerned with the applications to Civil Engineering.

The organising committee is grateful to keynote speaker, Prof. Timon Rabczuk, Bauhaus Universität Weimar, Chair of Computational Mechanics, Germany, for his very interesting keynote speech entitled 'Machine Learning Based Solutions of Partial Differential Equations'.

Special thanks go to members of the Scientific Committee of NME 2022 for reviewing the articles published in this volume and for judging their scientific merits. Based on the comments of reviewers and the scientific merits of the submitted manuscripts, the articles were accepted for publication in the conference proceedings and for presentation at the conference venue. The accepted papers are of a very high scientific quality and contribute to the advancement of knowledge in all research topics relevant to NME conference.

Finally, the organising committee would like to thank all authors, who have contributed to this volume and to those who have presented their research work at the conference in MS Teams.

Zwijnaarde, Belgium

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Prof. Magd Abdel Wahab is a Full Professor of Applied Mechanics in the Faculty of Engineering and Architecture at Ghent University, Belgium. He received his B.Sc., 1988, in Civil Engineering and his M.Sc., 1991, in Structural Mechanics, both from Cairo University. Prof. Wahab completed his Ph.D. in Fracture Mechanics in 1995 at KU Leuven, Belgium. He was awarded the degree of Doctor of Science from the University of Surrey in 2008. He has published more than 600 scientific papers in solid mechanics and dynamics of structures and edited more than 30 books and proceedings. His research interests include fracture mechanics, damage mechanics, fatigue of materials, durability, and dynamics and vibration of structures.

Nonconforming Spectral Element Method for Oseen Equations and Navier-Stokes Equations

N. Kishore Kumar and Subhashree Mohapatra

Abstract In this paper, we discuss the performance of a least-squares-based spectral element solver for Oseen equations on two-dimensional curvilinear domains and three-dimensional Navier-Stokes equations. Both equations are solved in primitive form without any first-order reformulation. The spectral approximation is nonconforming, and the same order spectral element functions are used for both velocity and pressure variables. A suitable preconditioner has been proposed using ADN theory in order to control the condition number of the system. Numerical results are obtained using the preconditioned conjugate gradient method. Numerical results show that the method is exponentially accurate in both velocity and pressure variables. Mass conservation property of the used solver has been displayed.

1 Introduction

The Oseen and Navier-Stokes equations arise in many engineering applications. These equations have been widely studied using various numerical methods like finite difference methods, mixed finite element methods, least-squares methods, spectral methods and different nonconforming methods in the literature [5, 19, 26]. Our main focus is on least-squares-based numerical schemes.

Numerical methods based on the least-squares approach for elliptic differential equations, in elliptic Stokes and Navier-Stokes equations have been discussed in [4, 11, 18]. Least-squares methods offer an alternative approach to standard mixed formulations and many other computational advantages such as resulting systems being always symmetric and positive definite, allowance of equal order interpolation, etc. [2, 8, 9, 11, 22–24].

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