Numerical verification of wave propagation by meshless strong-form method

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1. INTRODUCTION

Strong-form meshless methods are based on directly discretising the governing partial differential equations (PDE) employing various node distributions (uniform, cosine, or random) in the domain without using any shape functions and connectivity information [1]. The present work uses meshless local differential quadrature (LDQ) method for the discretization of space derivative terms and Newmark-β method for the time discretization in the governing PDE [4]. The two methods are coupled to obtain the displacement, velocity, and acceleration at different nodes in the domain.

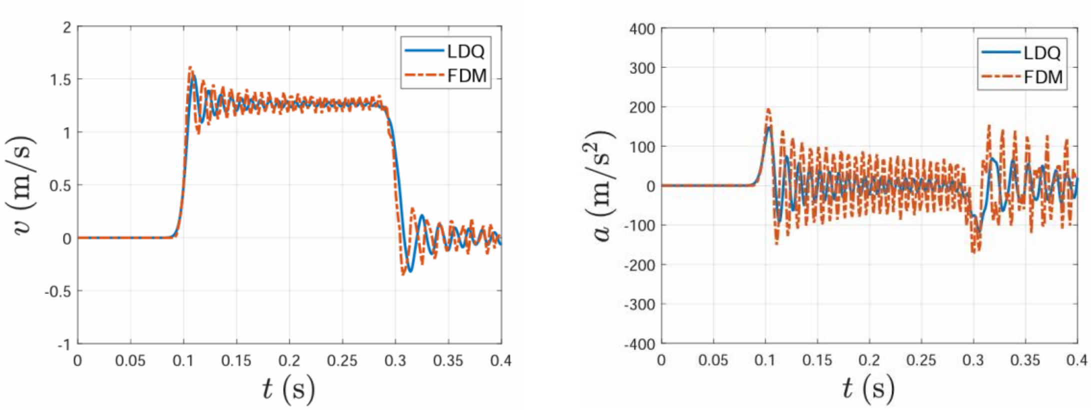
2. OBJECTIVE

The primary *motivation* of present work is to lay the foundation for simulating crack propagation, in the dynamic loading conditions, by strong-form methods. The *objective* of present work is thus to successfully demonstrate the coupling between LDQ and Newmark schemes, and their results comparison with finite element method (FEM) and finite difference method (FDM) [2] while solving one-dimensional (1D) dynamic mechanical equilibrium equation. The *novelty* of present work is thus to correctly explain the macro-scale numerical wave propagation solution with the micro-scale physics explained by spring-mass system.

3. CONTRIBUTIONS

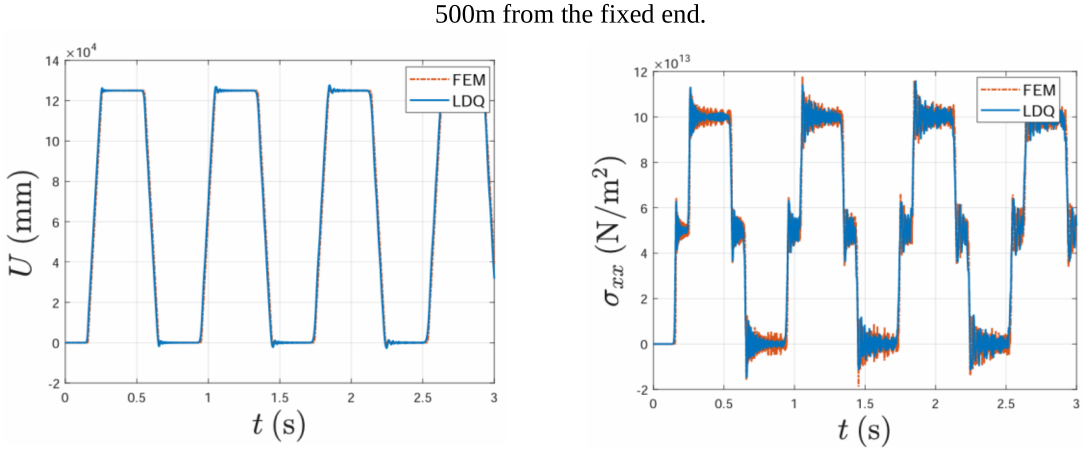
The primary contribution of present work is to develop a numerical formulation demonstrating the coupling between LDQ and Newmark-β methods. This formulation is employed to solve 1D dynamic equilibrium equation under various boundary conditions (Neumann, Dirichlet, and impact loading). The numerical results are then validated against FDM and FEM coupled with explicit time discretization schemes. The proposed LDQ + Newmark scheme is able to solve dynamic problems employing uniform, random, or cosine nodes, where other schemes may not be able to handle these nodal distributions.

4. RESULTS



(a) (b)

Figure 1: Results for (a) velocity and (b) acceleration using uniform nodal distribution at a distance of 500m from the fixed end.



(a) (b)

Figure 2: Results for (a) displacement and (b) stress using uniform nodal distribution at a distance of 250m from the fixed end.

5. CONCLUSION

The solution to 1D dynamic equilibrium is successfully verified (for Neumann boundary condition) comparing the results with FDM (Figure 1) and FEM (Figure 2). It is seen that, LDQ method shows much smaller oscillations (which may be occuring due to discretization error) than FDM method. The present numerical results are also compared with FEM and they found to be in good agreement.

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