Universitat Politècnica de Catalunya, Barcelona, 15–19 April 2013

Numerical Simulation of Fast Transient Dynamic Phenomena in Fluid-Structure Systems

A Short Course by F. Casadei

The objective of the Course is to provide participants with a good understanding of state-of-the-art techniques for the numerical simulation of fast transient dynamic phenomena, which occur in many safety-related applications.

These are typically explosions, crashes, impacts etc., both due to natural phenomena and to malicious actions such as terrorist attacks.

The Course covers in some depth structural aspects, since the primary focus is on structural behavior and collapse simulation. The modeling of fluids via an ALE formulation and the coupling between the two domains (Fluid-Structure Interaction) are also considered, as they play an important role in these analyses.

An important part of the Course are the practical exercises. These are mainly hands-on interactive computer sessions, in which the participants use the EUROPLEXUS code (developed jointly by JRC and CEA) to solve both some academic problems, in order to consolidate the theoretical knowledge, and some typical medium-sized applications.

Programme:

Date/Time	Topics
Monday April 15, (10:00–12:00) Room B1-005	**1. Introduction (Solids)** a. Introductory example of a FSI problem i. Application spectrum and goals b. Modeling the structural domain i. Equilibrium equations ii. Explicit time integration scheme c. Treatment of essential boundary conditions i. The Lagrange multipliers method ii. Solving the linear system
Afternoon (14:00–16:00)	• Practical exercises (Room D1-101)
Tuesday April 16, (10:00–12:00) Room B1-005	**2. ALE formulation (Fluids)** a. Modeling the fluid domain i. Euler equations ii. Finite Element discretization iii. Finite Volume discretization (N-C, C-C) b. Mesh rezoning algorithms i. Motivation ii. Mean-based algorithms iii. Giuliani's algorithm c. Free surface modeling
Afternoon (14:00–16:00)	• Practical exercises (Room D1-101)

Wednesday April 17, (10:00–12:00) Room B1-005	**3. Classical Fluid-Structure Interaction** a. Motivation b. A classification of FSI algorithms c. Geometrical methods i. The FSA/FSR method d. Equilibrium-based methods i. The Uniform Pressure (UP) method e. A combined method i. The FSCR method f. Application to Finite Volumes i. Weak FSI for NCFV ii. Weak FSI for CCFV (conforming) g. Non-conforming FSI i. For FE / NCFV (strong approach) ii. For CCFV (weak approach) h. Some special FSI techniques/applications i. Modeling of perforated structures ii. Sloshing problems
Afternoon (14:00–16:00)	• Practical exercises (Room D1-101)
Thursday April 18, (10:00–12:00) Room B1-005	**4. Advanced FSI (with Failure/Fragmentation)** a. Structural failure and element erosion b. Fragmentation and flying debris i. Modeling of glass c. Treatment of failure with CCFV (conforming, weak FSI) d. Embedded FSI models i. The FLSR method (strong approach) ii. The FLSW method (weak approach) e. Advanced FSI example: structural vulnerability i. Scenarios ii. Geometry reconstruction iii. Simplified building vulnerability study iv. Accounting for dead (static) weight v. Modeling the explosive charge (AIRB, BUBB, JWLS) vi. Risk evaluation vii. Case studies. 1: Railway Station; 2: Metro Station; 3: Metro Carriage viii. Complete Metro / Railway Station simulation
Afternoon (14:00–16:00)	• Practical exercises (Room D1-101)
Friday April 19, (10:00–12:00) Room B1-005	**5. Further topics and applications** a. ALE description of structures b. Lagrangian contact i. Classical methods ii. Pinballs iii. SPH (for fluid-like materials) c. Meshless methods i. SPH for structures ii. DEM d. Spectral elements e. Spatial time step partitioning f. Domain decomposition g. Mesh adaptivity i. Application to solids ii. Application to fluids iii. FSI
Afternoon (14:00–16:00)	• Exams (Room D1-101)