Tesi da riproporre/non allocate

Structural integrity under extreme loads

Topic: High-fidelity models of blast waves

TITLE: Numerical models of Energetic materials

RESEARCH BACKGROUND:
General-purpose numerical platforms lack of detailed models for describing the detonation dynamics of energetic material. That is, explosive charges are usually modeled as homogeneous bodies, even though real explosive devices are strongly inhomogeneous and made of several components. This thesis aims to simulate, using a continuum mechanics approach, the detonation dynamic of real devices containing energetic materials.

RESEARCH ACTIVITIES:
1. Literature research on state-of-the-art models for describing the detonation dynamics
2. Investigation of the most promising identified models in a CFD environment
3. Calibration of numerical models using experimental data
4. Numerical simulations of blast-loaded plates and validation against experiments

METHODOLOGY: Numerical - Analytical

DURATION: 6-9 months

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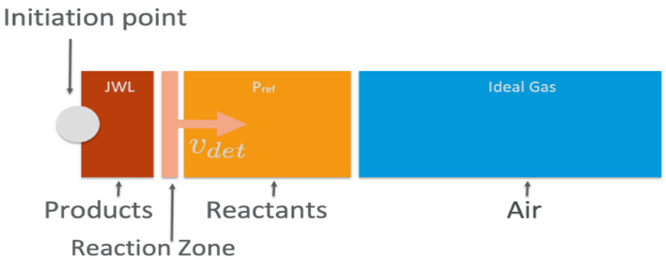

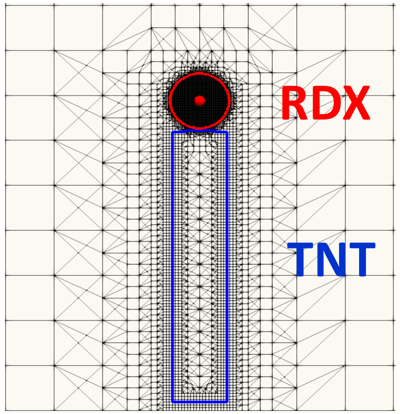

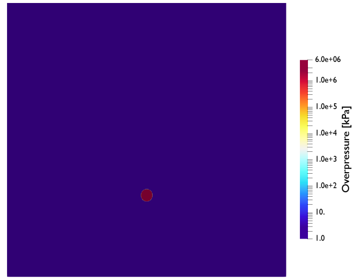
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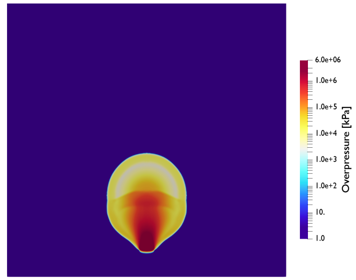
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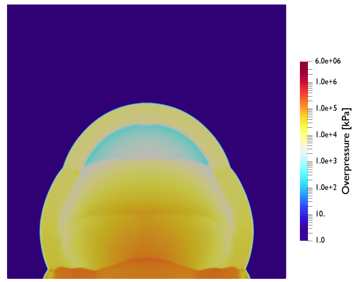
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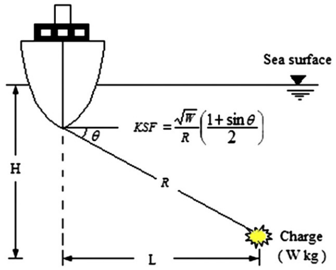
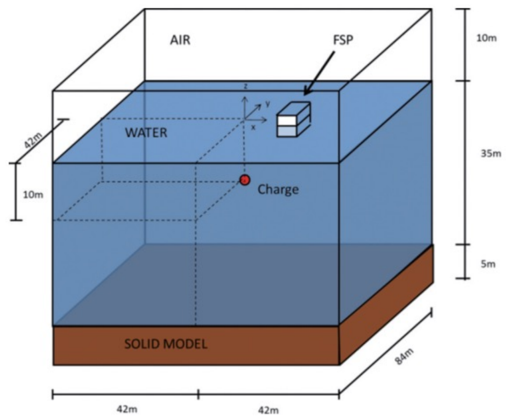
Structural integrity under extreme loads

Topic: High-fidelity models of blast waves

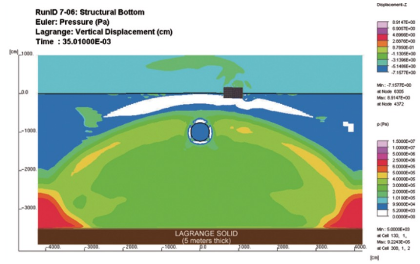
TITLE: Numerical models for underwater explosions (UNDEX)





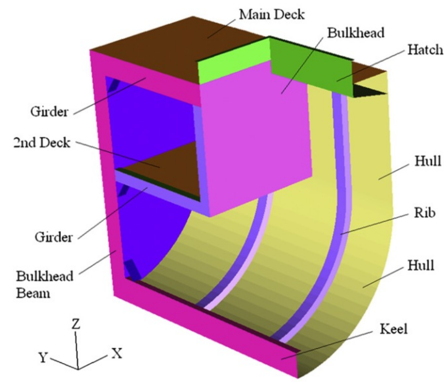
RESEARCH BACKGROUND:

Many studies have been performed for air-blast, while there is a lack of readily available numerical frameworks for underwater explosions due to the increased complexity posed by the interaction between water, shockwaves and air bubbles. The need for such tools is crucial for the assessment of naval structures.



RESEARCH ACTIVITIES:

1. Literature review of underwater explosion (UNDEX).
2. Modelling of simple UNDEX case studies.
    - Effect of different soils (clay, sandy, rigid) and of the free surface.
    - Effect of different explosive charges (conventional, aluminized).
3. Numerical structural assessment of representative naval structures against UNDEX.



METHODOLOGY: Numerical

DURATION: 9 months

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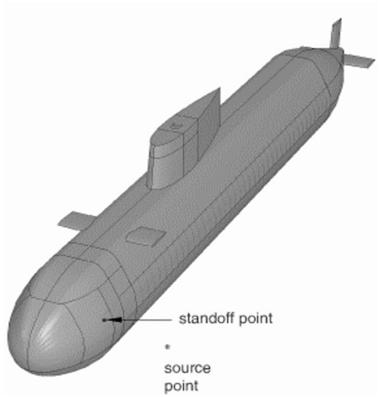
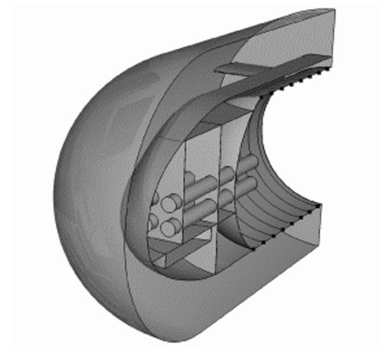




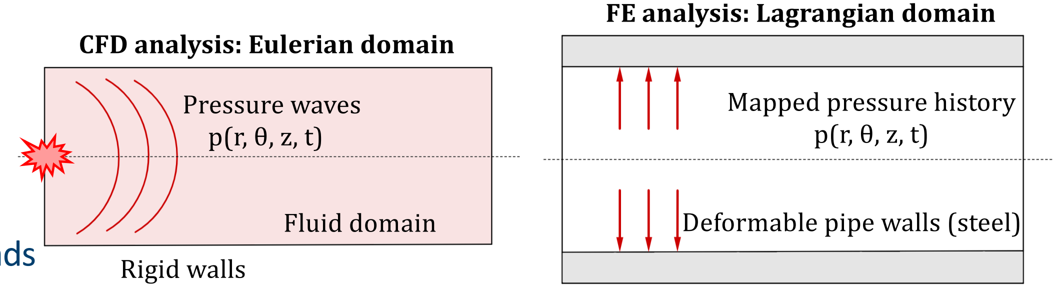
Structural integrity under extreme loads

Topic: Pipeline detonation modelling

TITLE: Numerical models of hazardous event in gas transportation pipelines

RESEARCH BACKGROUND:
Although pipelines are a consolidated infrastructure to transport gas, accidents still occur due to the hazardous inflammable compound considered. Numerical modeling of detonations in pipelines is a fast and reliable tool to assess current infrastructure against adverse events. The aim of this thesis is to simulate numerically cases where explosions occur to verify the safety of the pipelines.

RESEARCH ACTIVITIES:
1. Literature review of accidents in pipelines
2. Modelling of explosion propagation through CFD
3. Numerical investigation of three representative cases
    a. Investigation of Deflagration to Detonation Transition (DDT)
4. Numerical structural assessment of pipelines against impulsive loads



METHODOLOGY: Numerical
DURATION: 9 months

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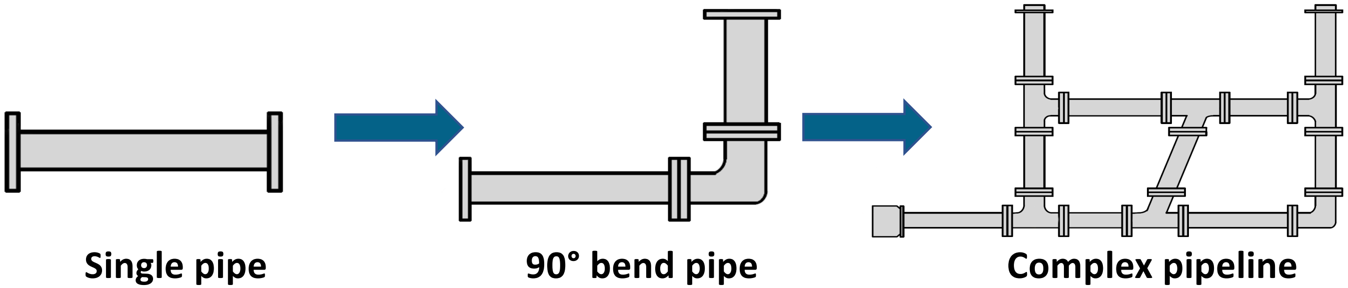
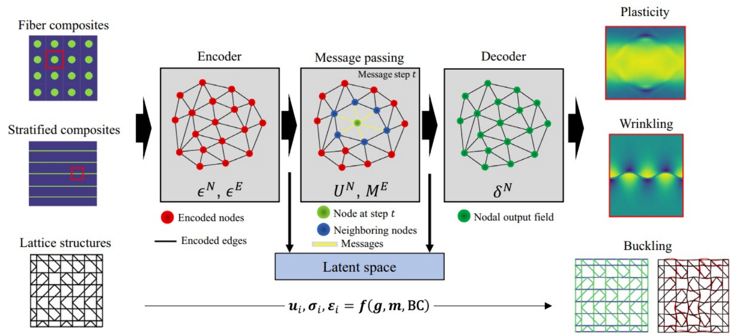


Structural integrity under extreme loads

Topic: High fidelity models and machine learning



TITLE: Numerical analysis of composite representative volume elements and development of machine learning-based surrogate models

RESEARCH BACKGROUND:

Composite materials are intrinsically multiscale materials that present multiple failure modes, which are challenging to describe through FE models. Numerical simulations may be combined with state-of-the-art machine learning methods to improve the computational efficiency and accuracy.

RESEARCH ACTIVITIES:

1. Numerical development of reference volume elements (RVEs) for composite materials (focus on interfacial properties fibre/matrix)
2. Investigation of state-of-the-art homogenization techniques for deriving the macro properties of RVEs.
3. Development of machine learning methods to replace computationally expensive numerical simulations.
4. Testing of the methodology on experimental and numerical data.

METHODOLOGY: Numerical

DURATION: 9 months

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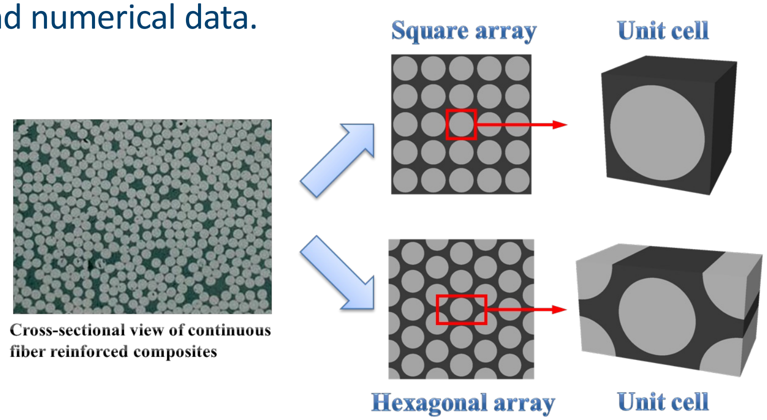
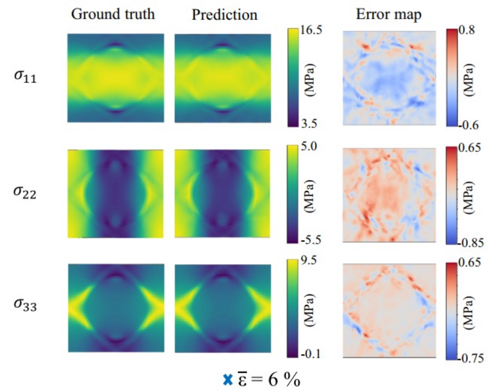


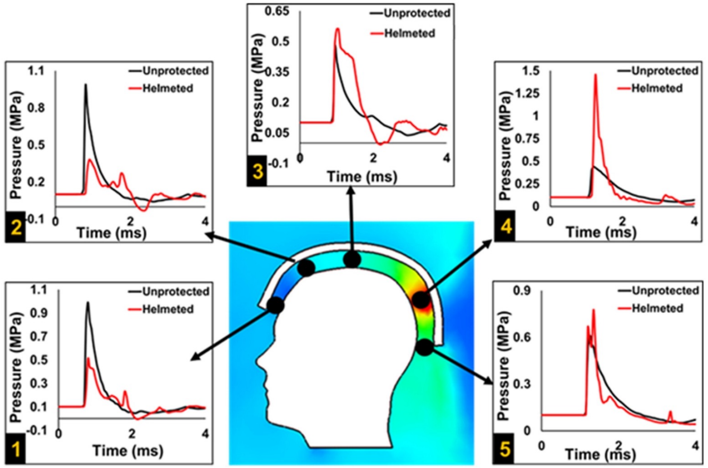
Cross-sectional view of continuous fiber reinforced composites



Structural integrity under extreme loads

Topic: High fidelity models of composite materials

TITLE: Numerical assessment of military helmets subjected to blast load



RESEARCH BACKGROUND:
Blast loading is a critical scenario that pose a threat to the personnel that wear a helmet which may be involved in accidents that lead to explosions. Helmets are a complex device whose design is defined by multiple requirements and have several constraints.

RESEARCH ACTIVITIES:
1. Literature review on the effect of blast waves on helmet and the head.
2. Numerical modelling of blast loading on a helmet
   (FE models of headform and helmet already partially developed from previous works)
3. Study of different concepts for blast effects mitigation
4. Numerical assessment of aforementioned new concepts

METHODOLOGY: Numerical

DURATION: 9 months

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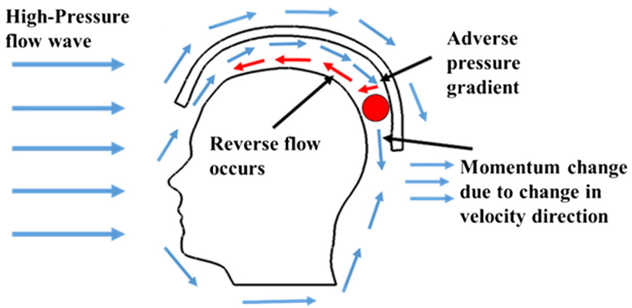
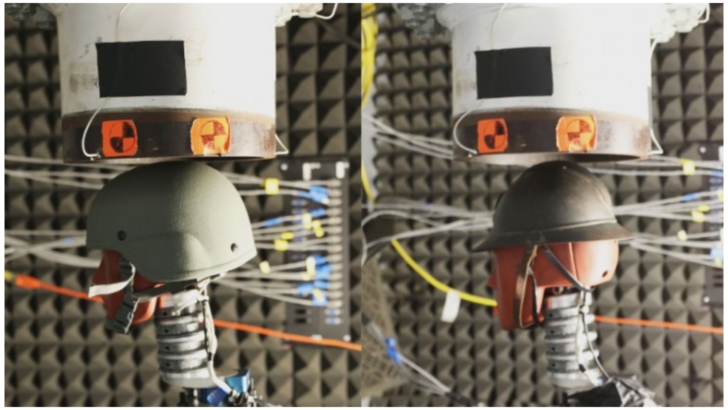
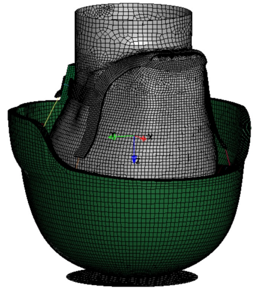
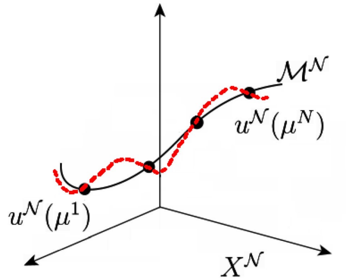




Structural integrity under extreme loads

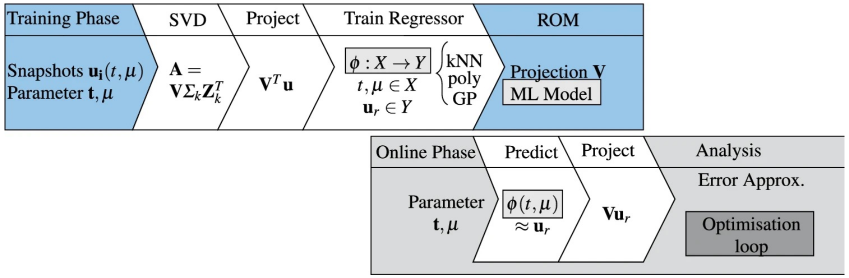
Topic: High fidelity models and machine learning





TITLE: Reduced order models applied to impacts engineering

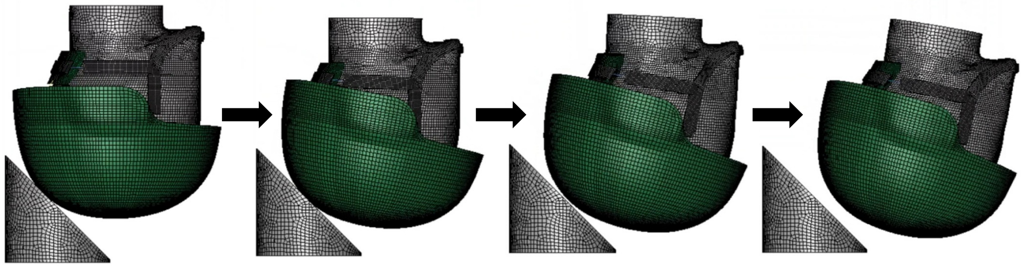
RESEARCH BACKGROUND:
Impact analyses are highly nonlinear and should be solved using explicit algorithms which are time-consuming. In recent years Reduced Order Models (ROMs) techniques are gaining momentum for multi-query simulations to alleviate the computational burden of such numerical problems. This thesis aims to define a ROM workflow that is able to replicate the nonlinear dynamics of impact on helmets as a Full Order Model (FOM).



RESEARCH ACTIVITIES:
1. Literature review on reduced order models (focus on non-intrusive methods)
2. Numerical implementation of simple benchmark cases
3. Model reduction of blunt impact on helmets (training phase)
4. Numerical assessment of reduced models and error estimation (online phase)

METHODOLOGY: Numerical

DURATION: 9 months



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Structural integrity under extreme loads

Topic: High fidelity models

TITLE: Development of a custom homogenized composite finite element

RESEARCH BACKGROUND:
Composite materials are intrinsically multiscale materials that present multiple failure modes, which are challenging to describe through FE models. Multiple criteria are present in the literature and commercial FE packages lack the implementation of all of them. This thesis aims at develop user defined finite element that implement different constitutive behaviour of composite materials.

RESEARCH ACTIVITIES:
1. Literature review on composite failure and post-damage behaviour.
2. Implementation of custom constitutive laws (programming language: Fortran)
3. Single element analyses of different constitutive laws and failure criteria.
4. Full scale numerical simulation of composite panels.

METHODOLOGY: Analytical-Numerical

DURATION: 6-9 months

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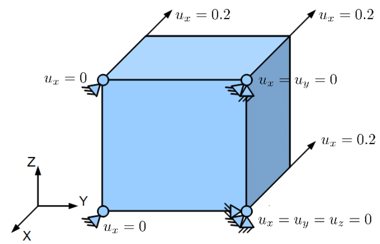
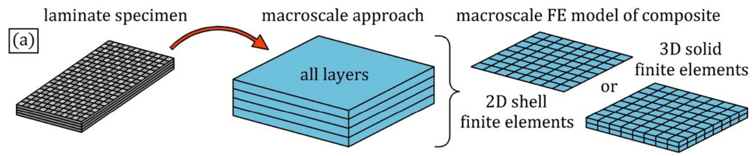
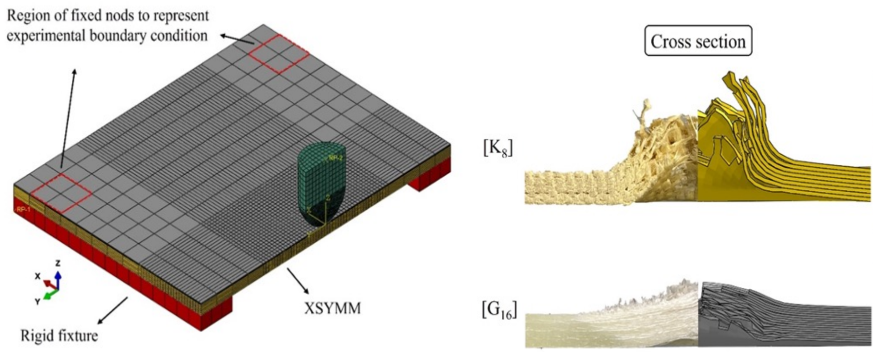


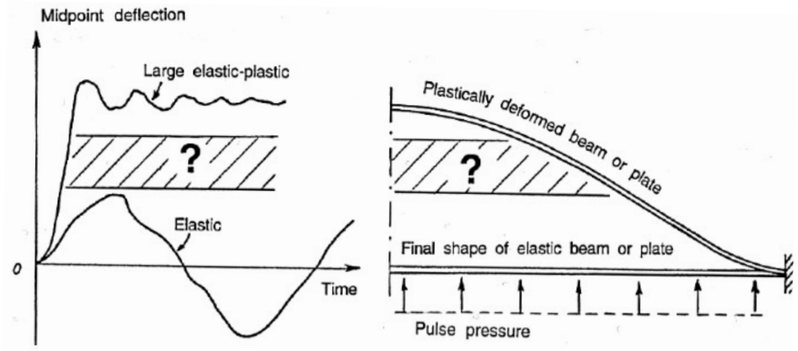




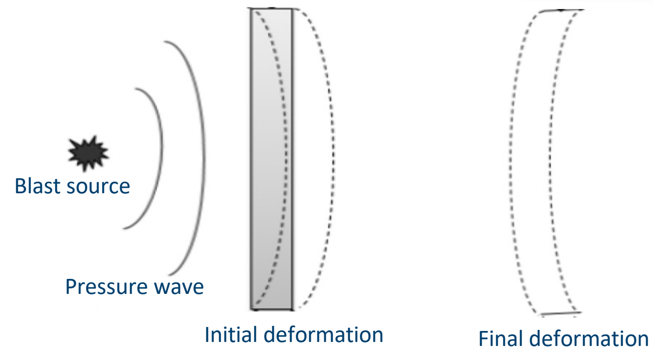
Structural integrity under extreme loads

Topic: High-fidelity models of blast loading

TITLE: Counter-intuitive behaviour of blast-loaded plates



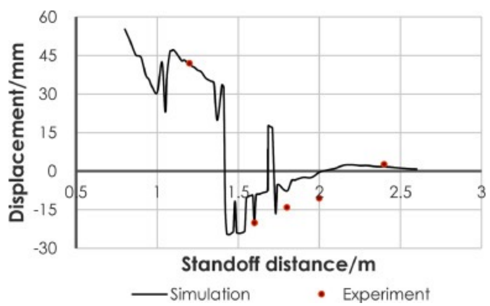
RESEARCH BACKGROUND:
Blast waves are strongly nonlinear loading conditions that may lead to counter intuitive results. For instance, under certain conditions, blast-loaded plates may get permanently deformed in the direction opposite to the loading. This counter-intuitive behaviour (CIB) still needs to be investigated to identify the governing parameters.



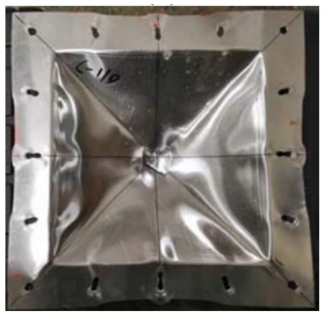
RESEARCH ACTIVITIES:
1. Literature review on blast-loaded plates and CIB.
2. Numerical simulation of metal plates under blast loading.
3. Numerical simulation of composite plates under blast loading.
4. Sensitivity analysis to identify the governing parameters of CIB

METHODOLOGY: Analytical-Numerical

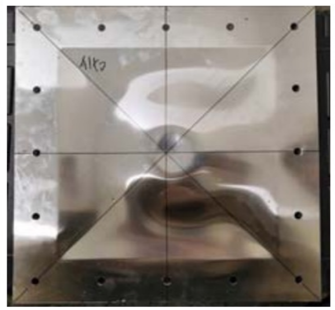
DURATION: 6 months



Shear failure at boundaries



Large plastic deformation



Counter intuitive behaviour

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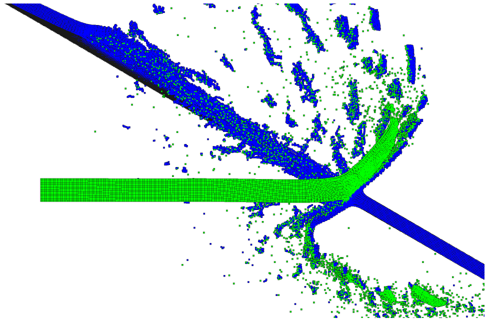
Nuove tesi

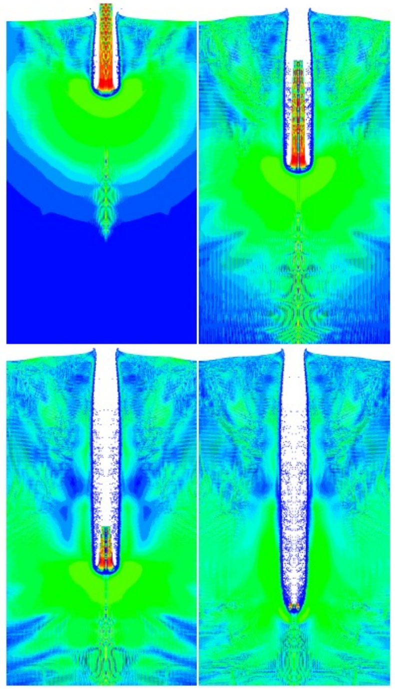
Structural integrity under extreme loads

Topic: High-fidelity models of ballistic impacts



TITLE: Numerical approaches for modelling the ballistic impact onto metallic and ceramic protections.

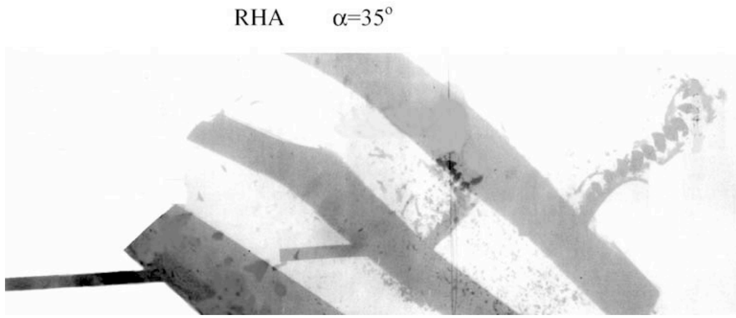
RESEARCH BACKGROUND:
Evolving threat capabilities require an update of protective structures. Ballistic grade steels and ceramic armours have been developed in the last decades to increase the safety level of the platforms they are installed on. This thesis aims to build high-fidelity models of such protections starting from data acquired under dynamical loading at high strain rates.



RESEARCH ACTIVITIES:
1. Literature review on metallic and ceramic materials for ballistic protection.
2. Numerical calibration of material properties with data from Split-Hopkinson Pressure Bar.
3. Development of numerical models (including, but not limited to, FE and/or meshless approaches).

METHODOLOGY: Numerical-Experimental

DURATION: 9 months



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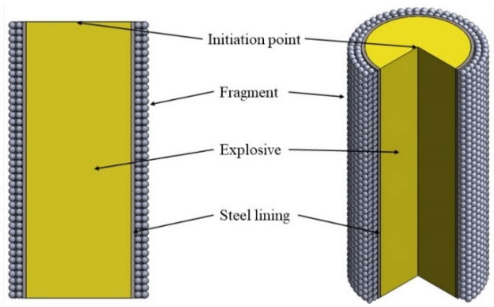
Structural integrity under extreme loads

Topic: High-fidelity models of blast/ballistic impacts

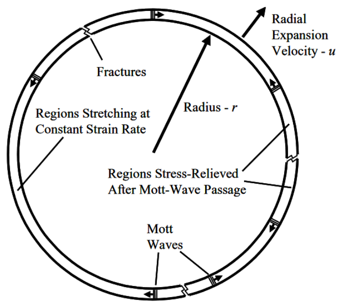
TITLE: Triggering the detonation of high-explosives through blast waves and fragments

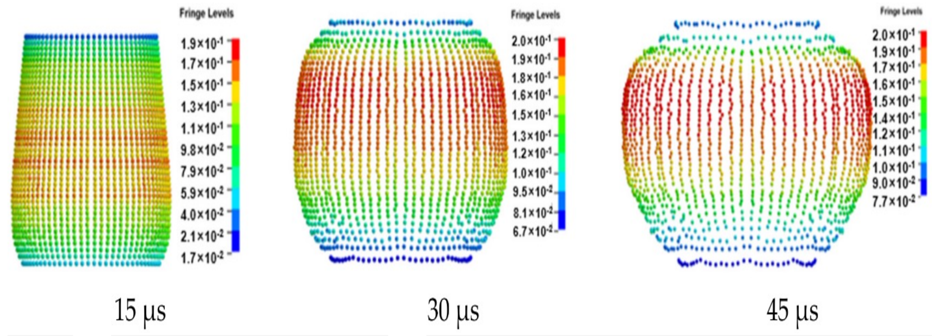


RESEARCH BACKGROUND:
The detonation of high-explosive materials may be triggered by impacting blast waves and fragments. Studying this phenomenon may be beneficial for the deployment of countermeasures to intercept threats before they reach the target.

RESEARCH ACTIVITIES:
1. Literature review on current materials and explosives.
2. Numerical simulation of scenarios that can trigger the detonation of high-explosives.
3. Statistical characterization of the fragmentation of exploding devices.

METHODOLOGY: Analytical-Numerical
DURATION: 6 months





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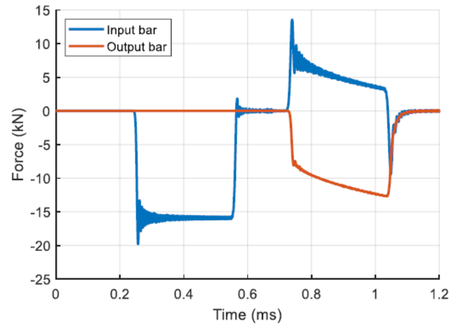
Structural integrity under extreme loads

Topic: Instrumentation for high strain rate measurements

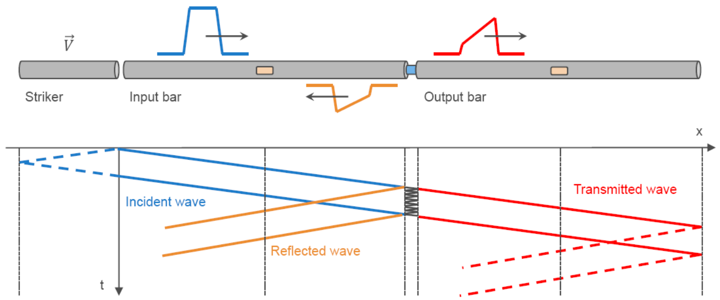


TITLE: Desing of a Split-Hopkinson Pressure Bar (SHPB)

RESEARCH BACKGROUND:
A Split-Hopkinson Pressure Bar (SHPB) is an experimental tool for studying the behaviour of materials under high strain-rate loading. No standardization has been reached in the scientific community, and different customized versions of such apparatus are available. The current thesis aims to design a novel experimental setup at Politecnico di Milano.

RESEARCH ACTIVITIES:
1. Literature review on current state-of-the-art architectures for SHPB devices.
2. Mechanical design, sizing and cost estimation of feasible solutions.
3. Numerical assessment of the proposed solution against data from the literature.
4. Assembly of the apparatus (to be defined).
5. Experimental validation (to be defined).

METHODOLOGY: Analytical-Numerical-Experimental
DURATION: 9 months



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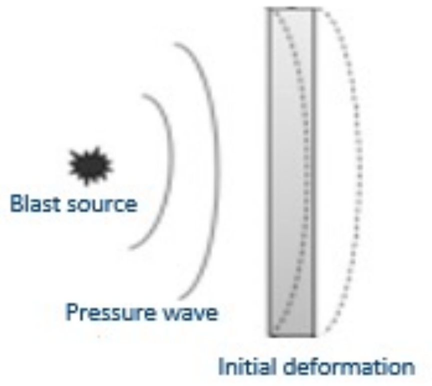
Possible collaboration:
JRC Ispra (European Commission)

European Commission
Joint Research Centre

Structural integrity under extreme loads

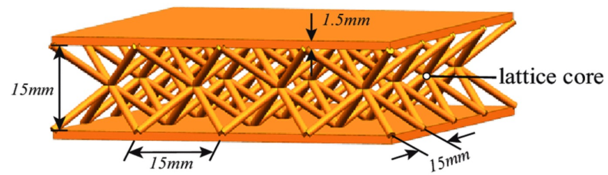
Topic: Advanced modeling of metamaterials sandwich panels

TITLE: Optimization of Metamaterial Sandwich Panels for Blast Loading Protection



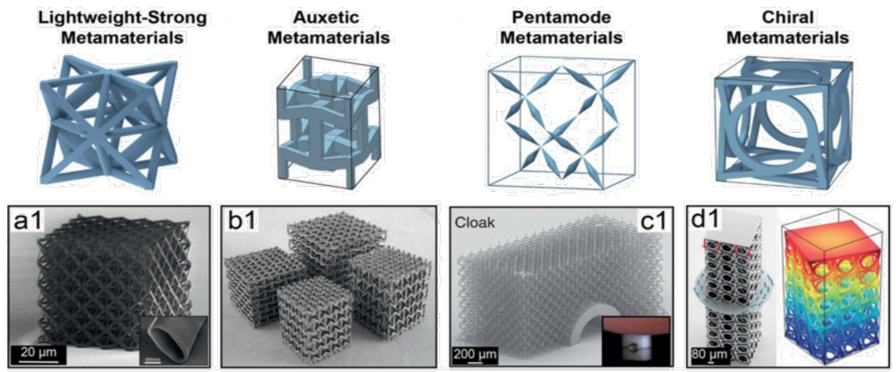
RESEARCH BACKGROUND:
Blast loading pose a significant threat to safety, with the potential to cause extensive damage to structures and individuals. The aim of this thesis is to develop an innovative approach to the design of protective panels, focusing on the use of metamaterials to enhance blast loading resistance.

RESEARCH ACTIVITIES:
1. Literature review on metamaterials and their applications in blast loading protection.
2. Design and numerical analysis of sandwich panels incorporating metamaterials to enhance blast resistance. The use of generative artificial intelligence will be considered.
3. Numerical simulations of blast loading scenarios to assess the effectiveness of optimized panels.



METHODOLOGY: Numerical - Analytical

DURATION: 9 months



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