DEFENCE ACADEMY
OF THE UNITED KINGDOM

Cranfield UNIVERSITY

Defence College of Management and Technology

State of the art in Europe and overview of the activity developed within WG3: 'Impact and Explosion'

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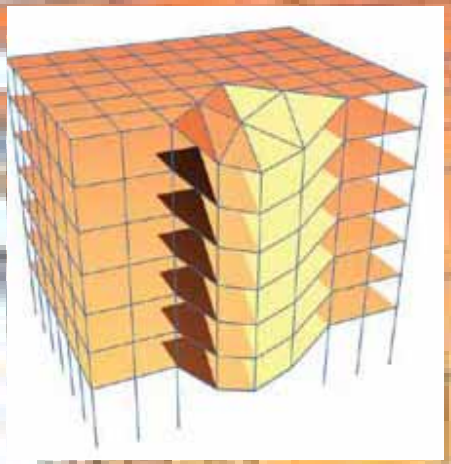
Introduction

Areas of research addressed by WG3: Impact and Explosion

- Whole building and building element response and robustness in the face of blast and impact loading
- Response of structures to blast loads from both high explosive events and gas explosions using experimental and numerical methods
- Response of buildings to underground explosions and the utility of seismic design methodologies to produce blast and impact resistant structures
- Response of structures and structural elements to impact from missiles and vehicles
- Development of existing expertise in general ‘dynamic loading’ towards impact and explosions studies.

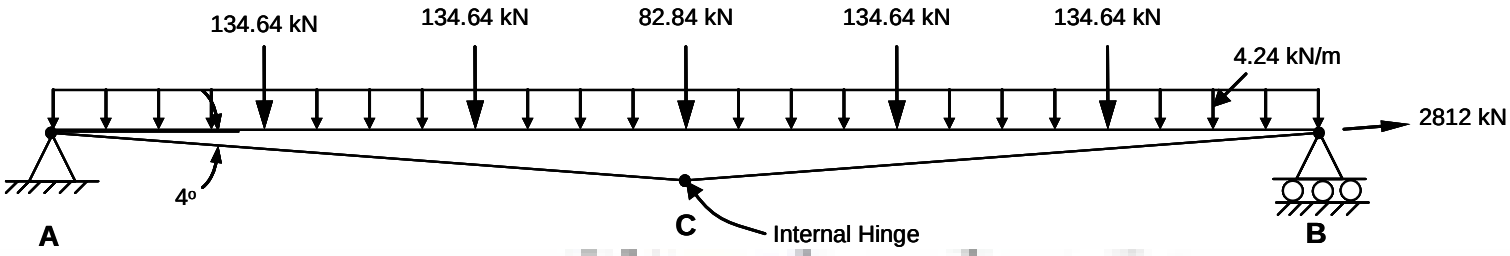
Response and robustness under blast and impact loading I

Mike Byfield – Southampton University UK: Prevention of Progressive Collapse



Structural connections must have sufficient ductile capacity to allow tying forces to develop without catastrophic failure

With low ductility connections Factors of Safety (FoS) are unacceptably low at around 0.2



$$FoS = \frac{528}{2812} = 0.19$$

Response and robustness under blast and impact loading II

Jean-François Demonceau (University of Liege, Belgium) and Lars Rölle (University of Stuttgart, Germany): Development of ‘robustness’

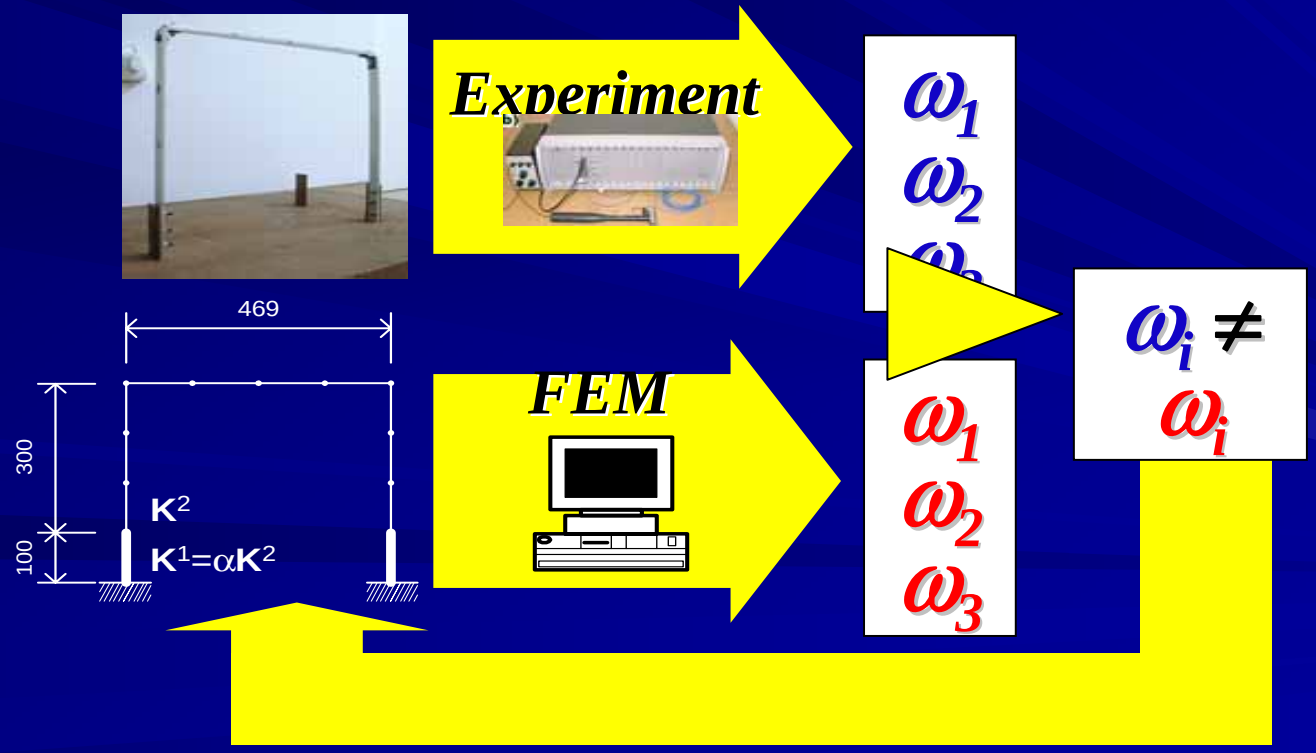
A consortium of five universities is currently engaged on studies to establish how robust structures can be achieved by the provision of joint ductility

STEEL JOINTS BEFORE (left) and AFTER (right) TESTING

Response and robustness under blast and impact loading III

Bartosz Miller (Rzeszow University of Technology, Poland): neural networks to ‘learn’ about damage assessment

Neural networks and other ‘soft computing’ techniques are being developed to complement the outputs from FE analyses and experiments



Response and robustness under blast and impact loading IV

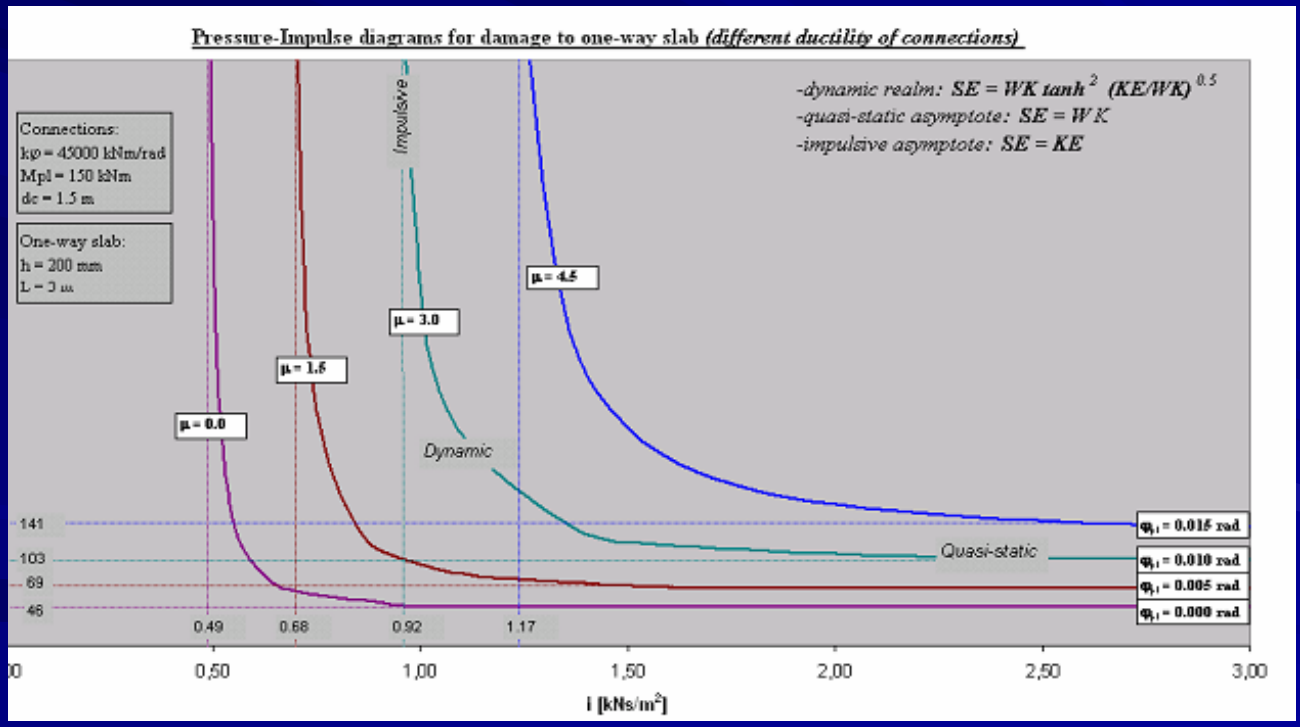
Kari Kolari (VTT Technical Research Centre, Finland): brittle fracture in sub-zero temperatures

The performance of steel sections in the context of ice-structure interaction via development of a new continuum model in ABAQUS

Blast loading and structural response I

Gianfranco De Matteis and Isodoro Langone (University of Chieti-Pescara, Italy): structural integrity of structures subjected to internal gas-explosion loading

Development of a ‘key element’ strategy (design appropriate load bearing walls) and ‘alternative load path’ strategy (allowing for limited collapse)

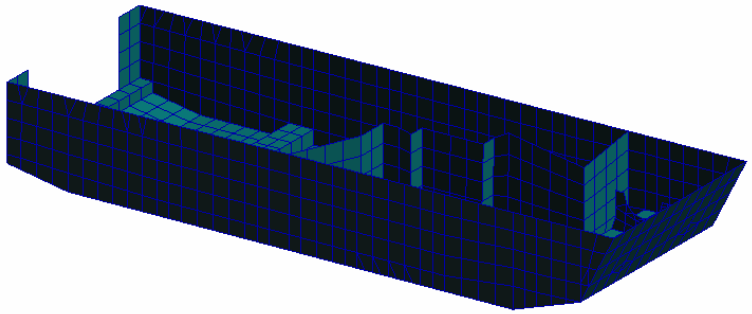


P-I DIAGRAMS FOR ONE-WAY SLABS OF DIFFERENT CONNECTION DUCTILITY

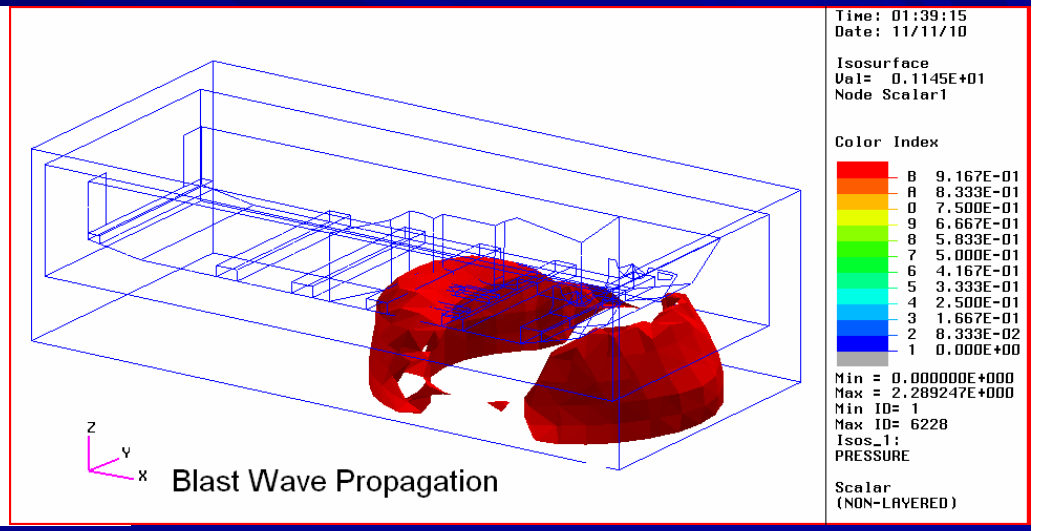
Blast loading and structural response II

Sami Kilic (Bogazici University, Istanbul, Turkey): numerical simulation of blast-structure interaction to understand response and develop improved designs

Numerical tools available include LS-Dyna and MSC.Dytran for Arbitrary Lagrangian-Eulerian (ALE) simulation of fluid structure interaction



Vehicle Model with Shell Elements



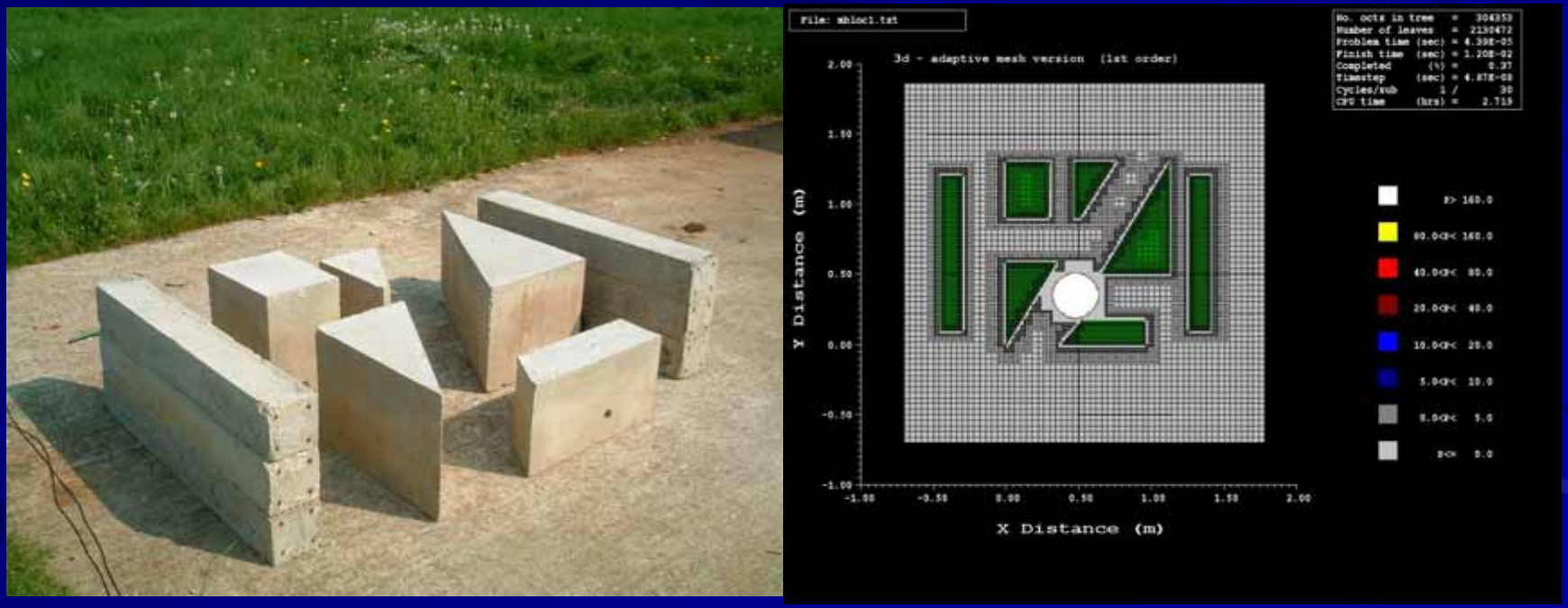
Blast Wave Propagation

SIMULATION OF VEHICLE RESPONSE TO MINE BLAST

Blast loading and structural response III

Peter Smith (Cranfield University, Defence Academy, UK): small scale experimental investigations complemented by numerical simulation

Studies into blast propagation in complex urban geometries to understand the phenomena of ‘shielding and ‘channeling’

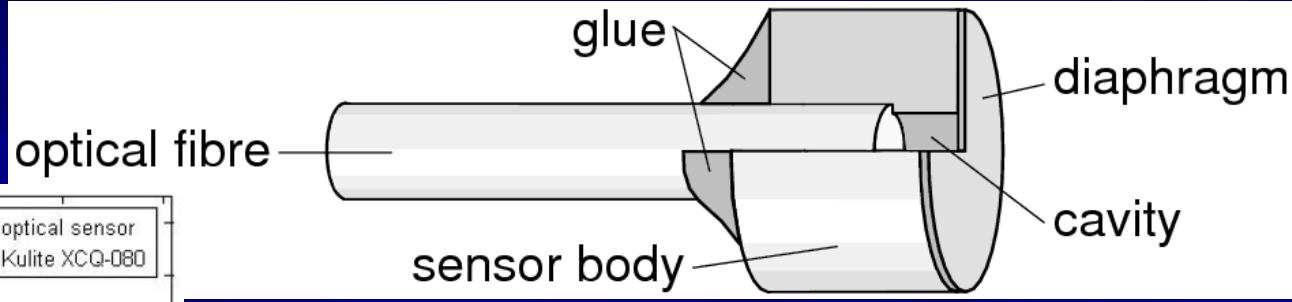


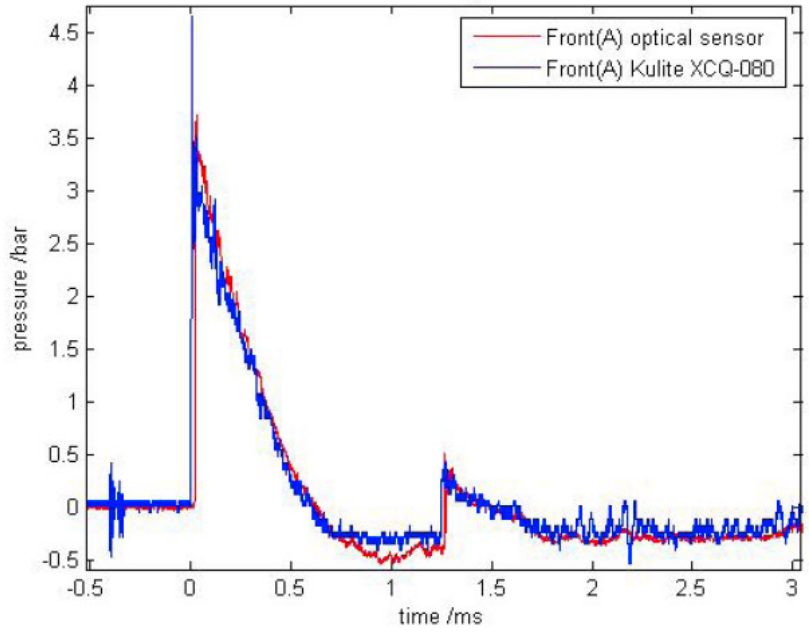
SMALL-SCALE EXPERIMENT and SIMULATION OF URBAN GEOMETRY

Blast loading and structural response IV

Andy Tyas (University of Sheffield, UK): blast and impact testing laboratory with a range of data acquisition systems

Development of new fibre-optic blast pressure transducers for non-invasive and high-resolution blast measurements



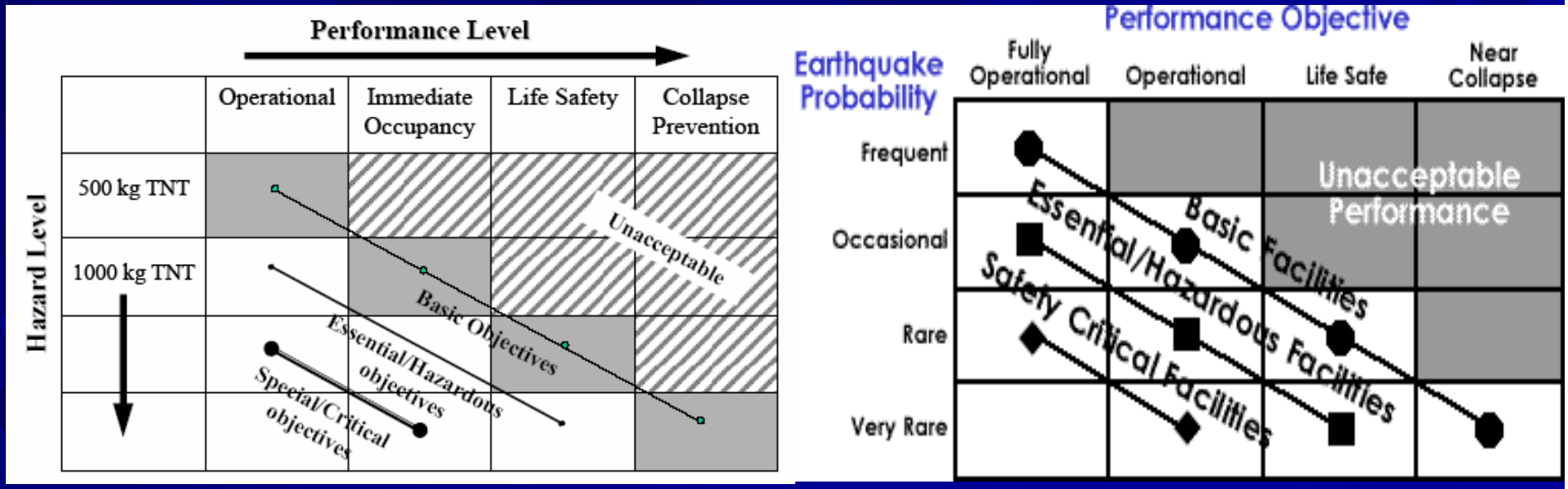


MINIATURISED BLAST PRESSURE TRANSDUCER AND ITS PERFORMANCE COMPARED TO A 'CONVENTIONAL' SYSTEM

Blast loading and structural response V

Florea Dinu (Romanian Academy, Timisoara, Romania): transfer of seismic design techniques to blast and impact design

Though there are differences between seismic, blast and impact resistant design techniques, there are similarities which can lead to a blast and impact design approach based on seismic techniques

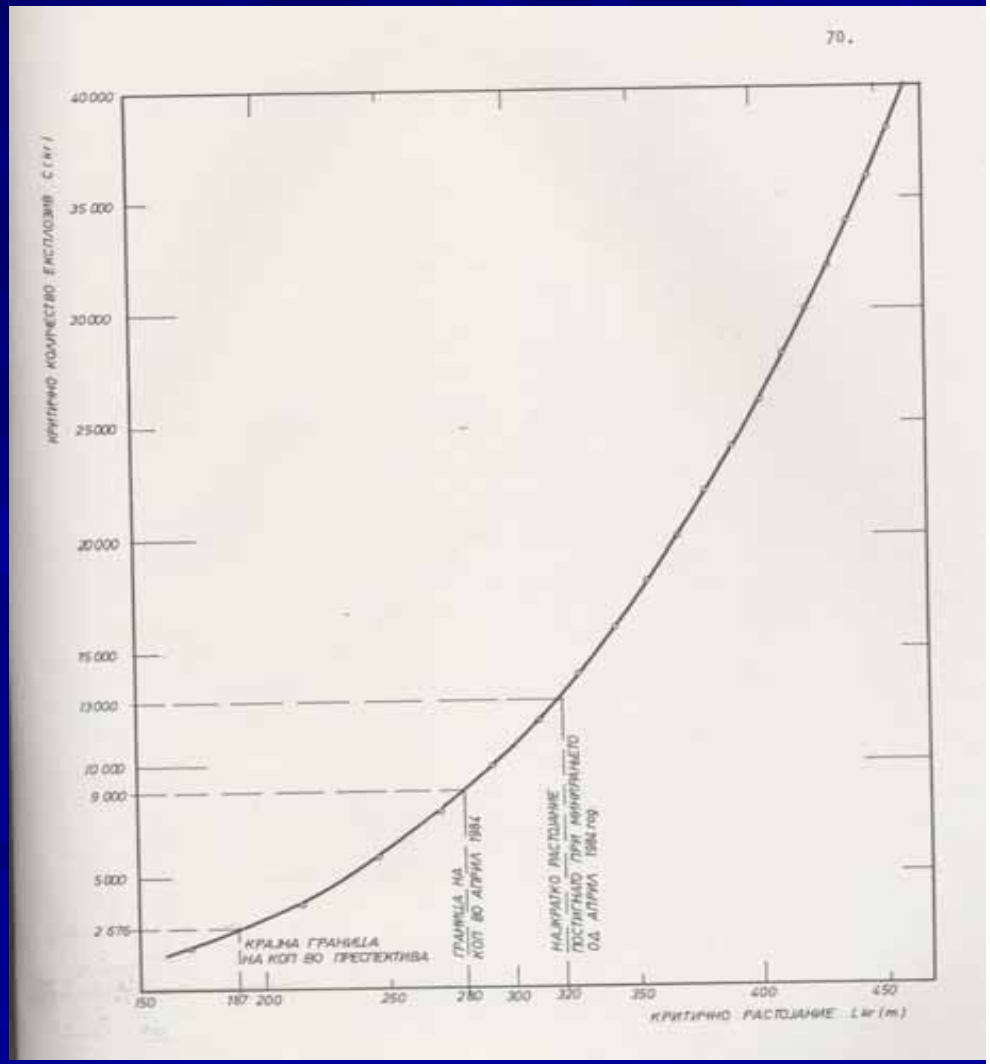


BLAST RESISTANT DESIGN APPROACH (Left) vs SEISMIC DESIGN APPROACH (Right)

Blast loading and structural response VI

Ljubomir Tashkov (Sts Cyril and Methodius University, Skopje, Macedonia): seismic effects of an explosion vs seismic effects of an earthquake

The response of a building to ground-shaking from an underground explosion can be investigated using the same principles and instrumentation as for earthquakes

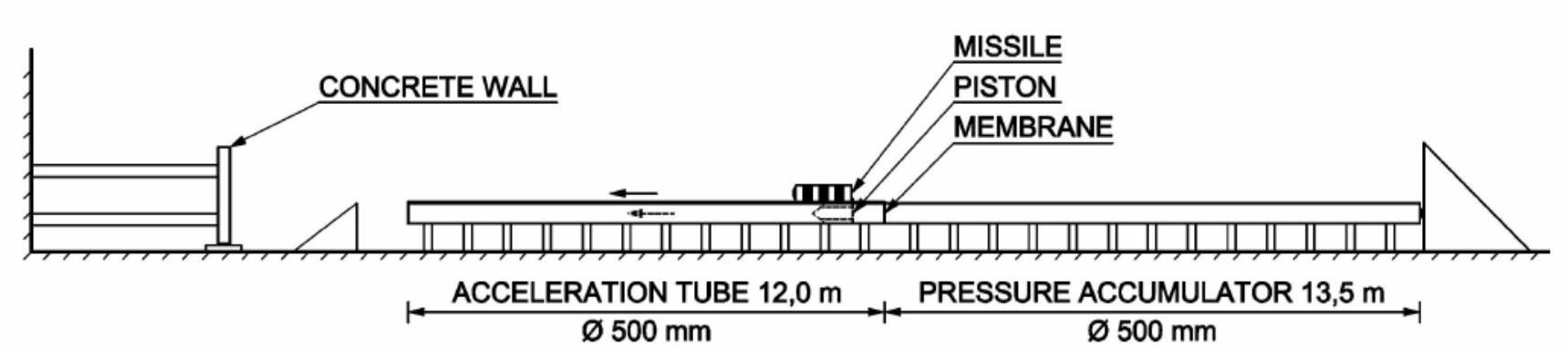


EXPLOSIVE MASS VS CRITICAL DISTANCE FOR A SPECIFIED STRUCTURAL RESPONSE LEVEL

Structural response to missile and vehicle impact I

Auli Lastunen (VTT Technical Research Centre, Finland): experimental investigations into impact and blast loading of structures and equipment

Ongoing work includes the use of both shock tubes (for testing shelter equipment against blast loading) and a compressed air-driven missile (for studying aircraft impact on nuclear power plant)

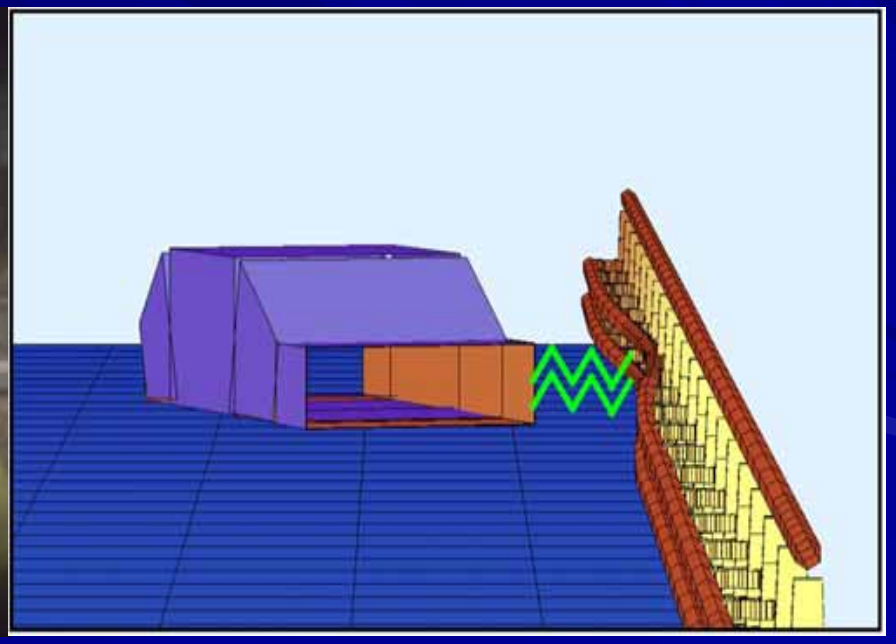


VTT COMPRESSED AIR-DRIVEN IMPACT APPARATUS

Structural response to missile and vehicle impact II

Christian Seiler (University of Munich, Germany): range of activities including capacity design methodology, earthquake engineering and blast testing

The capacity design methodology is being used to study the impact of vehicles on guardrails both experimentally and numerically

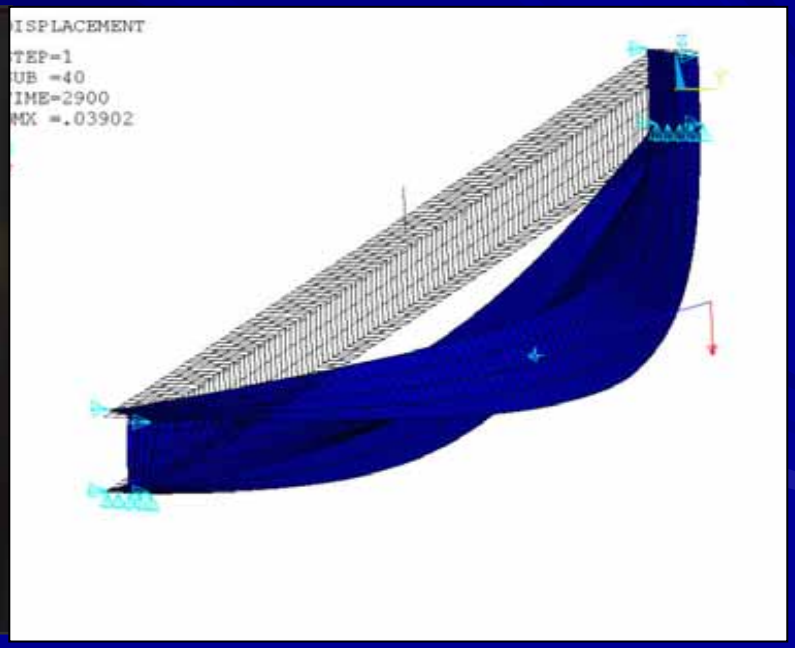


EXPERIMENTAL AND NUMERICAL IMPACT STUDIES

Other expertise in ‘dynamic loading’ I

Paulo Piloto (Polytechnic Institute of Bragança, Portugal): expertise in structural behaviour at elevated temperatures

Plans to develop work in the area of accidental events involving the combination of explosions with fire and impact with fire



EXPERIMENTAL AND NUMERICAL STUDIES OF STRUCTURAL ELEMENTS AT ELEVATED TEMPERATURES

Other expertise in ‘dynamic loading’ II

- Carlos Rebelo (University of Coimbra, Portugal): developing programme to study the dynamic behaviour of geosynthetically reinforced soil under blast and impact loading
- Monique Bakker (Eindhoven University of Technology, Netherlands): developing plans to study blast and impact resistant design in the context of Quantitative Risk Assessment (QRA) with regard to hazardous materials
- Michael Tzaferopoulos (Aristotle University of Thessaloniki, Greece): improvements in protective design to account for wider range of threats and materials, combination of effects, use of upgrades, better damage assessment and stabilization before repair

WG3 areas of activity

- Codes and standards related to robustness
- Vulnerability to progressive collapse due to localise damage from blast or impact
- Quantification of actions related to extreme events
- Protection systems and design methodologies to resist blast and impact
- Assessment and repairing of damaged structures
- Experimental testing
- Numerical simulation

Conclusions

Within the membership of COST C26 WG3 there is a wide range of relevant expertise. The agreed scope of the working group is comprehensive and addresses the important issues of Impact and Explosion within the overall action of “Urban habitat constructions under catastrophic events.”

THANK YOU FOR YOUR ATTENTION!