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Benjamin Terrade, Jad Zghondi, Gilles Armand, Laura Kerner, François Toutlemonde, J.M. Bosgiraud

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A UNIQUE DEVICE FOR TESTING THE LONG-TERM BEHAVIOUR OF A WHOLE SEGMENTS RING OF A DEEP TUNNEL

8TH INTERNATIONAL CONFERENCE

13-16 June 2022 - Nancy (France)

ON CLAYS IN NATURAL AND ENGINEERED BARRIERS FOR RADIOACTIVE WASTE CONFINEMENT

*TERRADE Benjamin**, *ZGHONDI Jad***, *ARMAND Gilles***, *KERNER Laura**, *TOUTLEMONDE François**, *BOSGIRAUD Jean-Michel****

*University Gustave Eiffel/MAST/EMGCU ** ANDRA, Meuse/Haute-Marne Underground Research Laboratory 55290 Bure, France ***ANDRA, 1 rue Jean-Monnet, 92298 Châtenay-Malabry Cedex, France

Motivation

Arch segment design is an important consideration for deep underground tunnels with progressive and anisotropic convergence. Andra's ongoing scientific and technological program covers a multi-criteria study concerning the integration of compressible elements in linings to cap the radial stress induced by Callovo-Oxfordian's convergence. Technological qualification requirements, as well as early mechanical behaviour have been demonstrated in Andra's underground research laboratory. The objective of this program is to demonstrate the long term mechanical robustness of different compressible linings, by applying long term mechanical loadings representing a period of 150 years, where rock convergence is initially anisotropic and progressive over the time. The first compressible segment tested in the program are "Voussoir monobloc compressible"(VMC©) made of claystone shell.

Testing system key values

Loading device

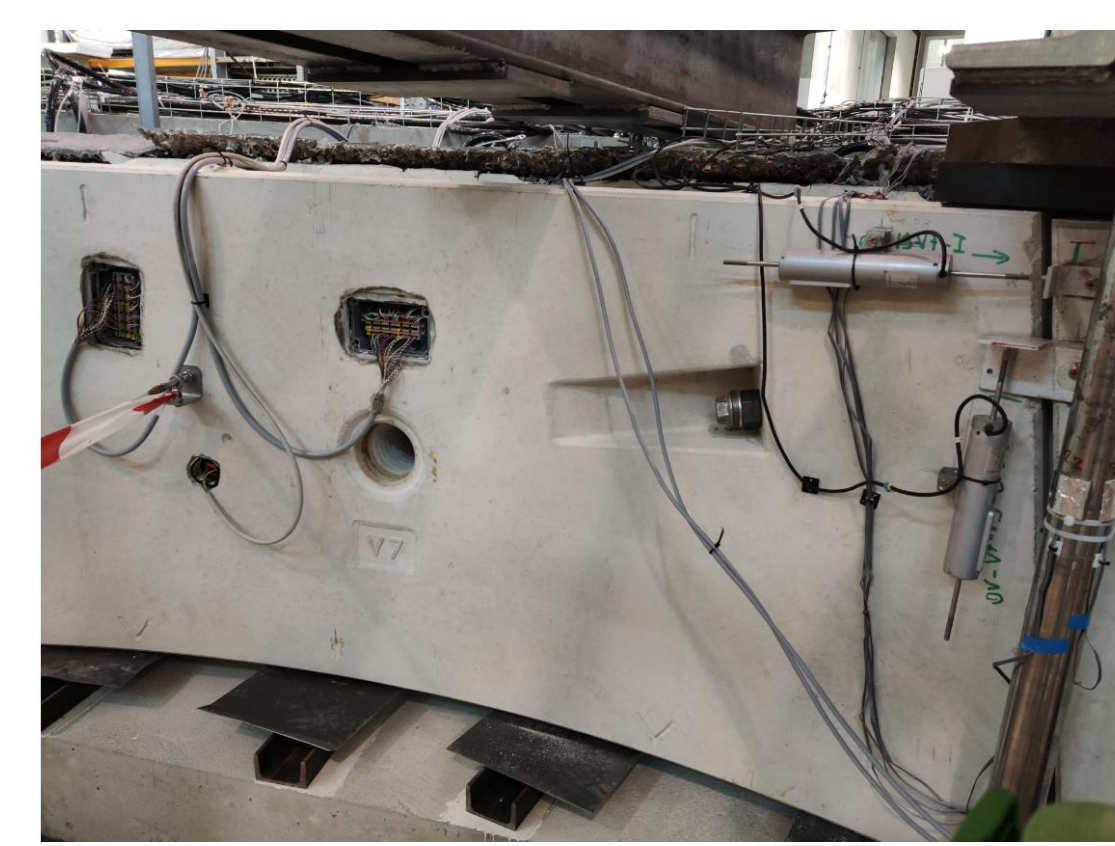
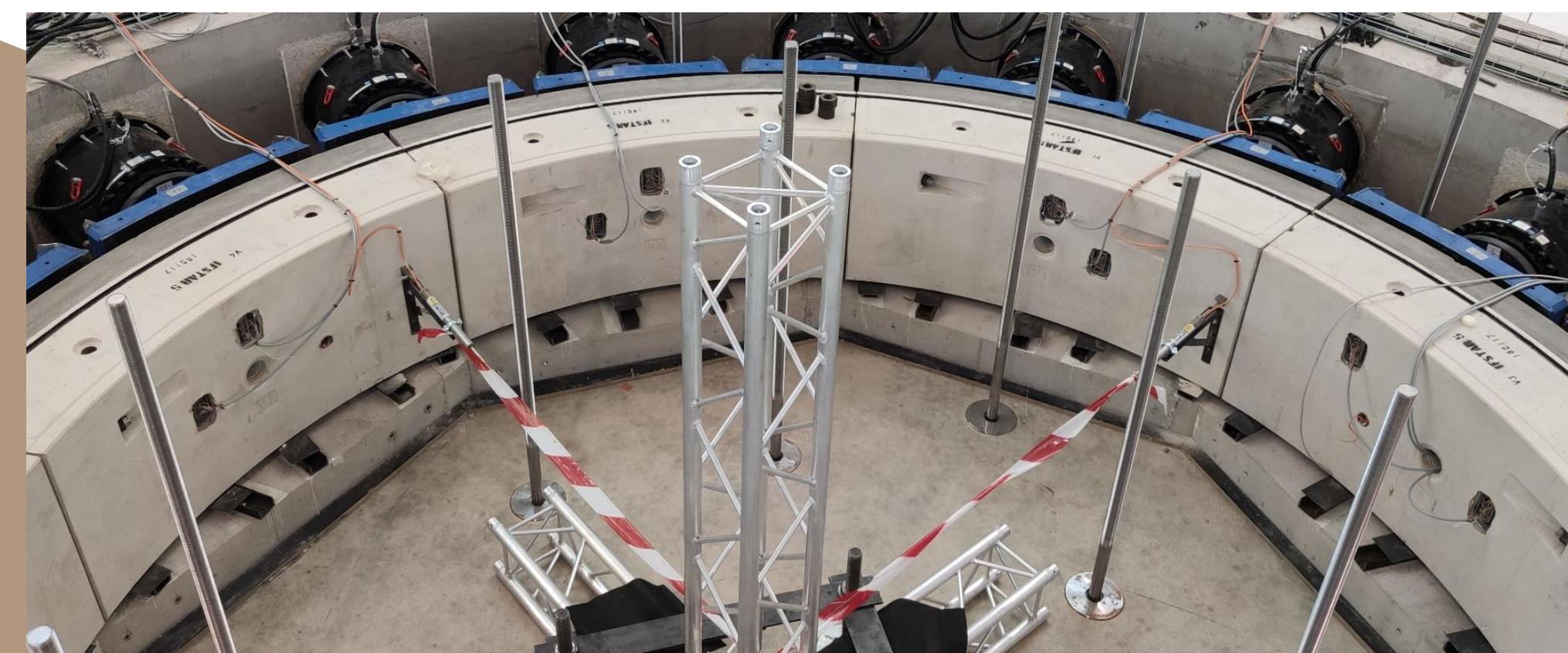
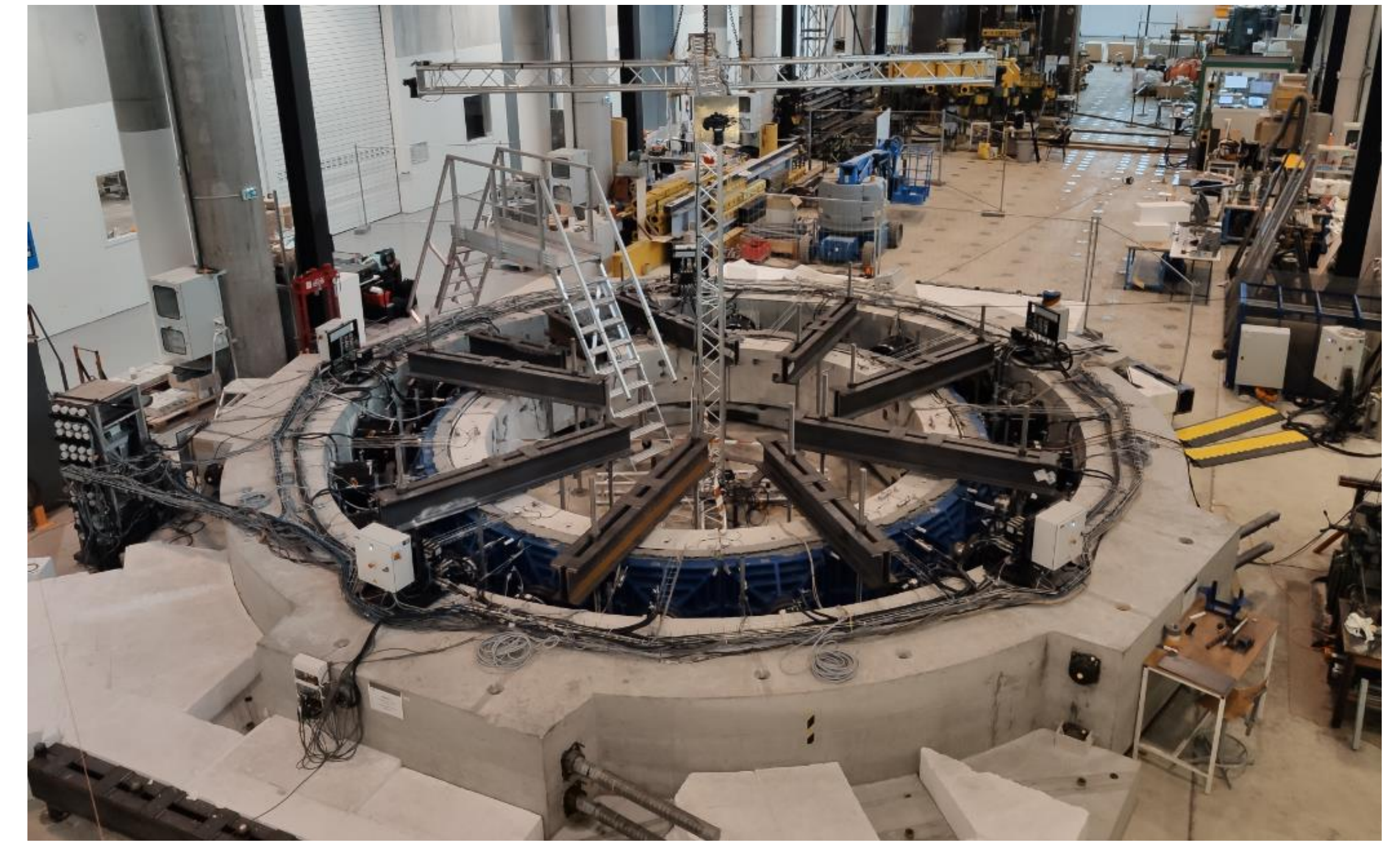
- Support: pre-stressed reinforced concrete ring
9m diameter/1m thickness
- 20 hydraulic jacks, load or displacement control
5000 kN maximal load & 150 mm rang
- Load spreading plate on the outer surface of the ring

Tested segments : VMC rings

- Three rings: reinforced concrete + compressible shell layer on the extrados
- Reinforced concrete:
 - Width = 0,8 m/thickness = 0,42 m
 - Concrete = C60/75 (C1 0,65)
 - Steel average reinforcement ratio =150 kg/m³
- Compressible layer (15cm)
 - Elasto-plastic behaviour, with 40% of compressibility
 - Ceramic shells tube shaped produced from Cox agglomerated and casted directly after concrete pouring

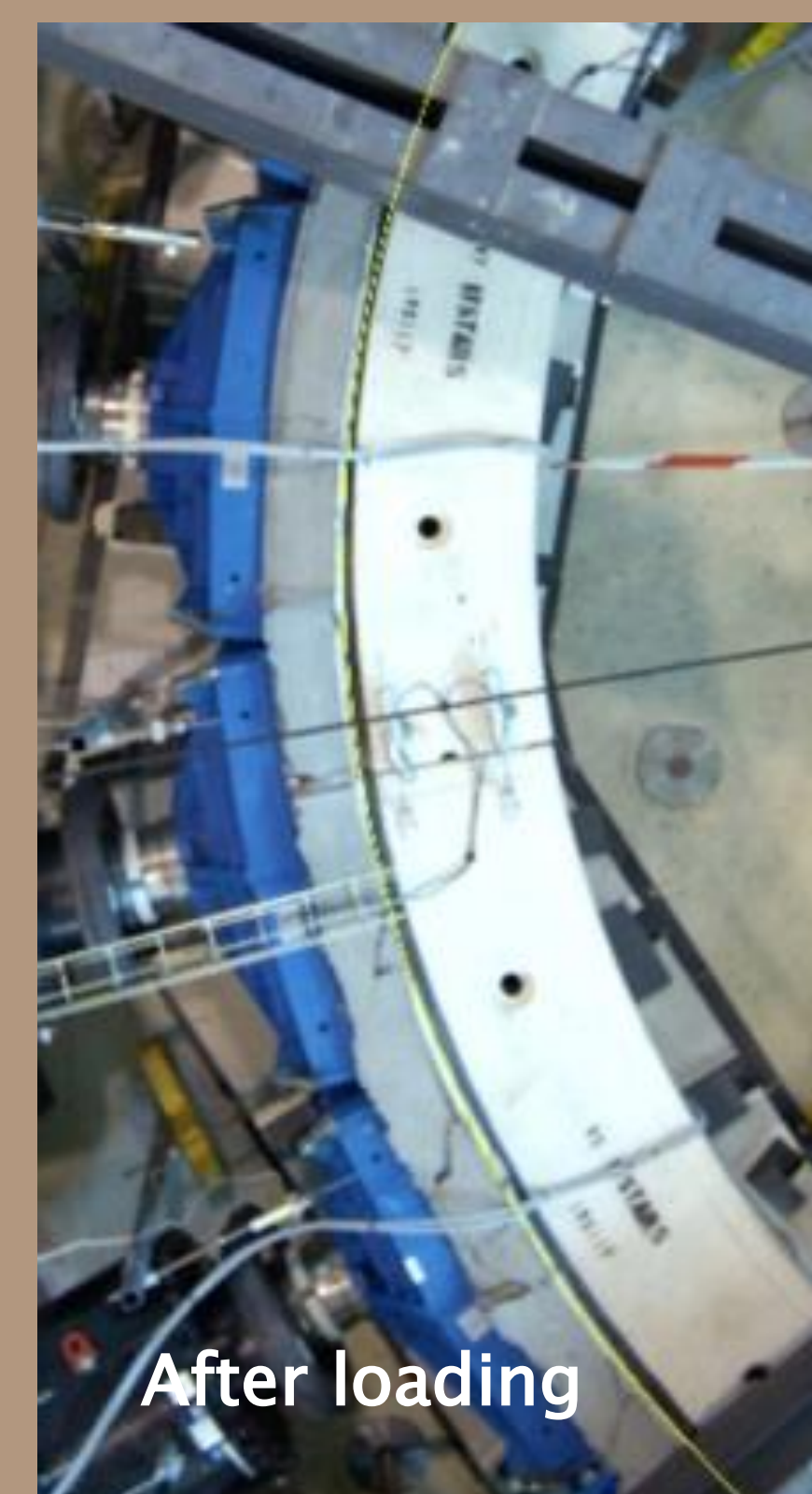
Experimental strategy

- More than 250 sensor:
 - Device monitoring : load/displacement of the jack, strain on the support ring...
 - Ring loading (stress/strain) & movement (convergence, displacement)...
 - Compressible layer deformation
- Visual diagnostics
 - High quality videos.
 - Visual damage evolution on the rings (pre & post testing)
- Simulation program



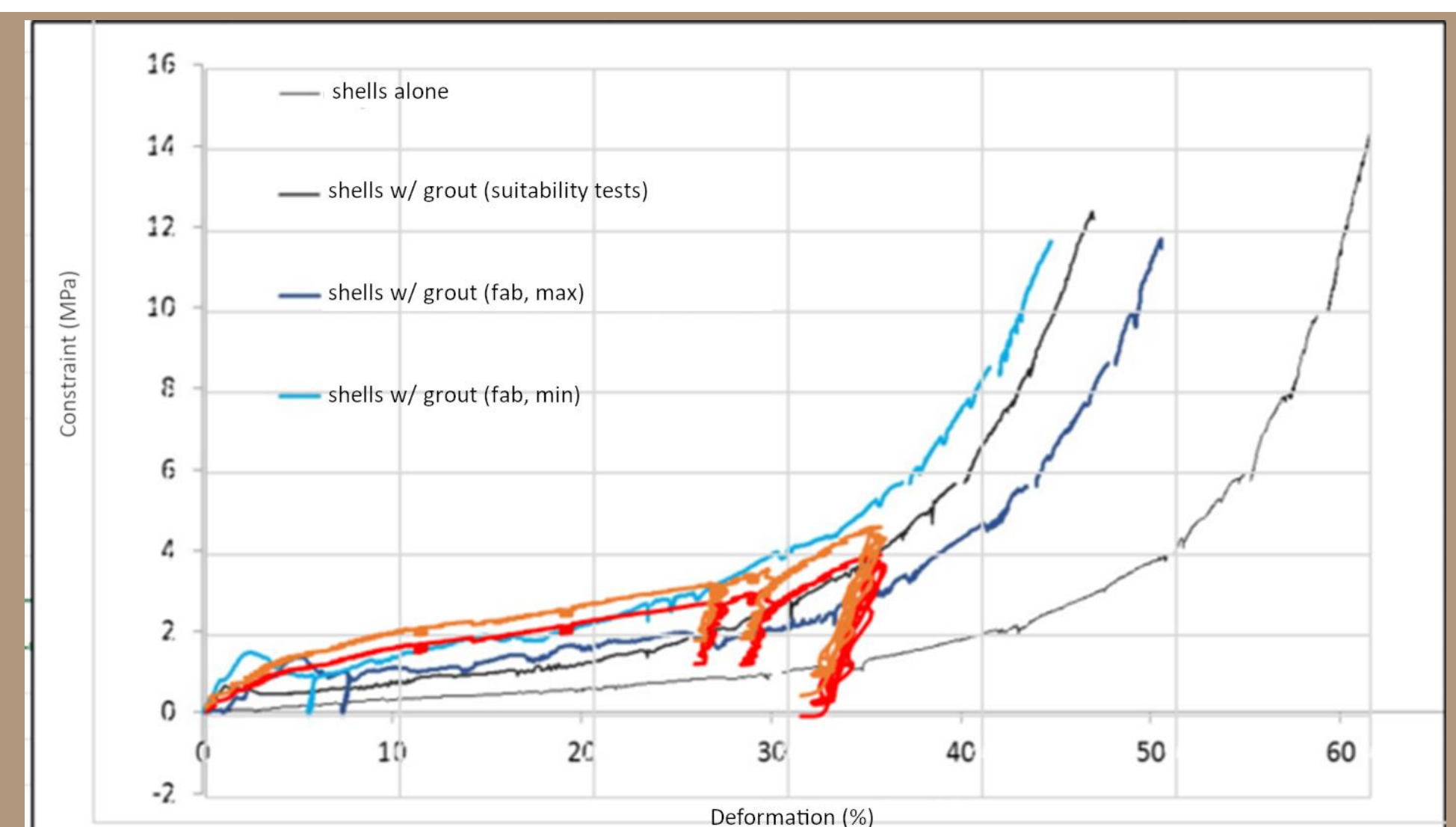
Carried out program

- Device validation :
1 ring with different accident loading
- Isotropic loading (VMC solution):
2 rings were tested



Ongoing analysis

- Workability of the experimental device was proven
- No structural damaged of the reinforced ring, and stress/strain measurement below the design criteria.
- The compressible VMC layer behaviour is proving it's benefit with delaying the ring loading



Compressible layer : Oedometric results Vs oedometric curves assessed from full scale testing (red/orange curves)

Perspectives

- Innovative device that can be use for other kind of ring loading demonstration
- Following tests:
 - VMC solution : several anisotropic loading patterns will be tested
 - One ring without a compressible layer, to consolidate mechanical analysis and interface effect
 - Different compressible ring solution adapted to the construction method (traditional, TBM,...)



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