

Proposed Benchmark Problem
**Structural Response of
a Concrete Interface Subjected to
Reverse Cyclic Load**

Prof. Victor E. Saouma

University of Colorado, Boulder/Politecnico di Milano

Eric Puntel

Politecnico di Milano

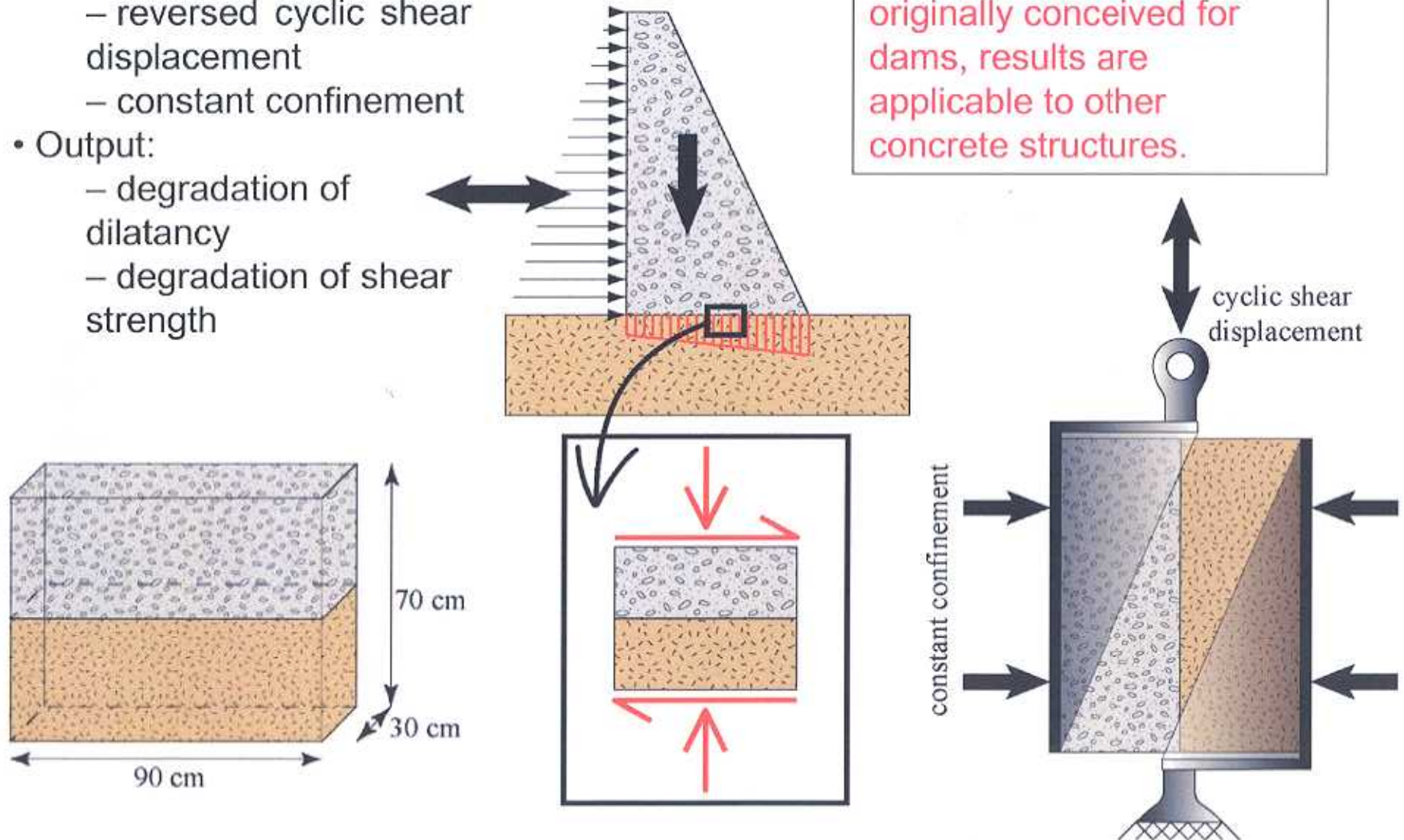
Background

- During his leave of absence from the University of Colorado at the Politecnico of Milano, Prof. Saouma performed tests on large jointed concrete specimens subjected to reverse cyclic loading.
- Tests were performed by Mr. Eric Puntel as part of his PhD thesis in the Structural Engineering Laboratory of Politecnico.
- Computational Enthusiasts are invited/challenged to provide a numerical prediction for those tests.
- Results will be compiled and presented at a forthcoming international event.

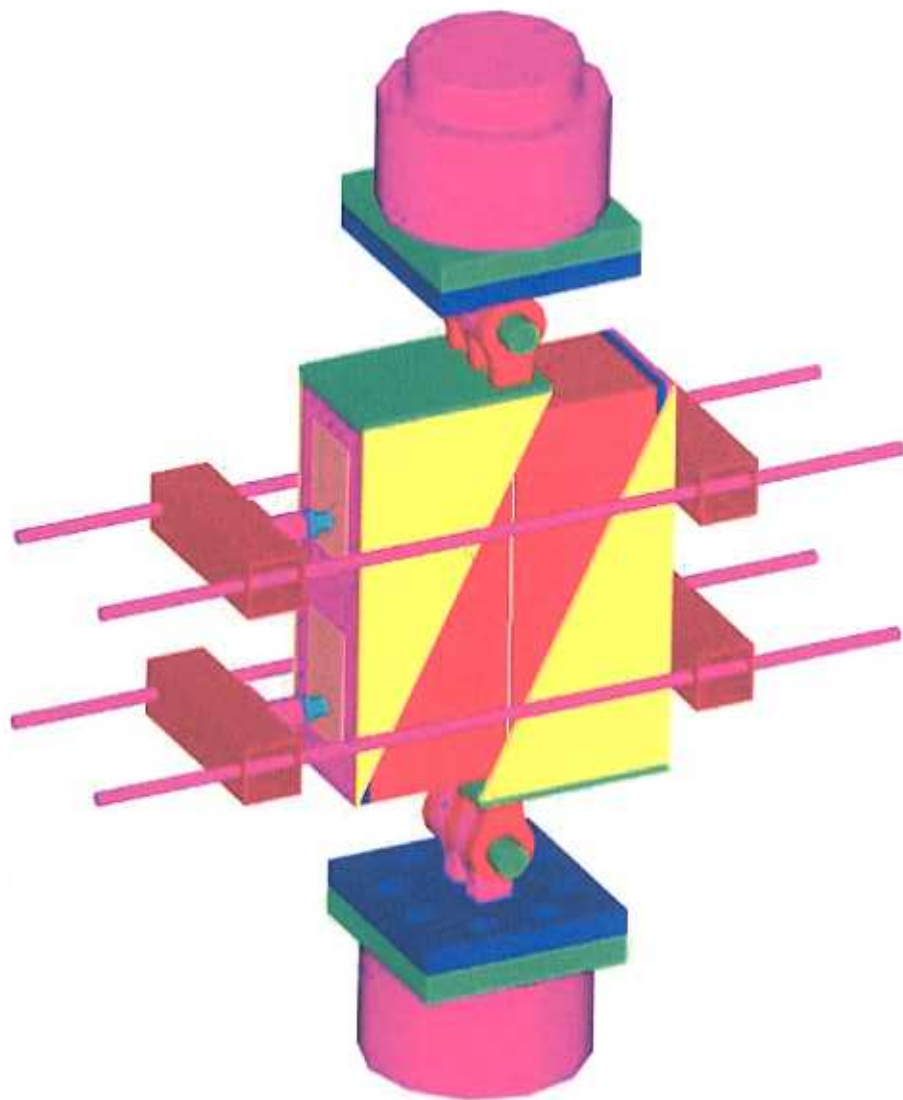
Experiments on cyclic behaviour of concrete joints

- Input:
 - reversed cyclic shear displacement
 - constant confinement
- Output:
 - degradation of dilatancy
 - degradation of shear strength

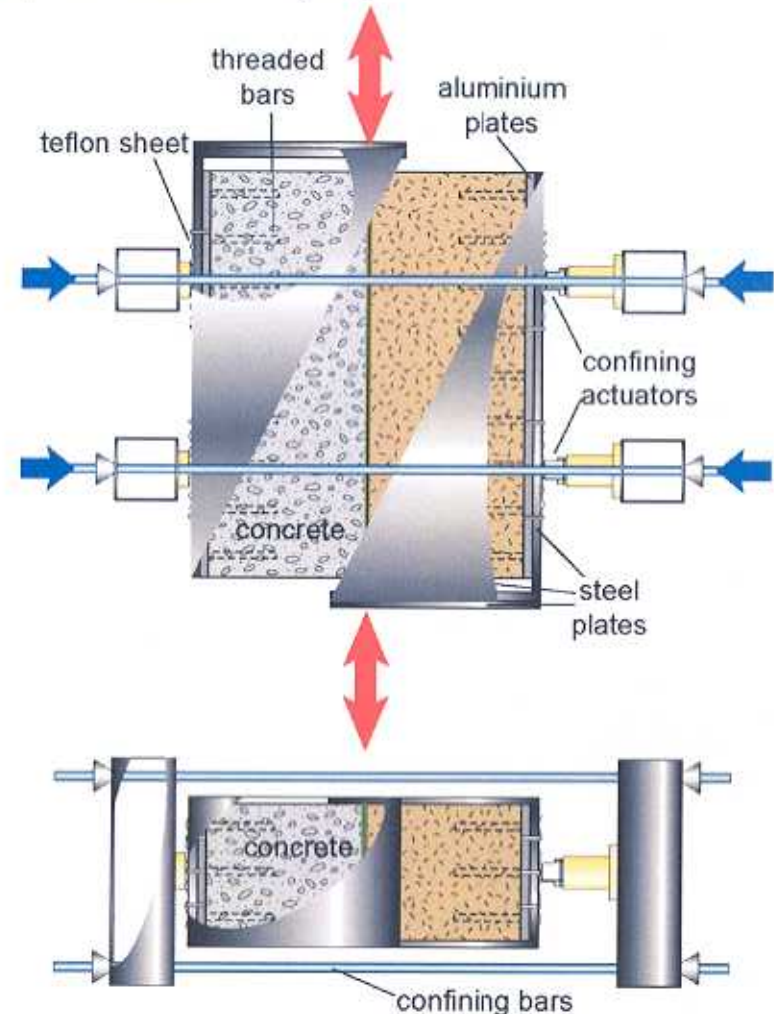
Whereas tests were originally conceived for dams, results are applicable to other concrete structures.



Experimental apparatus (1)



Experimental apparatus (2)



Two aluminium plates, cast together with the concrete blocks, are used to transfer the load from the steel frame to the specimen.

The aluminium plates have 36 threaded holes: 12 to bolt them to the steel frame and other 24 where threaded bars immersed in concrete are connected.

Specimen preparation

1. Cast first concrete block



2. Sandblast the surface



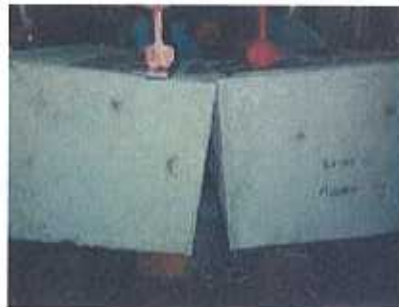
3. Cast second concrete block



4. Place aluminium plate with threaded bars (for load transfer from steel frame to concrete)



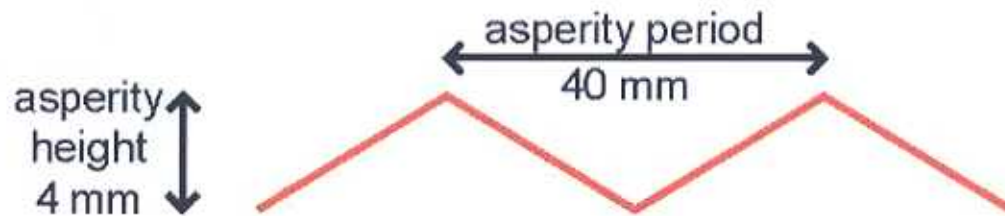
5. Break the specimen in four point bending



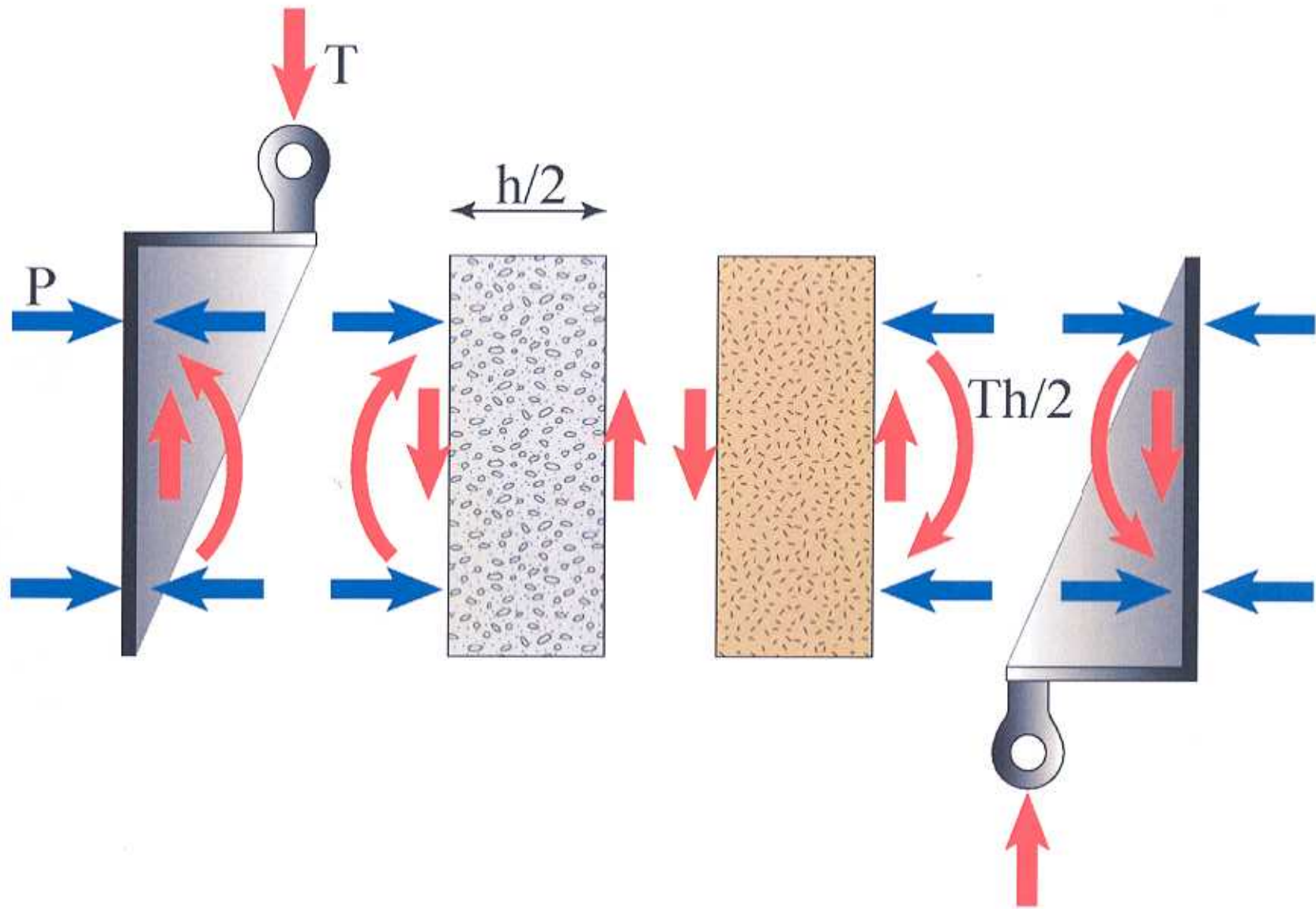
Surface Roughness

The interface has a roughness that was created in order to simulate rough joints (such as in dams).

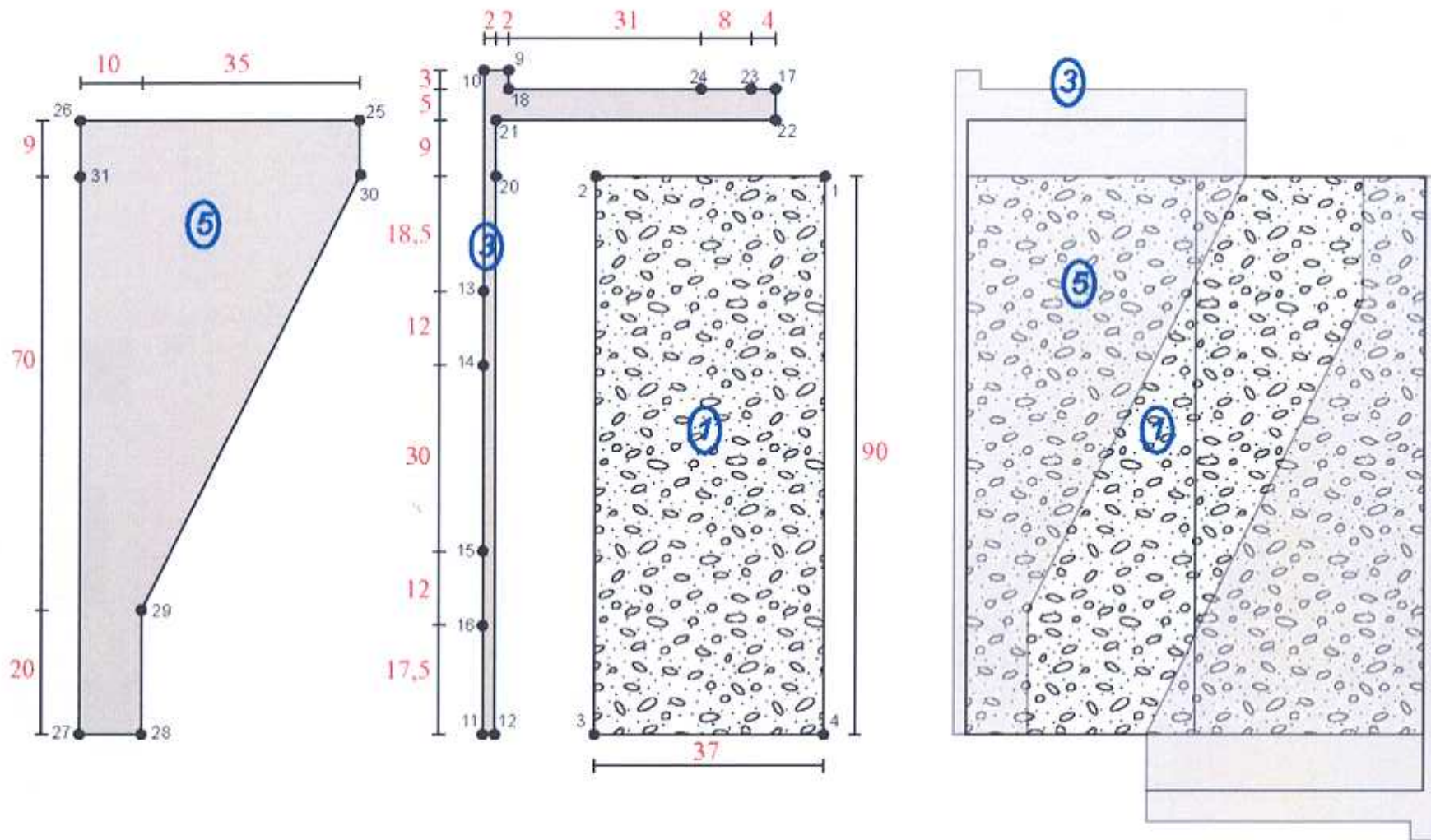
The asperities on the surface have a period of about 40 mm and a height of about 4 mm. The maximum aggregate size of the concrete mix is 25 mm.



Free body diagram



Simplified 2D geometry



Dimensions in centimetres given in red.

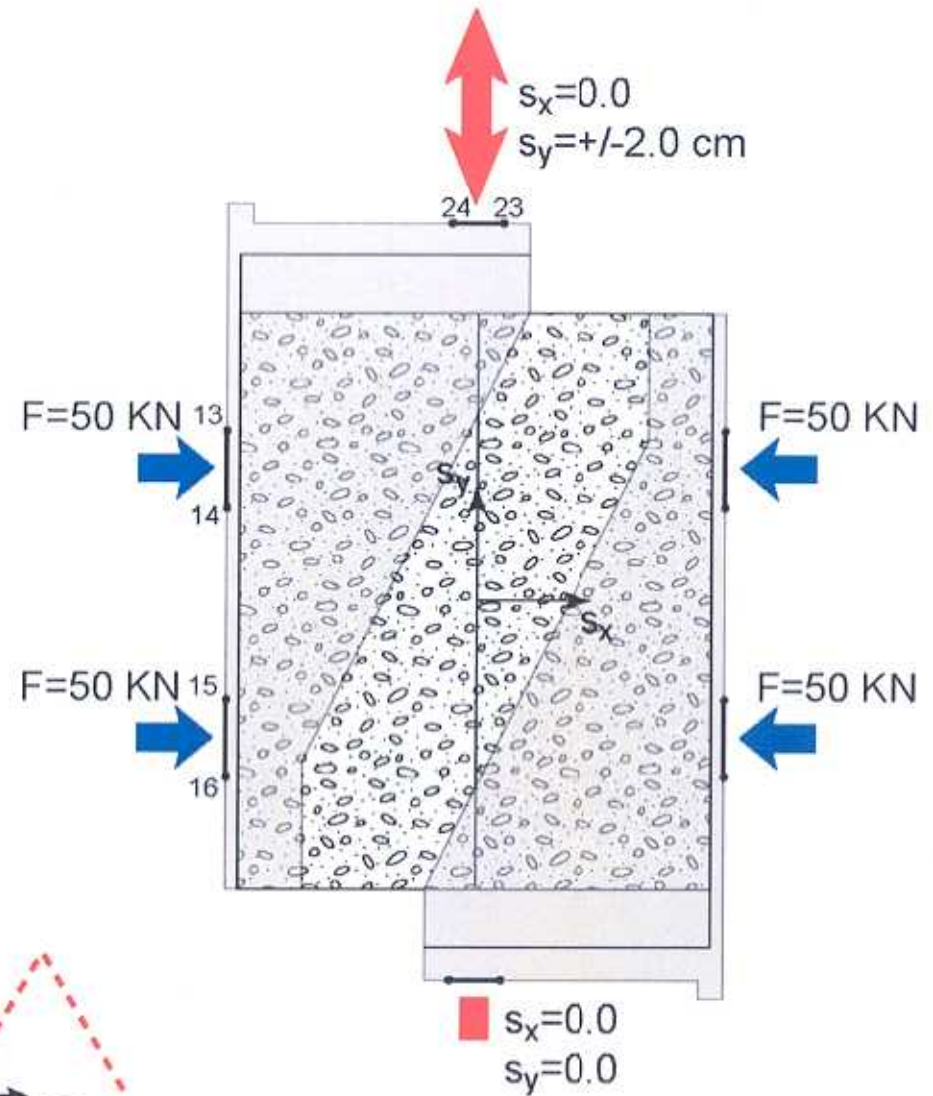
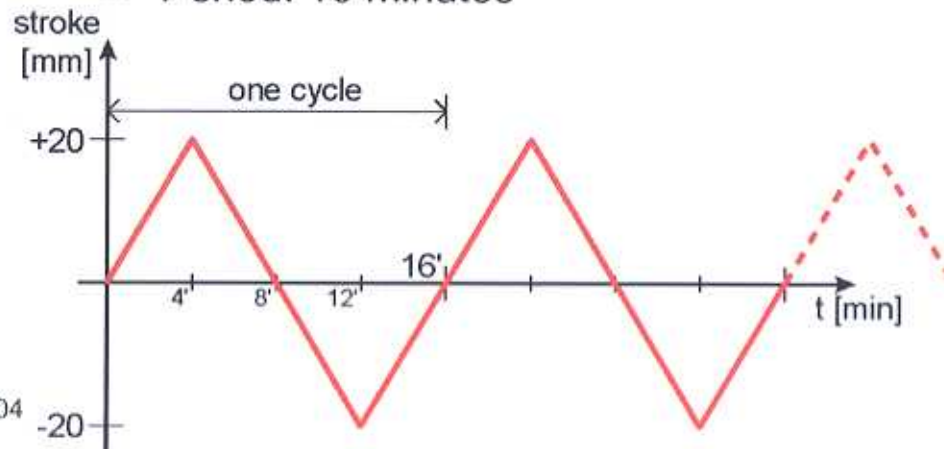
Coordinates of segments 2-3, 20-12 and 31-27 coincide.

Segment 1-4: interface crack.

3/16/2004 Thickness: 4 cm (patch 5), 33 cm (patch 3), 30 cm (patch 1).

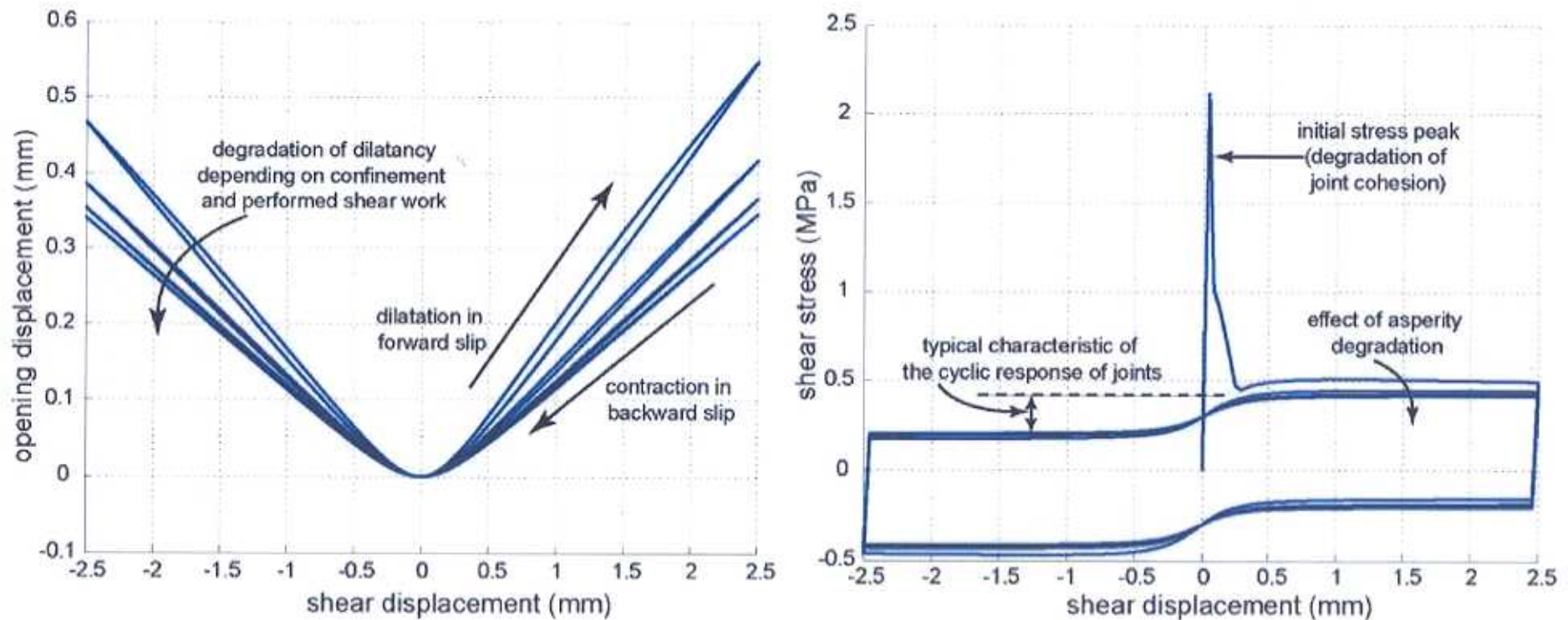
Boundary conditions and material properties

- Plane stress
- Concrete:
 - $E=25$ GPa
 - $\nu=0.2$
 - Compressive strength: 30 MPa
- Steel
 - $E=206$ GPa
 - $\nu=0.2$
- Imposed cyclic vertical load
 - Amplitude: 40 mm
 - Period: 16 minutes



Anticipated Response

The anticipated response, for cyclic shear displacement at constant confinement pressure, is shown below.



REQUESTED DATA

- Perform an analysis for 10 cycles.
- Provide the following
 - Mesh Details (picture, element types, number of nodes/elements).
 - FE Model (Program name, constitutive model, details of analysis).
 - Results (COD and CSD across the interface in the center of the crack in terms of external axial load) plotted, and in excel format.
- Preferred formats: Power-Point.
- Send results to saouma@civil.colorado.edu before June 2005.
- Additional test information can be obtained from eric@stru.polimi.it