EXPERIMENTAL RESULTS FOR THE INFLUENCE OF TURBULENCE ON THE ERODIBILITY OF A PORCELAIN CLAY

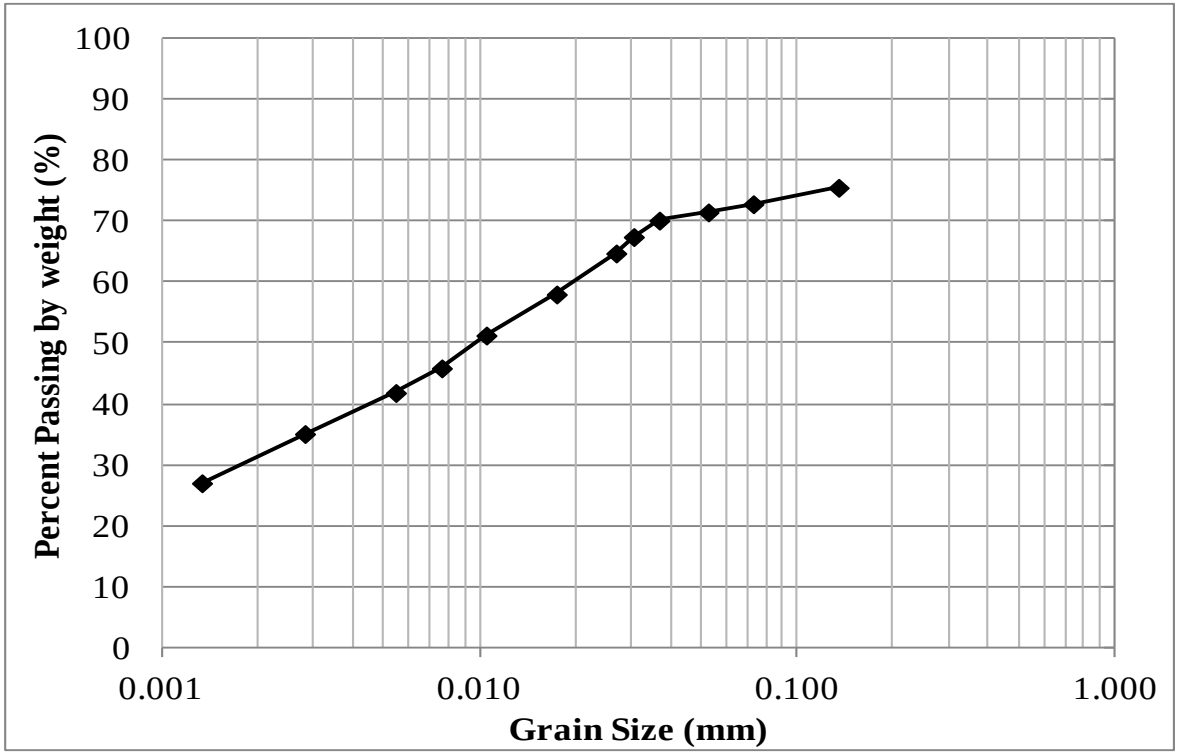
Jean-Louis BRIAUD, Oswaldo BRAVO, Kuang-An CHANG and Hamn-Ching CHEN

INTRODUCTION

- Influence of turbulence on the erosion function of porcelain clay using the Erosion Function Apparatus (EFA)
- Testing included:
  - Manufacturing three plates with varying roughness
  - Manufacturing one plate with a pier to evaluate the influence of the obstacle in the flow

PROPERTIES OF THE PORCELAIN CLAY

- D_{50} = 0.01 mm.
- w_L = 35%
- w_P = 18%
- w = 22%
- S_u = 18 kPa.

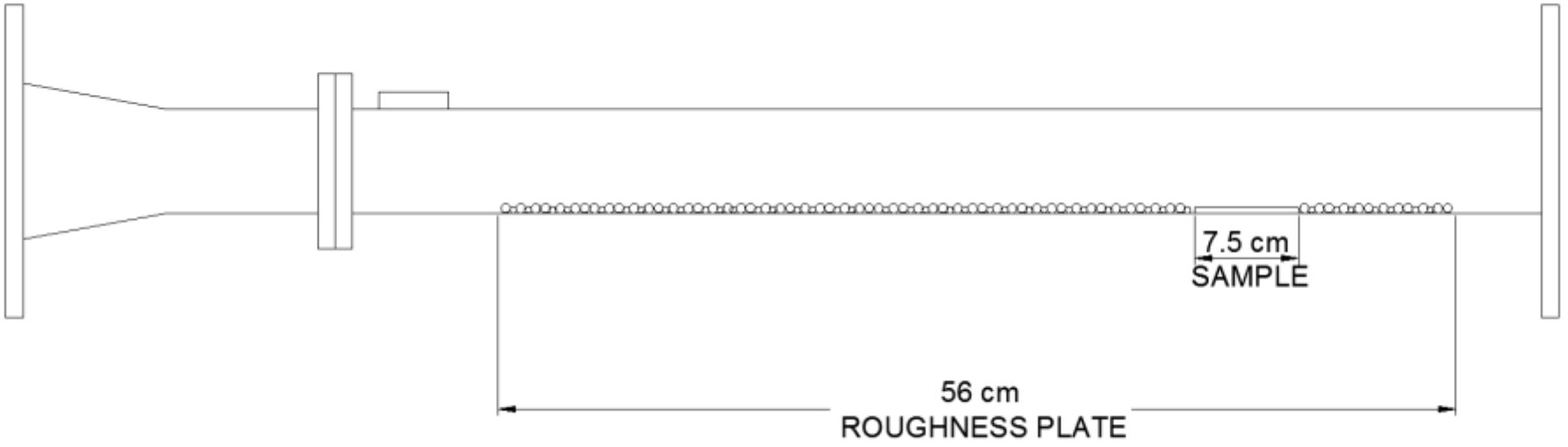


THREE ROUGHNESS PLATES

- SMOOTH
- GRAVEL with D_{50} = 2 mm
- GRAVEL with D_{50} = 10 mm

- PLATE 56 cm long, 10 cm wide
- Placed at bottom of EFA test section
- 7.5 cm diameter sample protrudes through plate

EFA TEST SECTION WITH ROUGHNESS PLATES

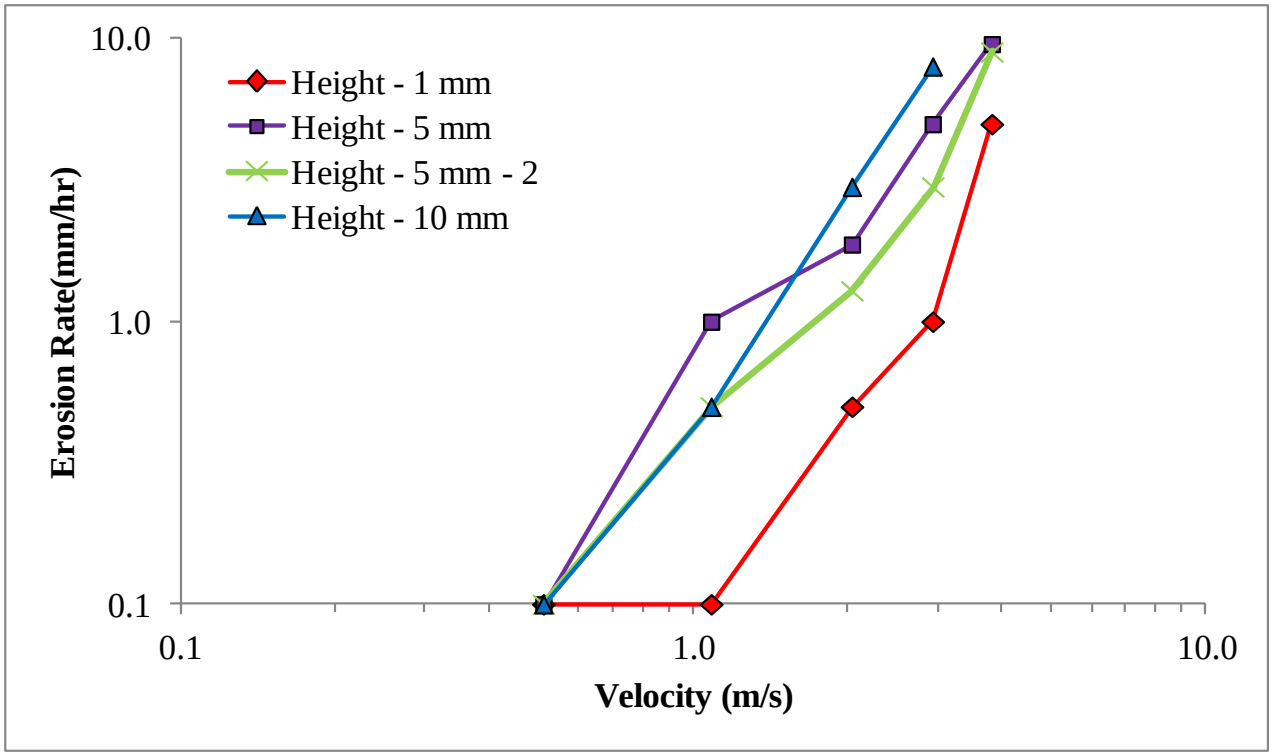



1.75 m/s

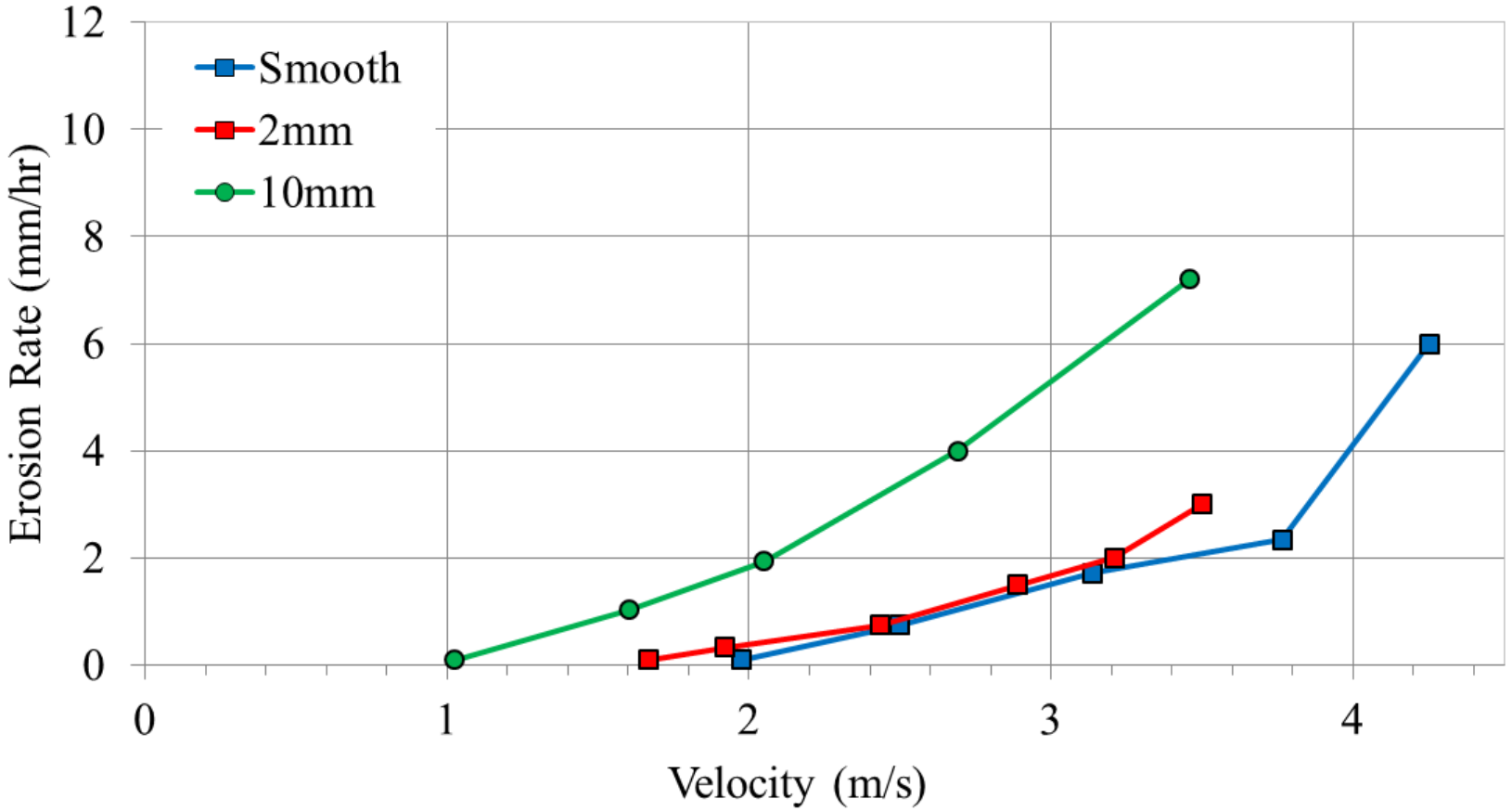

4.5 m/s

EFFECT OF SAMPLE PROTRUSION

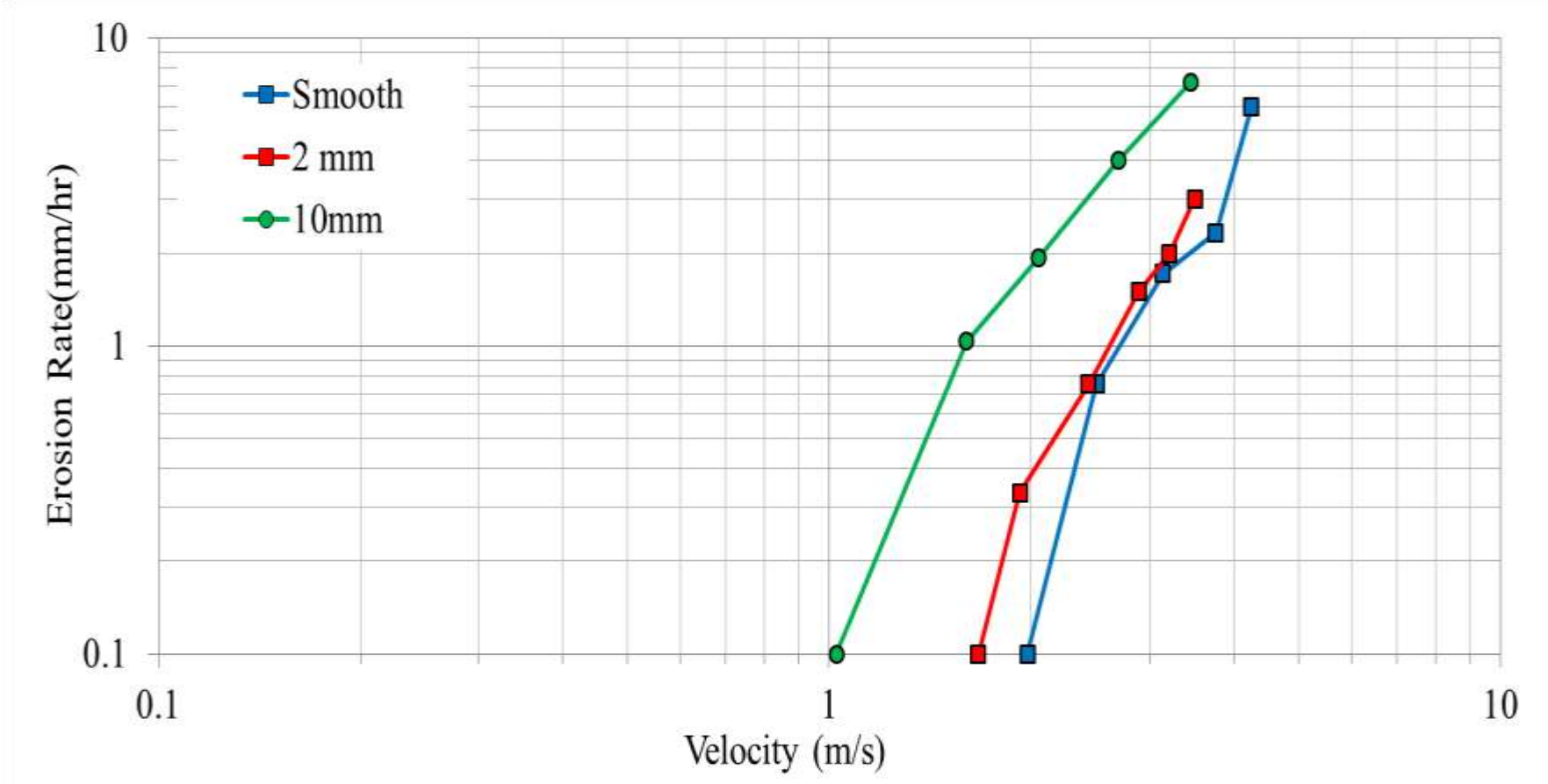
- Test done with 10 mm D_{50} PLATE
- Protrusion = 1 mm, 5 mm, 10 mm
- No major difference between 5 and 10 mm
- Protrusion set at 0.5 D_{50}



RESULTS (average of 4 tests)



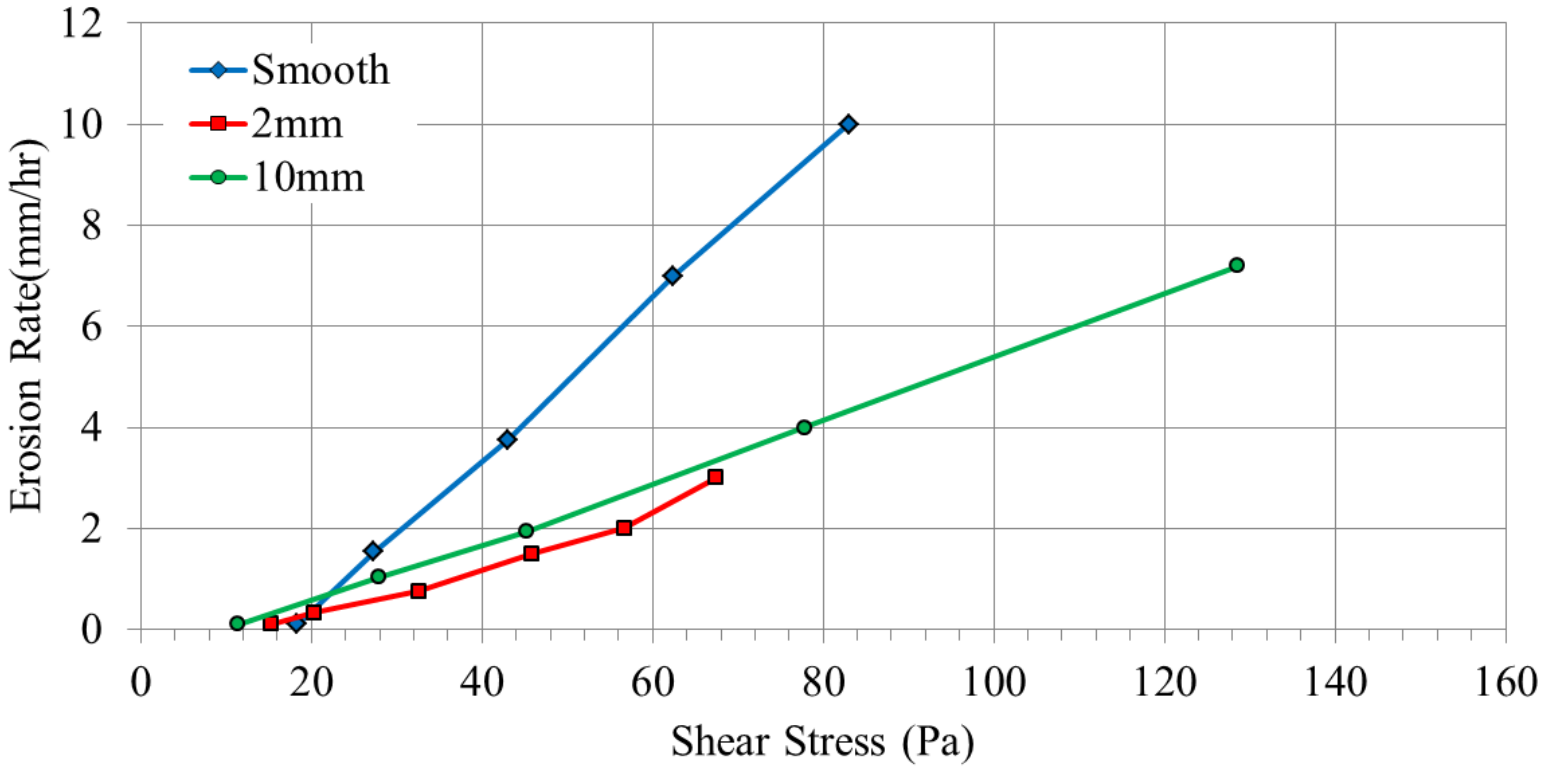
RESULTS (average of 4 tests)



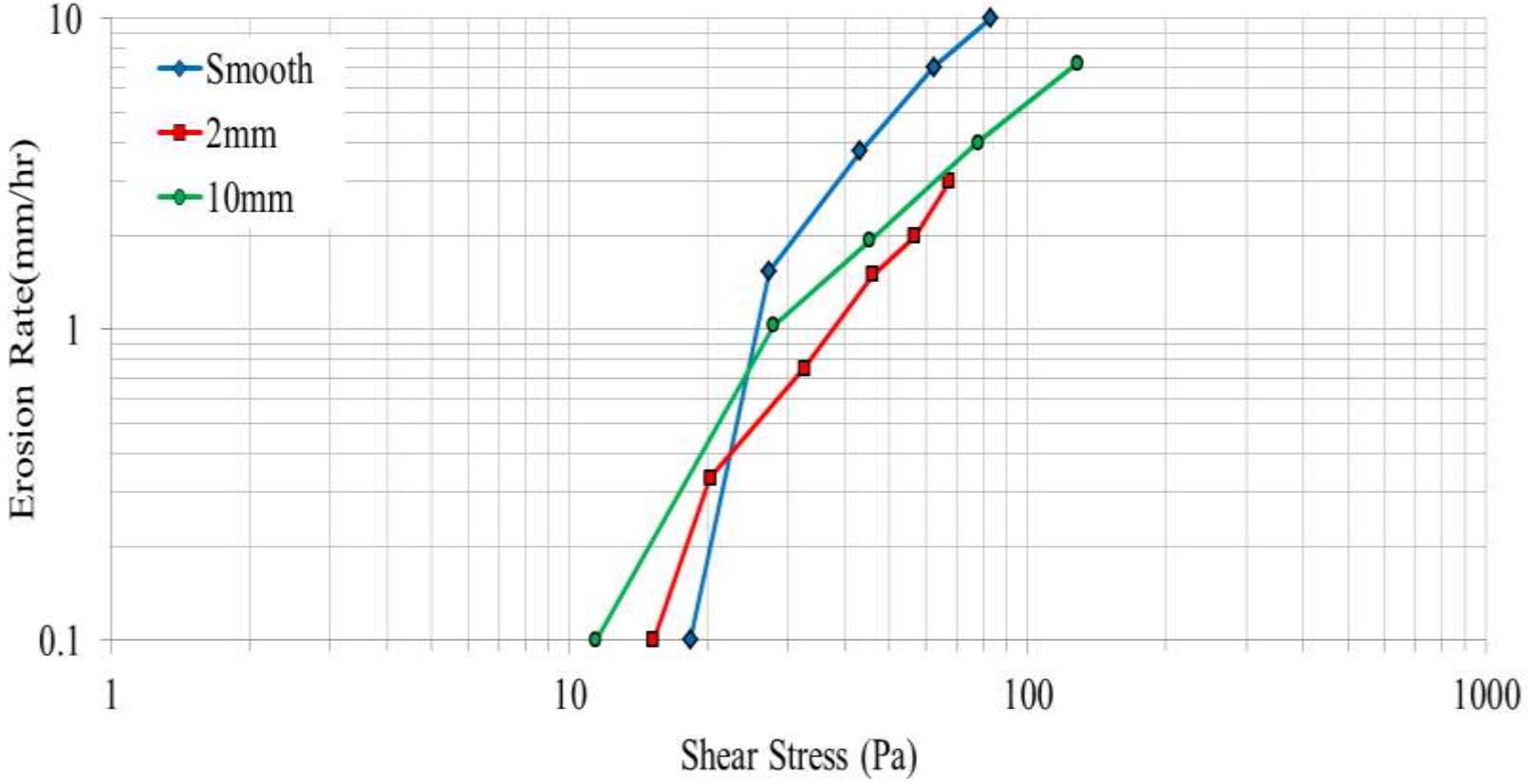
RESULTS

- Shear stress from Colebrook, 1939

$$\frac{1}{\sqrt{f}} = -2 \cdot \log\left(\frac{\varepsilon/D}{3.7} + \frac{2.51}{R_e\sqrt{f}}\right)$$



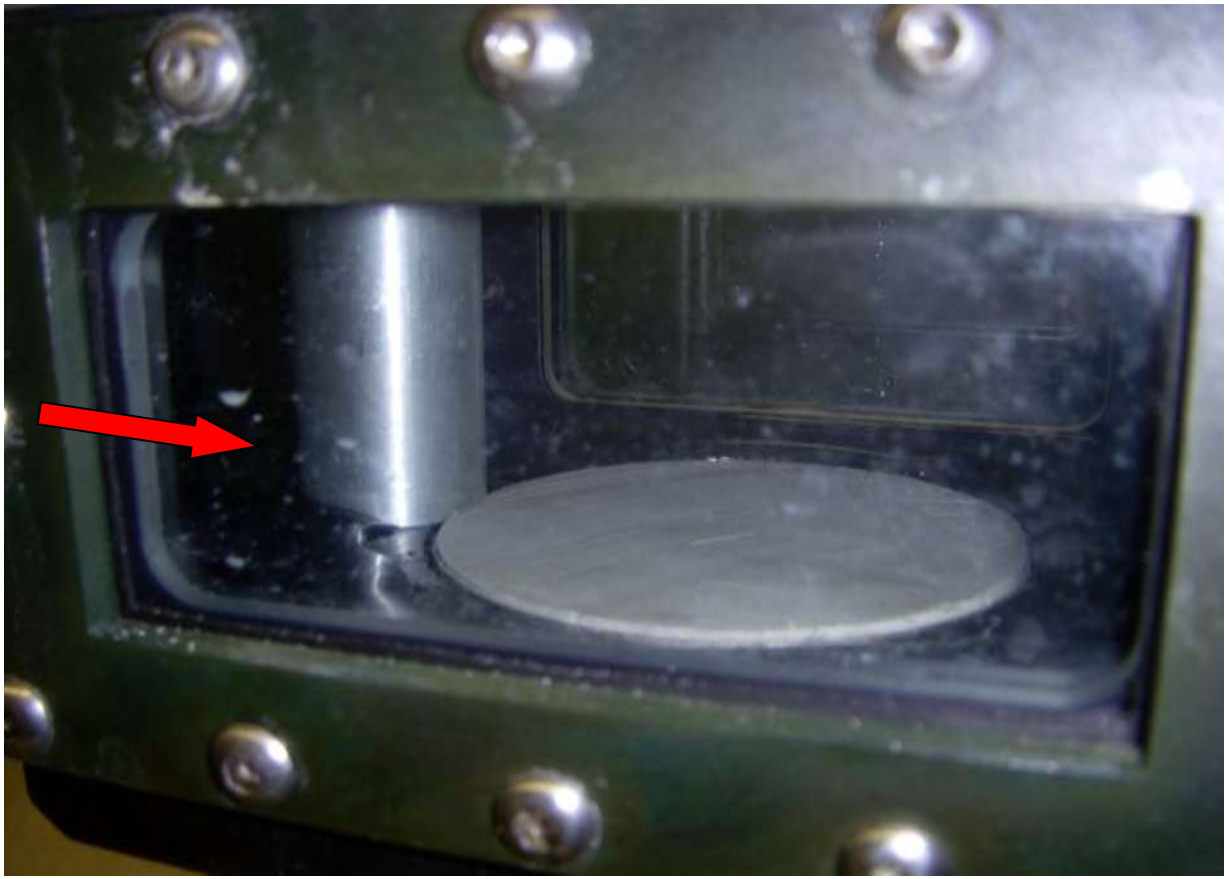
RESULTS


Smooth
2mm
10mm
Erosion Rate(mm/hr)
10
1
0.1
1
10
100
1000
Shear Stress (Pa)

FINDINGS

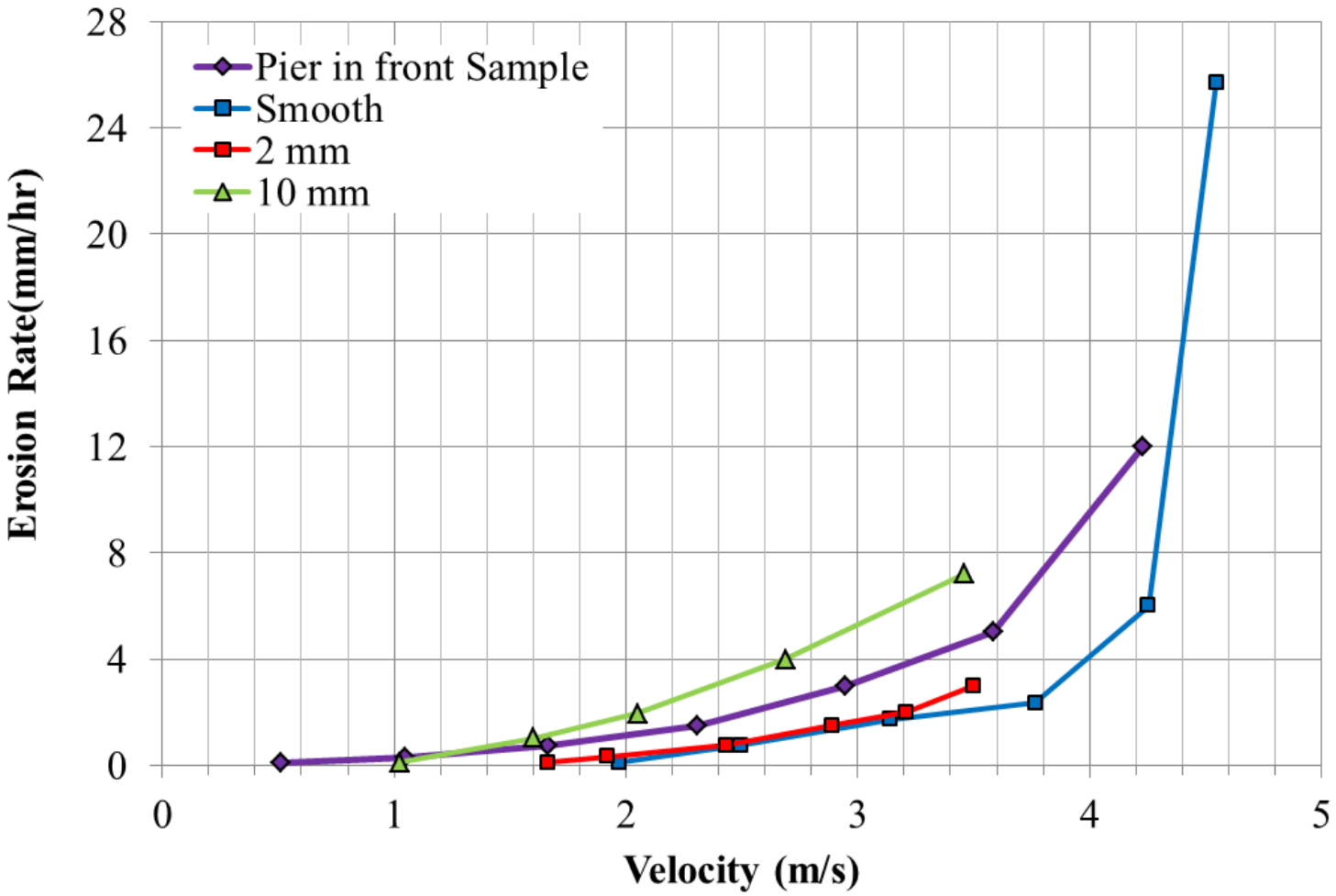
- V_c and τ_c decrease with increase in roughness.
- Slope of erosion function becomes less steep with increase in roughness.
- Slow motion videos show that for higher velocities, the stream lines of the water flowing over the sample pass over rather than attacking the sample

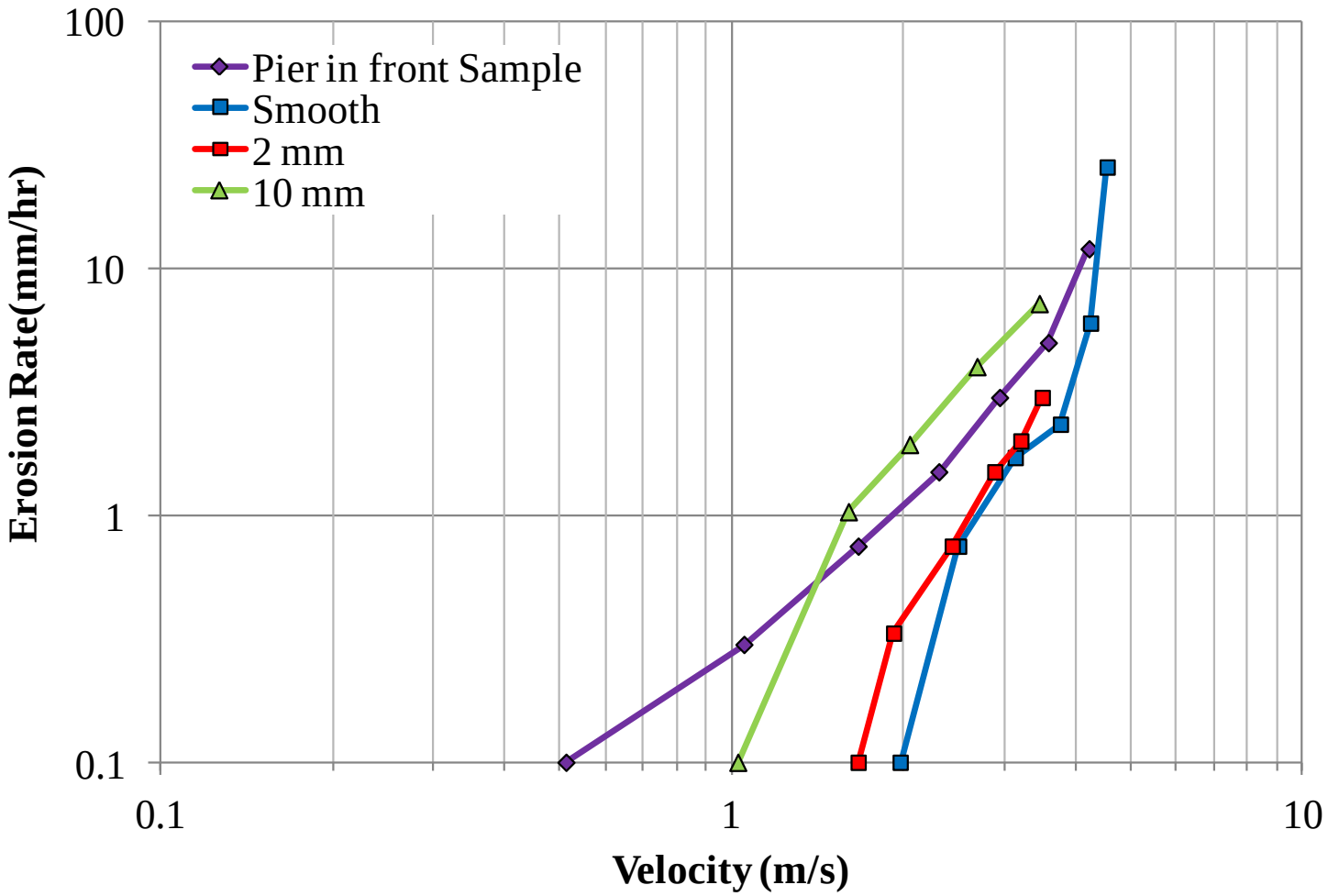
PIER TEST IN THE EFA (2.5 cm diameter)



RESULTS

- V_c for the pier was 0.5 m/s, comparable to the critical velocity for the D_{50} = 10 mm plate
- The slope of the erosion function was pronounced and similar to that of the smooth plate


Pier in front Sample
Smooth
2 mm
10 mm
Erosion Rate(mm/hr)
Velocity (m/s)
0
4
8
12
16
20
24
28
0
1
2
3
4
5


Pier in front Sample
Smooth
2 mm
10 mm
Erosion Rate(mm/hr)
100
10
1
0.1
0.1
1
10
Velocity (m/s)

CONCLUSIONS

- An increase in roughness and associated turbulence leads to lower V_c and τ_c

- However the slope of the erosion function becomes less steep with an increase in roughness