

Contact forces between seabed and fishing gear components

Birger Enerhaug

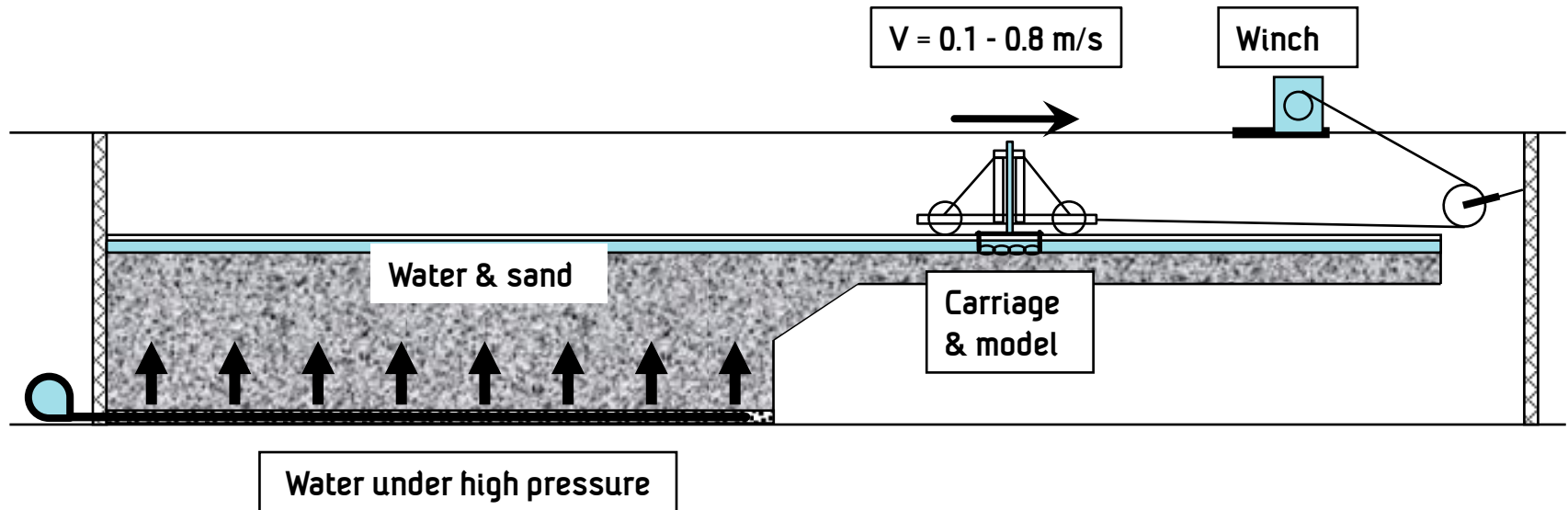
SINTEF Fisheries and Aquaculture
Trondheim, Norway

DEMat '11, Split, Croatia, 26-28 October, 2011

Background

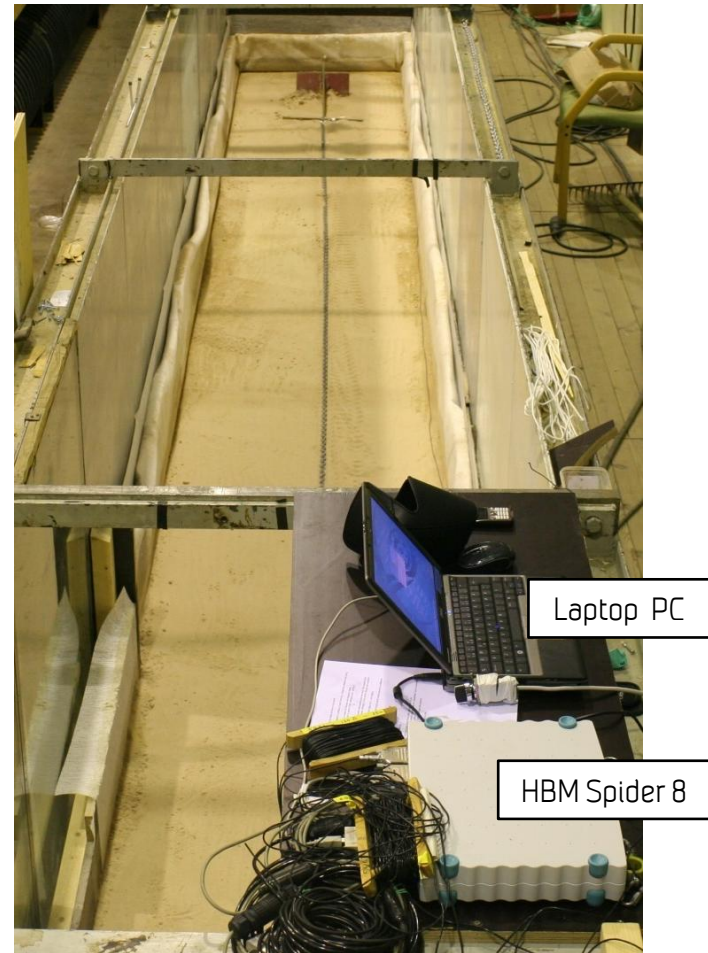
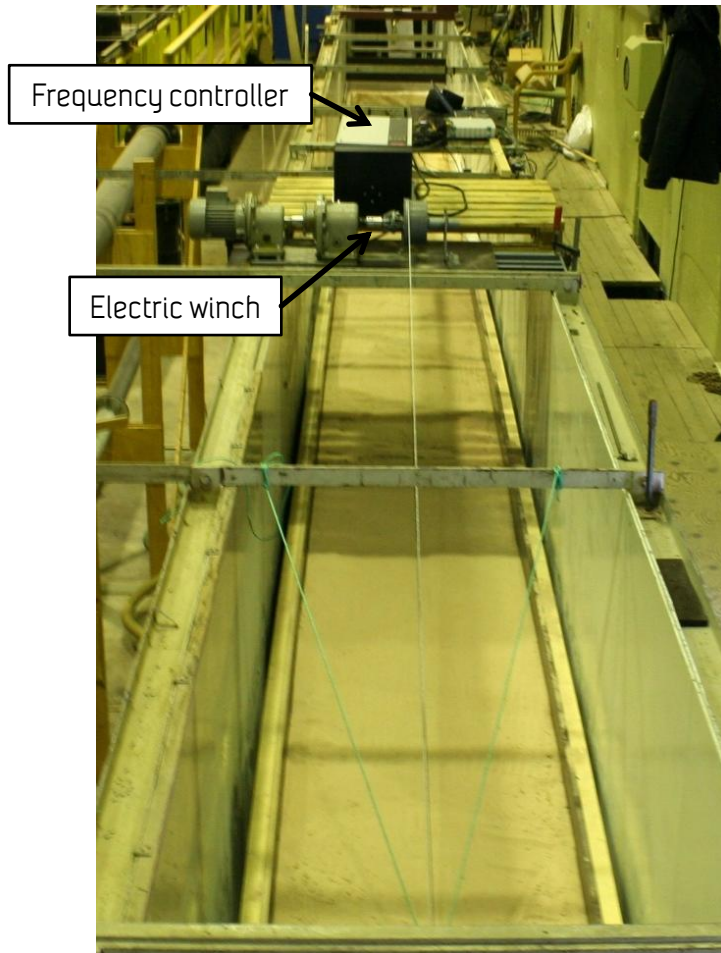
- **High fuel prices**
 - More energy friendly fishing methods
 - SINTEF project, 2007-2009 (reporting not finished)
- **Environmental issues**
 - Influence on benthic fauna
 - TRAPESE project (Paschen et al., 2000)
 - DEGREE project (Ivanović et al., 2006, 2010)
- **SOSS project ("Safe Operations of Subsea Systems")**
 - Better knowledge of the topics:
 - Anchor forces (deployment & retrieving)
 - Contact forces (chains & fishing gear components)

Test set-up

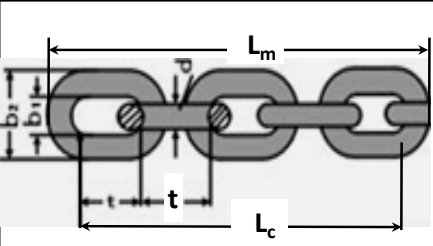
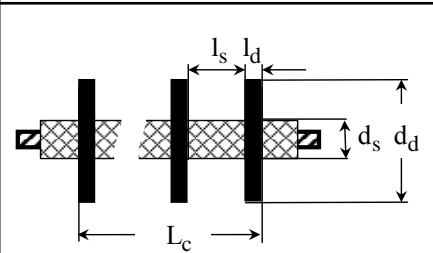
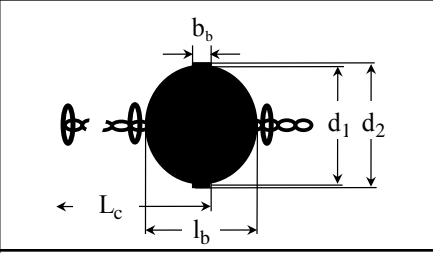
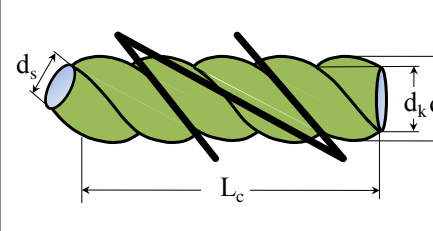


Sand: Baskarp no.15, $\rho = 1.71 \text{ Kg/m}^3$,
 $d_{10} = 0.08 \text{ mm}$, $d_{50} = 0.11 \text{ mm}$, $d_{60} = 0.13 \text{ mm}$

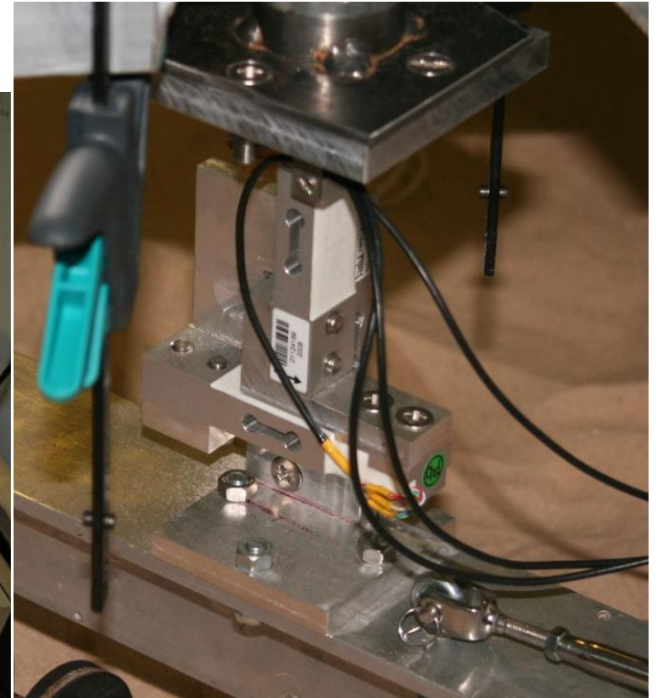
Experimental tank



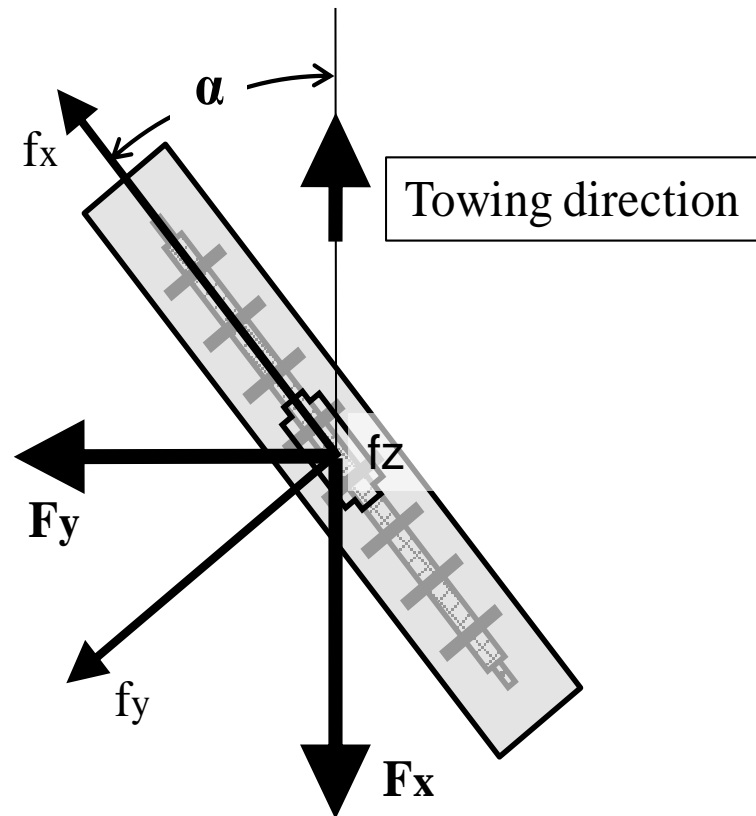
Model data

	Chain	Dimensions (mm)				Number of links	Length L_m / L_c (mm)	Weight in air (N)
		d	t	b_1	b_2			
	Short-linked	6	18.6	9.5	19.7	22	421/400	3.05
Long-linked	6	41.7	13.5	24	10	429/408	2.65	
	Rock-hopper	Dimensions (mm)				Number of discs	Length L_m / L_c (mm)	Weight in air (N)
		Spacer		Disc				
	Side part	l_s	d_s	l_d	d_d	8	390/318	4.4
	Bobbins	Dimensions (mm)				Number of bobbins	Length L_m / L_c (mm)	Weight in air (N)
		Width		Diameter				
	Banded	l_b	b_b	d_1	d_2	5	390/189	3.35
	Rope	Dimensions (mm)				Number of Strands	Length L_m / L_c (mm)	Weight in air (N)
		Rope		Strand				
	Z-twisted	d_r	d_k	d_s		4	430/410	1.5

Carriage with model and 3-component force transducer

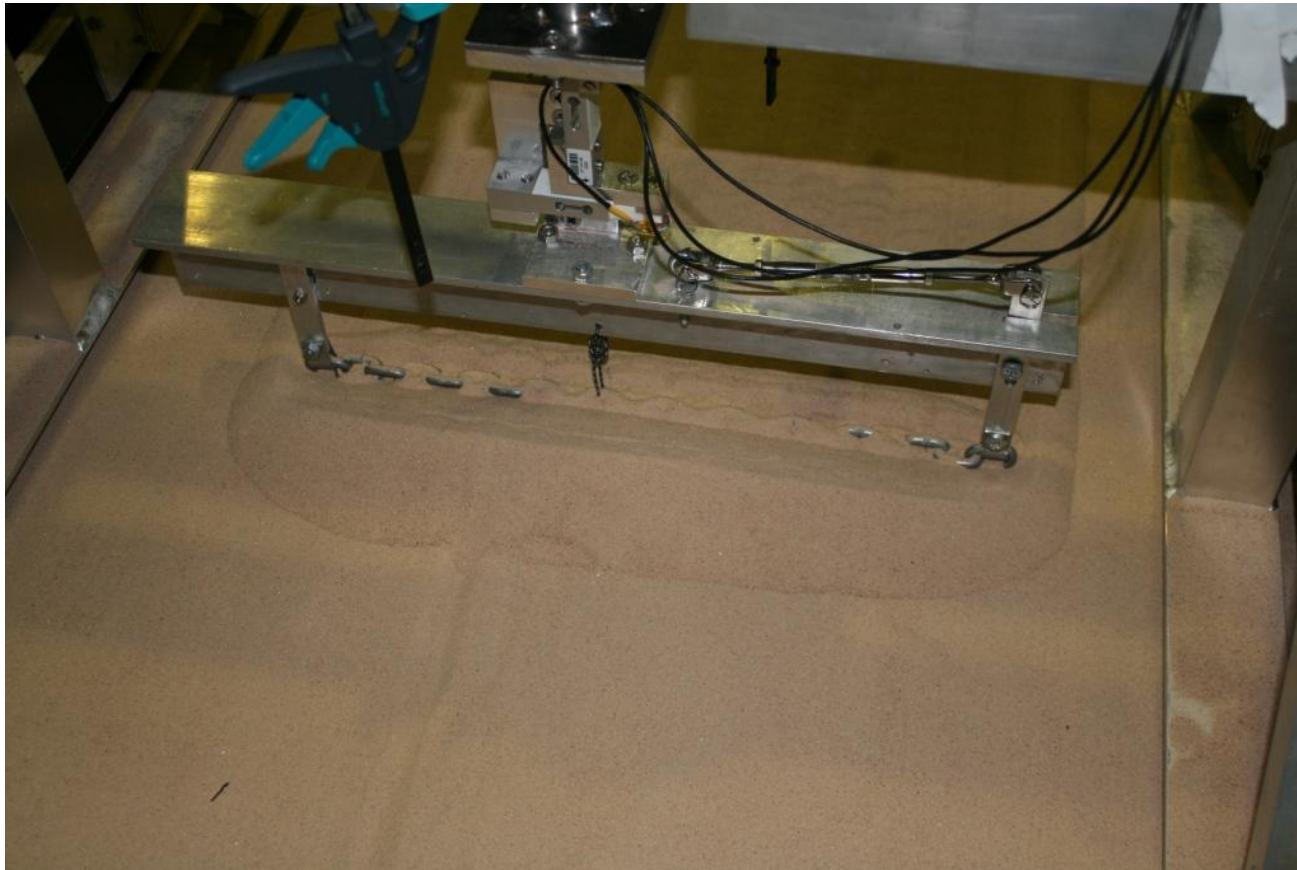


Definitions of Angle of Attack and Axis



Dry sand – short-linked chain

67 tests (not presented)



Dry & wet sand - Rockhopper

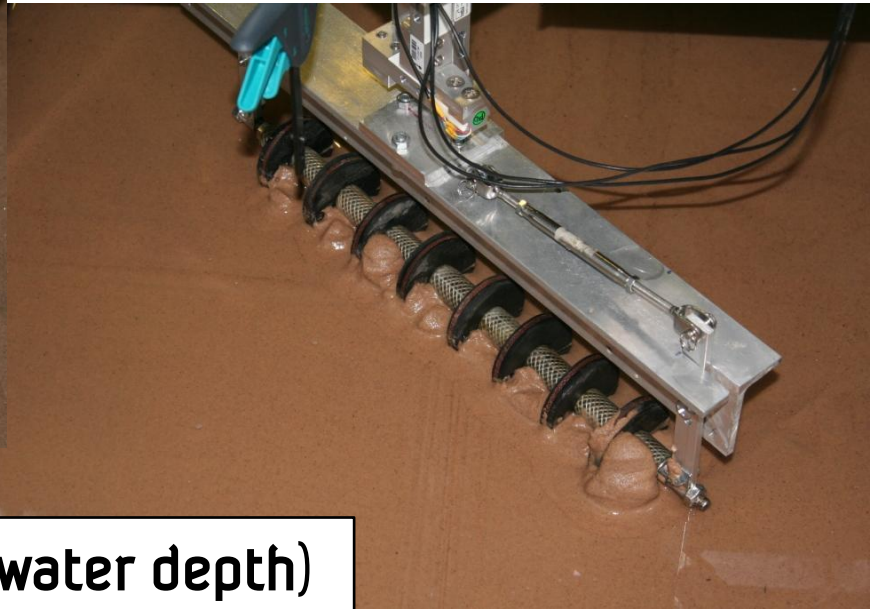
Dry sand

8 tests (not presented)



Wet sand (2 mm water depth)

A few test runs (not presented)



Submerged models (60-65 mm water depth)

Sorry, no pictures of submerged models!
Hard-disc with pictures crashed!

- Chain (short-linked): 33 tests (26 presented)
- Chain (long-linked): 18 tests (14 presented)
- Rockhopper: 42 tests (12 presented)
- Bobbins: 26 tests (all presented)
- Rope: 14 tests (all presented)

Short- & long linked chain

	Short-linked chain						Long-linked chain					
	Penetration = 2 mm			Penetration = 4 mm			Penetration = 2 mm			Penetration = 4 mm		
AoA (degr.)	fz (N)	Fx/Fz (-)	Fy/Fz (-)	fz (N)	Fx/Fz (-)	Fy/Fz (-)	fz (N)	Fx/Fz (-)	Fy/Fz (-)	fz (N)	Fx/Fz (-)	Fy/Fz (-)
0	1.23	1.37	-0.19	1.54	1.51	-0.23	1.46	0.89	0.07	3.39	1.16	0.00
0	0.83	1.24	-0.10	1.83	1.57	-0.21	1.53	0.87	0.05	2.73	1.18	-0.18
15	2.10	1.41	0.36	2.83	1.69	0.46	2.32	1.02	0.41	4.91	1.26	0.22
15	1.60	1.67	0.32	2.31	1.88	0.53	1.26	0.98	0.50	2.40	1.33	0.21
30	2.19	1.36	0.20	3.03	1.77	0.38	2.42	1.28	0.48	5.35	1.38	0.31
30	2.31	1.38	0.25	3.84	1.75	0.46	1.37	1.44	0.40	4.03	1.36	0.30
45	2.14	1.29	0.14	4.00	1.57	0.30	2.59	1.35	0.27	6.30	1.41	0.27
45	2.36	1.29	0.18	4.30	1.92	0.30	1.25	1.27	0.49	3.00	1.55	0.23
60	2.88	1.27	0.12	6.66	1.57	0.15	2.08	1.36	0.25	6.32	1.46	0.19
60	2.05	1.51	0.05	4.40	1.73	0.16	1.19	1.38	0.36	3.47	1.50	0.21
75	3.09	1.27	0.06				1.64	1.41	0.16	5.28	1.49	0.10
75	3.07	1.25	0.06				1.20	1.57	0.19	3.42	1.56	0.10
90	3.77	1.29	0.05	8.94	1.46	0.06	2.03	1.26	0.06	3.54	1.61	-0.04
90	3.05	1.28	0.01	5.36	1.79	0.05	1.26	1.40	-0.04	3.32	1.69	0.02

Rockhopper, bobbins & rope

AoA (degr.)	Rockhopper			Bobbins - free/rolling			Bobbins - fixed			Rope		
	fz (N)	Fx/Fz (-)	Fy/Fz (-)	fz (N)	Fx/Fz (-)	Fy/Fz (-)	fz (N)	Fx/Fz (-)	Fy/Fz (-)	fz (N)	Fx/Fz (-)	Fy/Fz (-)
0				1.94	1.09	-0.11				2.89	1.24	0.05
0				2.72	1.07	-0.01				3.58	1.42	0.00
15	5.18	1.57	0.05	2.51	1.09	0.00	2.84	1.03	-0.01	5.32	1.32	0.06
15	4.03	1.69	0.03	2.10	1.18	-0.04	2.40	1.08	-0.03	2.17	1.26	0.11
30	8.91	1.52	-0.13	2.26	1.02	-0.14	2.97	0.97	-0.01	5.44	1.22	0.02
30	6.22	1.57	-0.13	2.07	1.09	-0.16	2.31	1.02	-0.01	1.64	1.02	0.05
45	8.91	1.36	-0.18	2.85	0.84	-0.31	2.94	0.96	-0.08	3.82	1.02	0.00
45	6.67	1.39	-0.20	2.45	0.85	-0.31	2.33	0.96	-0.08	1.65	0.96	0.12
60	8.22	1.17	-0.12	2.60	0.65	-0.43	2.79	0.88	-0.04	3.44	0.92	0.05
60	5.46	1.24	-0.20	2.30	0.66	-0.43	2.08	0.99	0.01	2.00	0.92	0.02
75	8.11	1.01	-0.10	2.31	0.51	-0.39	3.18	0.76	-0.01	3.32	0.92	0.00
75	5.57	1.04	-0.10	2.04	0.55	-0.49	2.36	0.74	-0.01	2.00	0.88	0.00
90	6.70	0.98	-0.02	2.00	0.35	-0.08	2.28	0.70	0.01	2.20	0.95	0.01
90	6.00	1.01	0.00	2.13	0.32	-0.02	2.53	0.66	0.00	1.12	0.82	0.04

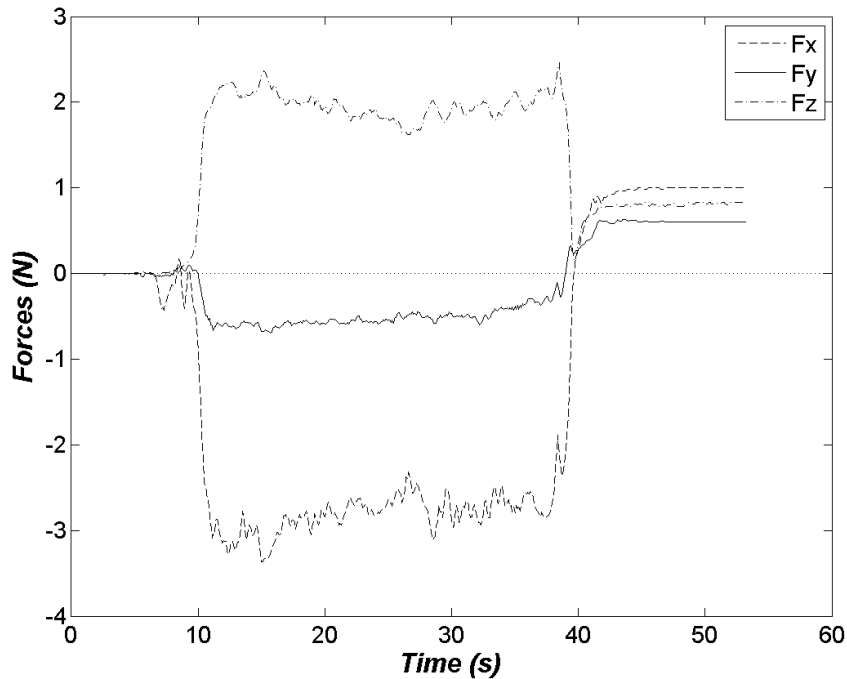
Results

The following results are for models with:

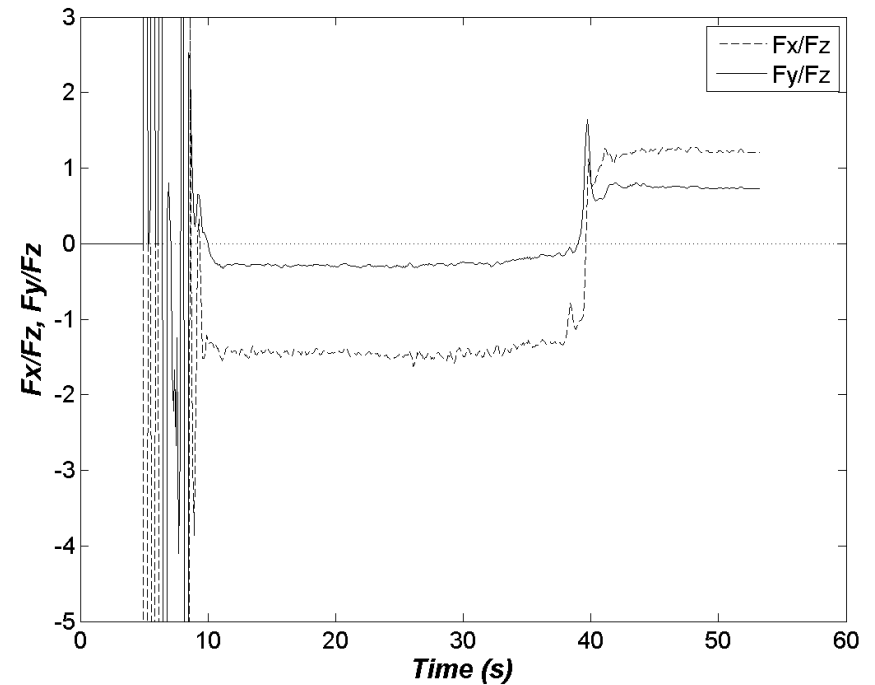
- 2 mm penetration depth
- 65 mm water depth
- 0.19 m/s towing speed

Rockhopper - Dry sand

7 mm penetration, AoA = 60 degr



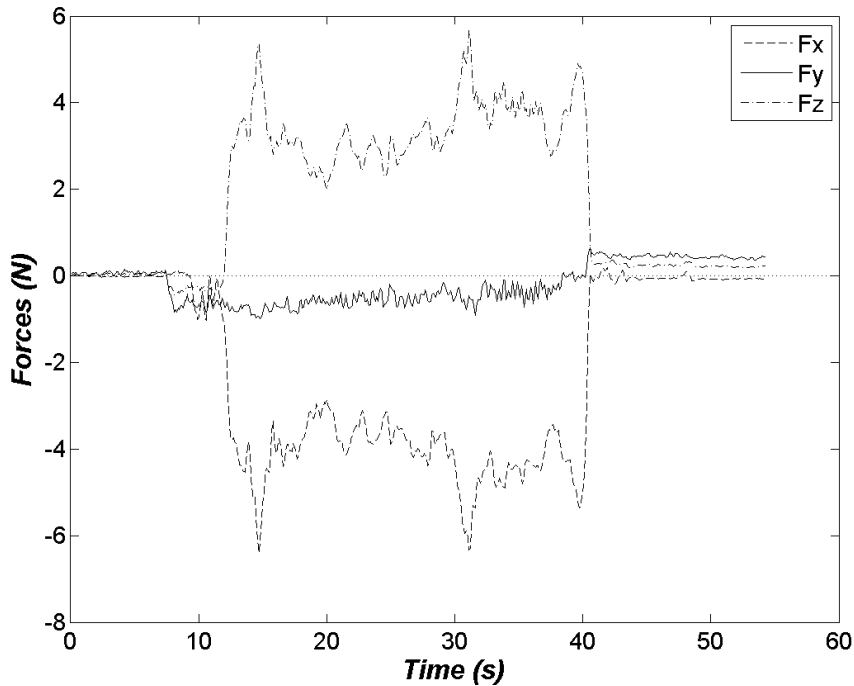
Global forces



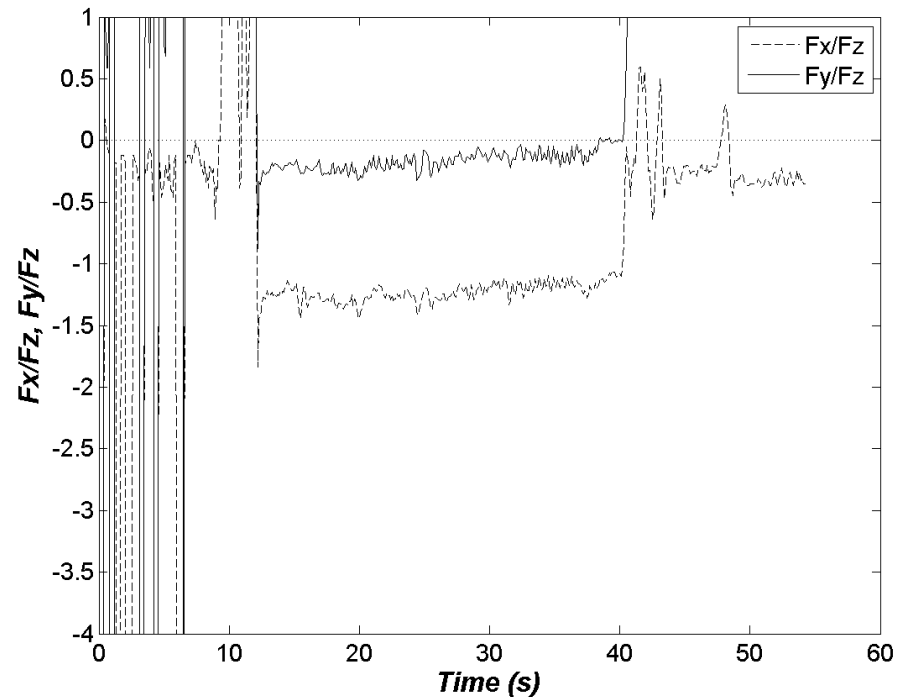
Friction coefficients

Rockhopper - Submerged, 65 mm water depth

2 mm penetration, AoA = 60 degr



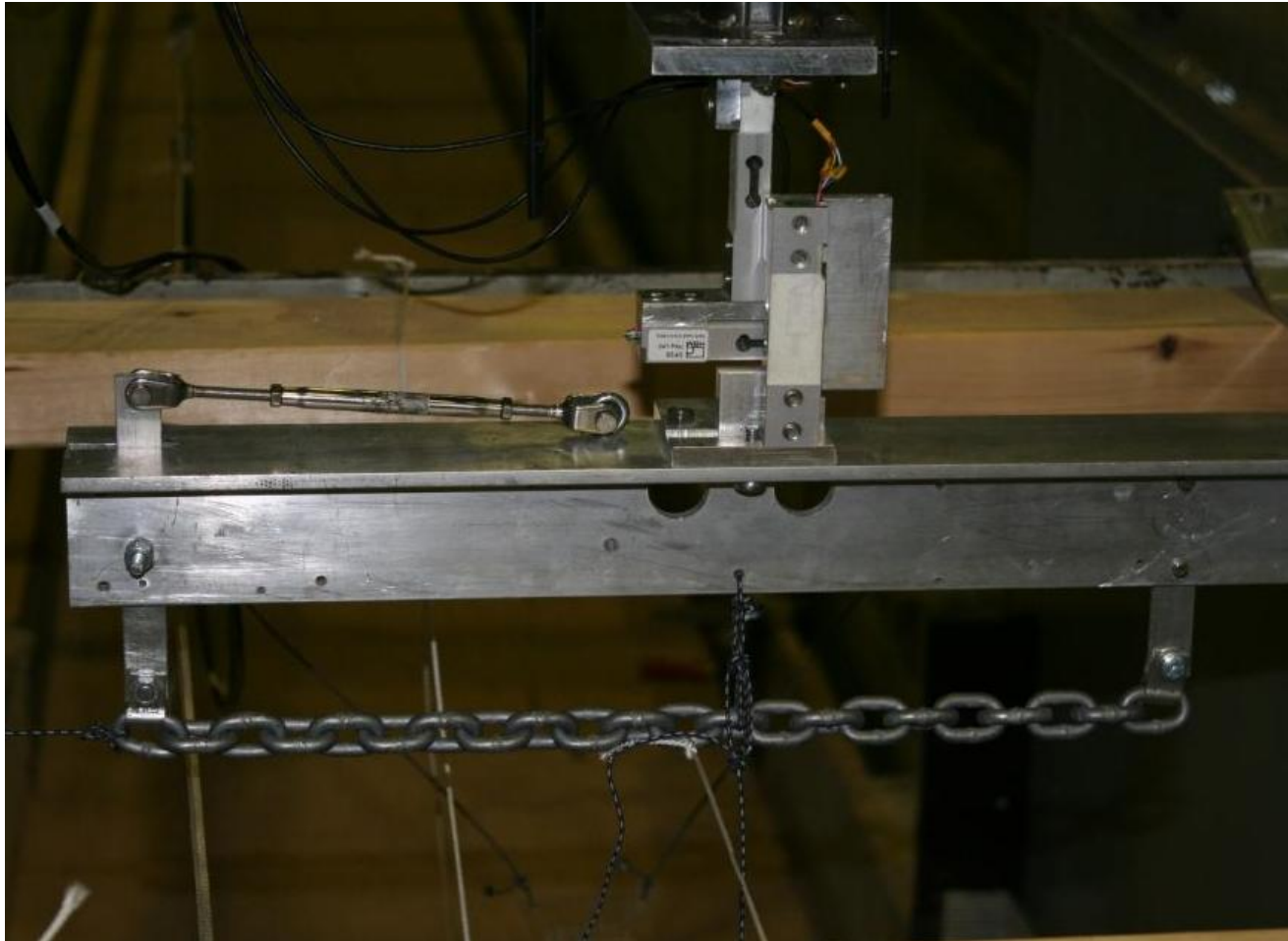
Global forces



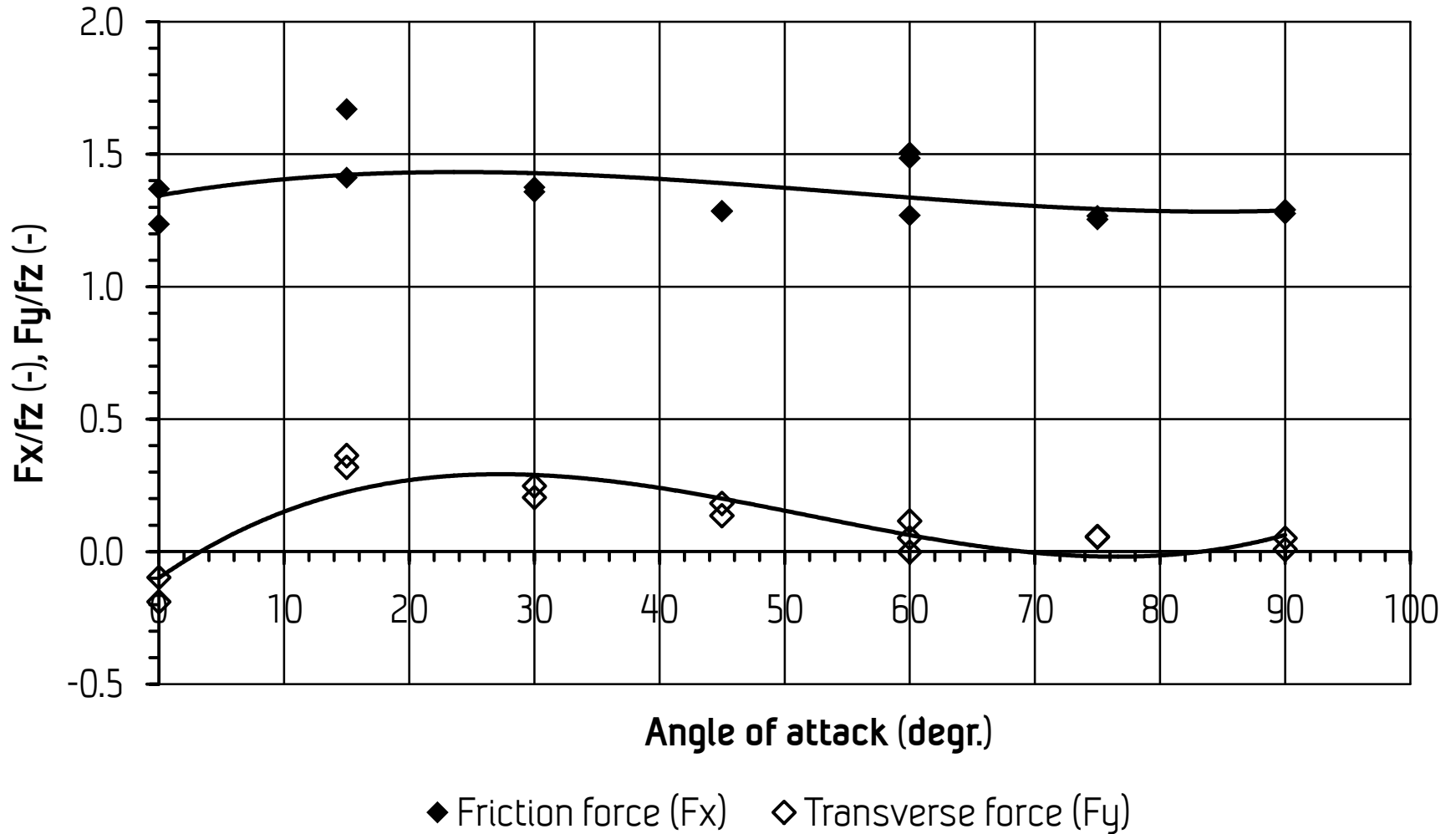
Friction coefficients

(hydrodynamic forces included)

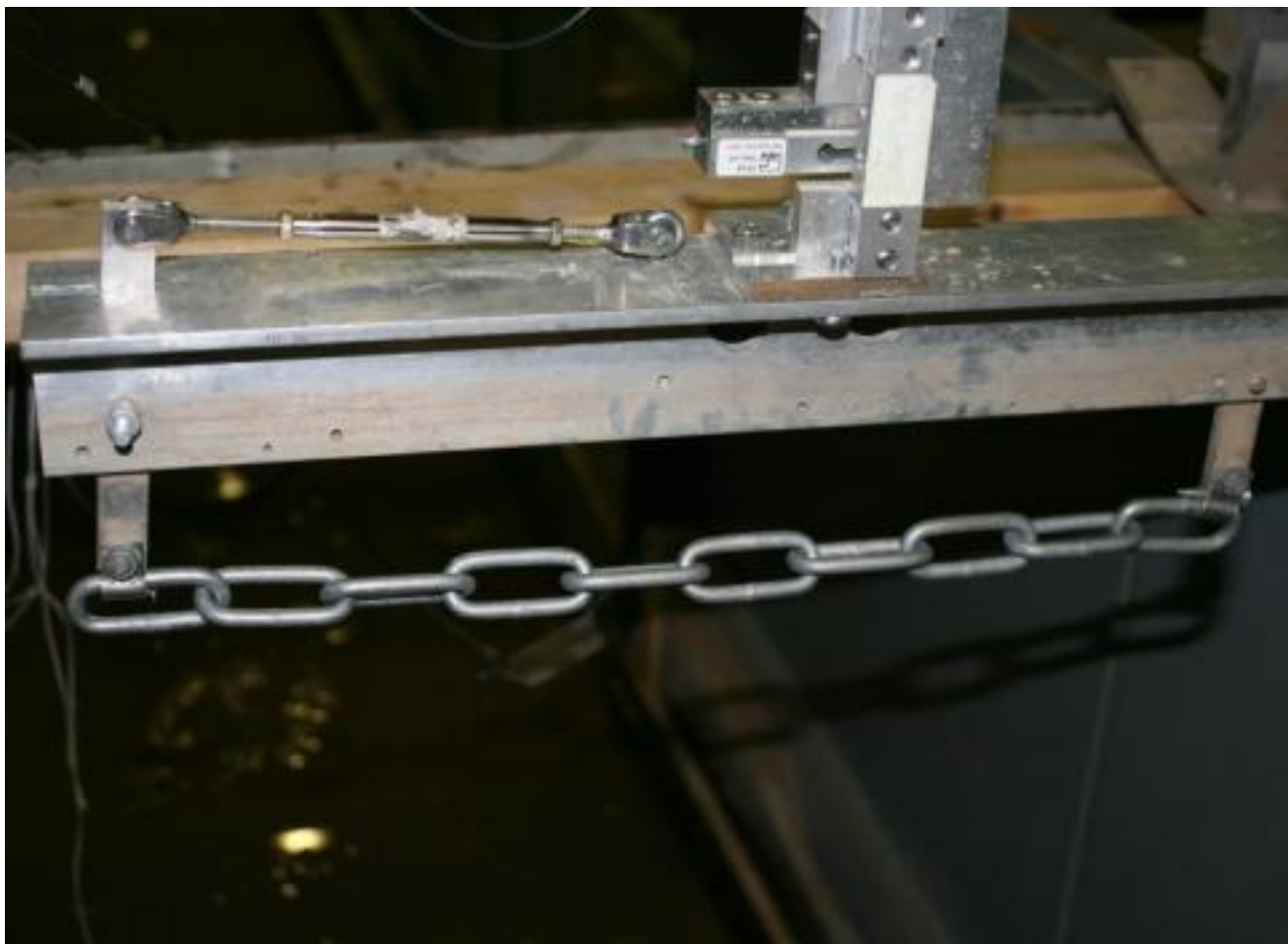
Short-linked chain



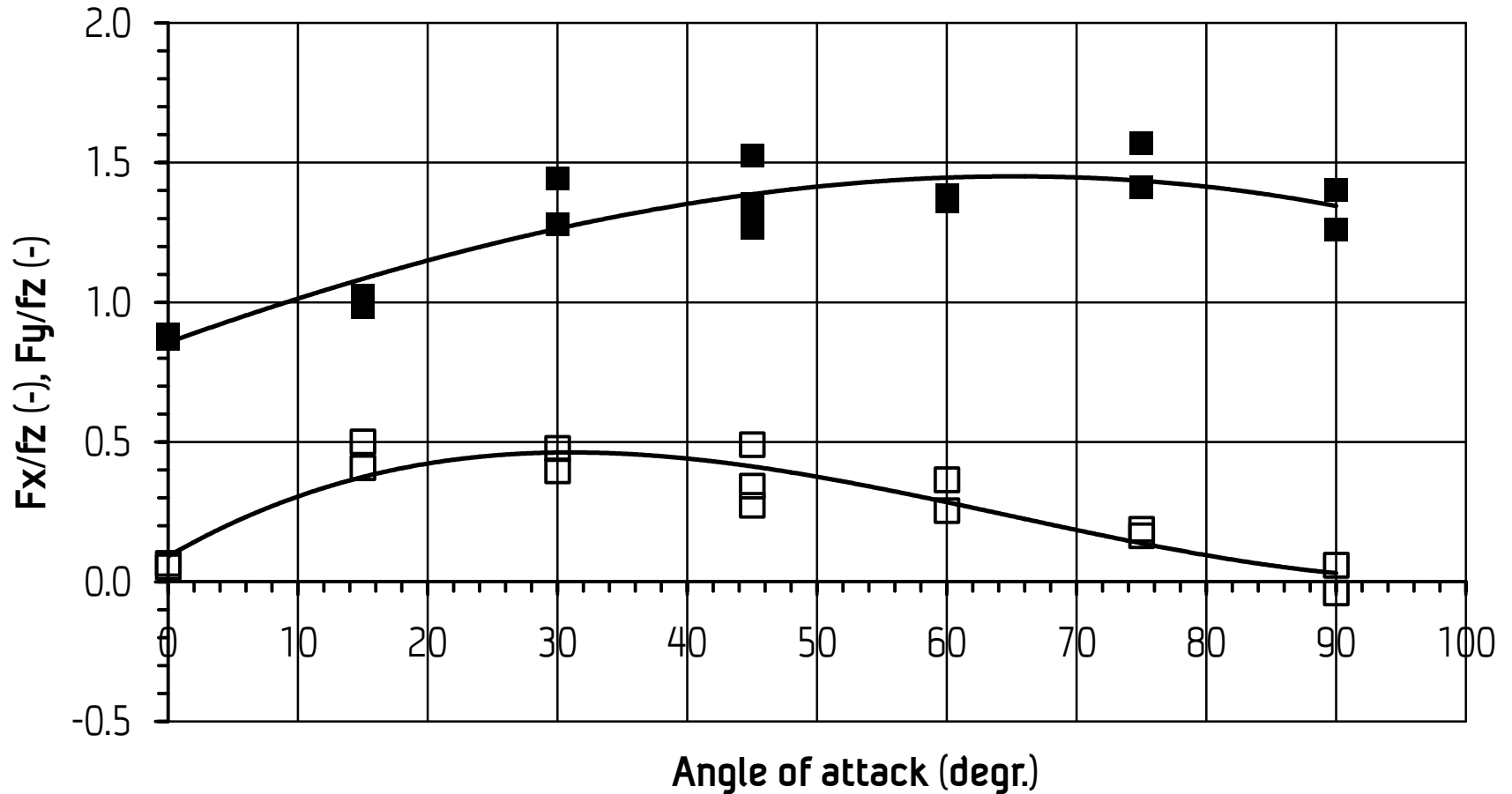
Short-linked chain



Long-linked chain

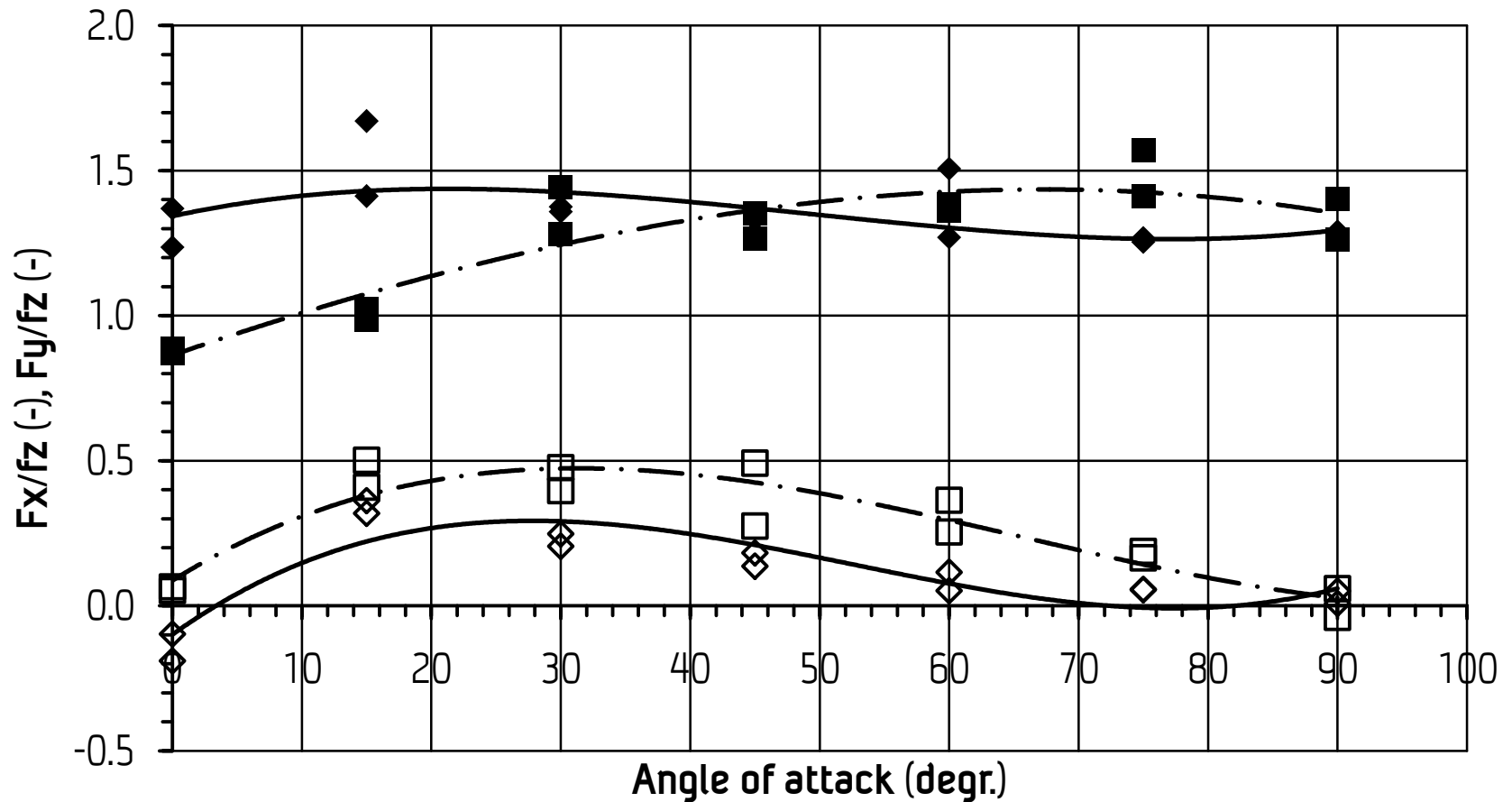


Long-linked chain



■ Friction force (F_x) □ Transverse force (F_y)

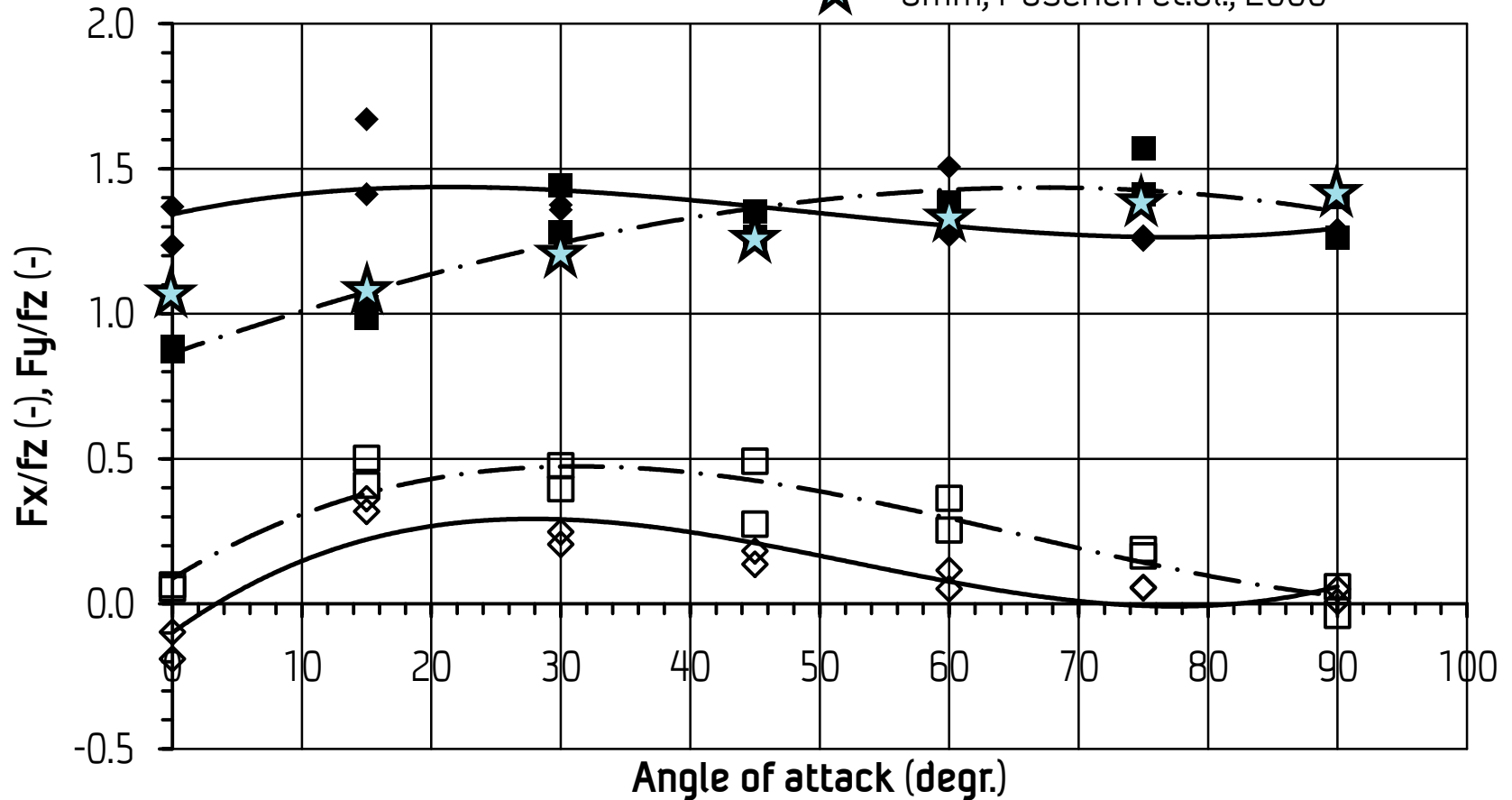
Short- and Long-linked chain



◆ Fx - Short-linked ◇ Fy - Short-linked ■ Fx - Long-linked □ Fy - Long-linked

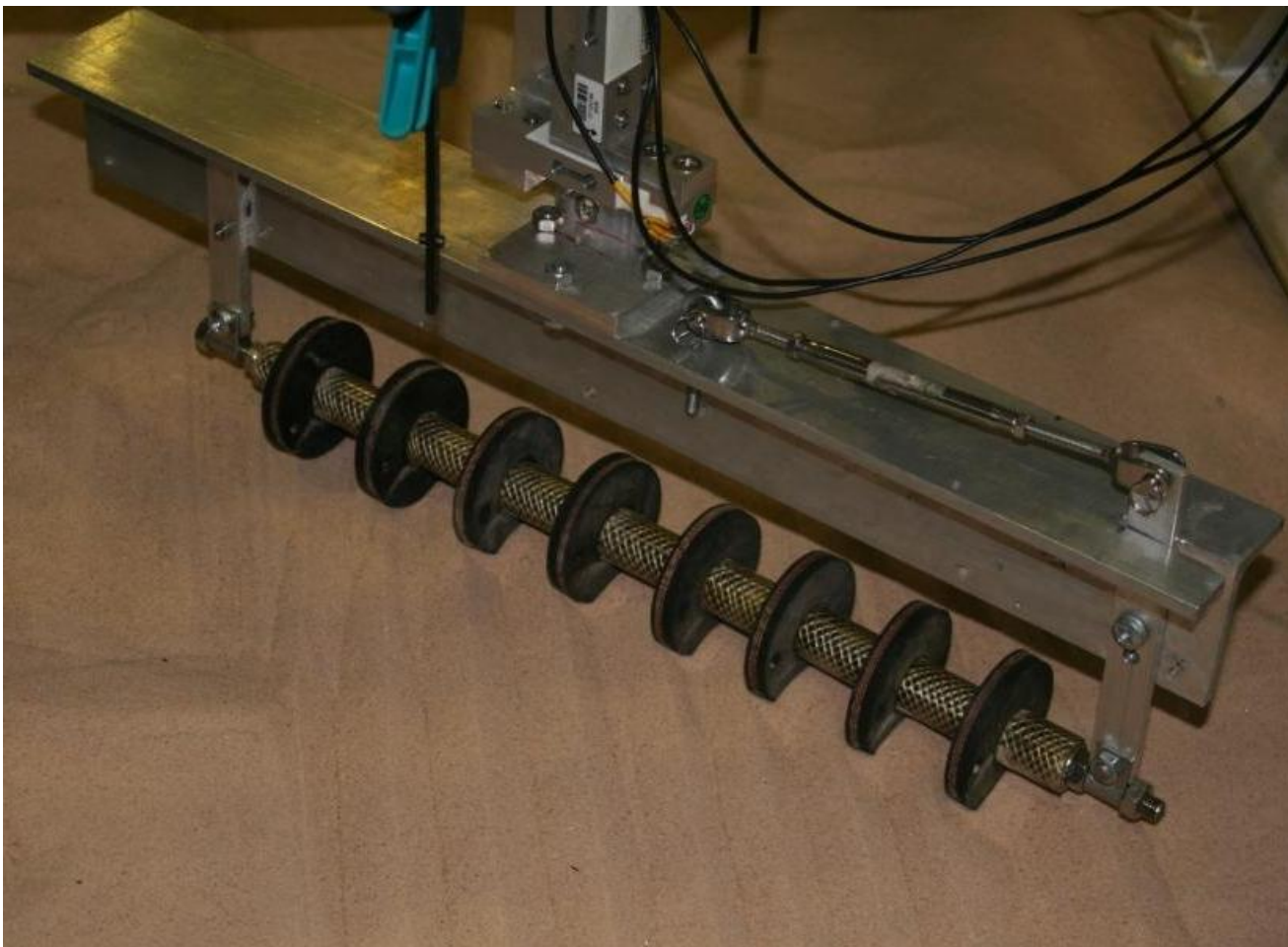
Short- and Long-linked chain

★ 8mm, Paschen et.al., 2000

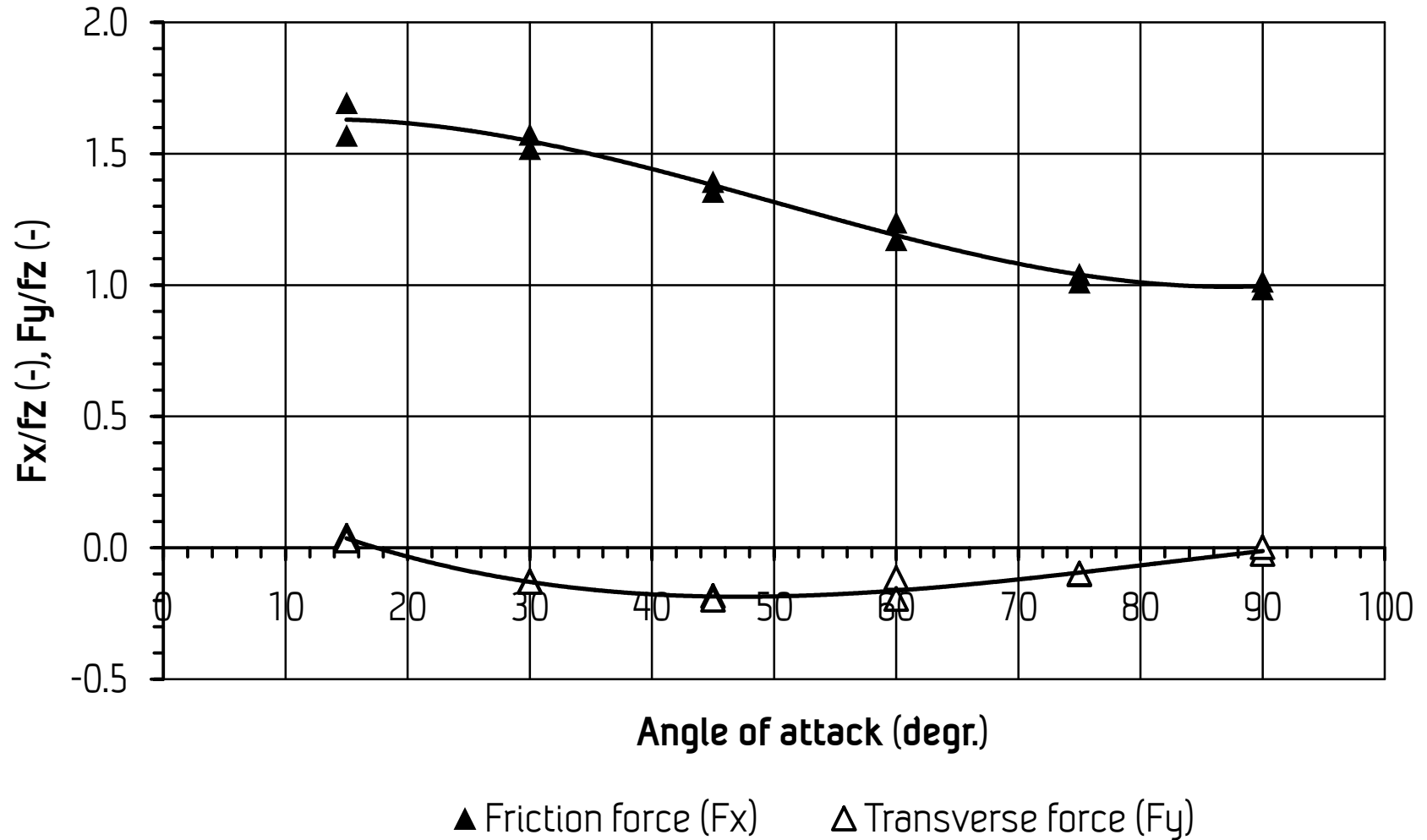


◆ F_x - Short-linked ◇ F_y - Short-linked ■ F_x - Long-linked □ F_y - Long-linked

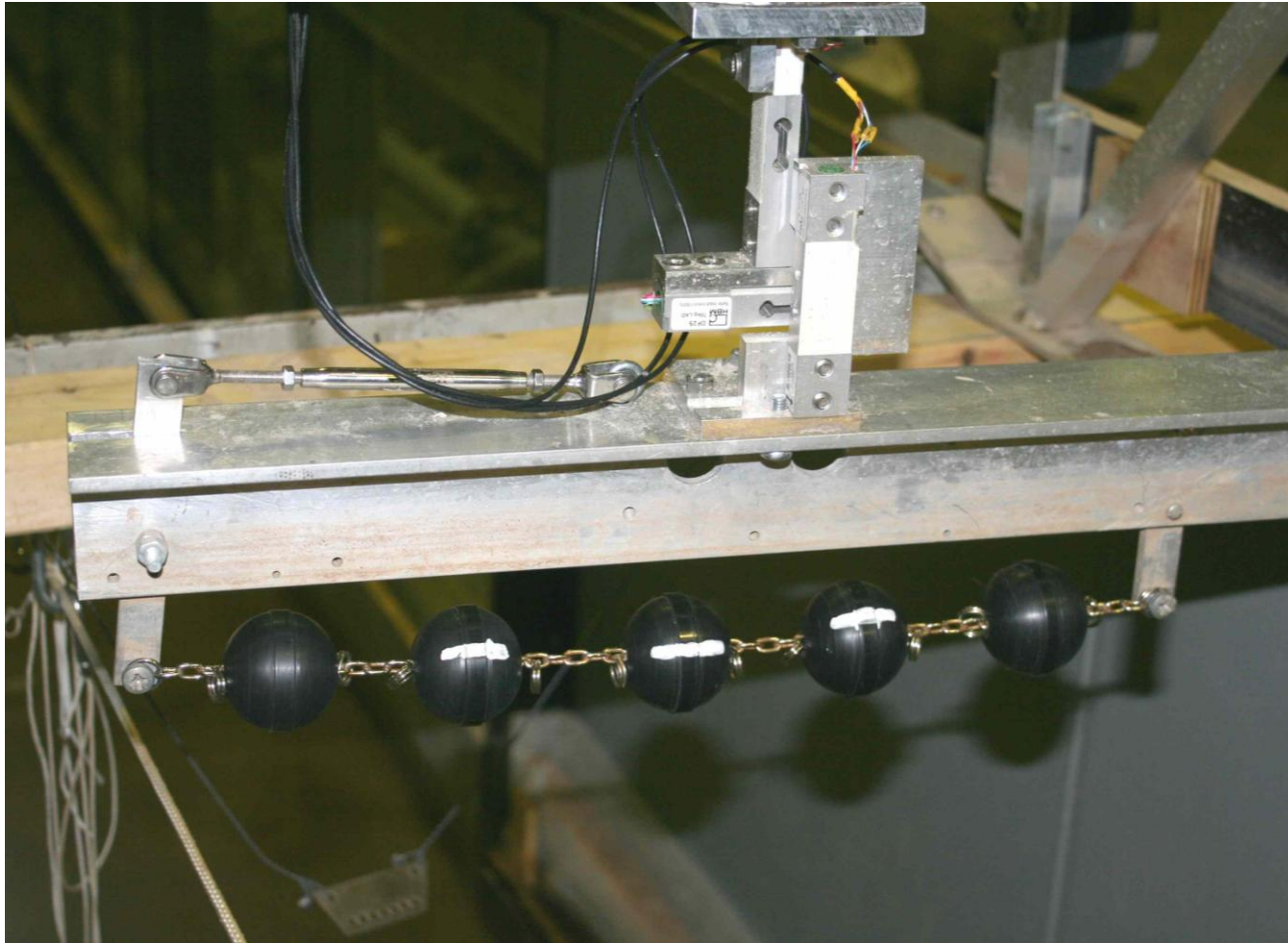
Rock-hopper



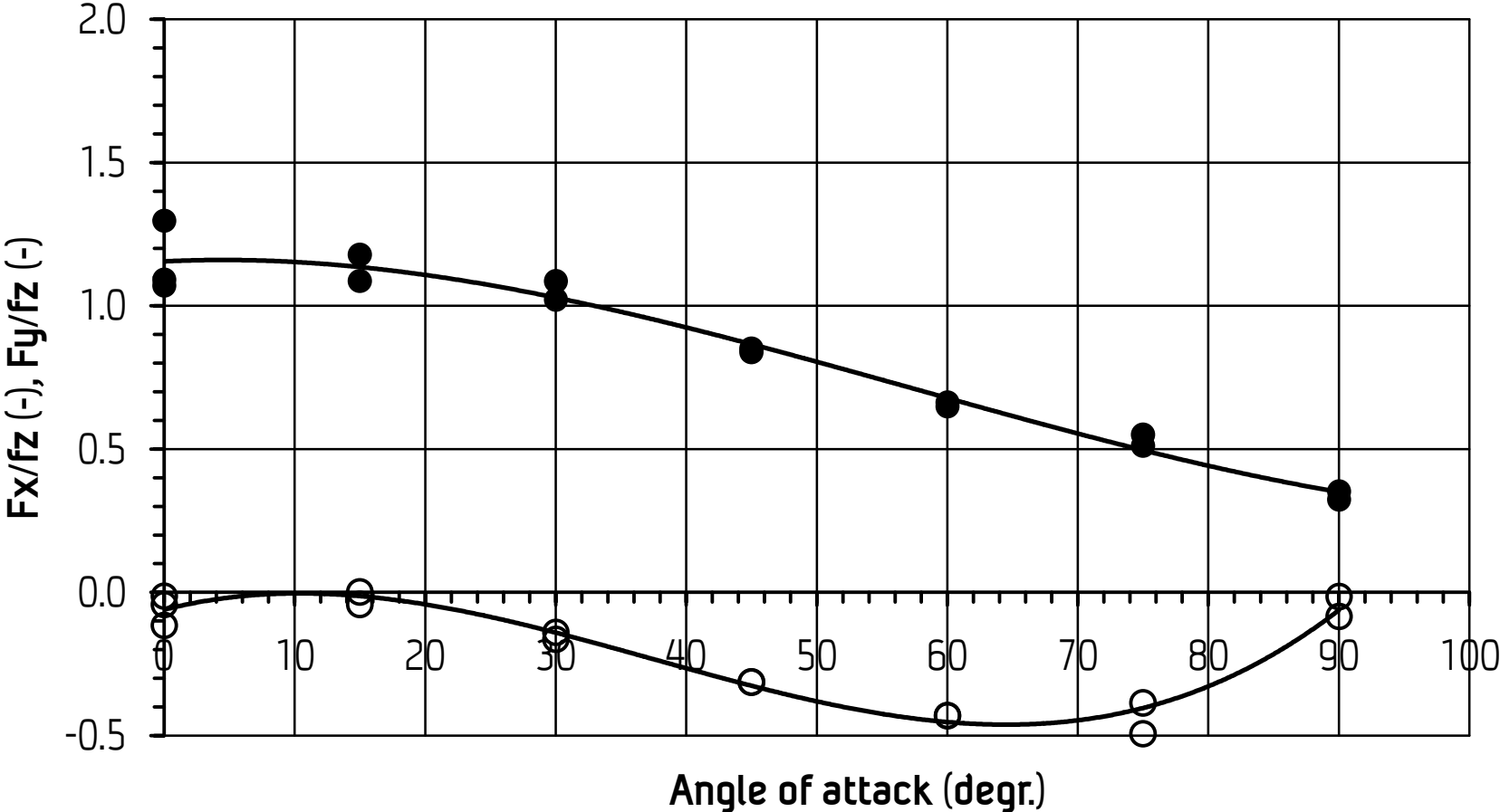
Rock-hopper (side part)



Bobbins

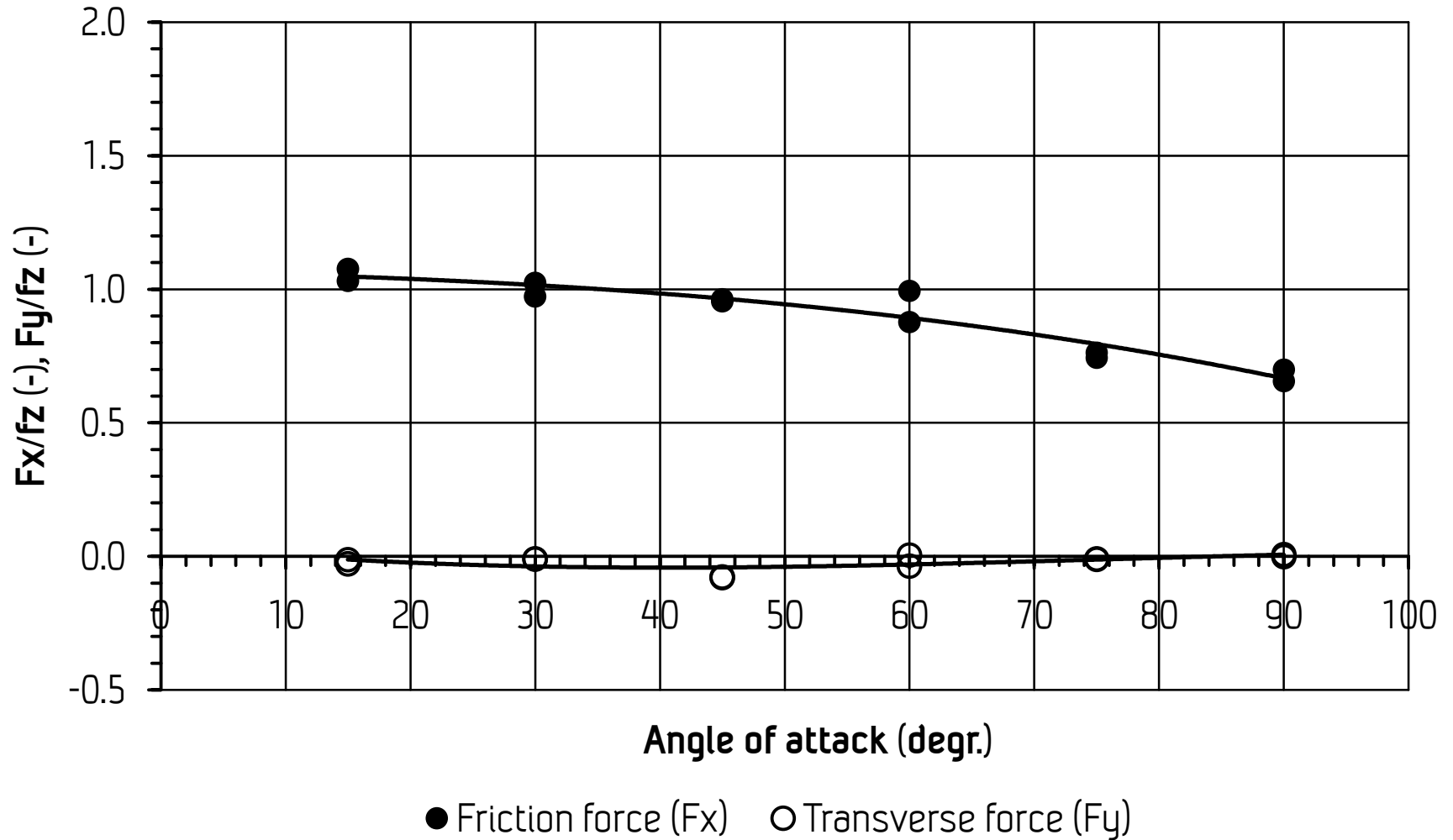


Bobbins - rolling

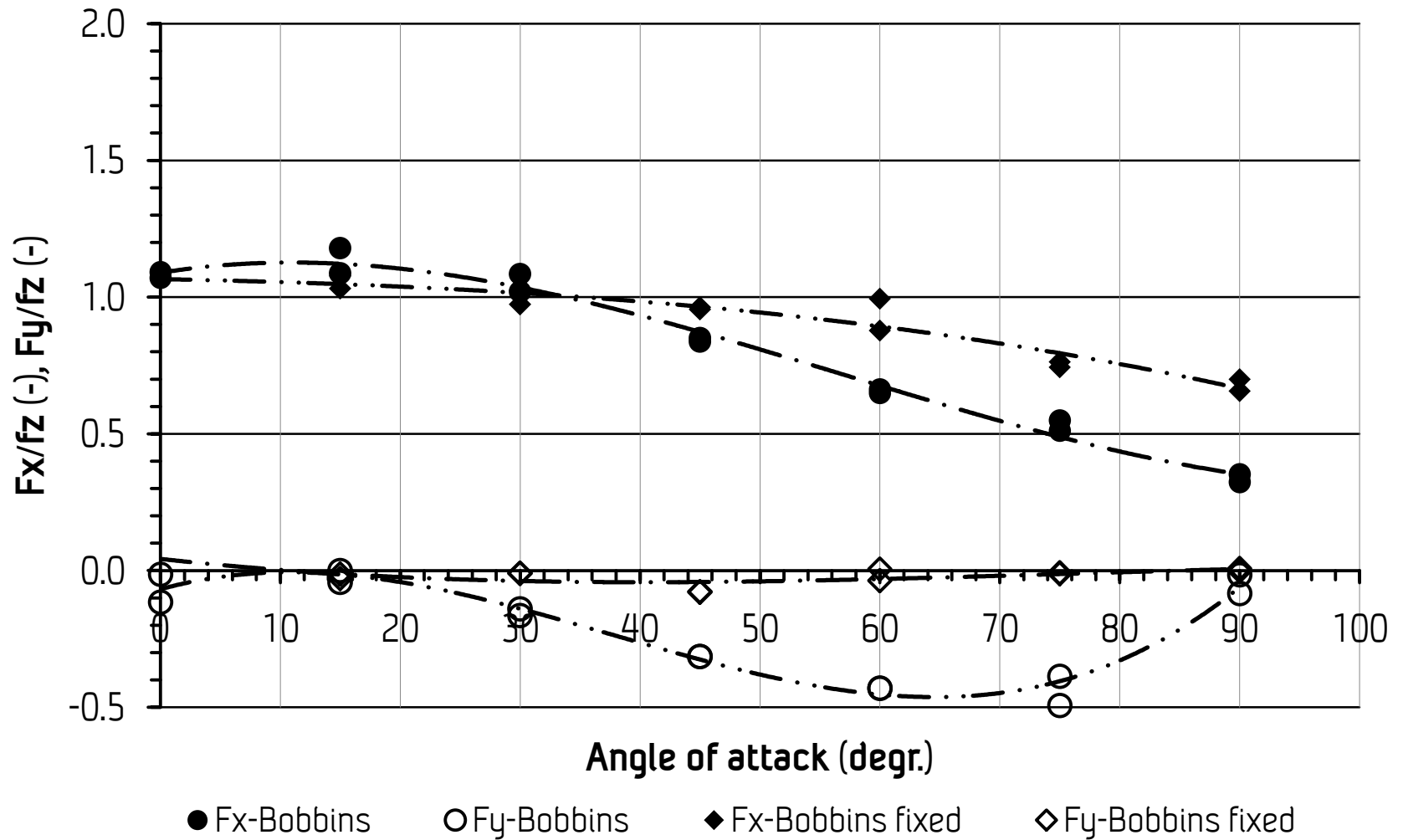


● Friction force (F_x) ○ Transverse force (F_y)

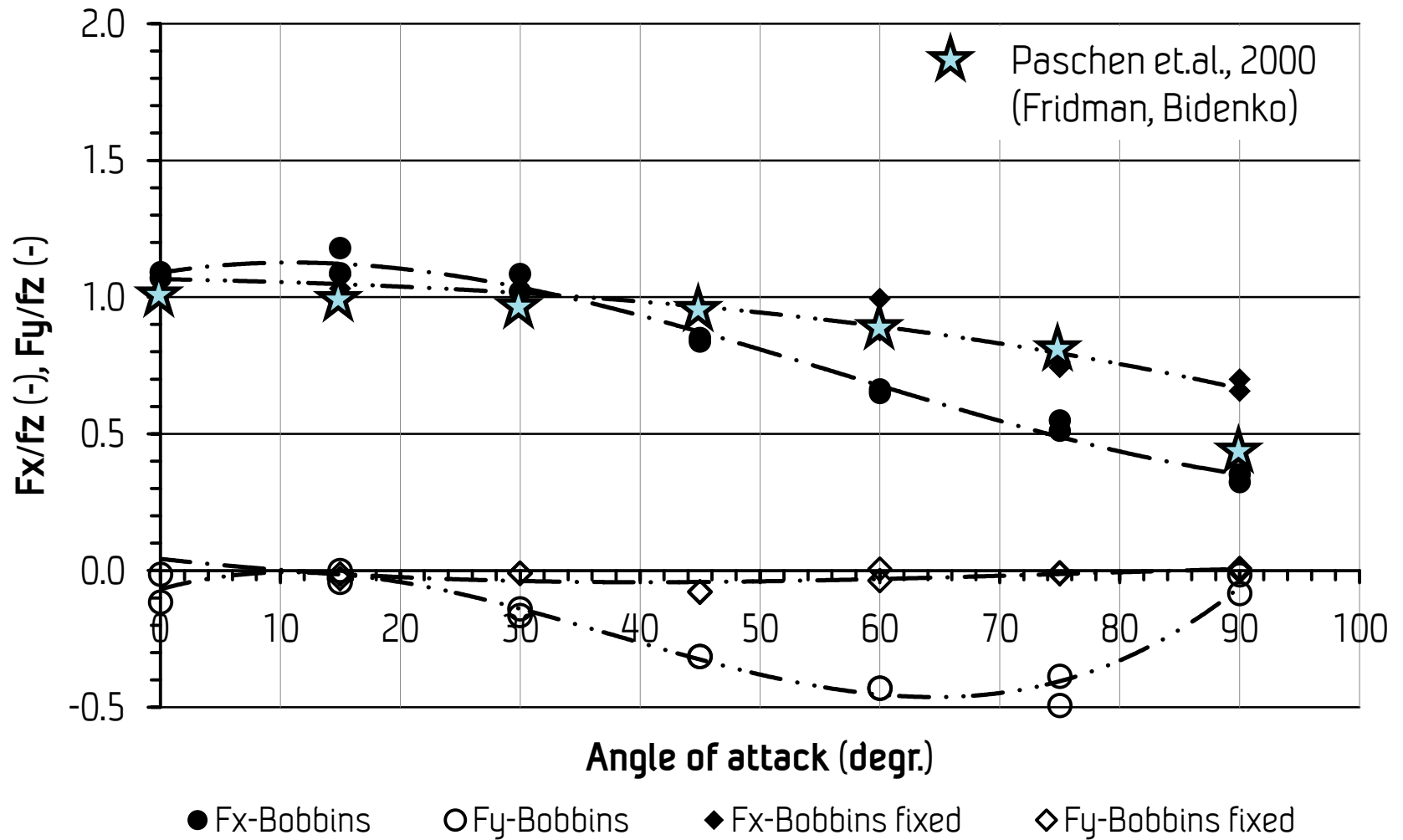
Bobbins - fixed



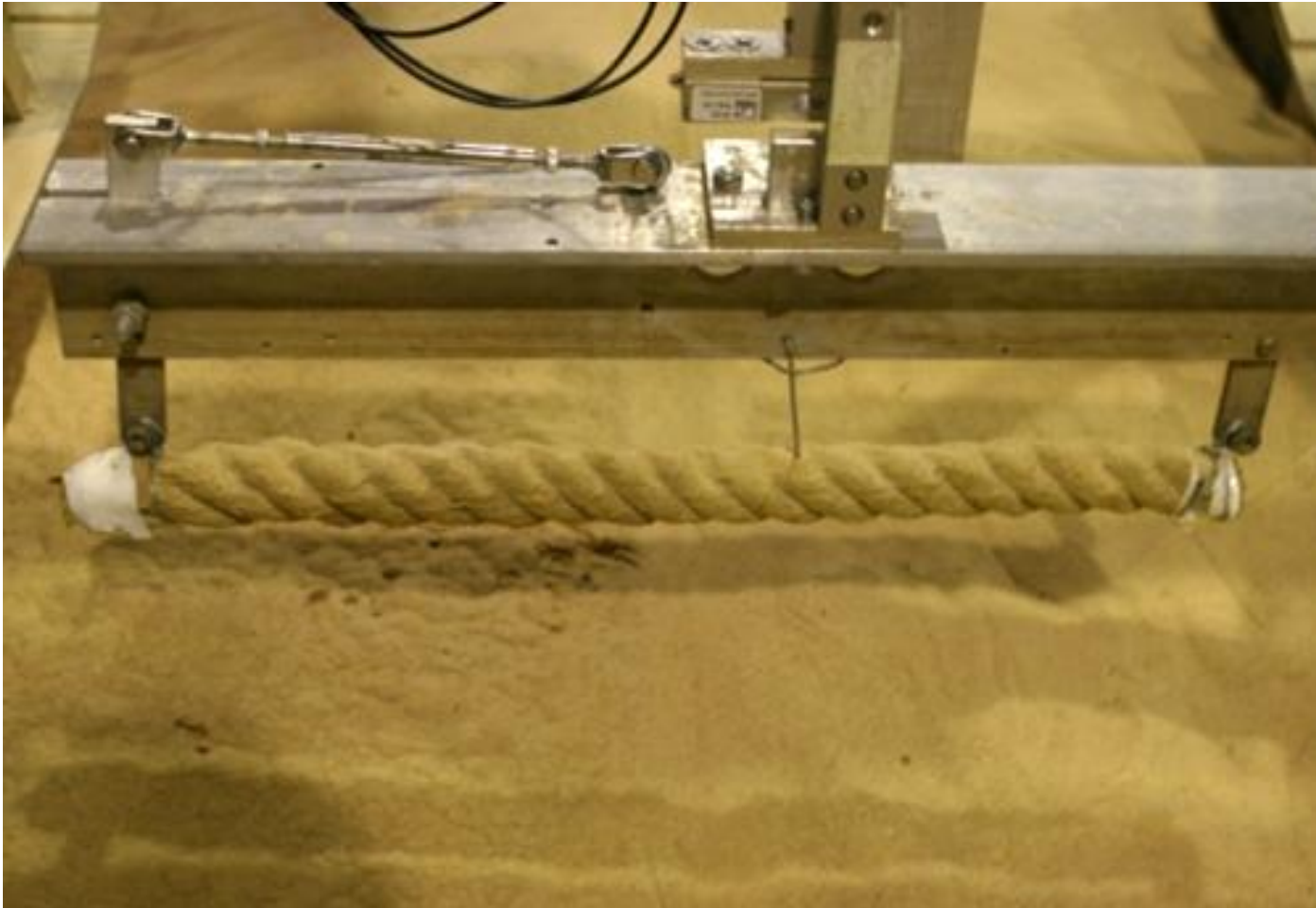
Bobbins - rolling & fixed



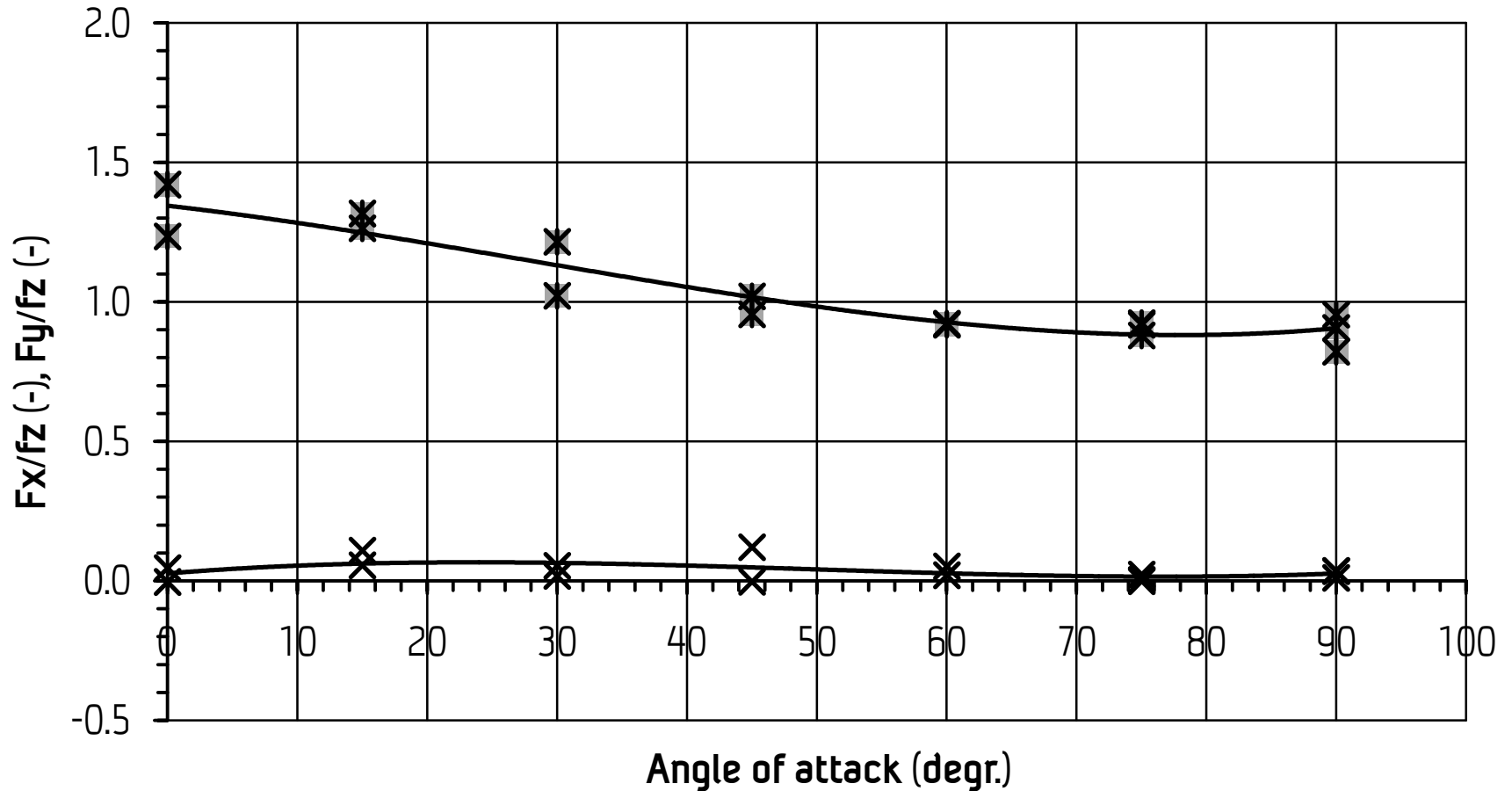
Bobbins - rolling & fixed



4-stranded rope

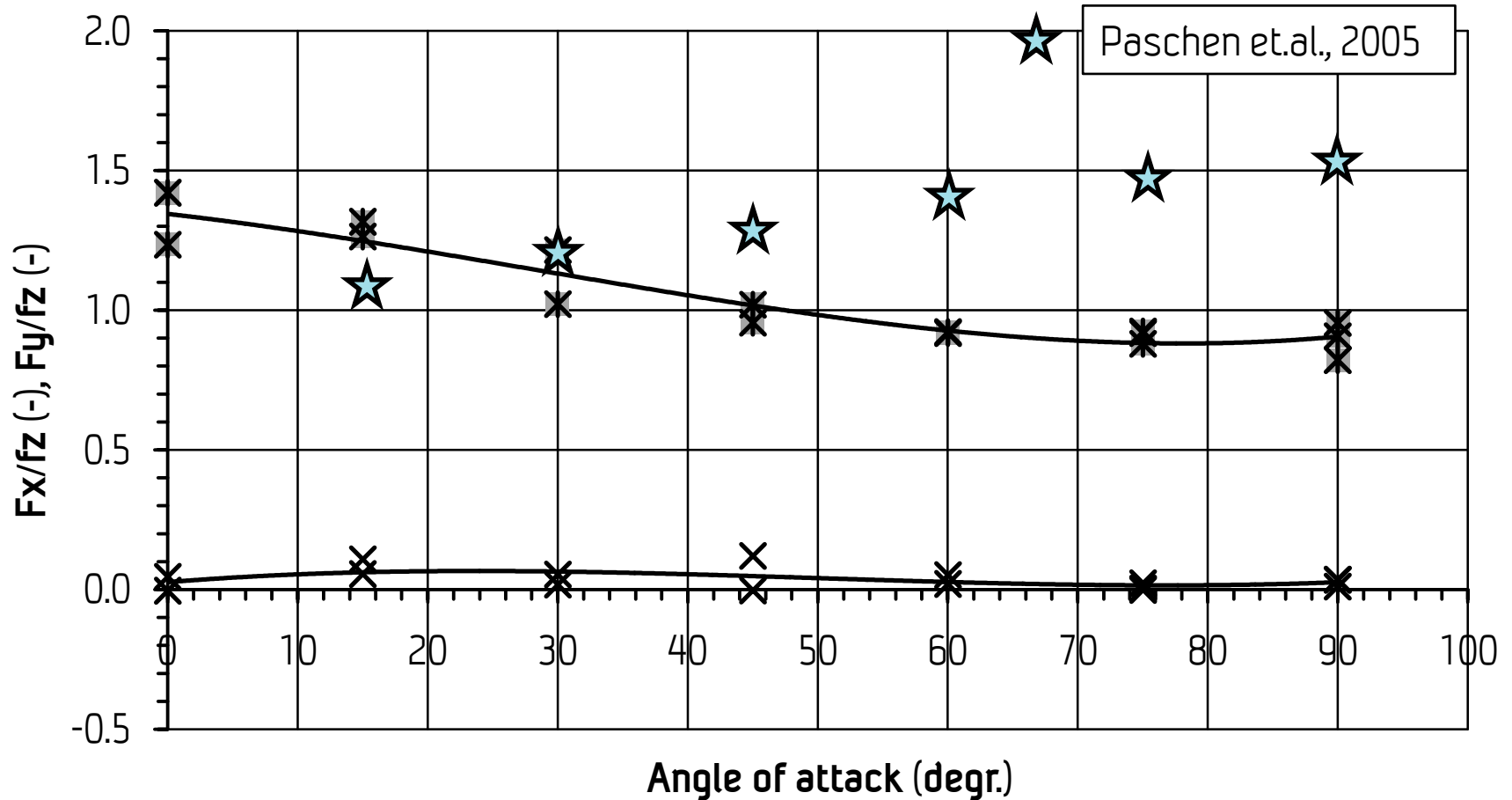


4-stranded rope



✱ Friction force (F_x) ✱ Transverse force (F_y)

4-stranded rope



✱ Friction force (F_x) ✕ Transverse force (F_y)

Bottom seining (fly dragging) rope

2" rope with steel wires – 4.5 kg/m in air



Further works

Procedure

- Do we need to introduce "compactness" classes (as Paschen, 2000) in our analysis?

(The use of a fixed penetration depth instead of applying the models net (submerged) weight gave a vertical force that varied with angle of attack and model.)

Scaling

-How can/should these results be transformed to full scale values?

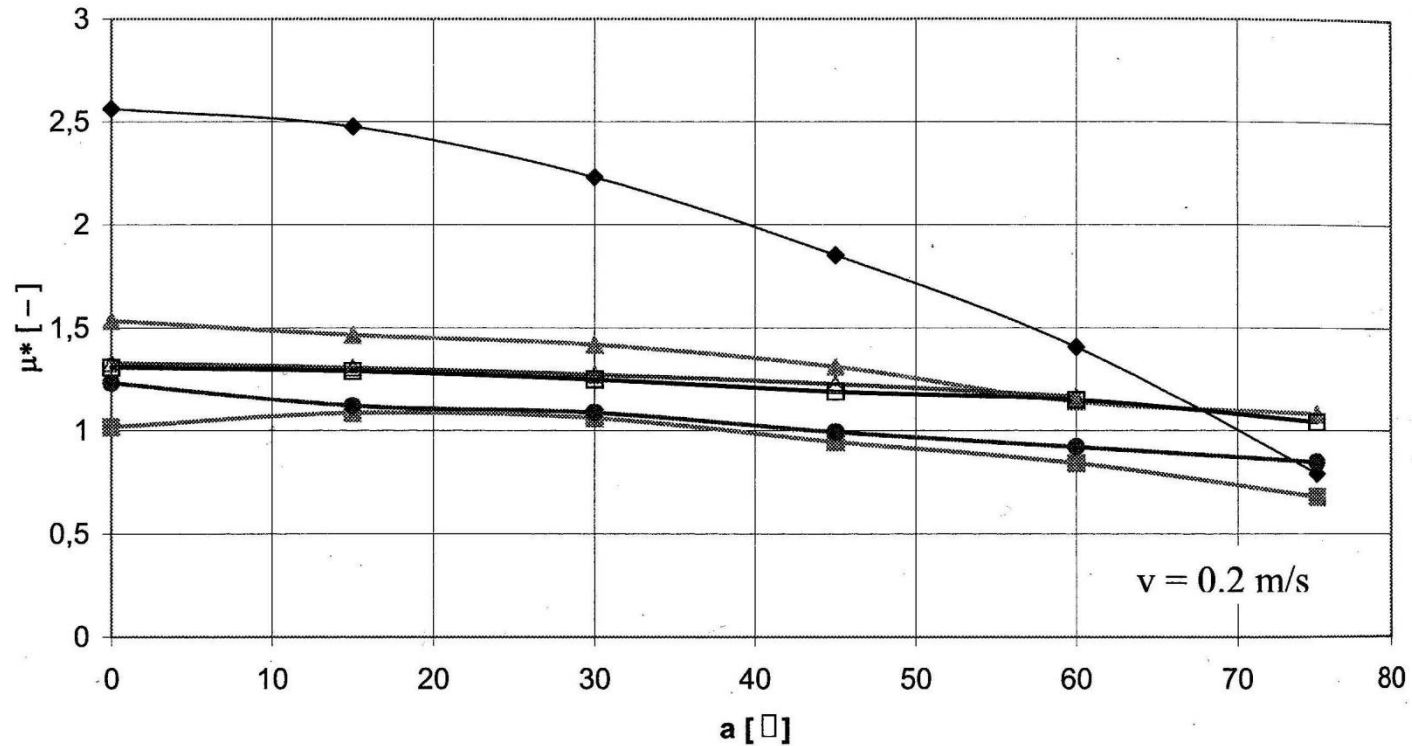
(As long as the model sand has approximately the same ability to take up pressure, Schuring, 1977 concludes that speed and forces can be scaled according to Froude's law.)



Thank you for your attention!

Text

Paschen, 2005



◆ 103.75 - cylinder ▣ 41.25 - cylinder ▲ 44.8 - hercules-z
▴ 40.57 - sisal-z □ 39.29 - pp-z ● 36.06 - pp-#