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Greenstick innovations for dredging

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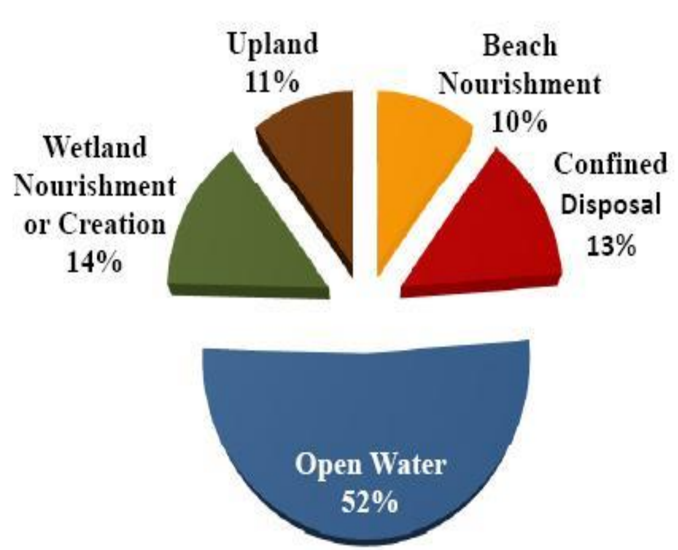
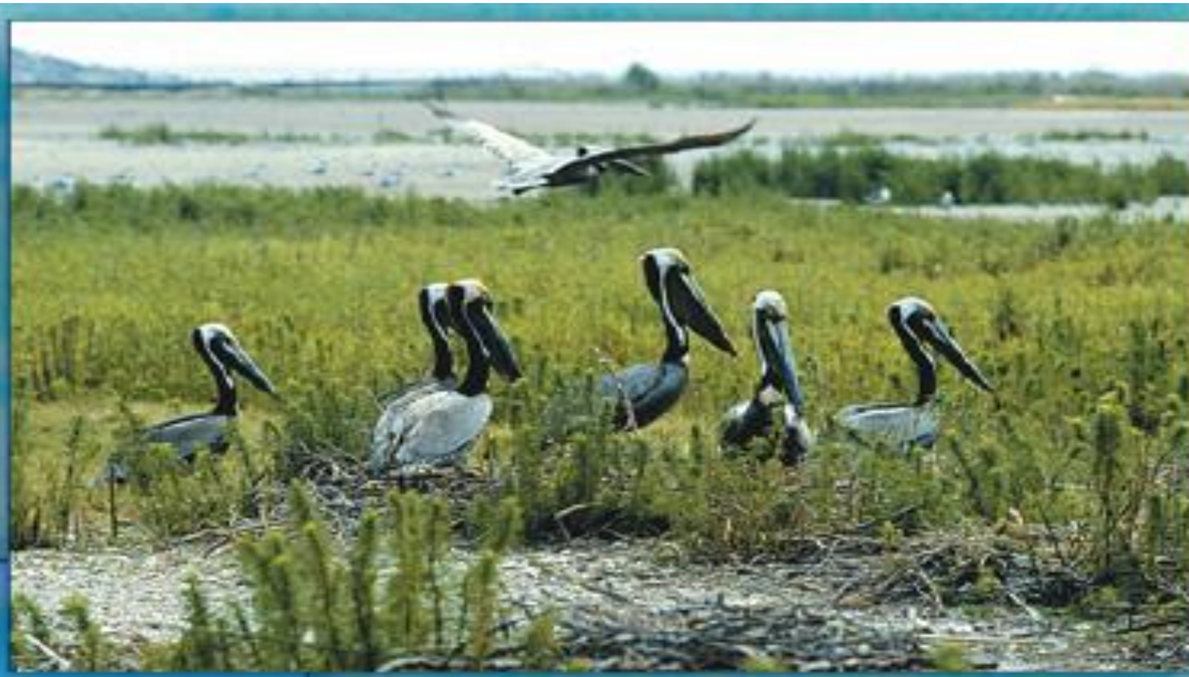


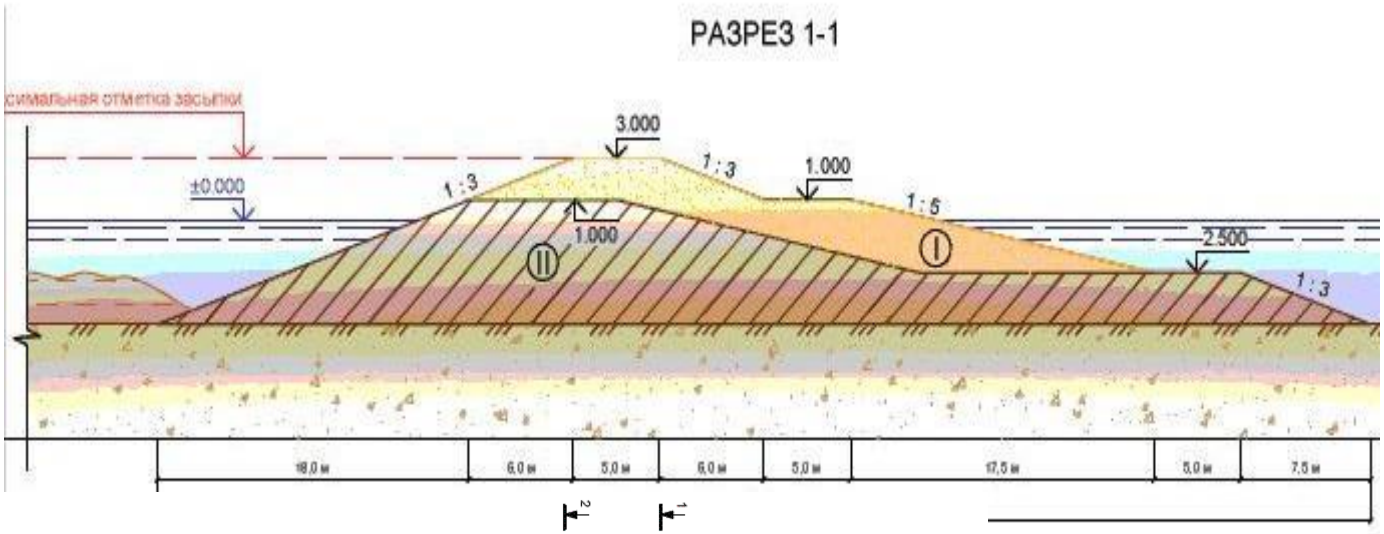


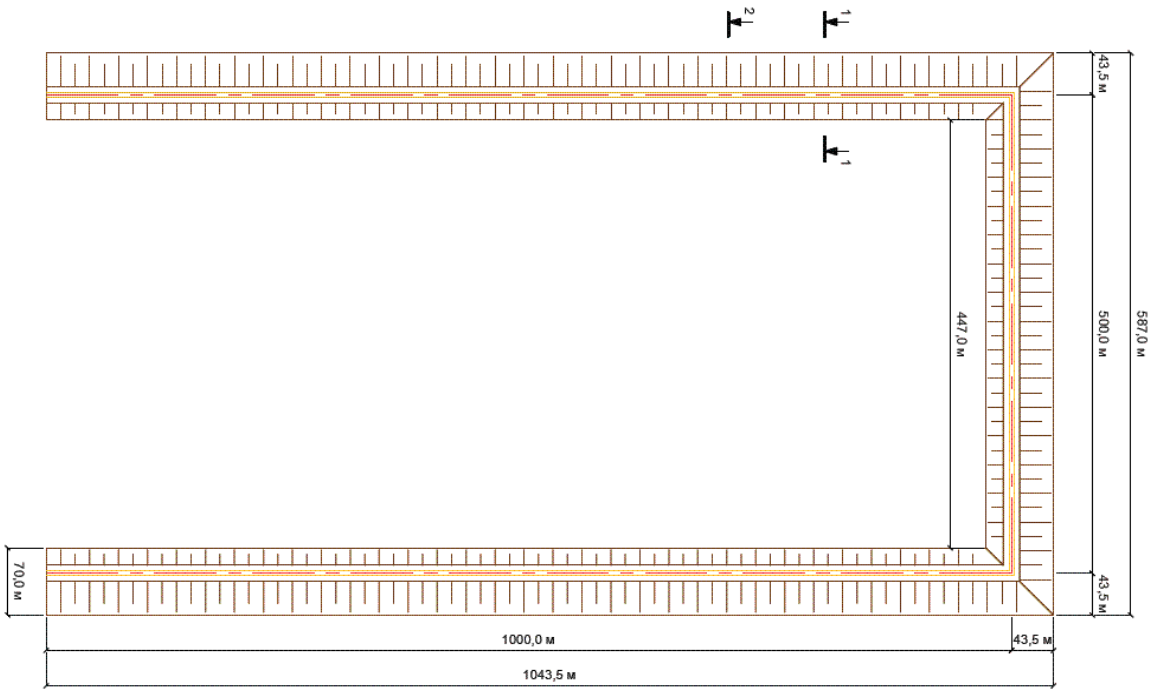
Pelicans on artificial island of dredged soils.Mobile harbor. Alabama. USA

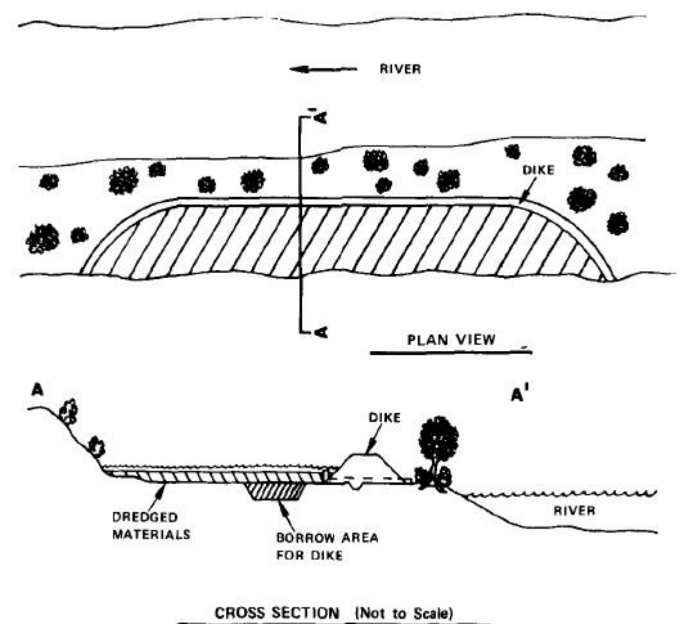
Artificial territories of dredged soils

Artificial territory of dredged soils. Rostoc, Drigge, Germany

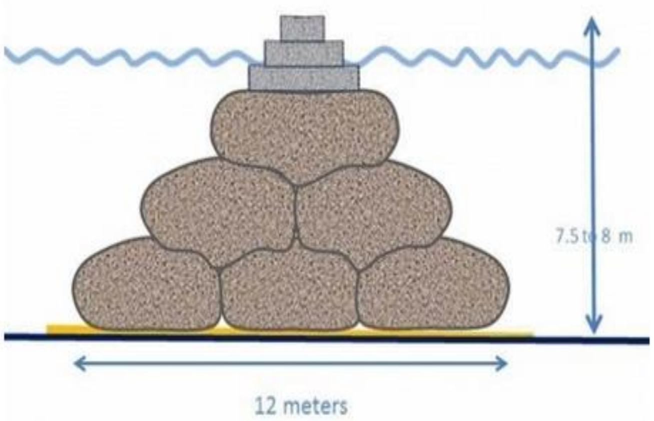
Dams for dredged deposits

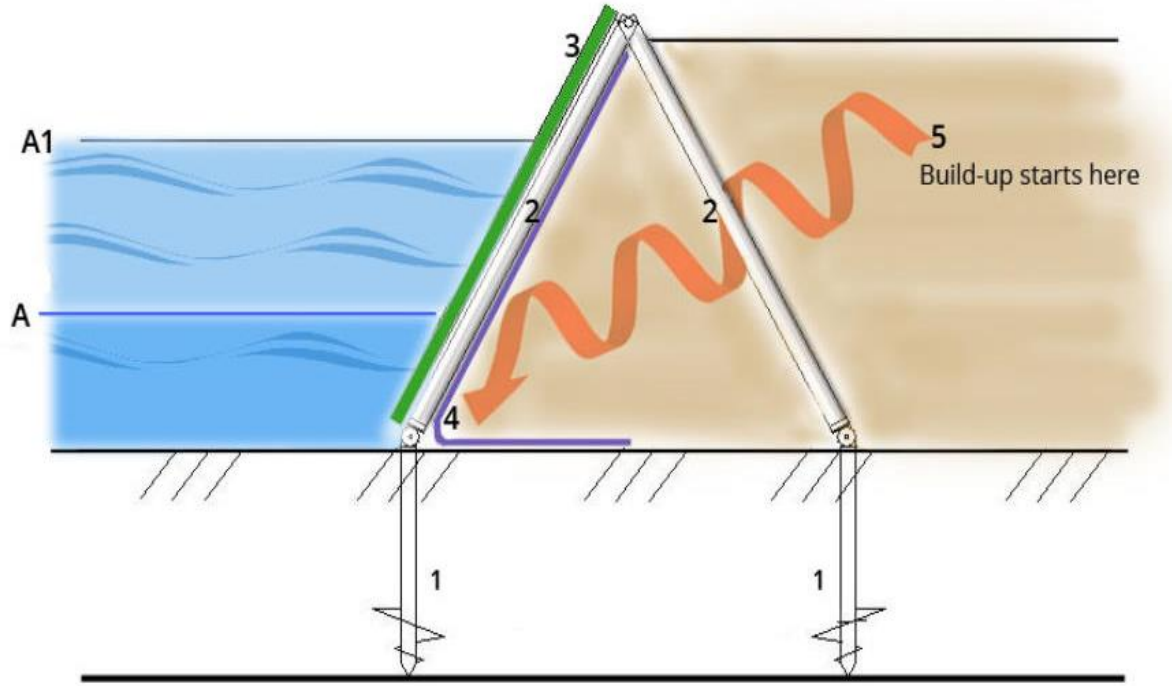


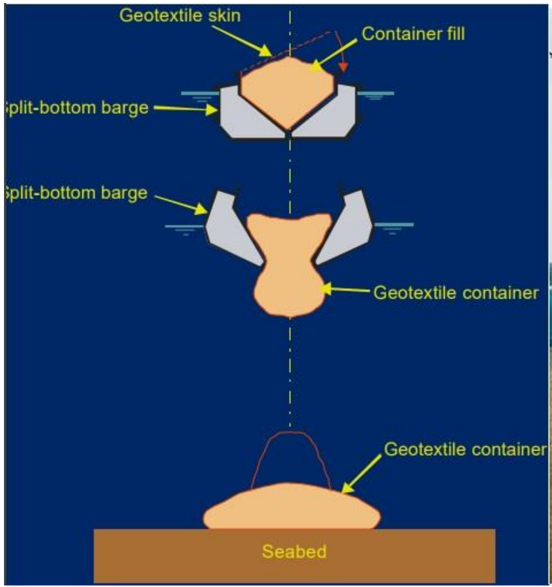




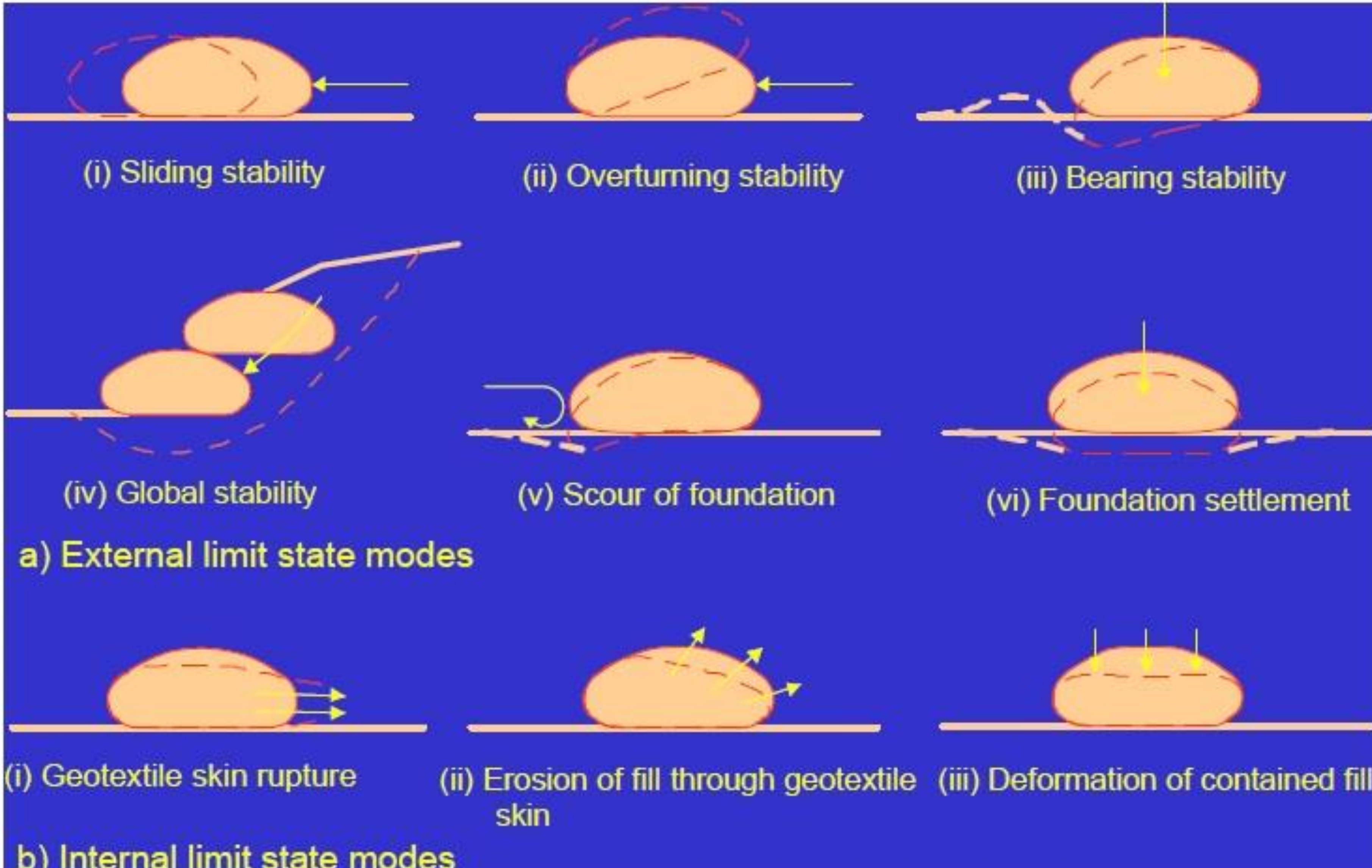
Dams for dredged deposits



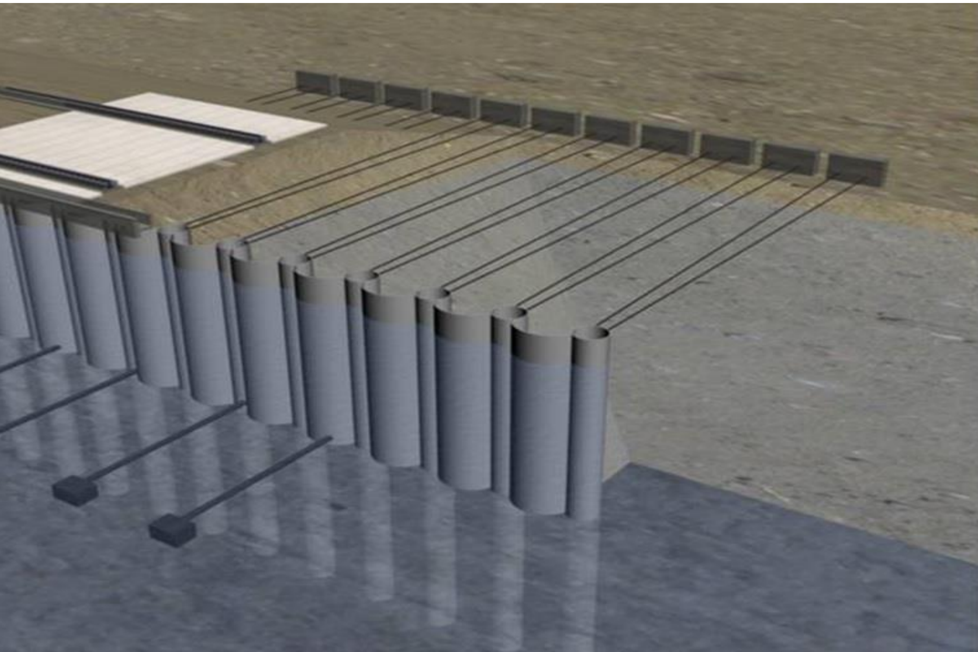




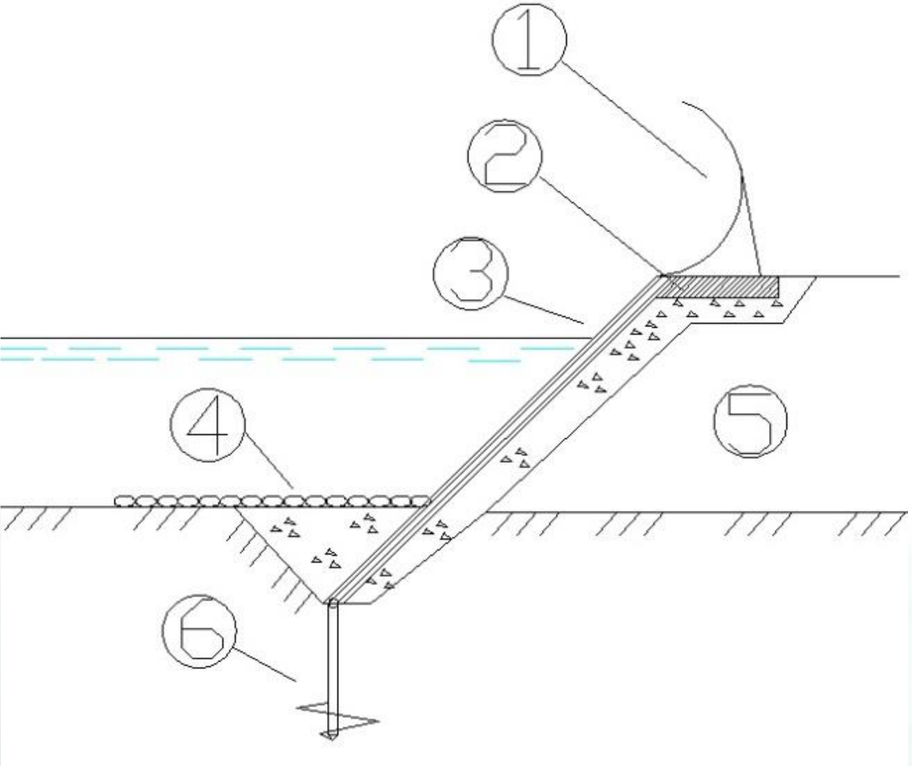
Geotube® systems: limit state modes

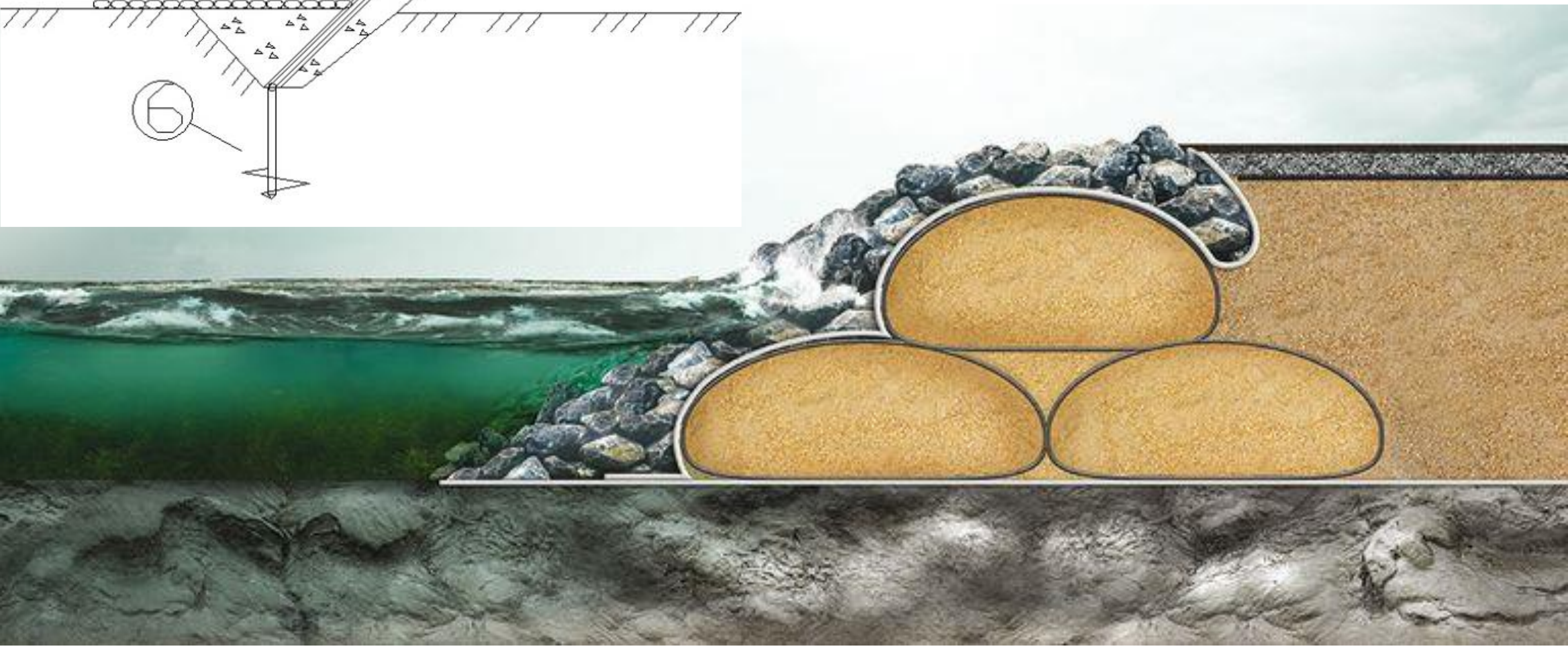


Steel vertical “fence” structure

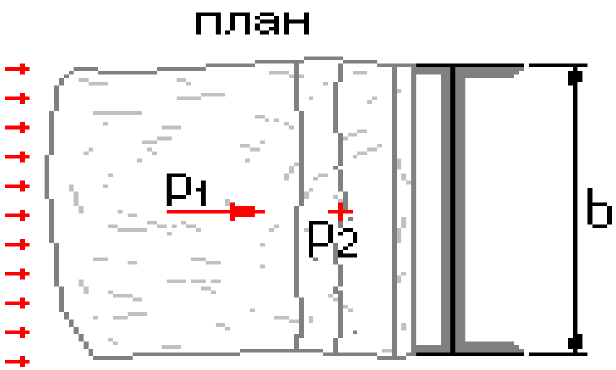


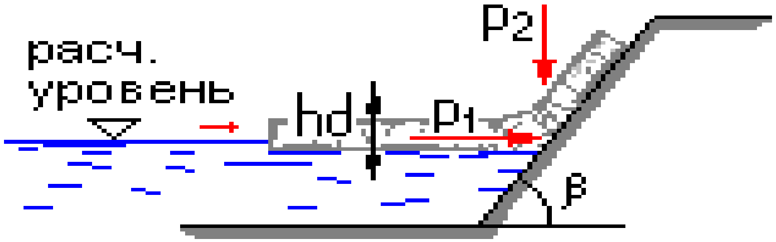
Greenstick Sea Wall





Ice loads calculations for inclined wall



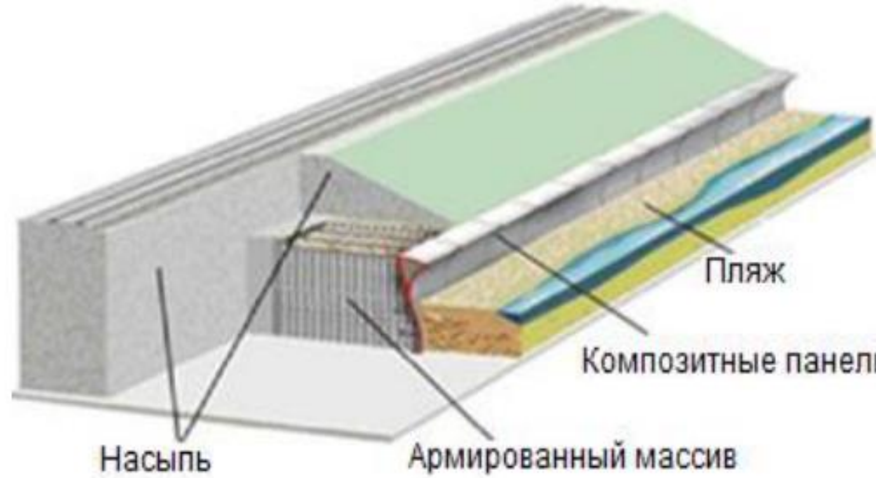


Ice loads calculations for inclined wall

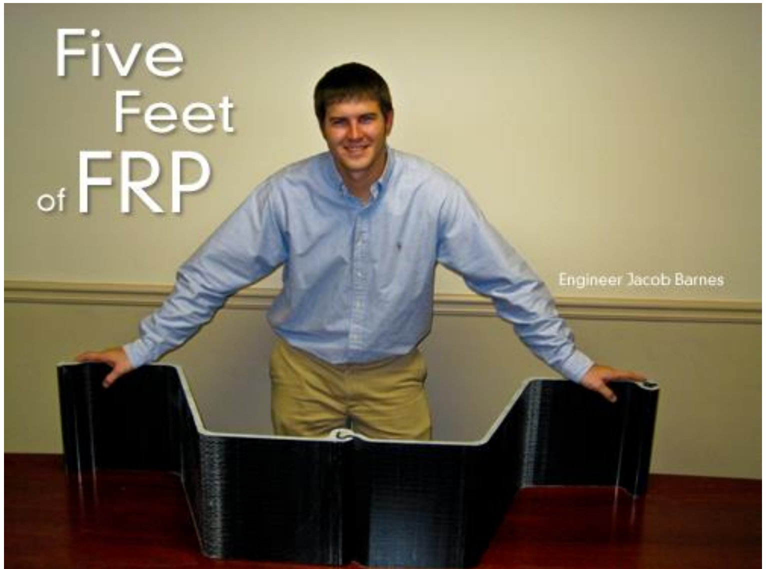
Characteristics	Symbol	Quantity	Measure
Ice –air temperature, C	Tl	-5	°C
Ice width	Hd	0.1	m
Max. square of ice field, 1% insurance	Al	100	m2
Speed of ice field	vl	0.15	m/sec

Characteristisc	Symbol	Quantity	Measure
Vertical force from ice movement	P1	108	кН
Horizontal force from temperature extension of ice	P2	108	кН

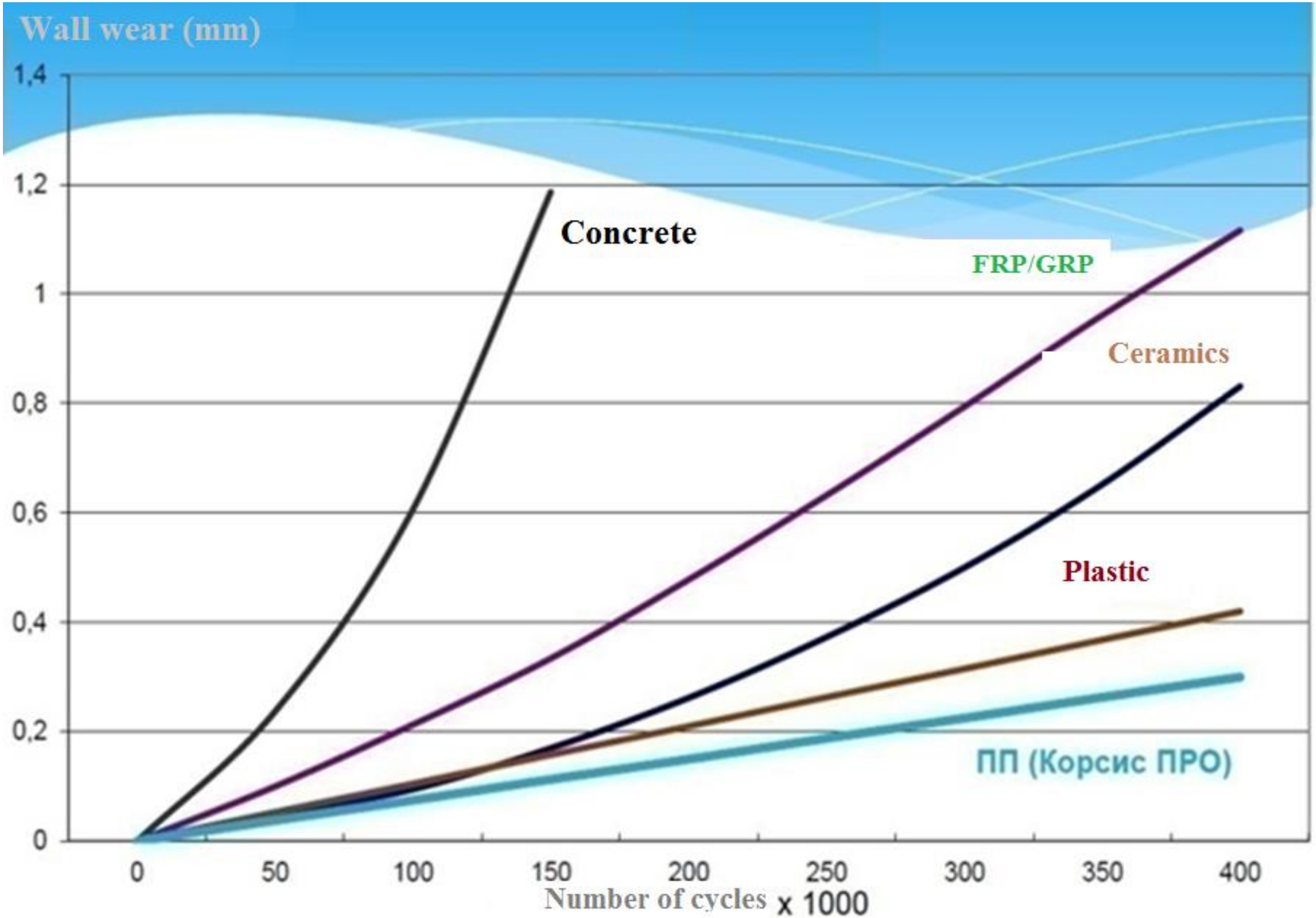
FRP: Apatech Sea Wall and Australian Breackwater



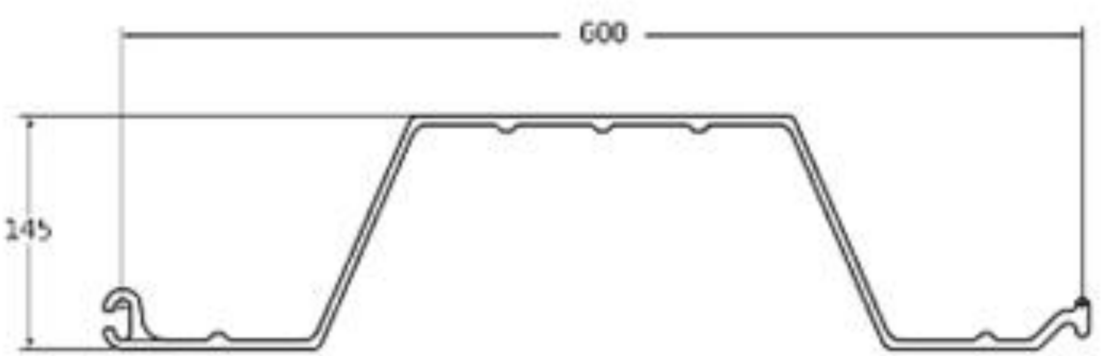
Infussion and pultrussion



Material abrasion. Darmstadt method



Physical characteristics of FRP SHK-150 sheet pile



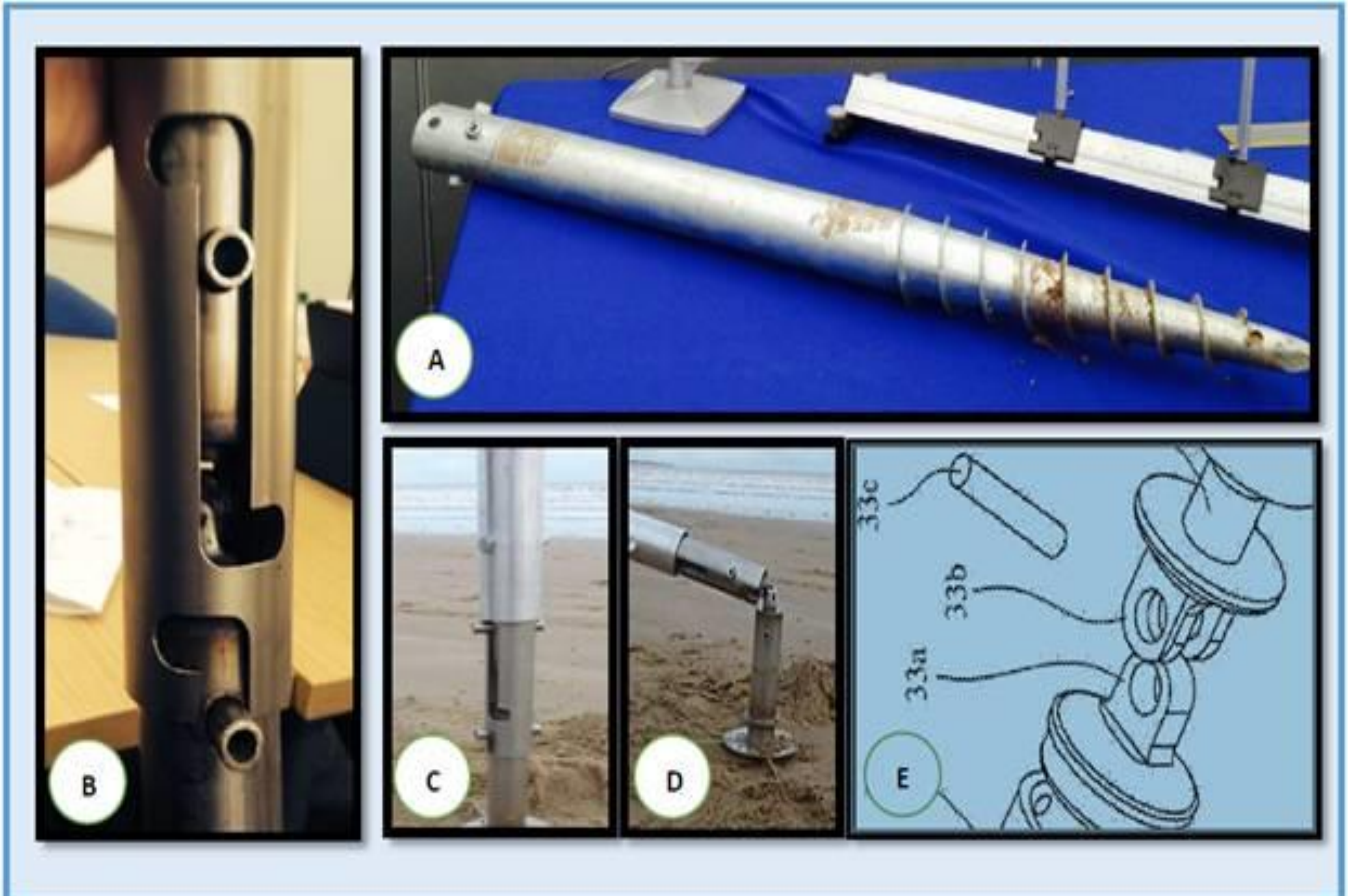
Characteteristics	Measure	Value
Allowable moment (M)	kN-m/m	237
Inertion moment (I_y)	cm^4/m	17885
Inertion moment (I_x)	cm^4/m	1684
Resistant moment (W_x)	cm^3/m	210
Strength limit (R)	MPa	1126
Width	mm	600
Depth	mm	145
Thickness	mm	5

Greensticks Grip

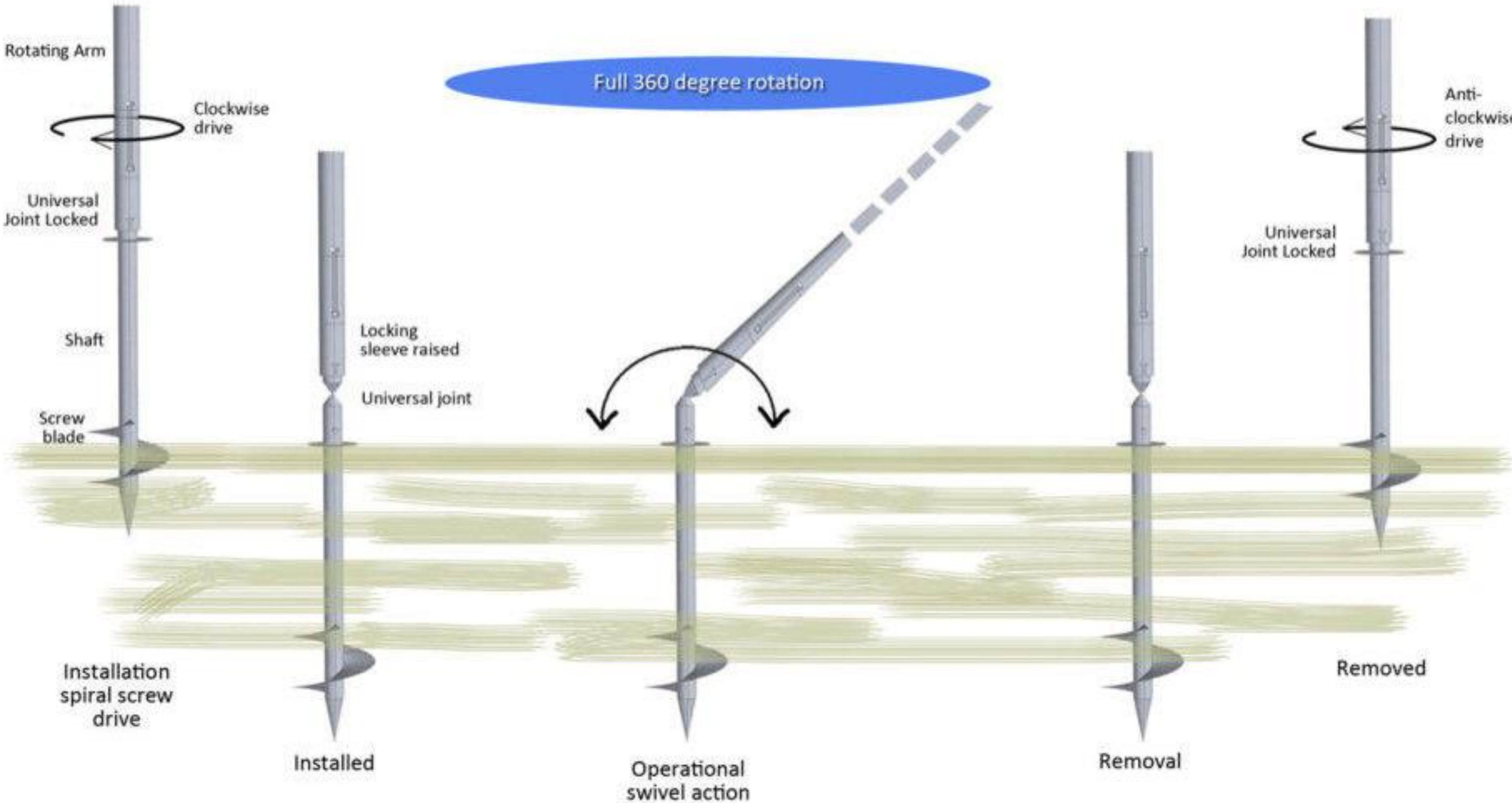


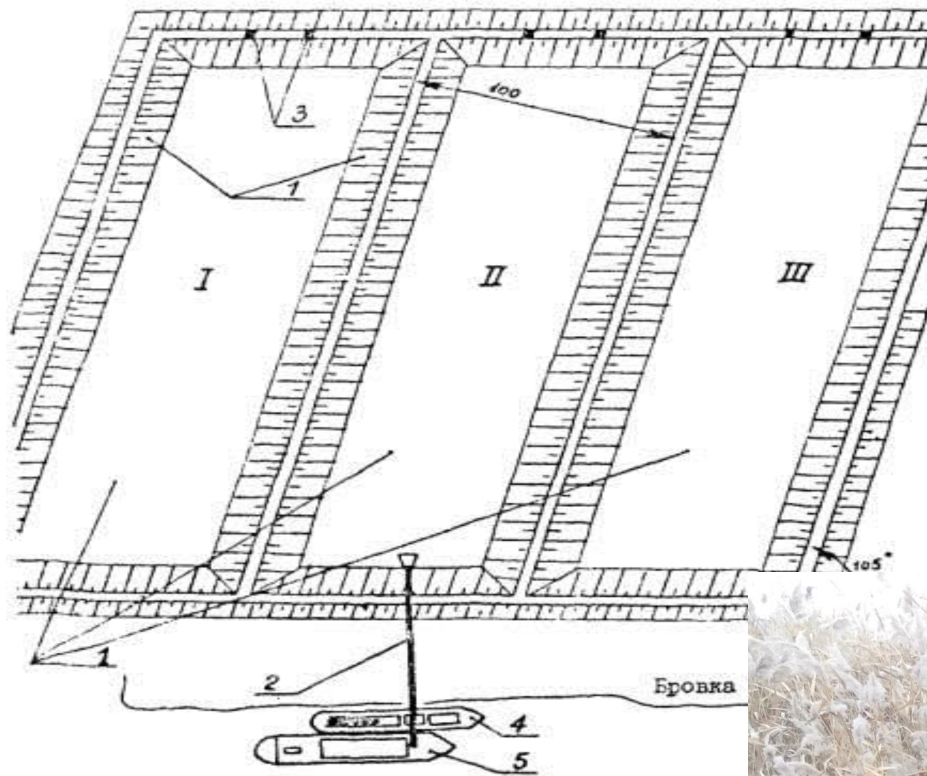


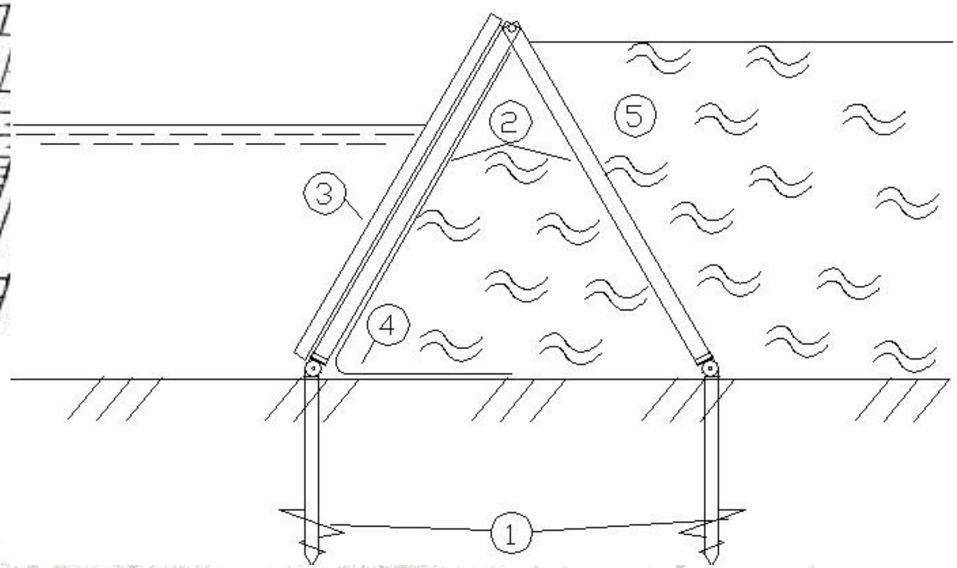
Greenstick grip



Greenstick pile

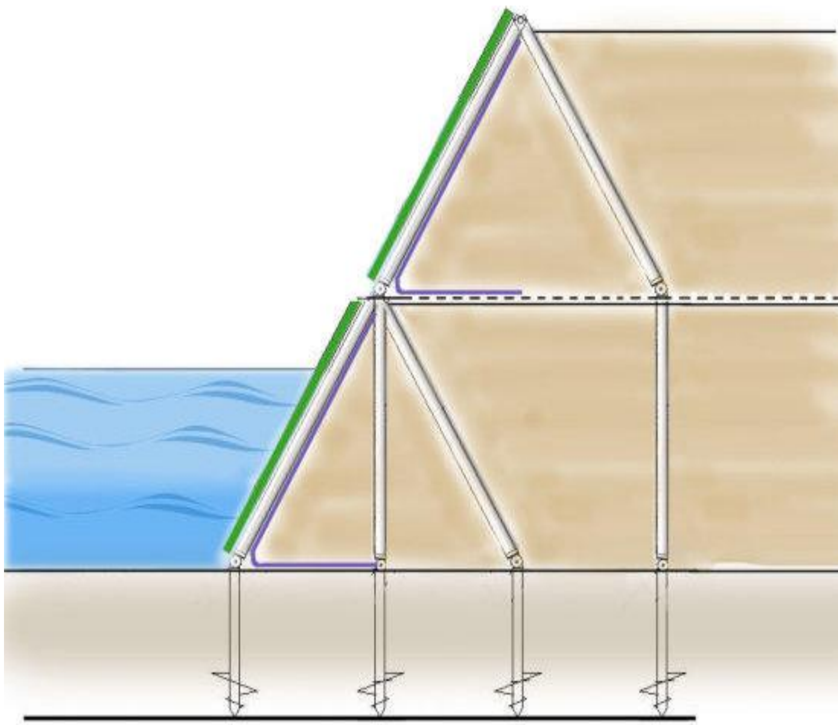


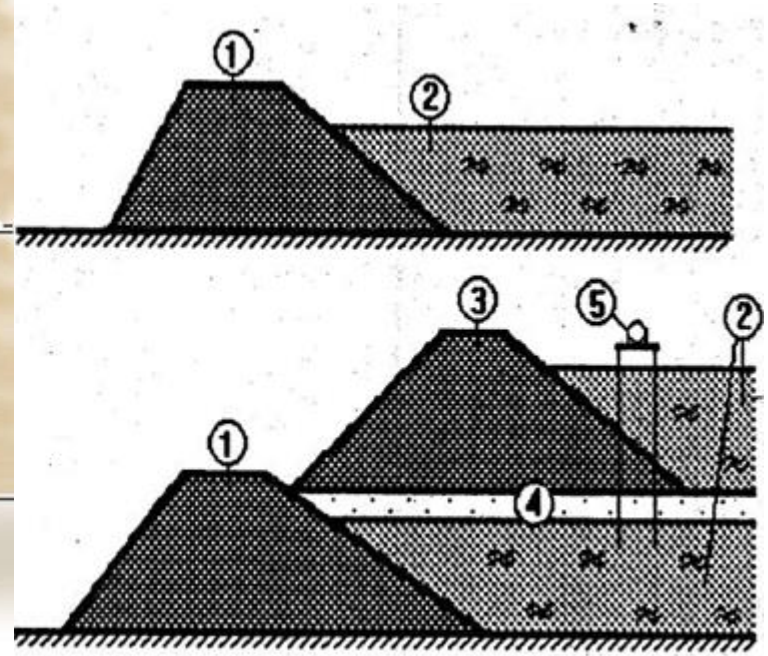

3
1
I
II
III
1
2
Бровка
4
5


2
5
3
4
1

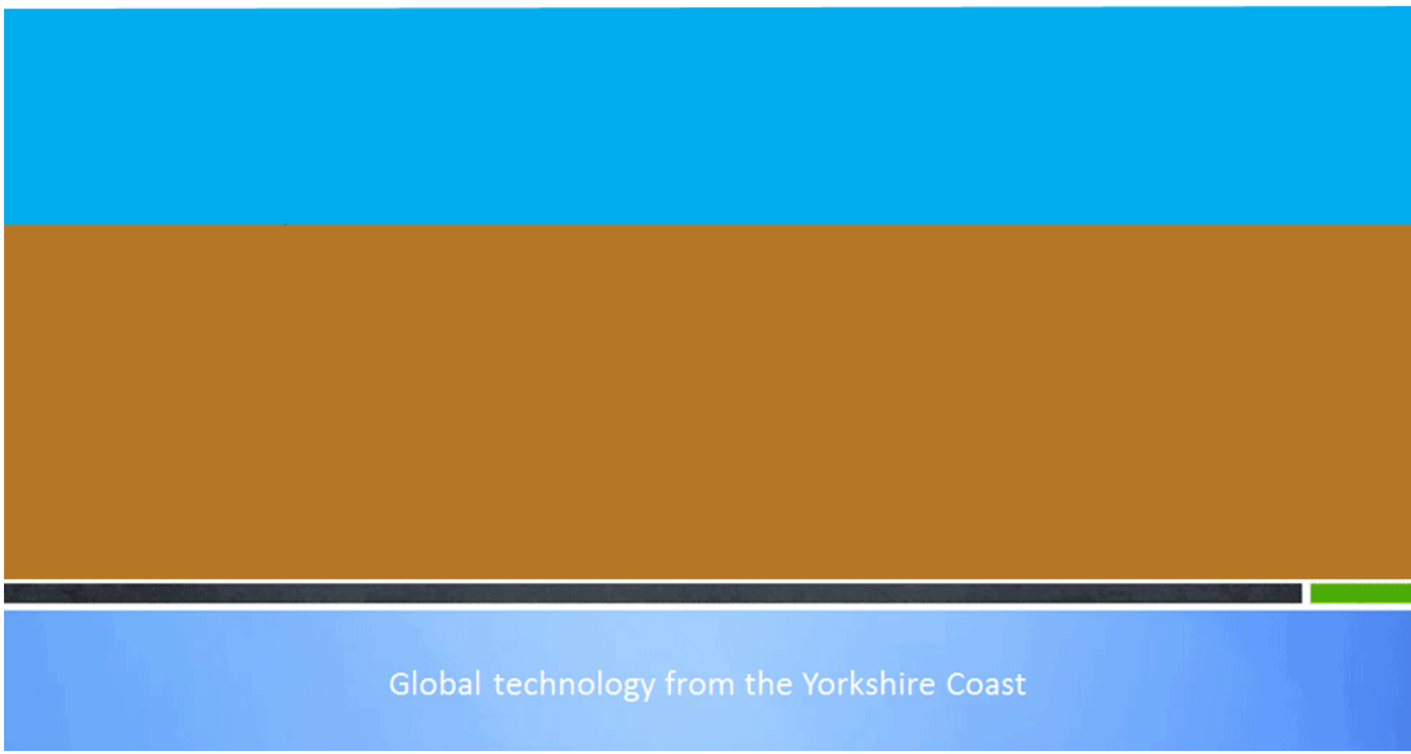

КВ 08-79

Greenstick wall installation for 2nd dredged layer

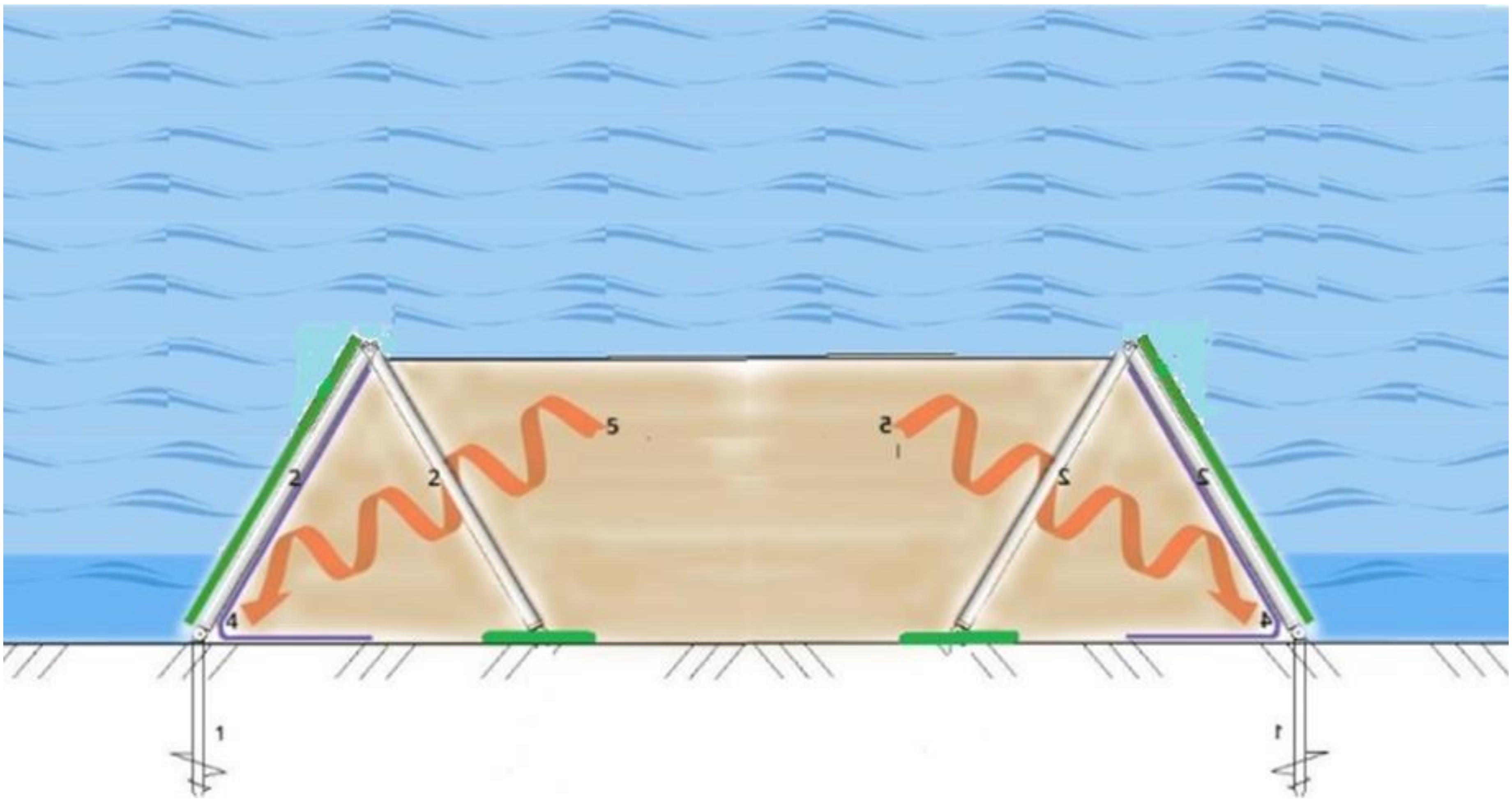




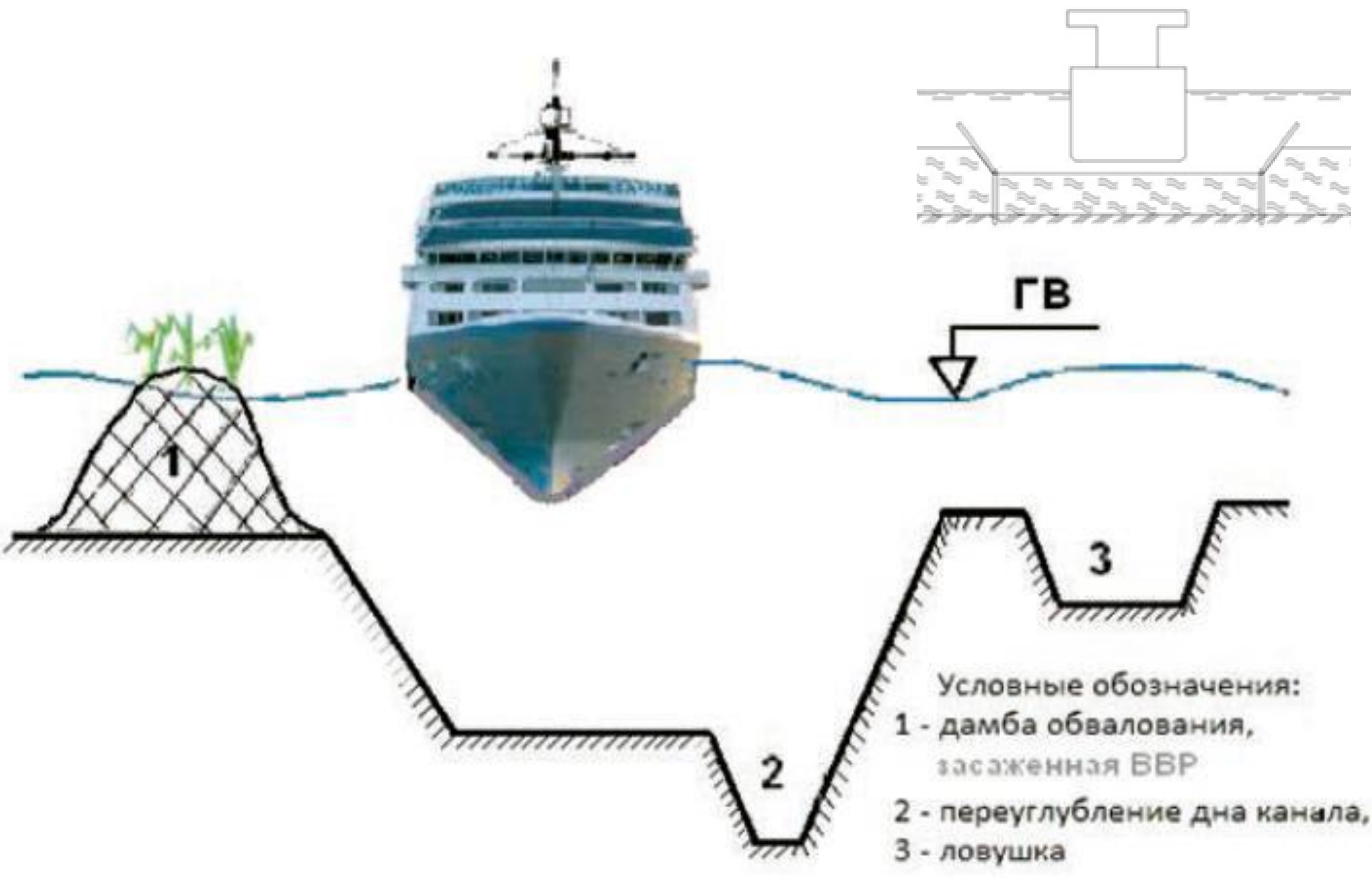
Technology of installation of Greenstick Walls



Decisions for underwater dumping deposits



Decisions for approach channels



Tests of Walls in Waves flume

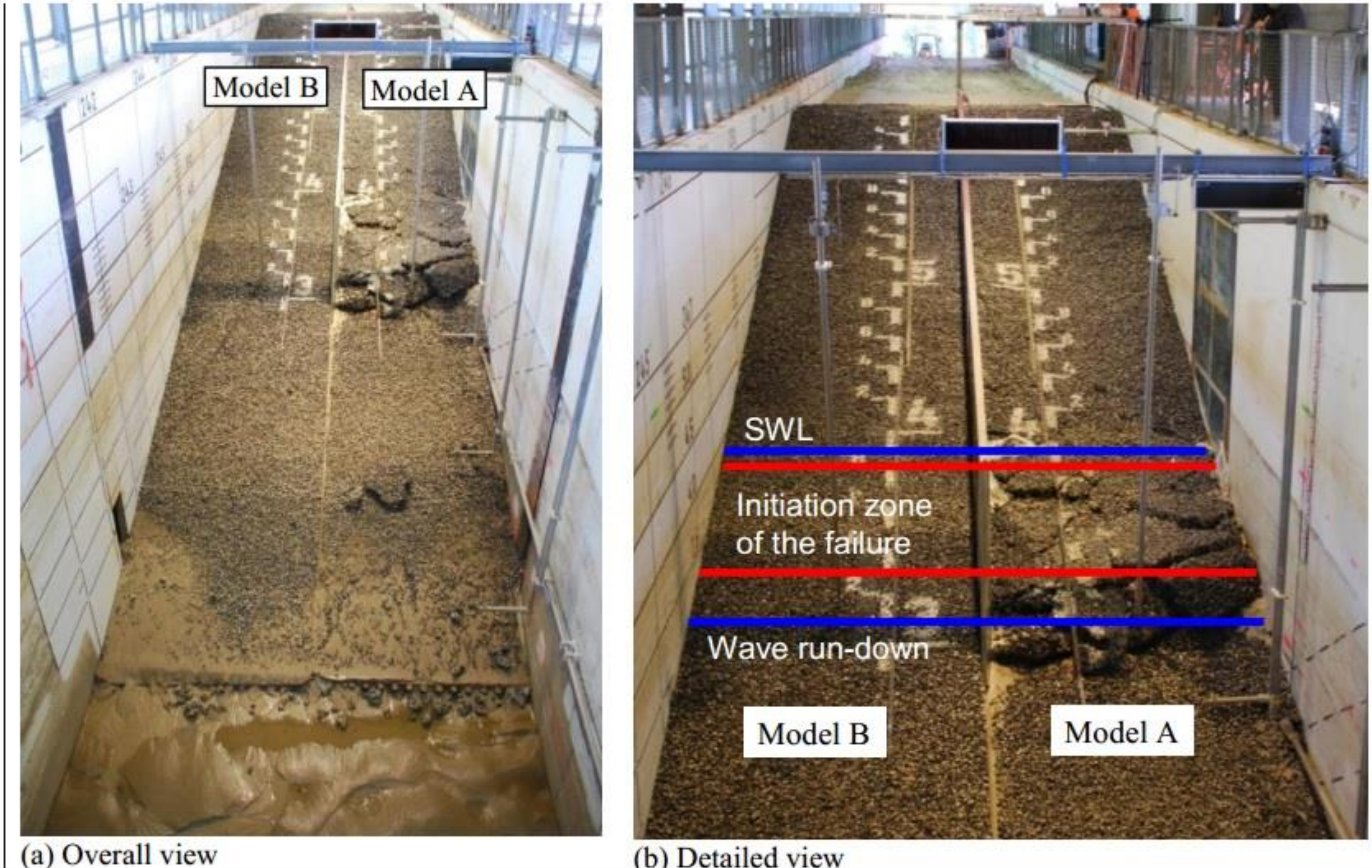
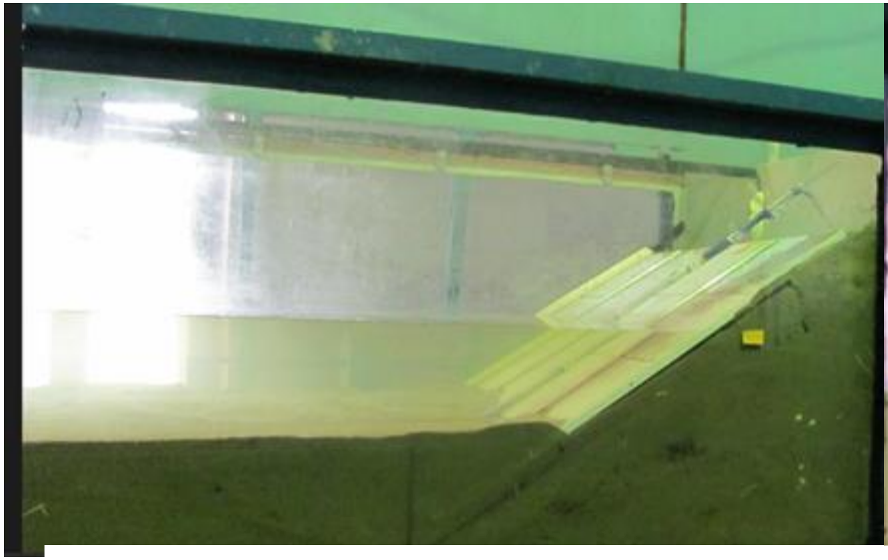
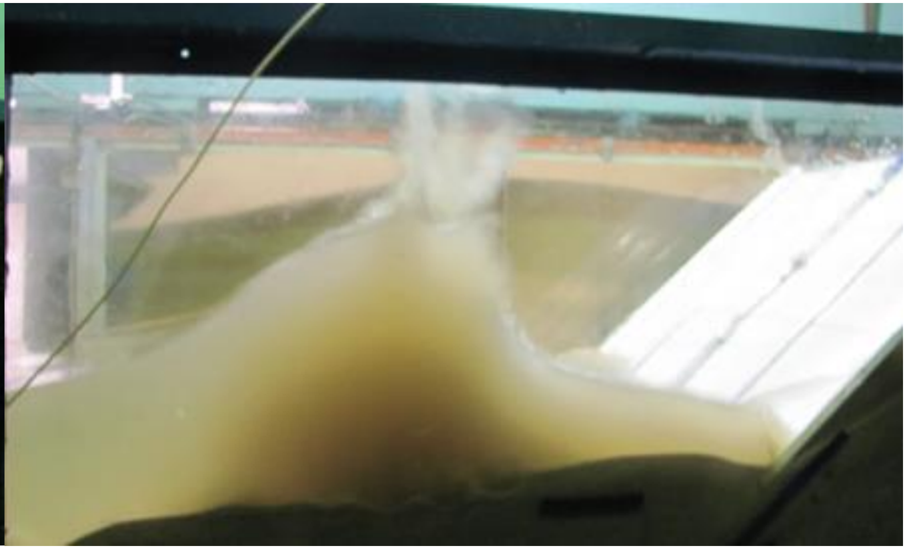


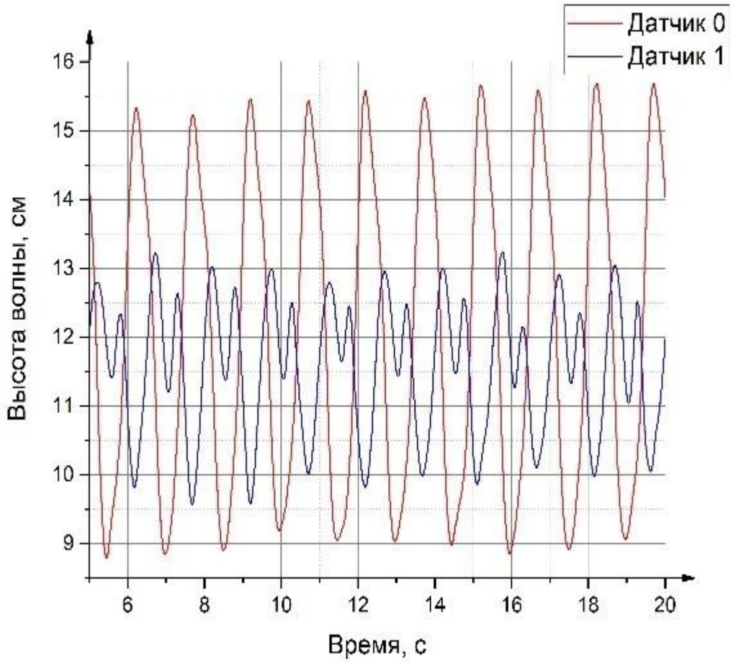
Figure 8. Extent of damage for revetment Model A after regular wave test 09051802 with H =1.3m, T = 5.0s and h =3.9m

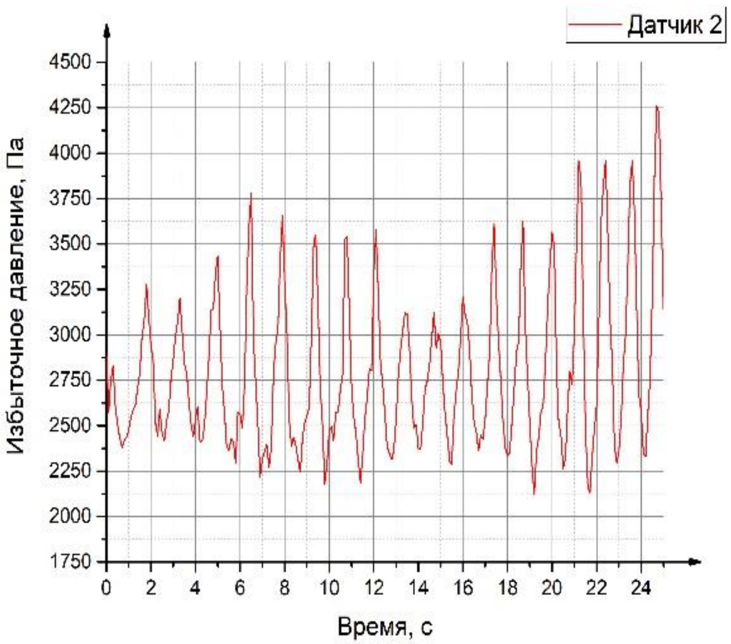
Tests of Greenstick Wall in Waves flume of

http://hydromech.org.ua/en/





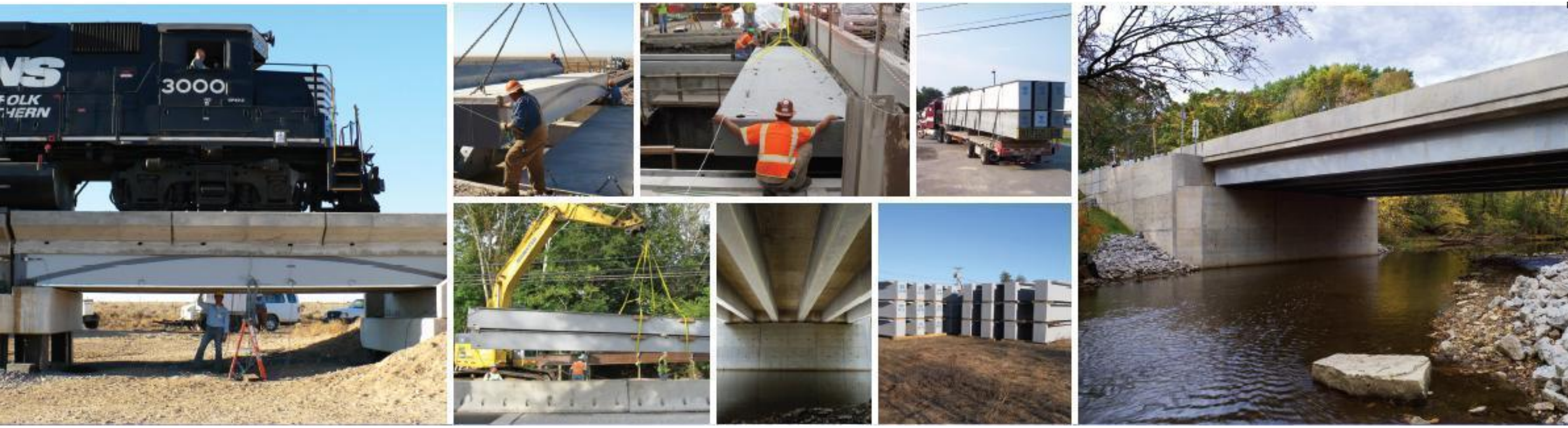




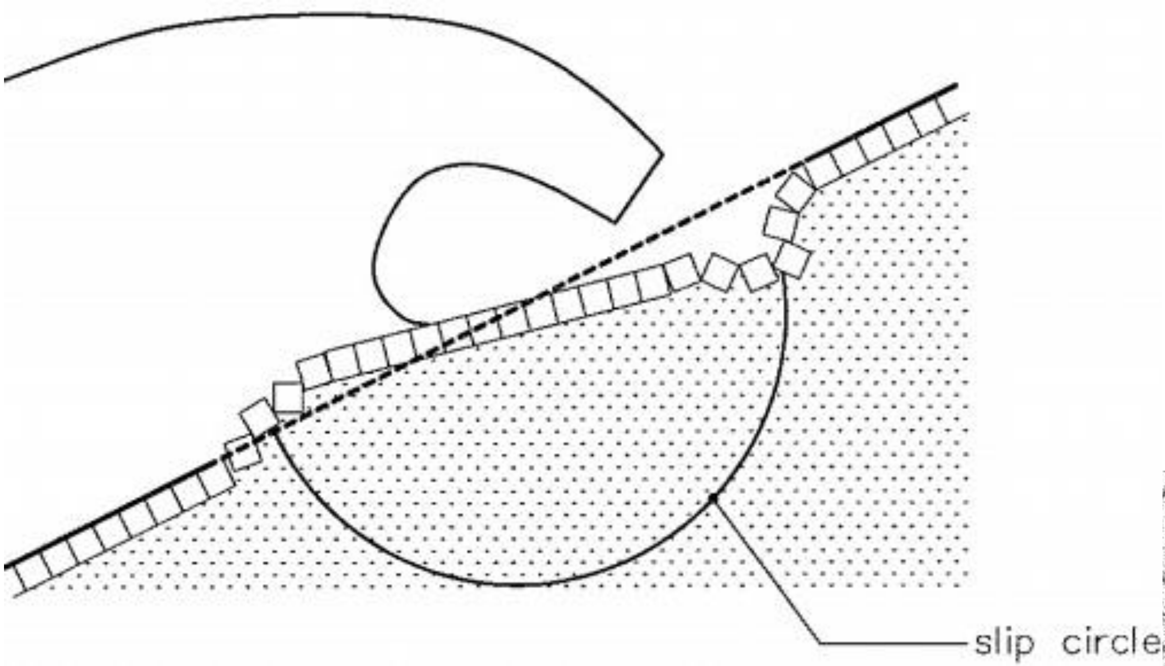
Waves flume`s tests results

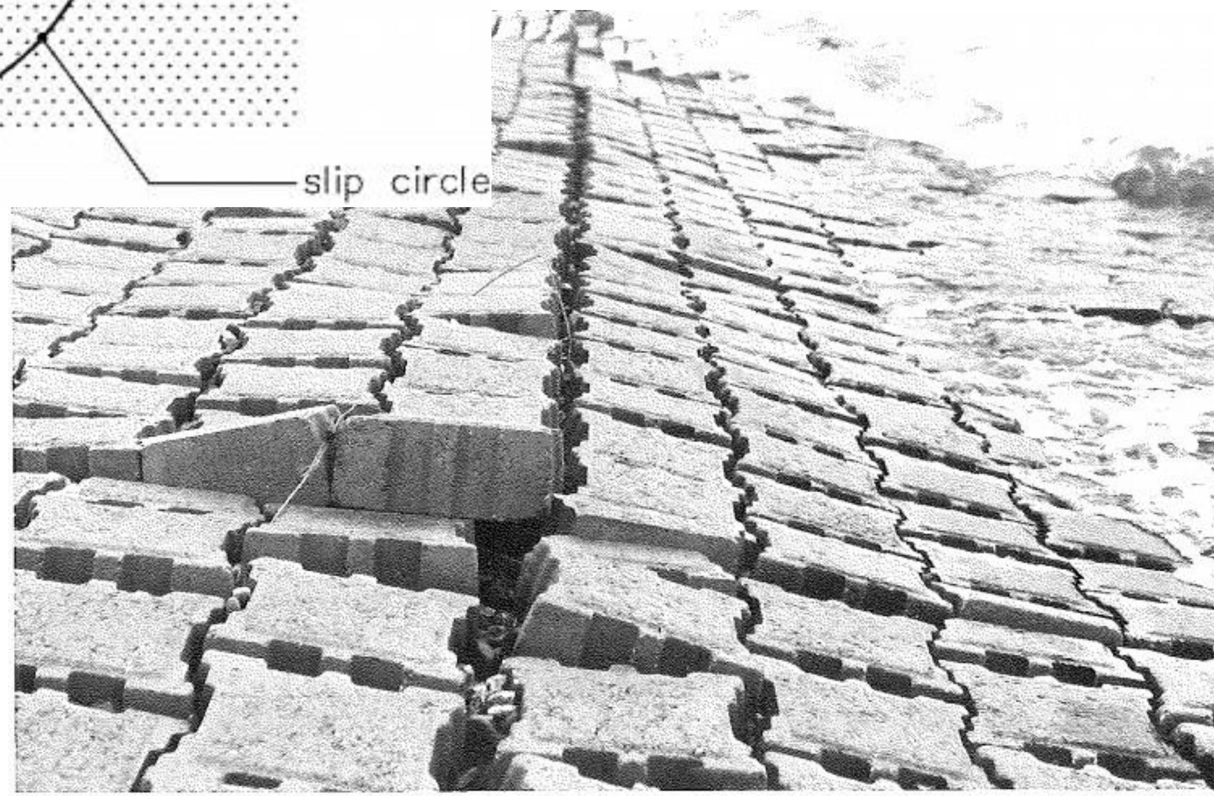
Experiment №	Gauge	Period, sec	Medium waves height, sm	min waves height, sm	max waves height, sm	Reflection rate	Waves height, m	Waves spead, m/sec
14_11_otr_1	0	0,68	4,484	3,361	6,07	0,399	0,373 (0,658)	0,274 (1,013)
	1	0,619	4,506	3,058	6,57	0,404		
	2	1,227	7,248	5,787	9,839	0,211		
	3	1,237	7,705	5,106	10,756	0,438		
23_11_1	0	1,897	3,388	2,021	3,999	0,156	3,784 (5,949)	1,938 (3,046)
	1	1,107	1,189	0,335	1.757	0,744		
	2	2,008	4,653	3,739	5,386	0,176		
	3	1,402	1,75	0,135	3,069	0,915		
23_11_2	0	1,836	4,574	2,365	5,651	0,21	3,705 (5,517)	1,97 (2,934)
	1	1,064	1,273	0,239	2,538	0,833		
	2	1,925	6,019	5,063	6,456	0,171		
	3	1,73	2,418	1,659	2,843	0,909		

FRP(HCB) bridges http://innovativeglobal.net/products/hc-bridge



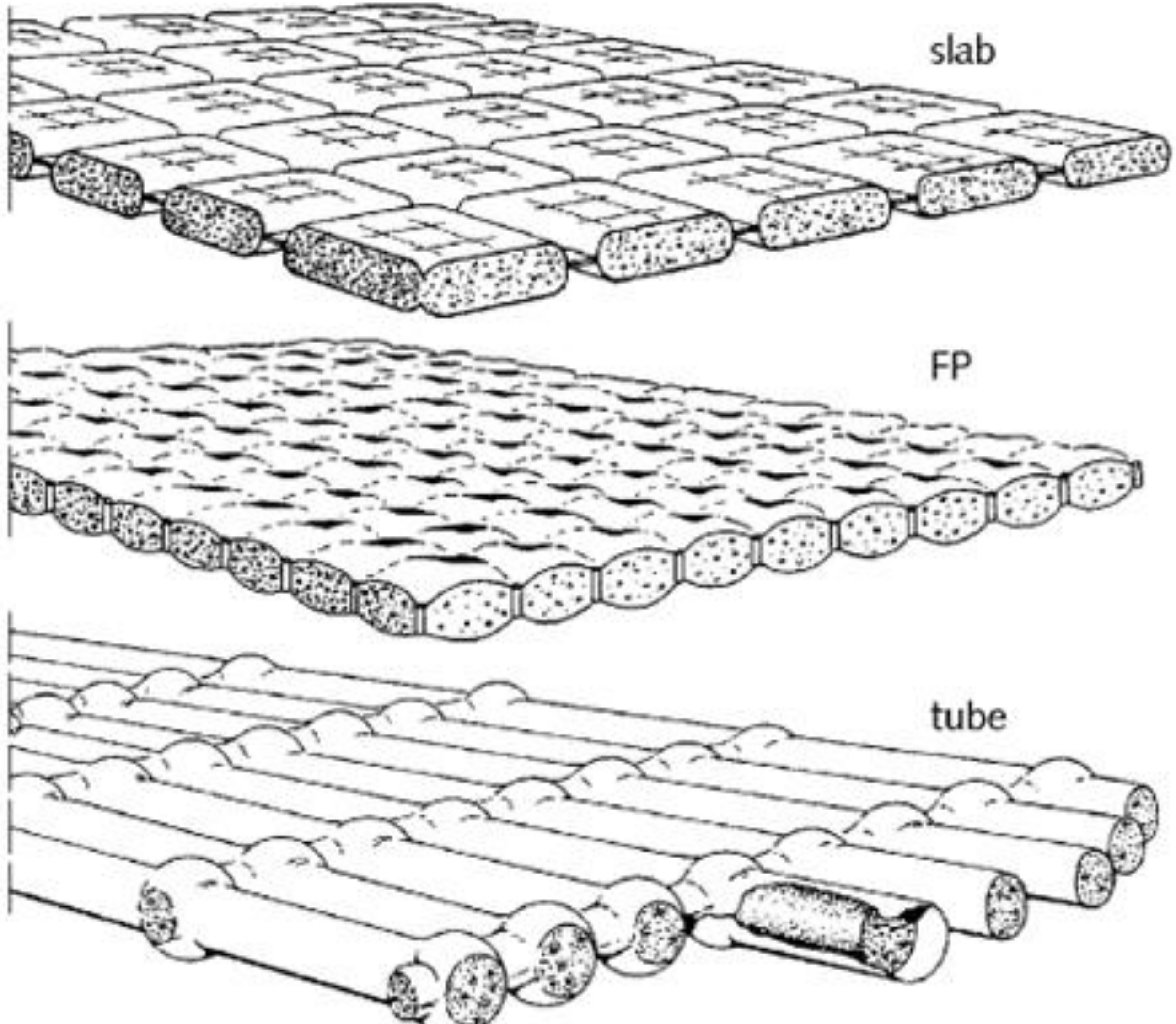
The distortion of an S-profile



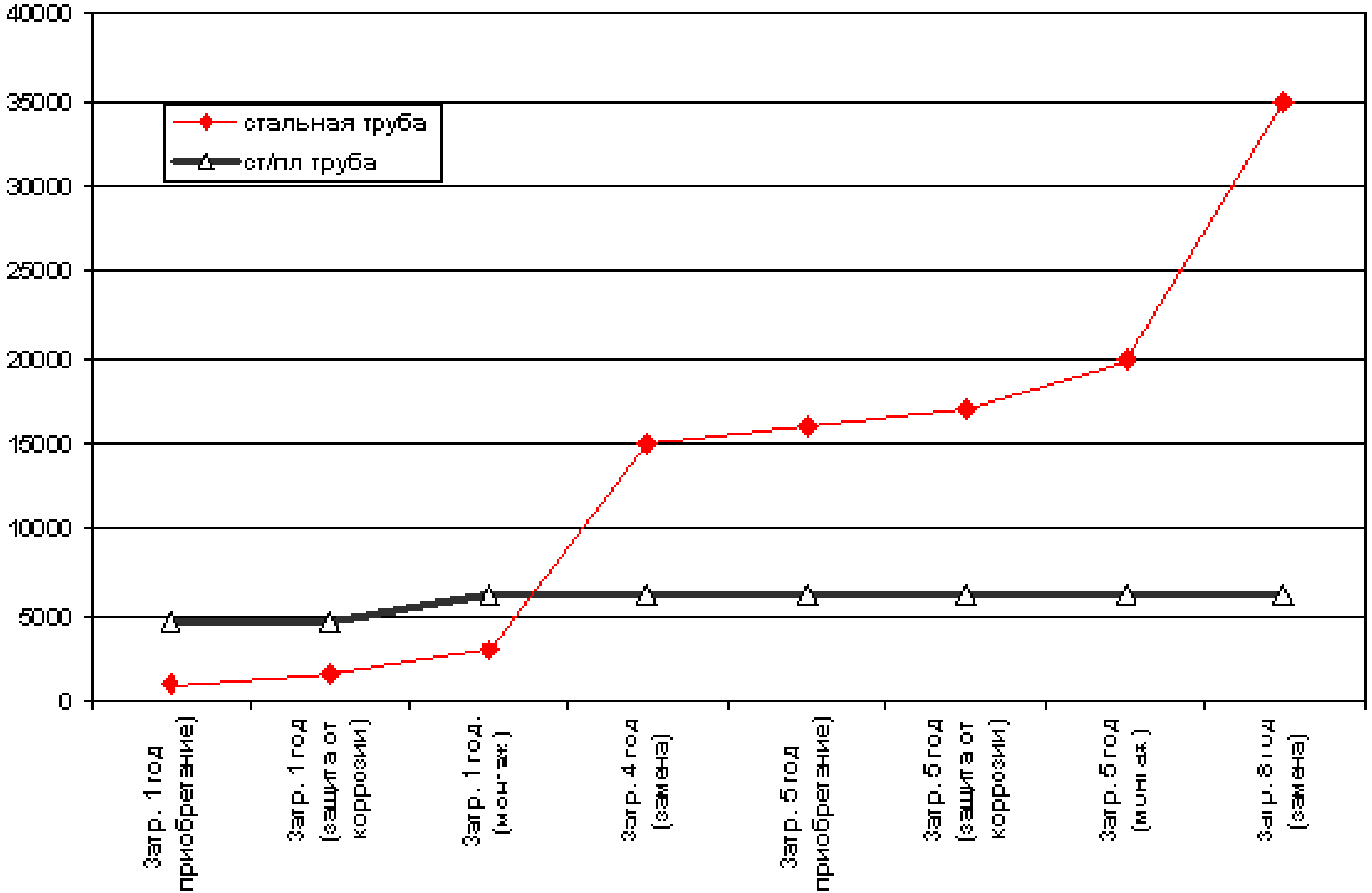


The turned-up corner of a mattress – test section near Lelystad.

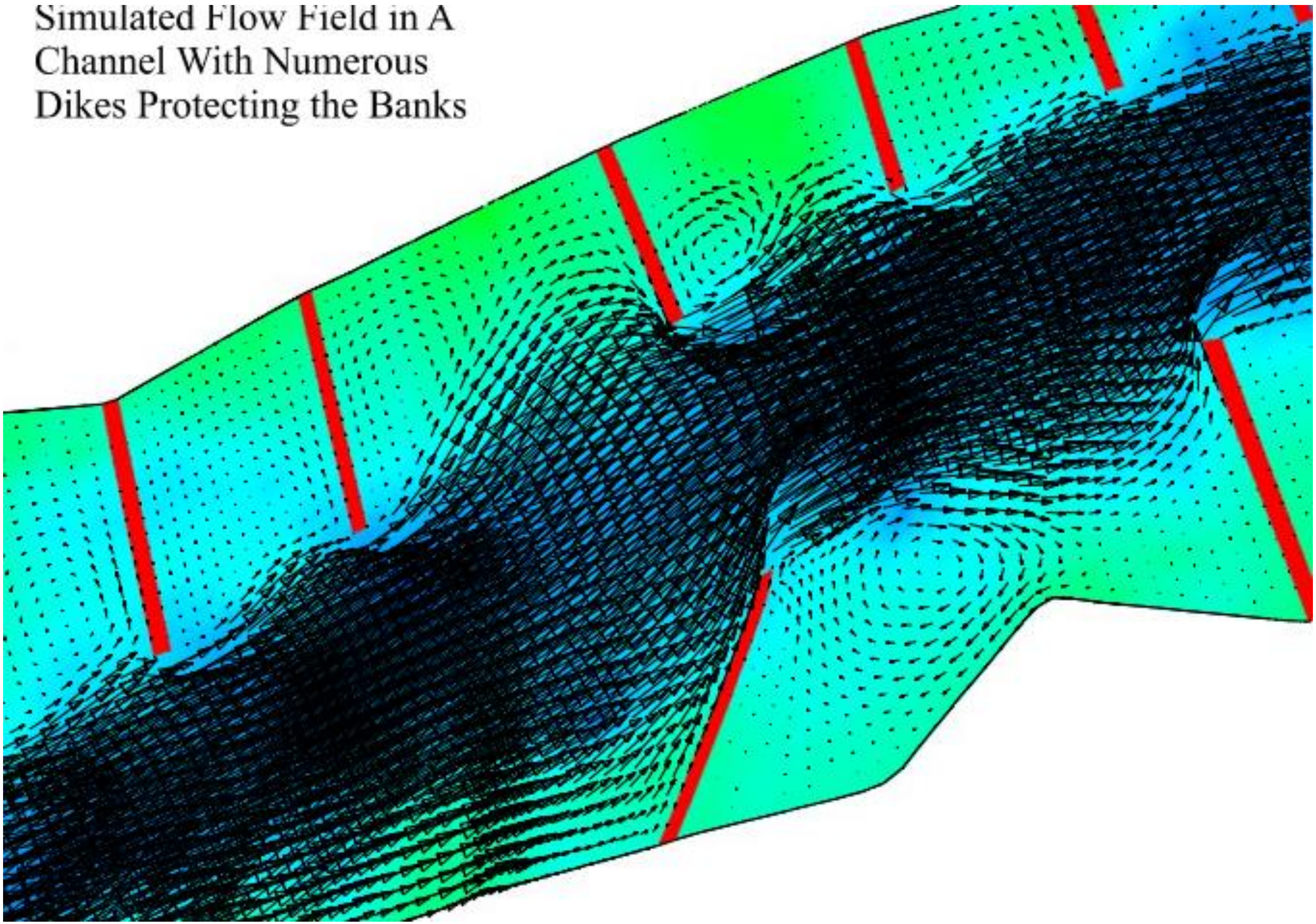
Concrete-filled mattresses



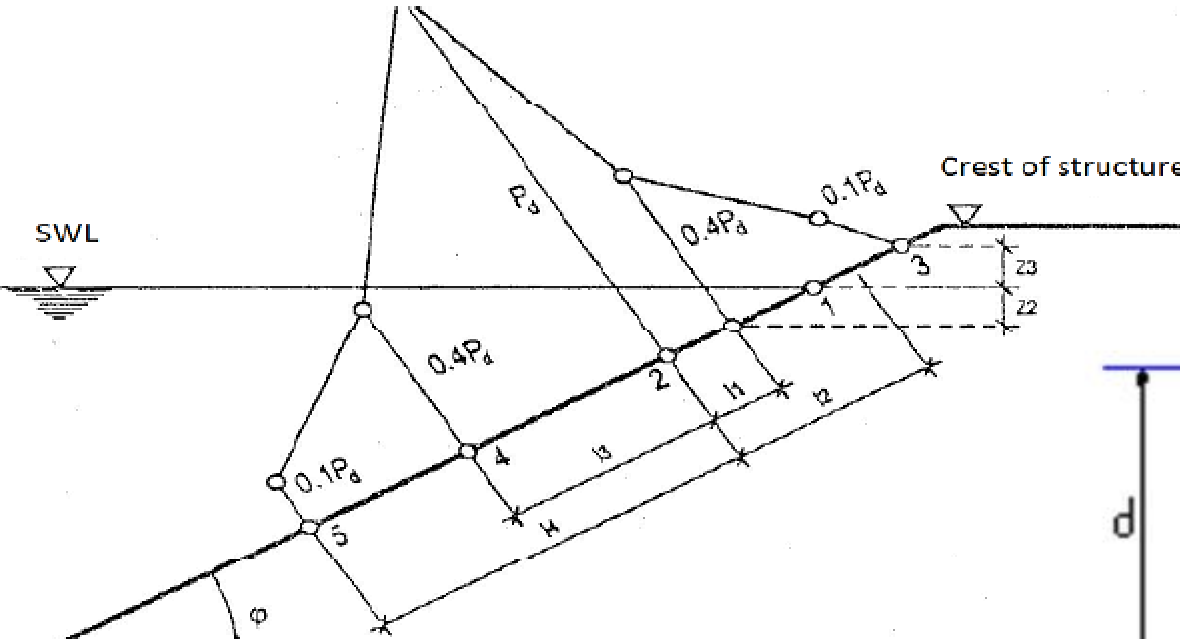
Price comparison of steel and FRP pipes



Decisions for underwater dums guiding the stream



Wave pressure distribution on slope

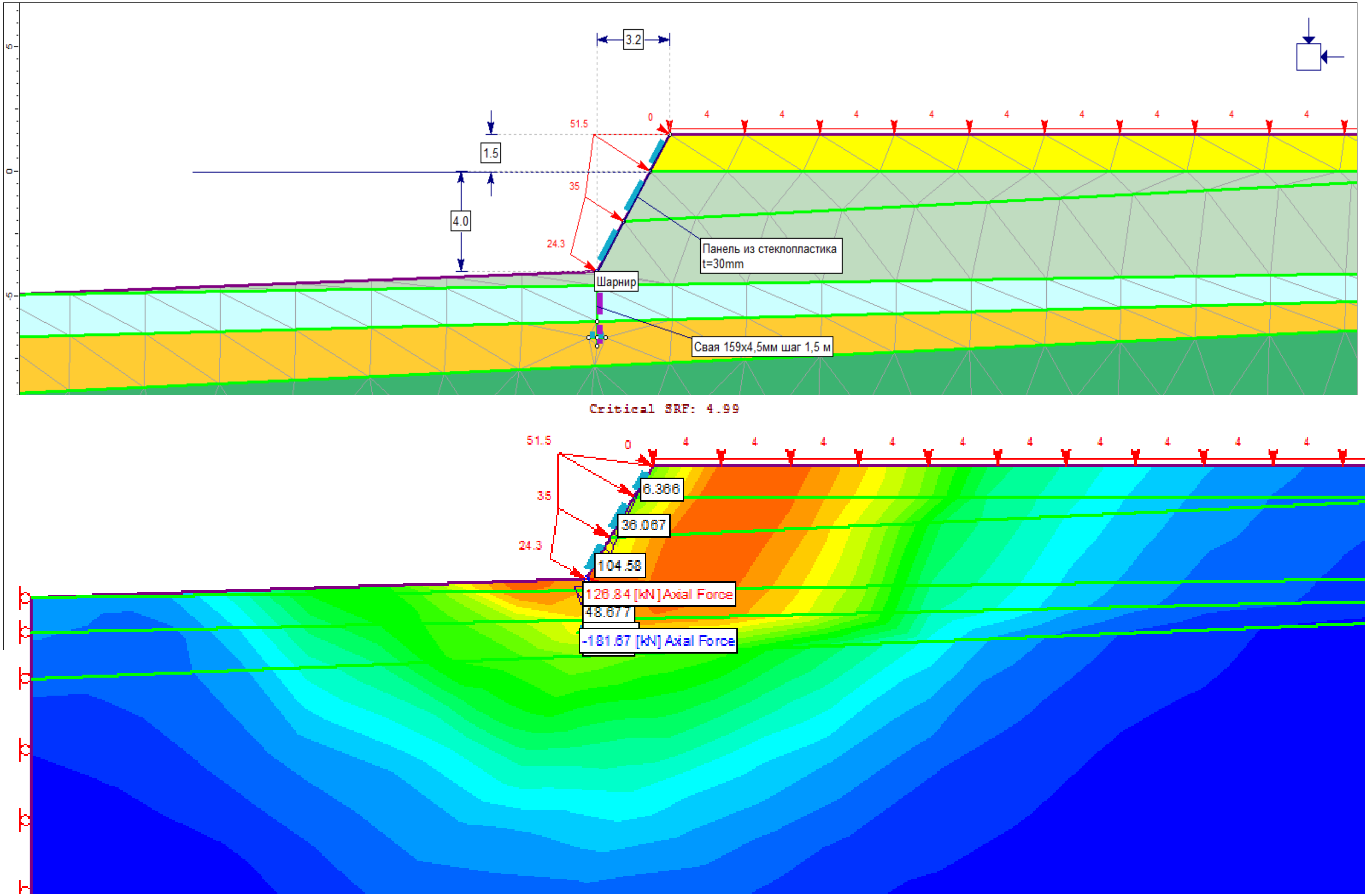


Scheme characteristics	Symbol	Quantity	Measure
Wind speed, 10m hight		15	m\sec
Bottom depth	(d)	2	m
Slope angle	(Fi)	44	°
Plates size	(bf)	30	m

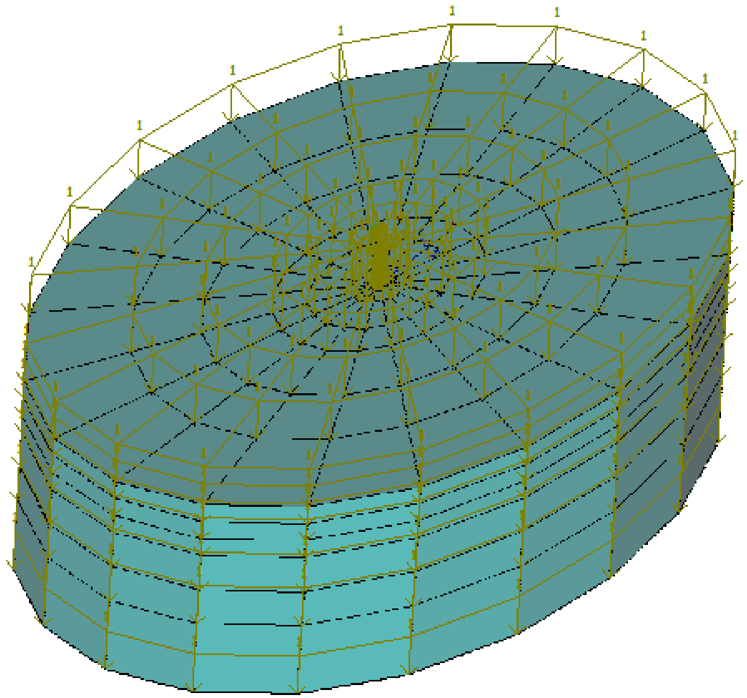
Waves loads calculations for Greenstick inclined wall

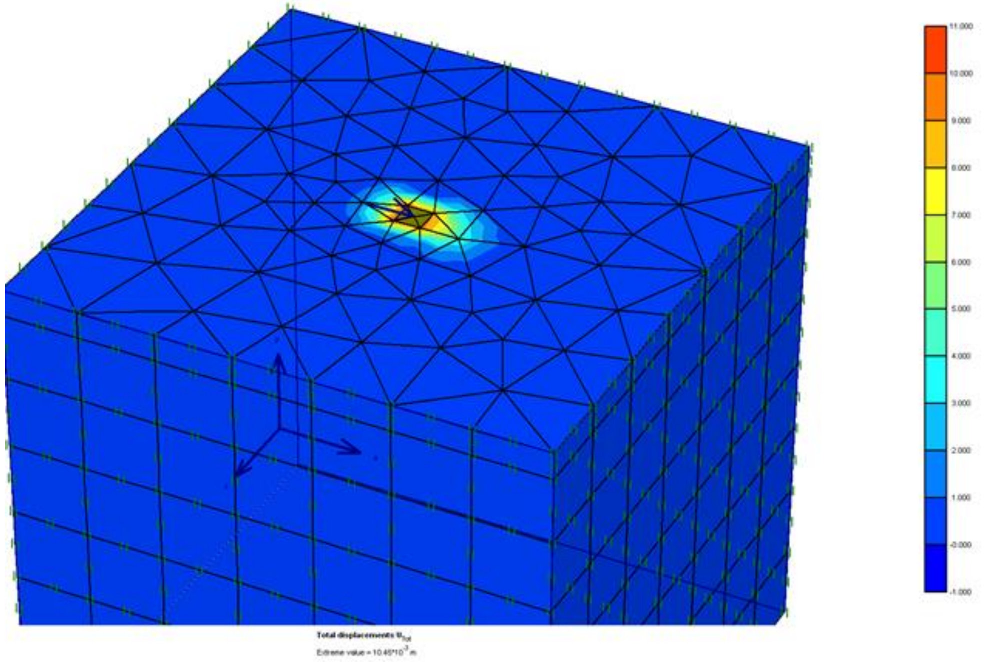
Waves characteristics	Symbol	Quantity	Measure
Medium waves height	(h_)	2.25	m
Medium waves length	(La_)	33.88	m
Medium waves period	(T_)	7.11	sec
First waves collapse depth	(dcr)	1.68	m
last waves collapse depth	(dcru)	0	m
Calculated waves height in front of wall	(hr)	4.26	m
Exceedance of max. wave above of calculated level	(nu)	3.2	m

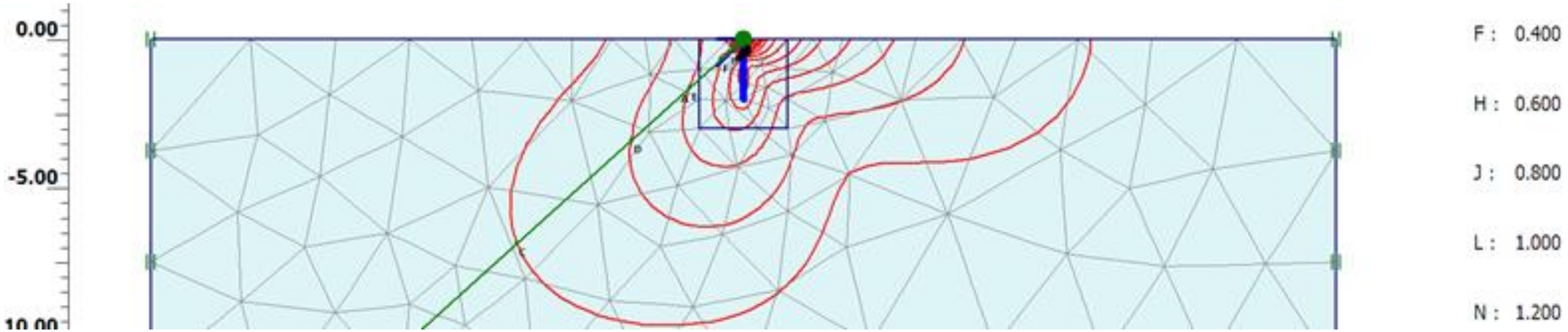
FEM calculations of Greenstick Wall



FEM Greenstick grip calculations

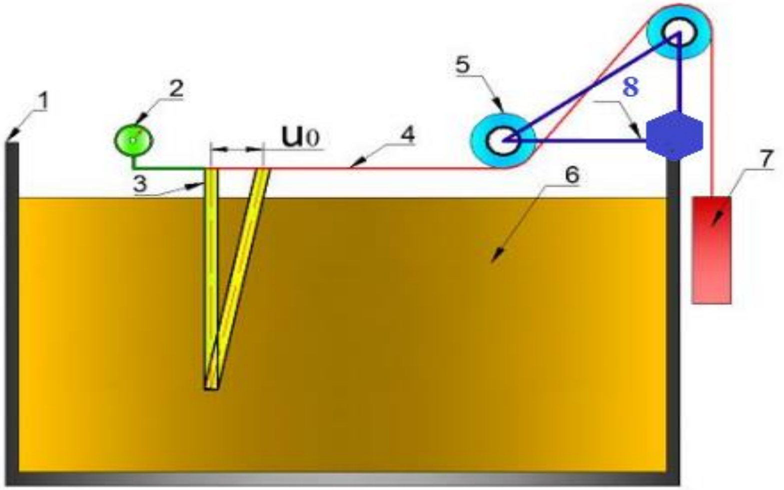






Tests of Greenstick grip in soil tray of BLASDARI

www.blasdari.com



Pile`s type	Anchorage aility, kg, for angle of inclined uplift force					
	Hori-zontal	20	30	45	60	Vertical
"Krinner" pile	42,40	57,49	26,34,32	33,42,35	48	32
Screw pile	40	58,62	55,72	55,62	57,65	83,80,72

Vertical uplift capacity of "Kriner" screw pile

$$Fd = \sin\beta \times \Sigma[\gamma c \times (a1 \times C1 + a2 \times P \times hi) \times A] + [\gamma c \times U \times fi \times (Hi - d)]$$

- Fd $(tons)$ = Vertical uplift capacity
- β (°)=$Angle\ of\ Thread$
- hi (m) = The depth of each i-th thread.
- A $(m2)$ = The projection of the working area of the blade.
- U (m) = Perimeter of pile shaft
- Hi (m)= Shaft length, measured from ground surface to first thread
- d (m) = Diameter of the pile shaft
- γc $(dimentionless)$= Coefficient of working conditions, for compressing, tensile and alternating loads
- $a1$ & $a2$ $(dimentionless)$= Constants dependent upon φ
- φ (°) = The estimated value of the angle of internal friction of soil in the work area
- $C1$ $(tons m2 ⁄)$ = The estimated value of the specific adhesion of soil in the work area
- P $(tons m3 ⁄)$ = Unit weight of the soil, determined through Appendix A.
- e $(dimentionless)$ = Porosity, the results of engineering-geological surveys
- fi $(tons m2 ⁄)$ = Calculated resistance of the soil on the screw piles
- 4.3, by taking the median value for all layers within the depth of the pile (above the thread).
- IL $(dimentionless)$ = Flow index

Soil type		Vertical bearing capacity (tons) of Greenstick screw pile of size **900x74**, depending on the porosity (inverse of density) of the soil. For compressive loading (top), tensile loading (middle) and alternating loads (bottom).						
		0.45	0.55	0.65	0.75	0.88	0.95	1.05
Large sand particles	Slightly wet	1.116 0.837 0.418	0.947 0.710 0.355	- - -	- - -	- - -	- - -	- - -
	Wet	0.976 0.697 0.279	0.829 0.592 0.237	- - -	- - -	- - -	- - -	- - -
	Saturated	0.837 0.558 0.139	0.710 0.474 0.118	- - -	- - -	- - -	- - -	- - -
Average sand particles	Slightly wet	1.218 0.914 0.457	1.049 0.787 0.394	0.947 0.710 0.355	- - -	- - -	- - -	- - -
	Wet	1.066 0.761 0.305	0.918 0.656 0.262	0.829 0.592 0.237	- - -	- - -	- - -	- - -
	Saturated	0.914 0.609 0.152	0.787 0.525 0.131	0.710 0.474 0.118	- - -	- - -	- - -	- - -
Small sand particles	Slightly wet	1.449 1.087 0.543	1.244 0.933 0.467	0.734 0.543 0.271	- - -	- - -	- - -	- - -
	Wet	1.268 0.906 0.362	1.089 0.778 0.311	0.633 0.452 0.181	- - -	- - -	- - -	- - -

	Saturated	1.087 0.725 0.181	0.933 0.622 0.156	0.543 0.362 0.090	- - -	- - -	- - -	- - -
Silty sands	Slightly wet	1.634 1.225 0.613	1.429 1.071 0.536	0.639 0.480 0.240	0.305 0.229 0.114	- - -	- - -	- - -
	Wet	1.429 1.021 0.408	1.250 0.893 0.357	0.559 0.400 0.160	0.267 0.190 0.076	- - -	- - -	- - -
	Saturated	1.225 0.817 0.204	1.071 0.714 0.179	0.480 0.320 0.080	0.229 0.152 0.038	- - -	- - -	- - -
Sandy Loam	Solid State $0 \le I_L \le 0.25$	1.750 1.313 0.656	1.341 1.005 0.503	0.931 0.699 0.349	0.587 0.440 0.220	- - -	- - -	- - -
	Plastic State $0.25 < I_L \le 0.75$	1.050 0.750 0.300	0.721 0.515 0.206	0.497 0.355 0.142	0.331 0.236 0.094	0.217 0.155 0.062	- - -	- - -
	Flowable State $0.75 < I_L$	0.917 0.612 0.153	0.601 0.401 0.100	0.413 0.275 0.069	0.270 0.180 0.045	0.173 0.115 0.029	- - -	- - -
Loam	Solid State $0 \le I_L \le 0.25$	2.031 1.523 1.269	1.489 1.117 0.930	1.101 0.826 0.688	0.853 0.640 0.533	0.705 0.529 0.441	0.511 0.383 0.319	- - -
	Plastic State $0.25 < I_L \le 0.75$	1.324 0.993 0.662	1.076 0.807 0.538	0.820 0.615 0.410	0.634 0.476 0.317	0.433 0.325 0.217	0.323 0.242 0.161	- - -
	Flowable State $0.75 < I_L$	- - -	- - -	0.476 0.340 0.136	0.363 0.259 0.104	0.280 0.200 0.080	0.208 0.149 0.060	0.178 0.127 0.051
Clay	Solid State $0 \le I_L \le 0.25$	- - -	1.920 1.440 1.200	1.458 1.093 0.911	1.089 0.816 0.680	0.874 0.655 0.546	0.722 0.542 0.451	0.558 0.419 0.349
	Plastic State $0.25 < I_L \le 0.75$	- - -	- - -	1.029 0.772 0.515	0.876 0.657 0.438	0.728 0.546 0.364	0.550 0.413 0.275	0.462 0.347 0.231
	Flowable State $0.75 < I_L$	- - -	- - -	0.594 0.424 0.170	0.523 0.373 0.149	0.440 0.314 0.126	0.407 0.291 0.116	0.360 0.257 0.103

Installation Torque – Results for “Krinner” screw pile

Soil Type (Sand Only)		Installation Torque (kN.m) of Greenstick screw pile of size **900x74**, depending on the porosity (inverse of density) of the soil. Expressed as a range 10-15% greater than that calculated using equation 4.2, for the reasons explains at the end of section 4.4.						
		0.45	0.55	0.65	0.75	0.85	0.95	1.05
Large sand particles	Slightly wet	0.136 0.143	0.086 0.090	-	-	-	-	-
	Wet	0.119 0.125	0.076 0.079	-	-	-	-	-
	Saturated	0.102 0.107	0.065 0.068	-	-	-	-	-
Average sand particles	Slightly wet	0.113 0.118	0.076 0.080	0.048 0.051	-	-	-	-
	Wet	0.099 0.104	0.067 0.070	0.042 0.044	-	-	-	-
	Saturated	0.085 0.089	0.053 0.055	0.036 0.038	-	-	-	-
Small sand particles	Slightly wet	0.094 0.099	0.075 0.079	0.051 0.053	-	-	-	-
	Wet	0.083 0.086	0.066 0.069	0.044 0.046	-	-	-	-
	Saturated	0.071 0.074	0.057 0.059	0.038 0.040	-	-	-	-
Silty sands	Slightly wet	0.083 0.087	0.067 0.070	0.044 0.046	0.030 0.031	-	-	-
	Wet	0.073 0.076	0.058 0.061	0.038 0.040	0.026 0.027	-	-	-
	Saturated	0.063 0.065	0.050 0.052	0.033 0.034	0.023 0.024	-	-	-

Greenstick anchorage (screw part not showed)

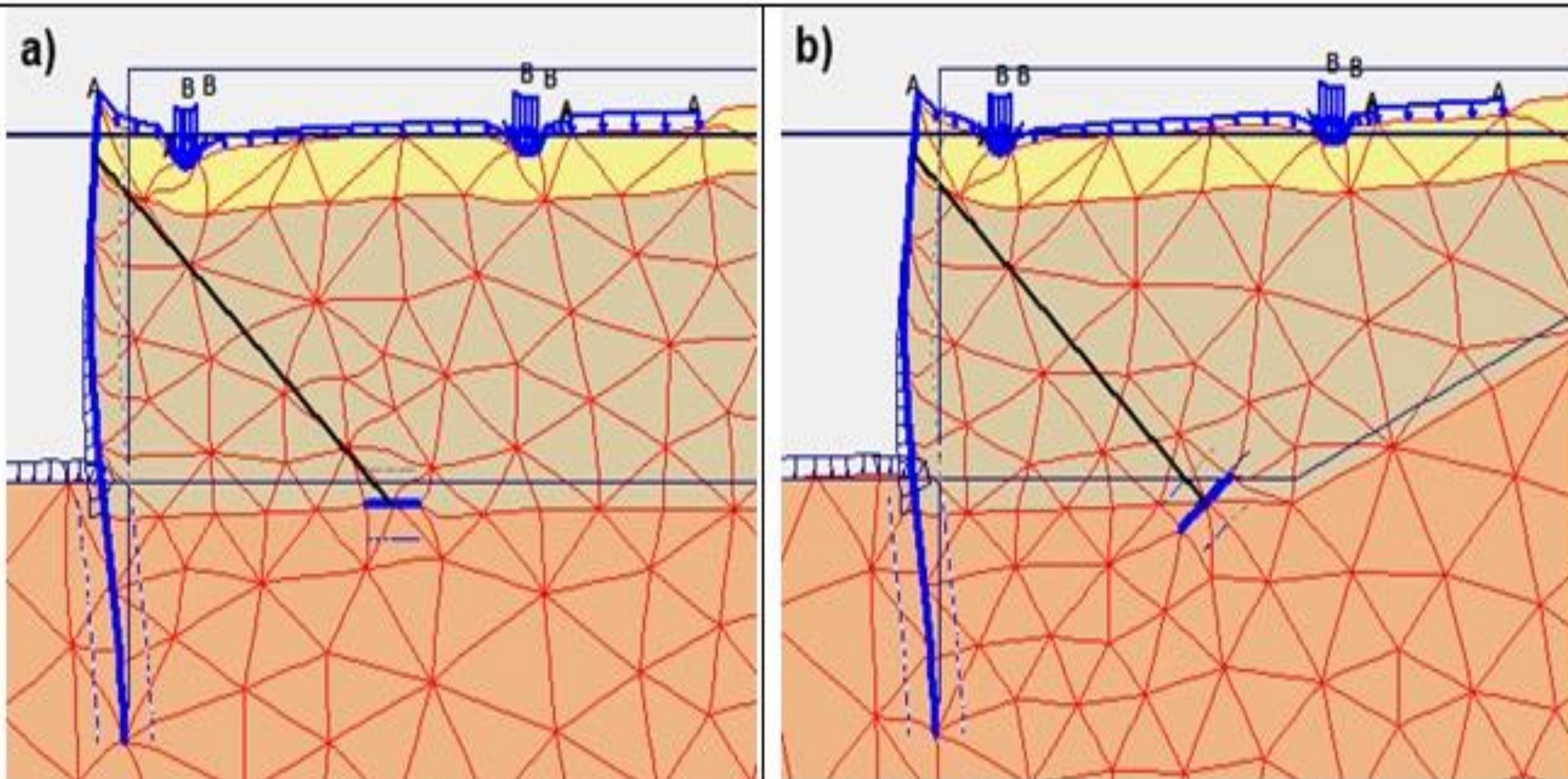


Figure *a*. Greenstick anchorage.

Figure *b*. German anchorage.

Efficiency Benefits of Greenstick piles

- Vertical deployment:
- No requirement to drill at angle
- Smaller, lighter weight Greenstick may be used
- Smaller drilling devices may be used
- Speedier deployment
- Rotating arm allows more flexibility to link to structure
- Stability of structure:
- Beneficial in shifting patterns of deposition of bed material
- Potential reduction in scour protection methods
- Angled Greenstick provides solid foundation
- Substantially smaller dimensions required than conventional piles:
- Lighter piles can be transported more easily
- Energy efficiencies
- Re-deployment
- Re-use rather than new manufacture
- Temporary structures often gain quicker Planning agreement

Environmental Benefits of Greenstick piles

- Less deoxygenation of water helps protect sea life
- Screw piles rather than pile driven:
- Less impact on the sea-bed
- Reduced impact on sea mammals habitat
- Removable, allowing the environment to recover
- Damage limitation, particularly in flood defence projects
- Smaller vessels used for deployment
- Recyclable

Financial Benefits of Greenstick piles

- Production costs:
- Simple design, few complex parts, variety of materials may be used
- Lighter weight, requiring less raw material
- Transportation costs:
- Lighter weight product
- Deployment costs:
- Smaller vessel required
- Easier to deploy than conventional piles
- Wastage costs:
- Greenstick can be easily reclaimed and re-used
- Environmental costs:
- Less intrusive to marine environment

Thank you for attention