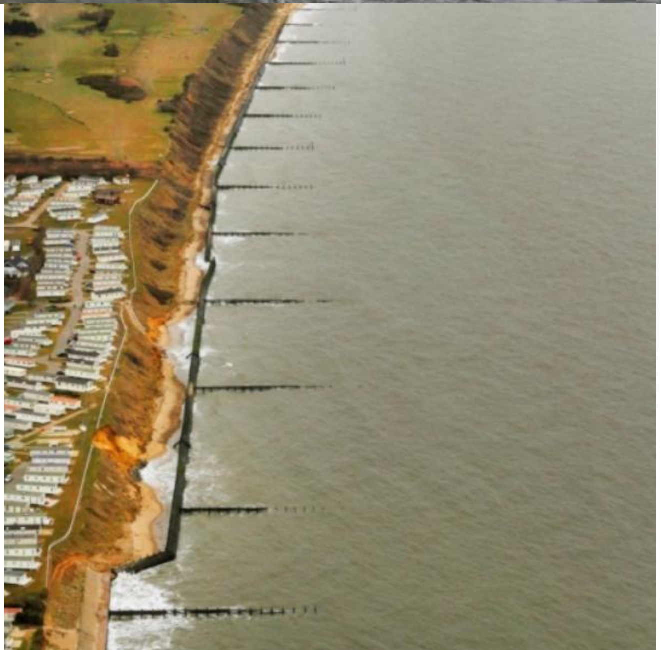
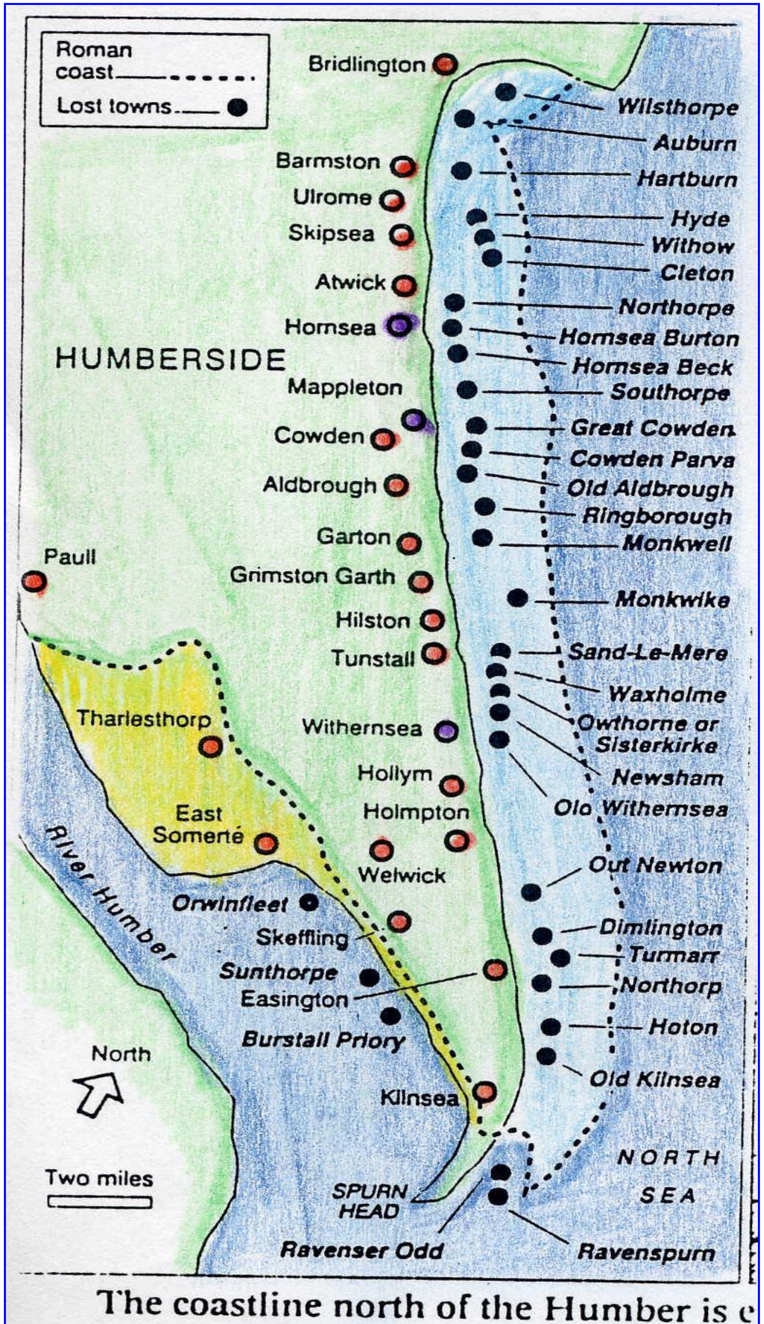
GREENSTICK ENERGY
10 Church Lane
Carnaby
East Riding of Yorkshire
YO16 4UP
Telephone: +44 (0)1262 604898
dhw@greenstickenergy.com
www.greenstickenergy.com

Greenstick coastal/flood defense

Gennady Meltsov, Ph.D.,M.B.A.,
+38063-94-17-559
gm@greenstickenergy.com

Coastal erosion





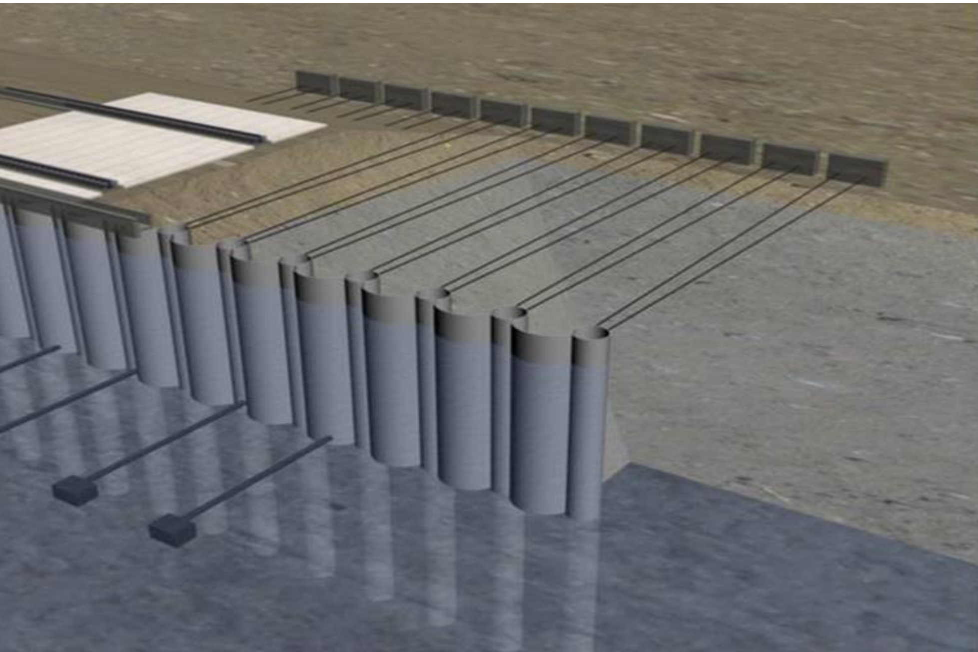
The Holderness Coast has one of the fastest rates of erosion in the world.

A farmer called Sue Earle has lost 200m of good arable land in just 10 years!

Coastal protection. Present decisions



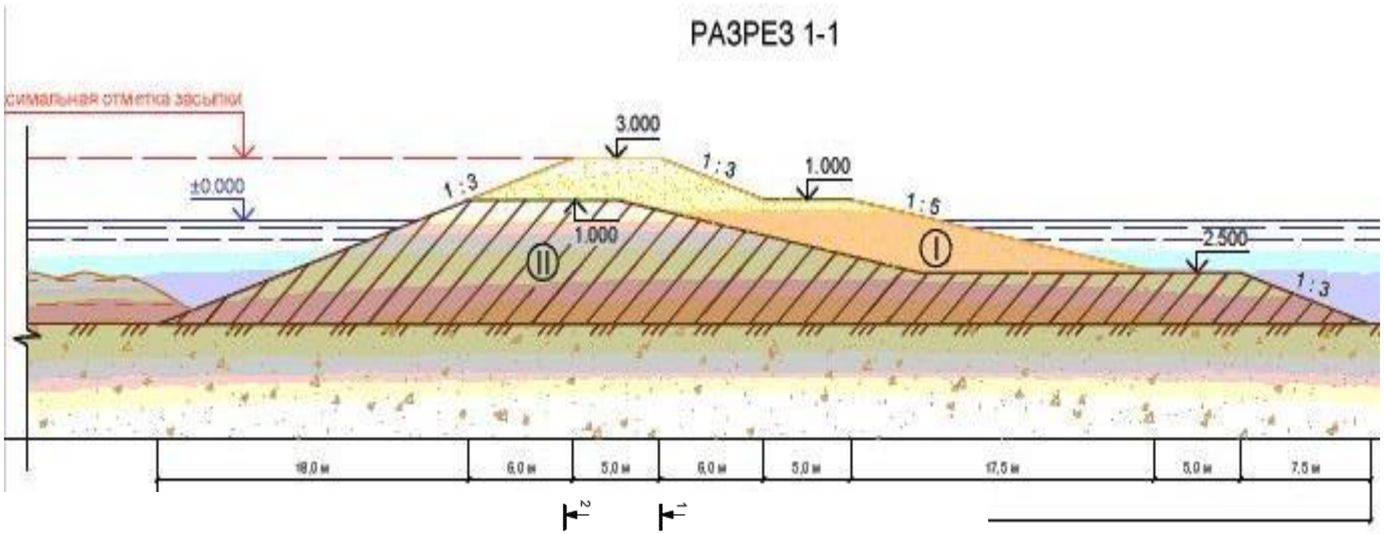

Steel vertical “fence” structure

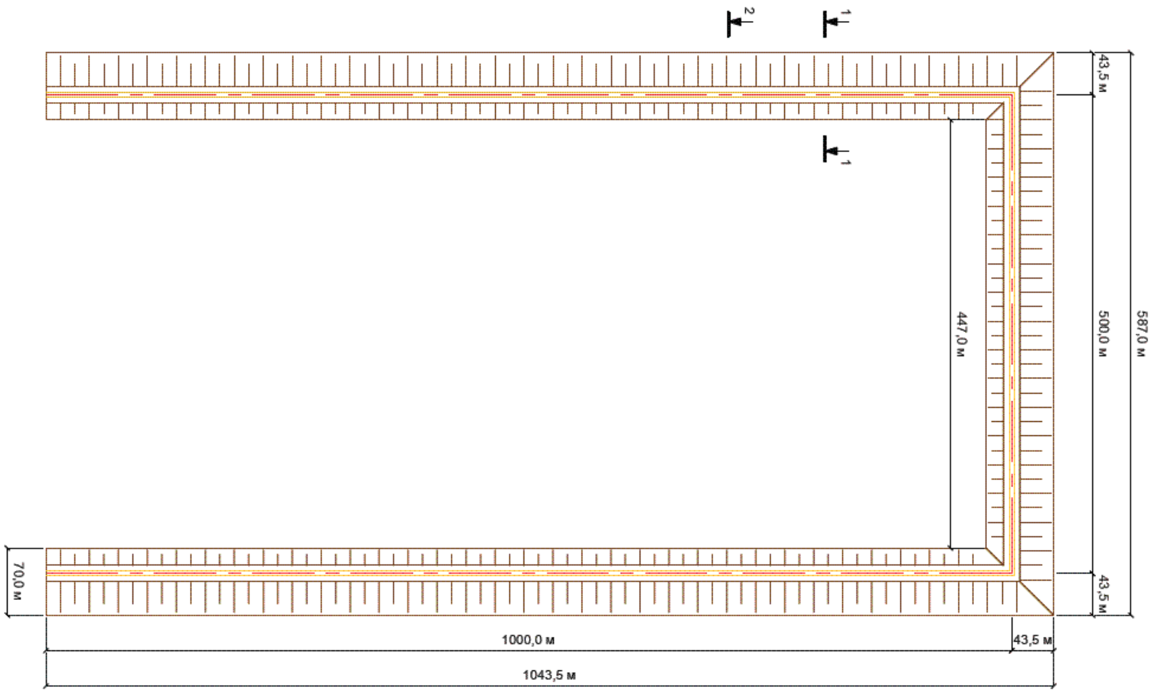


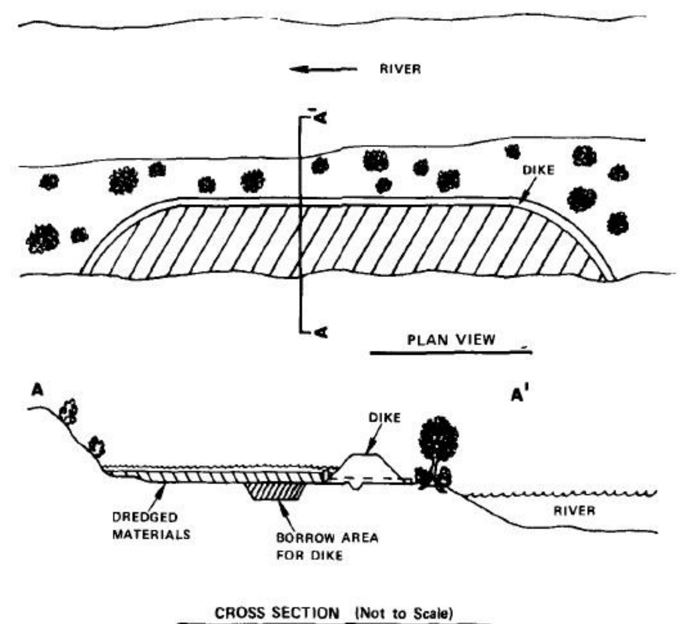

HITACHI

Artificial territories of dredged soils

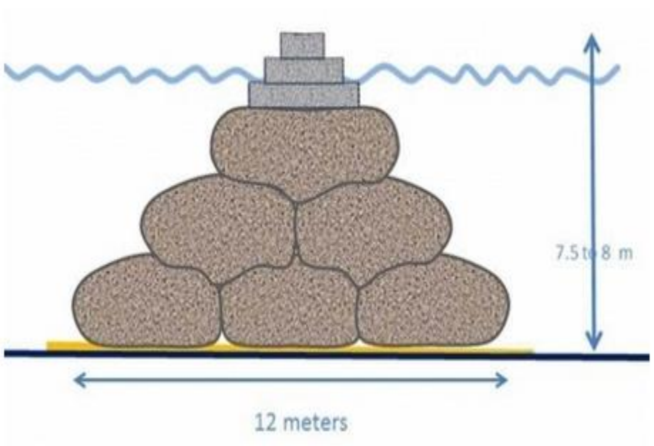
Dams for dredged deposits

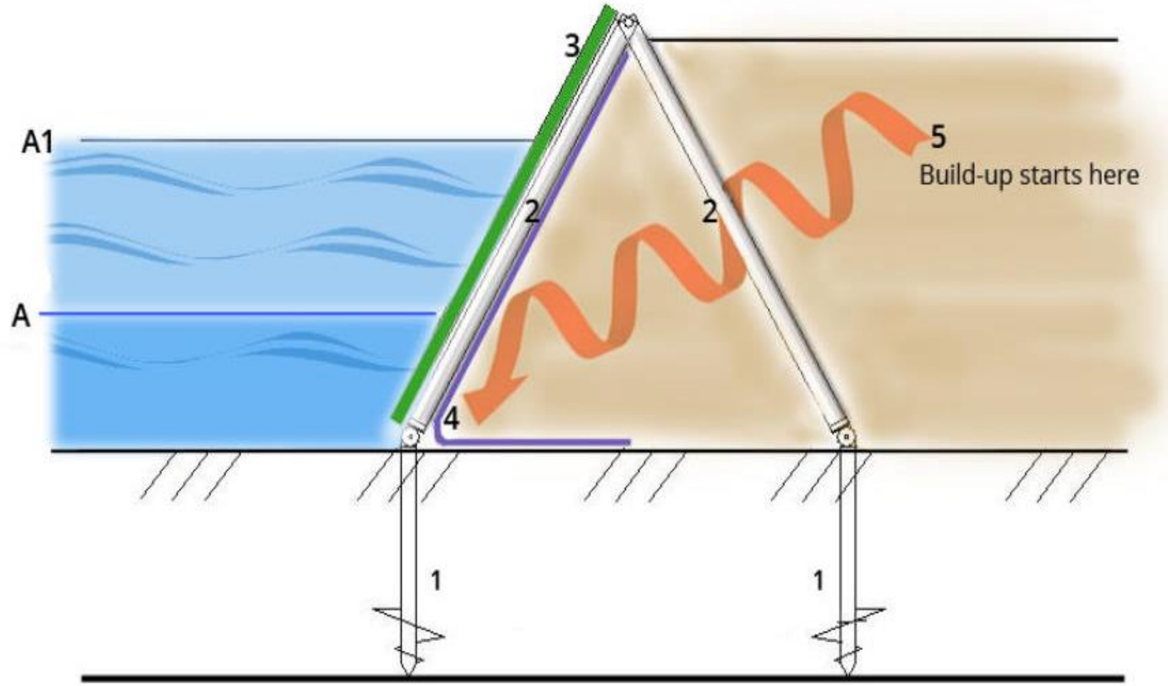


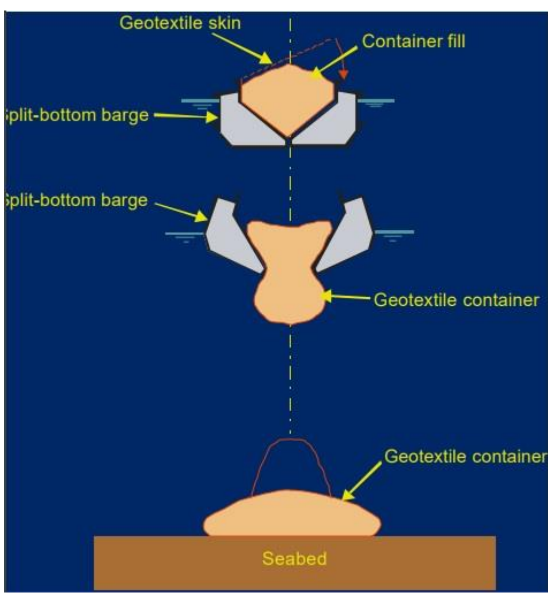


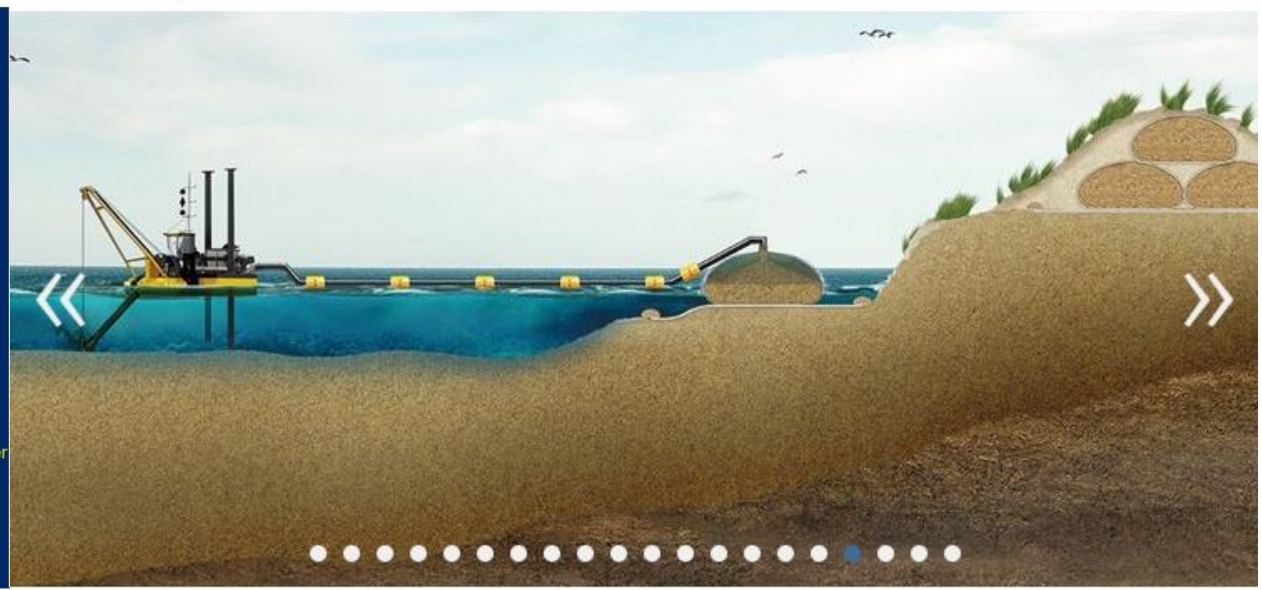


Dams for dredged deposits

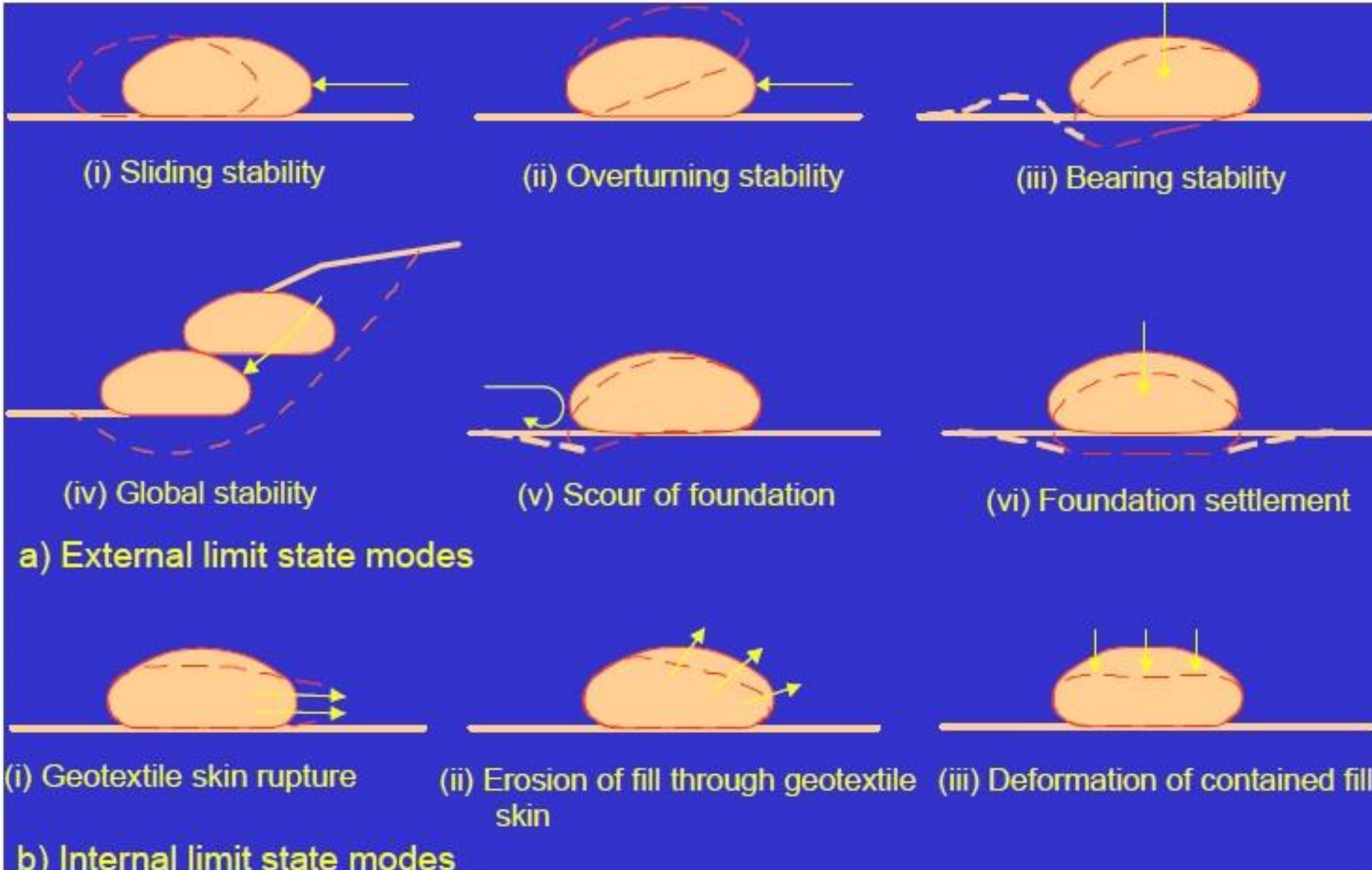




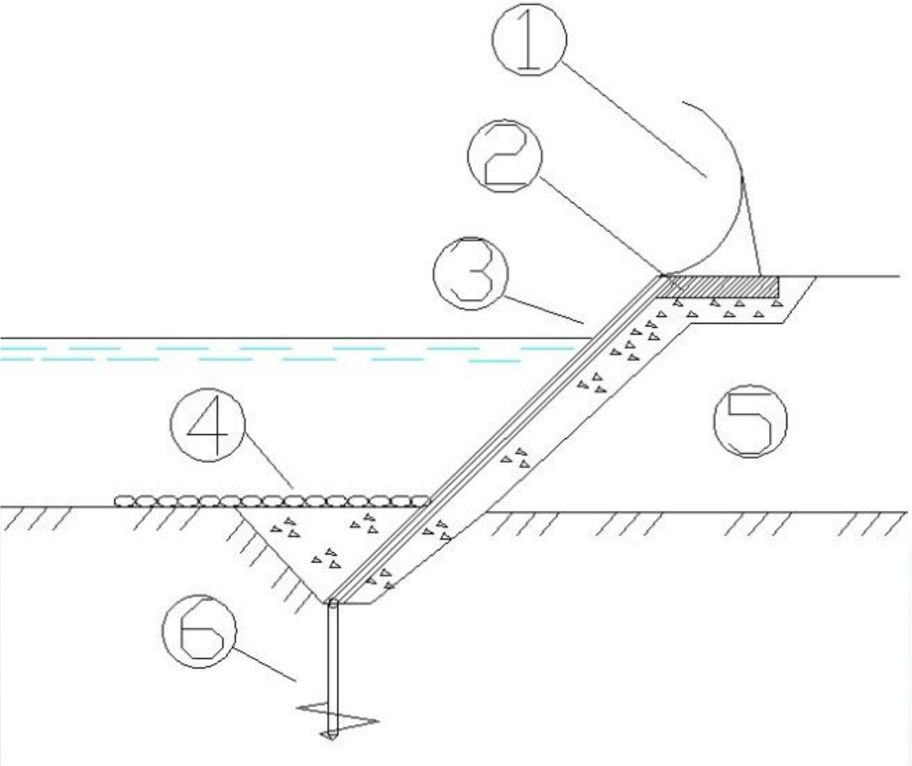


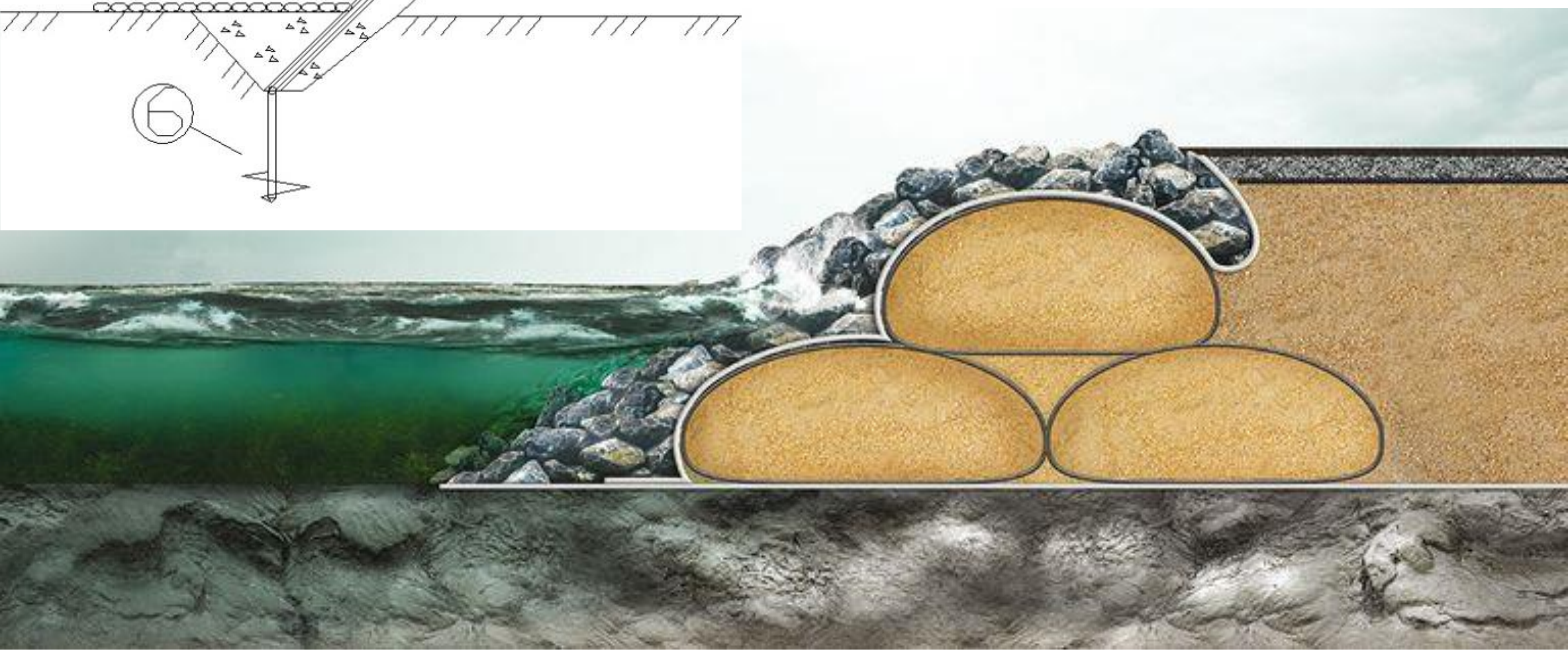


Geotube® systems: limit state modes

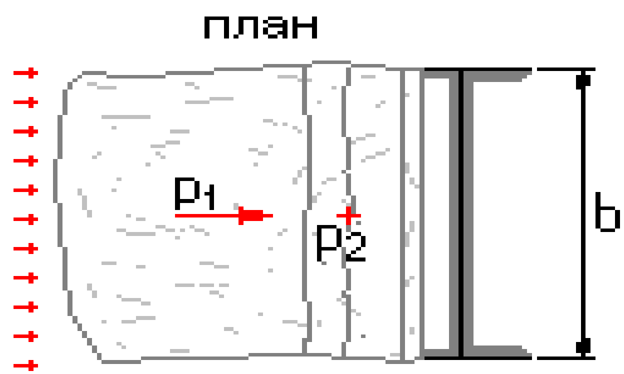


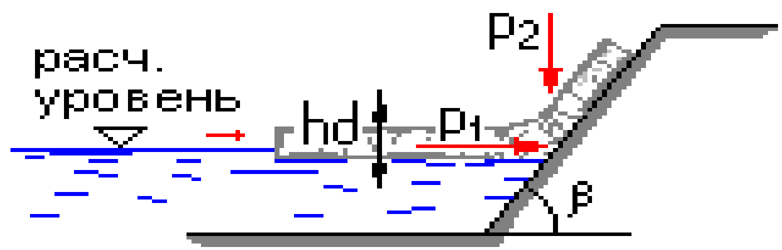
Greenstick Sea Wall





Ice loads calculations for inclined wall



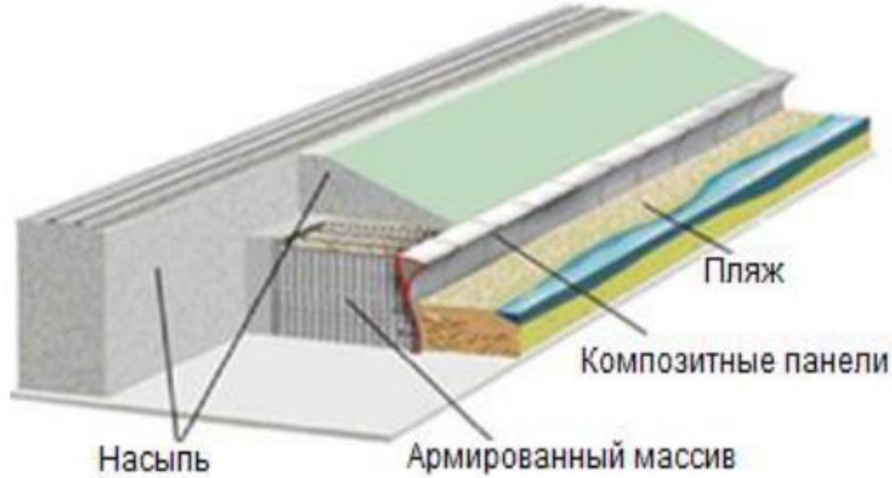


Ice loads calculations for inclined wall

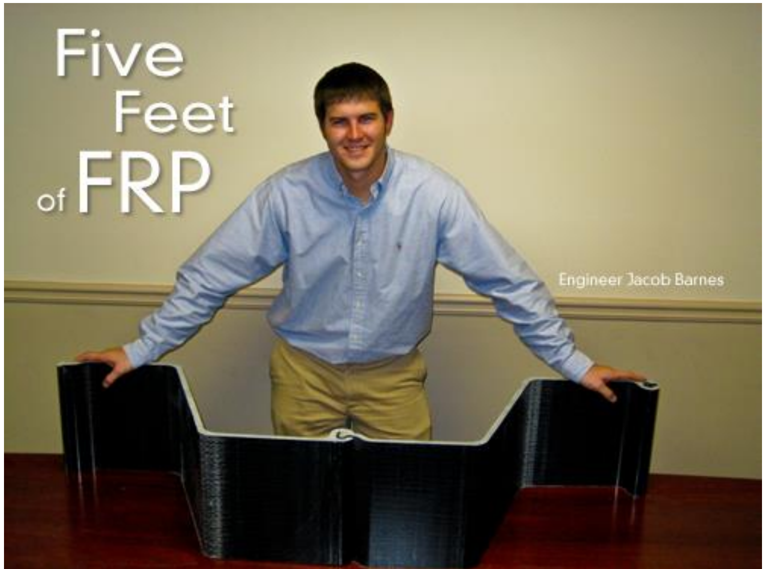
Characteristics	Symbol	Quantity	Measure
Ice –air temperature, C	TI	-5	°C
Ice width	Hd	0.1	m
Max. square of ice field, 1% insurance	AI	100	m2
Speed of ice field	vI	0.15	m/sec

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

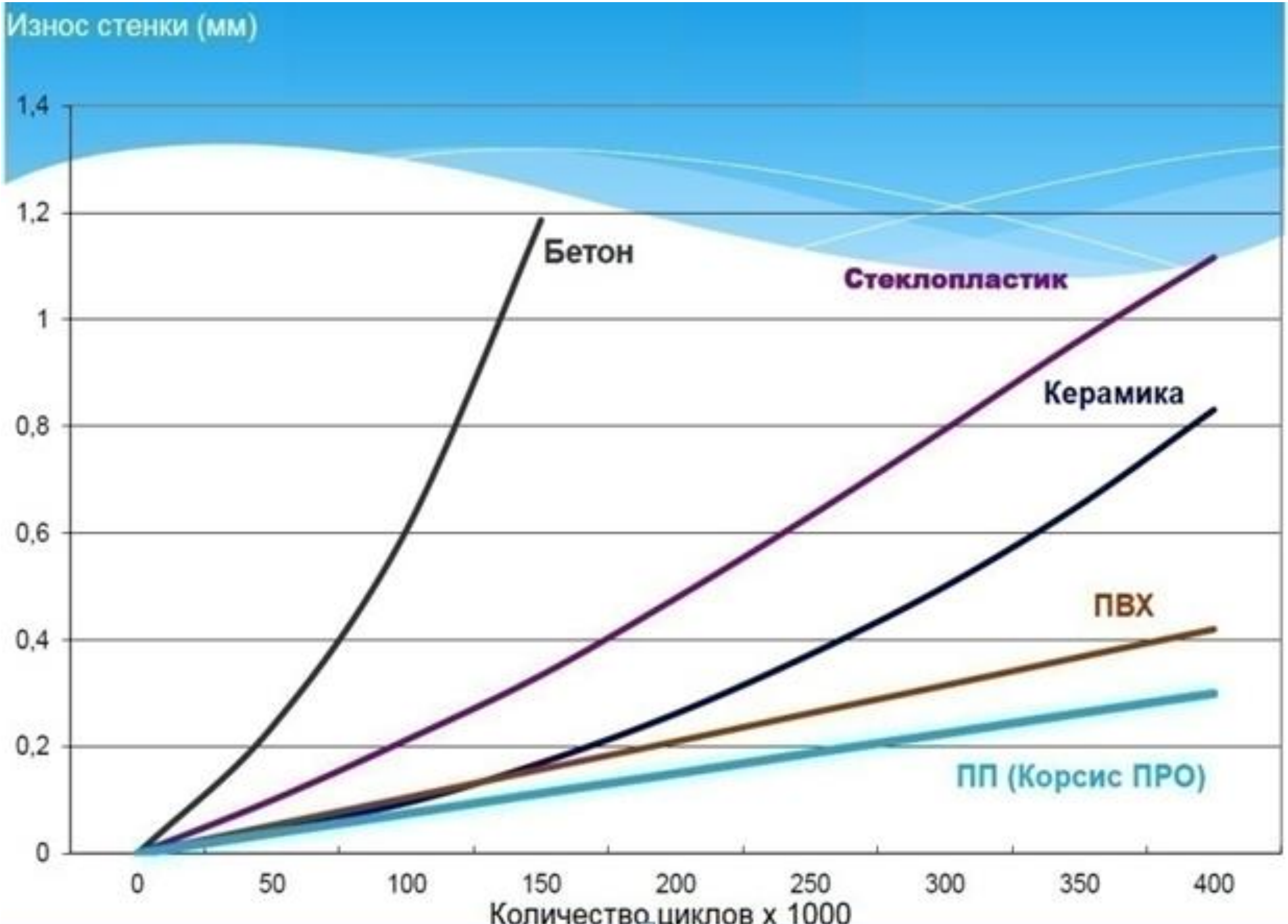
FRP: Apatech Sea Wall and Australian Breackwater



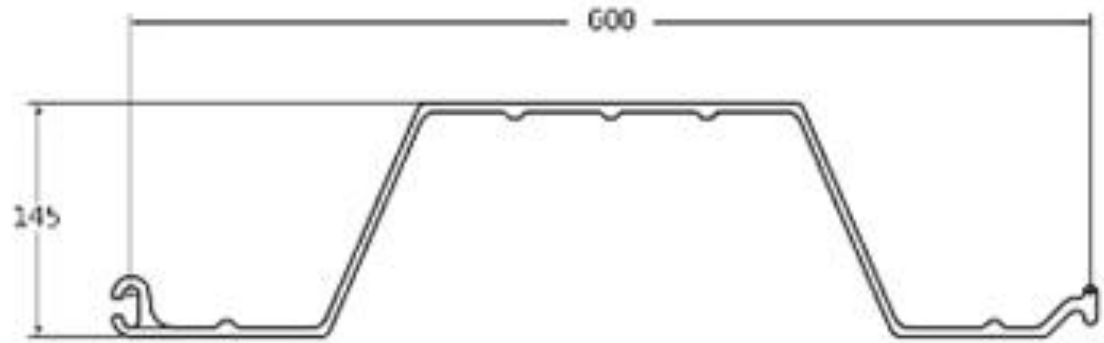
Infussion and pultrussion



Material abrasion. Darmstadt method



Physical characteristics of FRP SHK-150 sheet pile



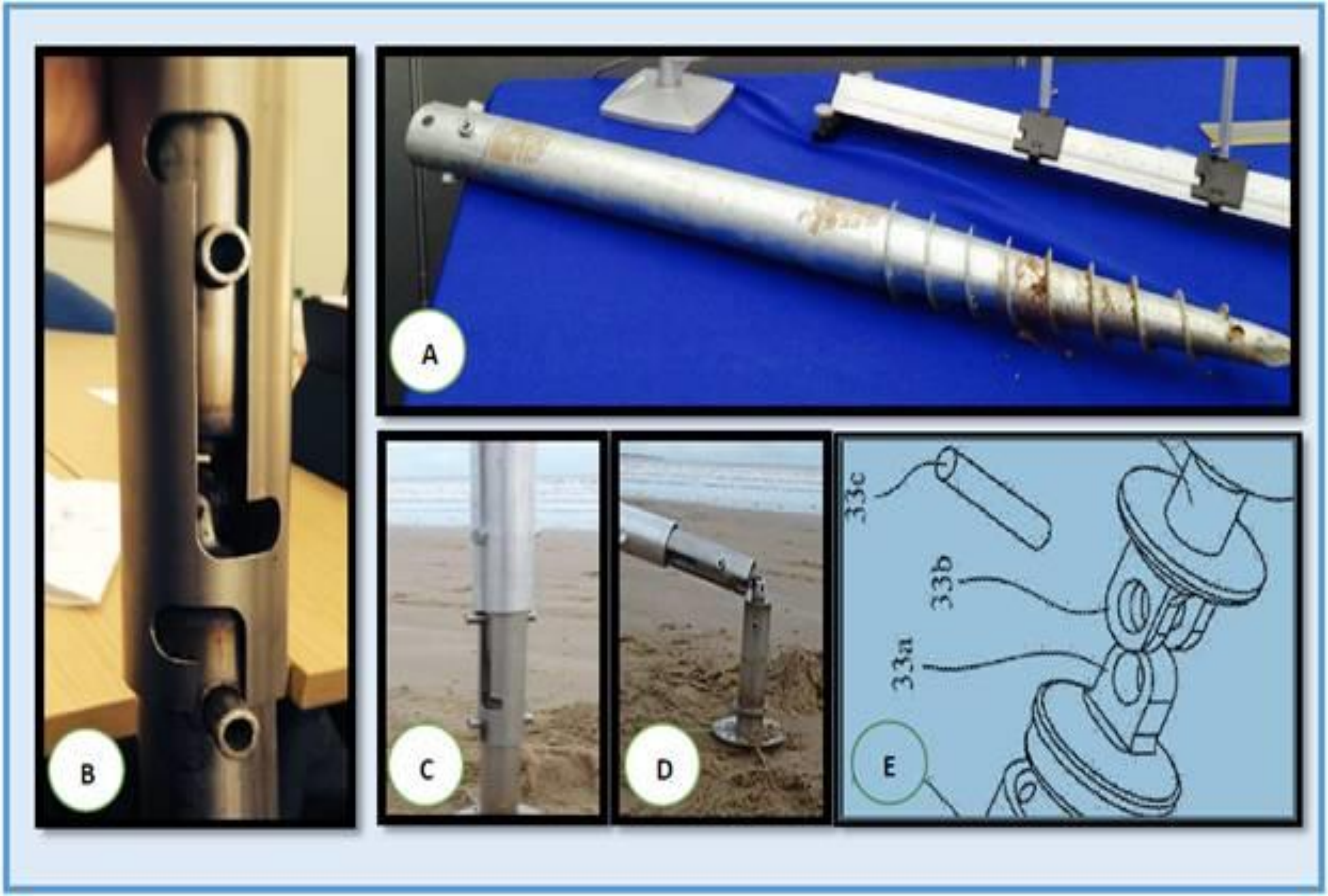
Characteteristics	Measure	Value
Allowable moment (M)	kN-m/m	237
Inertion moment (I_y)	cm^4/m	17885
Inertion moment (I_x)	cm^4/m	1684
Resistant moment (W_x)	cm^3/m	210
Strength limit (R)	MPa	1126
Width	mm	600
Depth	mm	145
Thickness	mm	5

Greensticks Grip

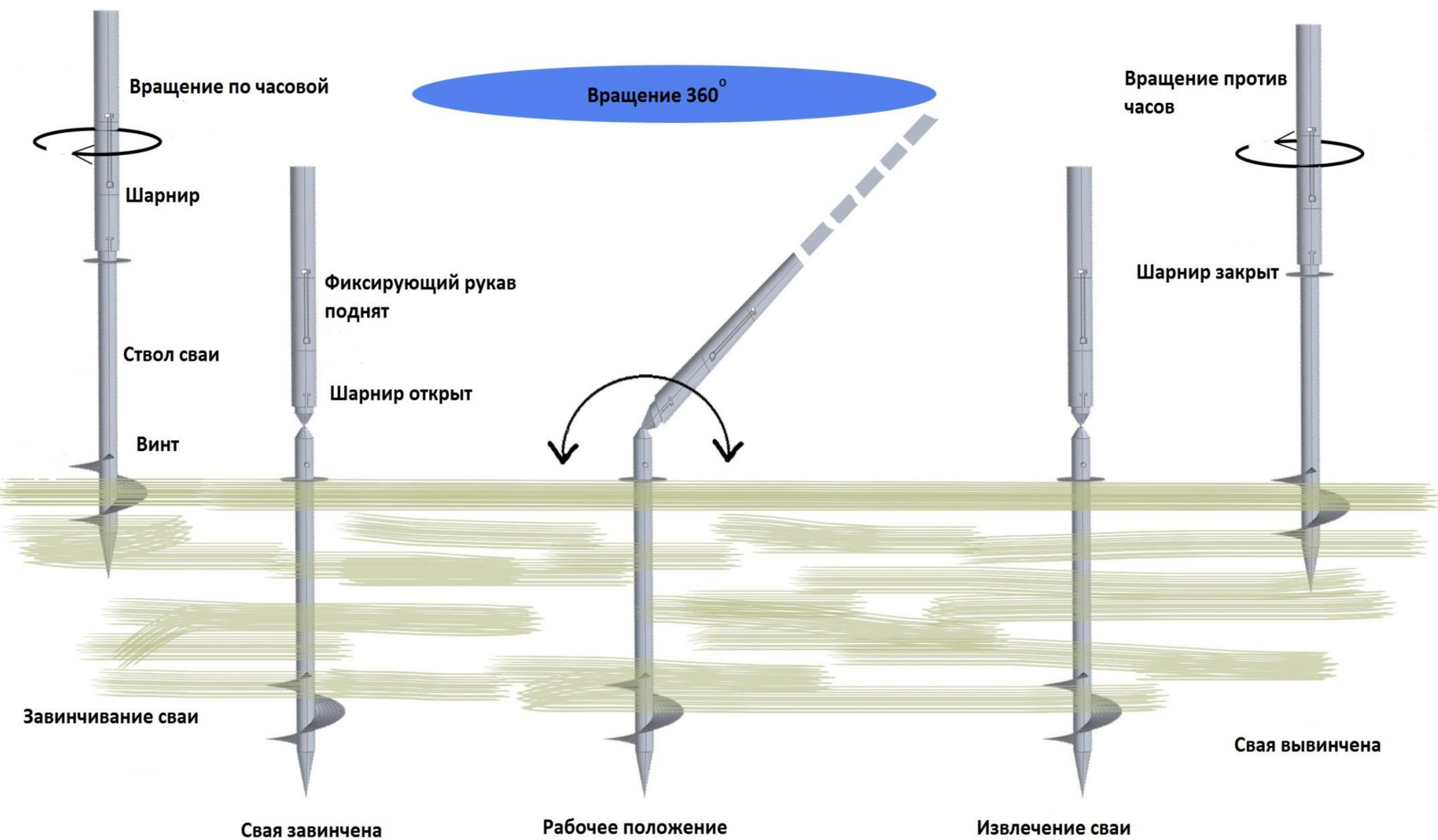


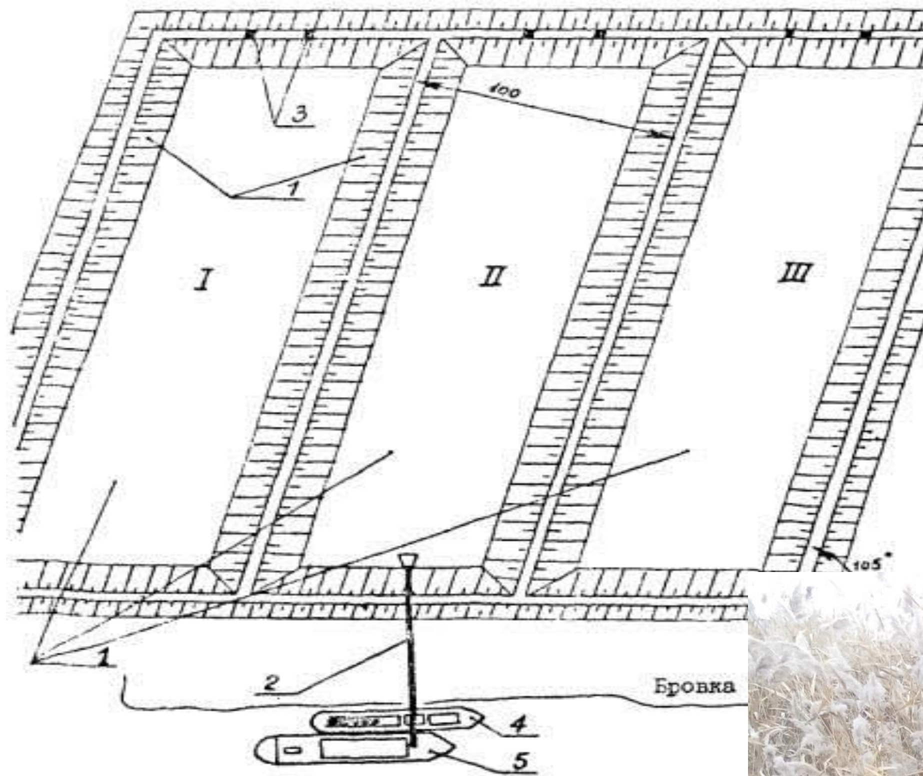


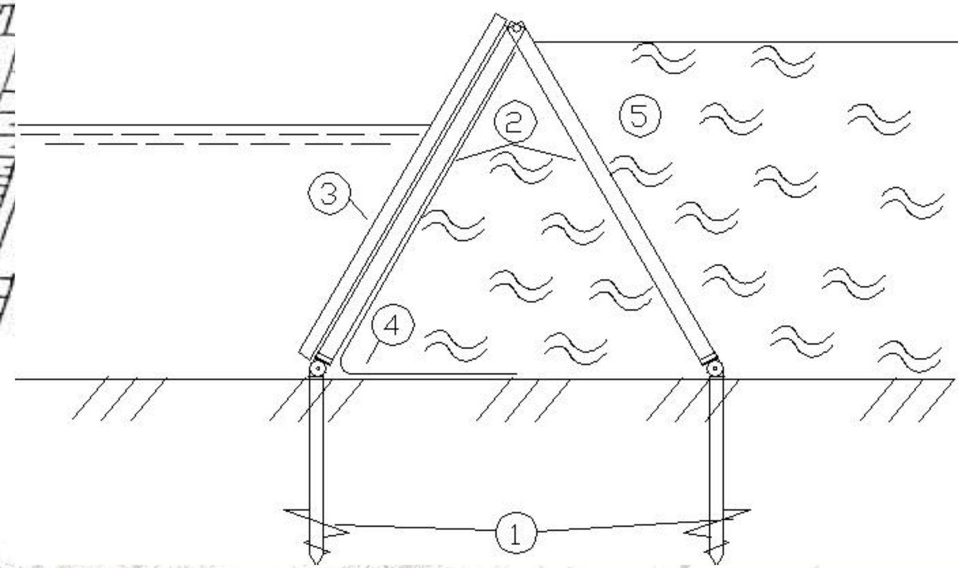
Greenstick grip



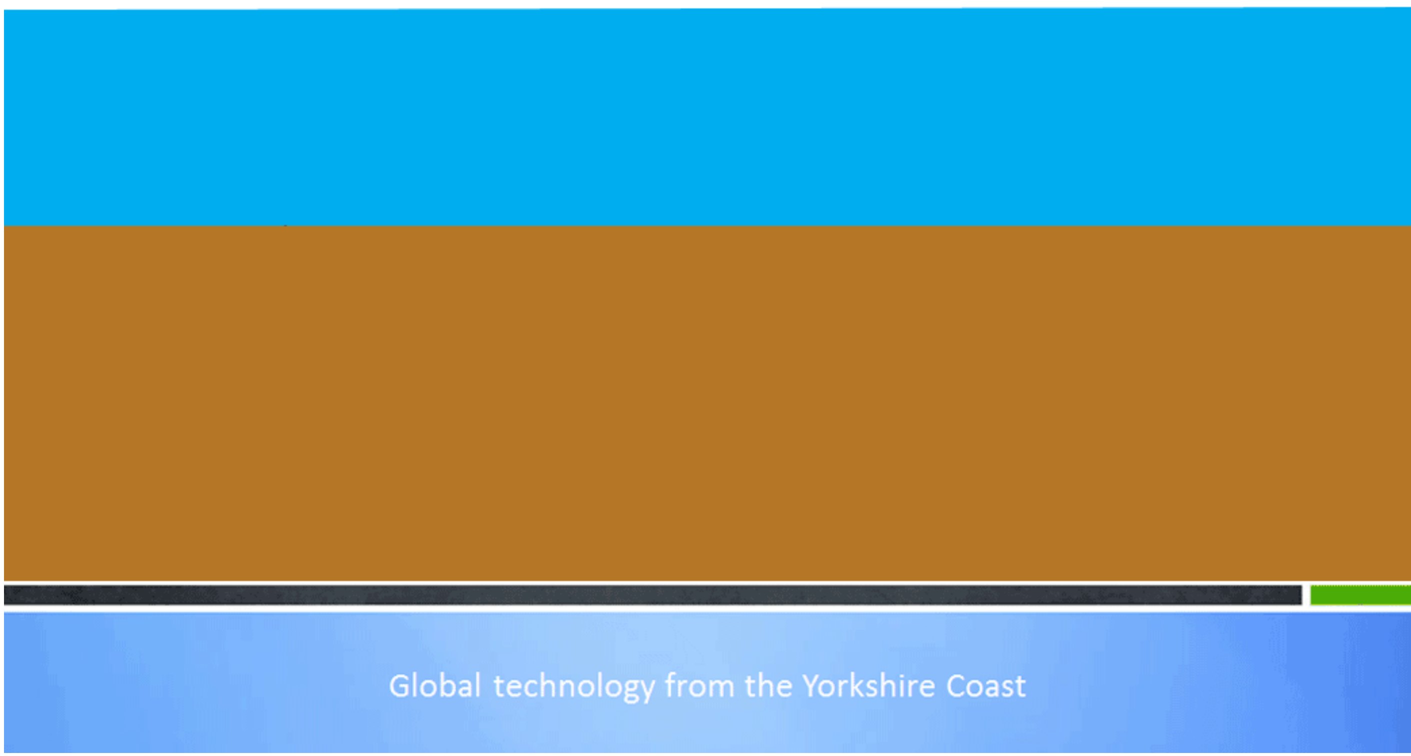
Greenstick pile



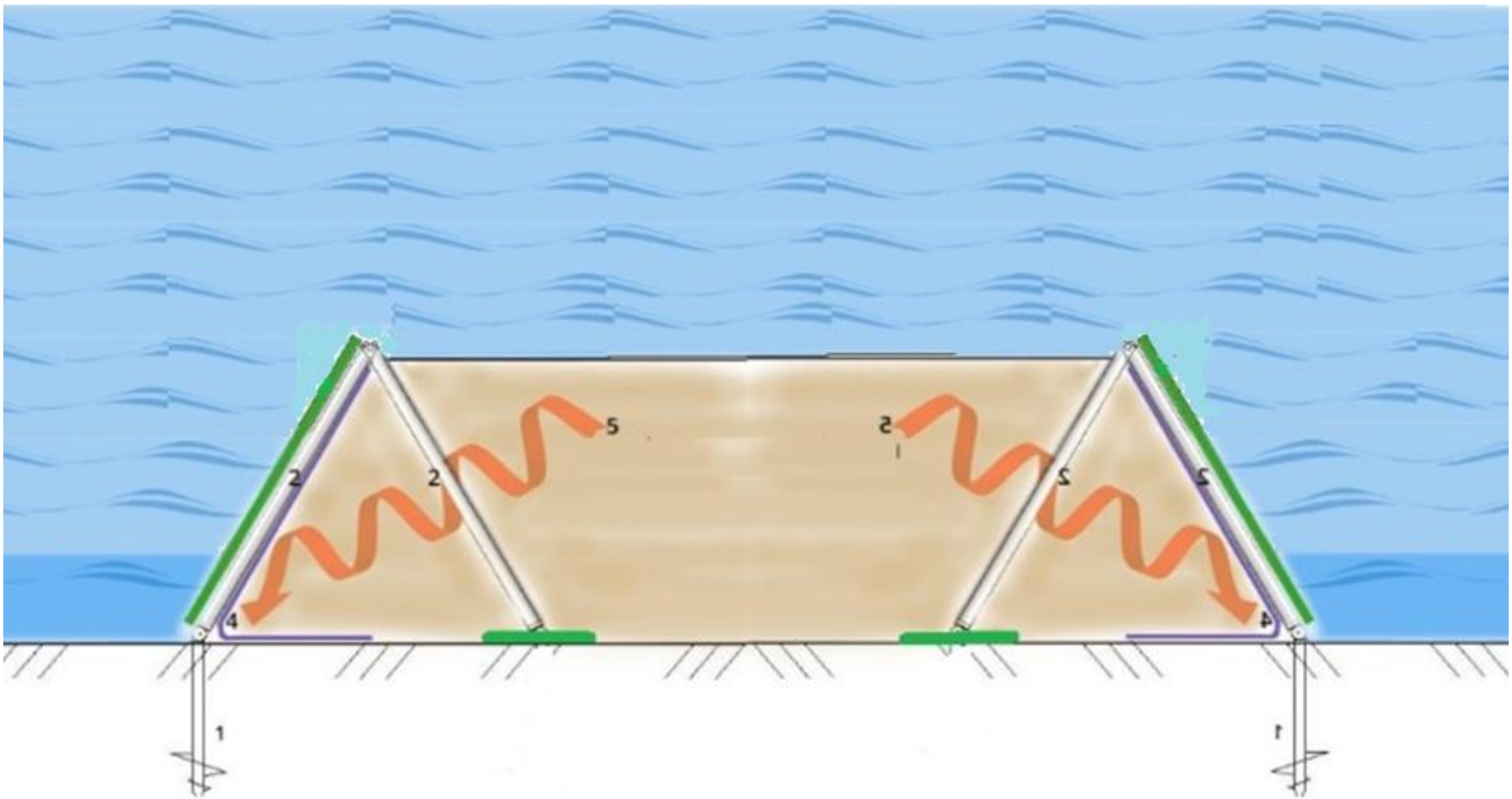

3
1
400
I
II
III
105°
1
2
Бровка
4
5


2
5
3
4
1

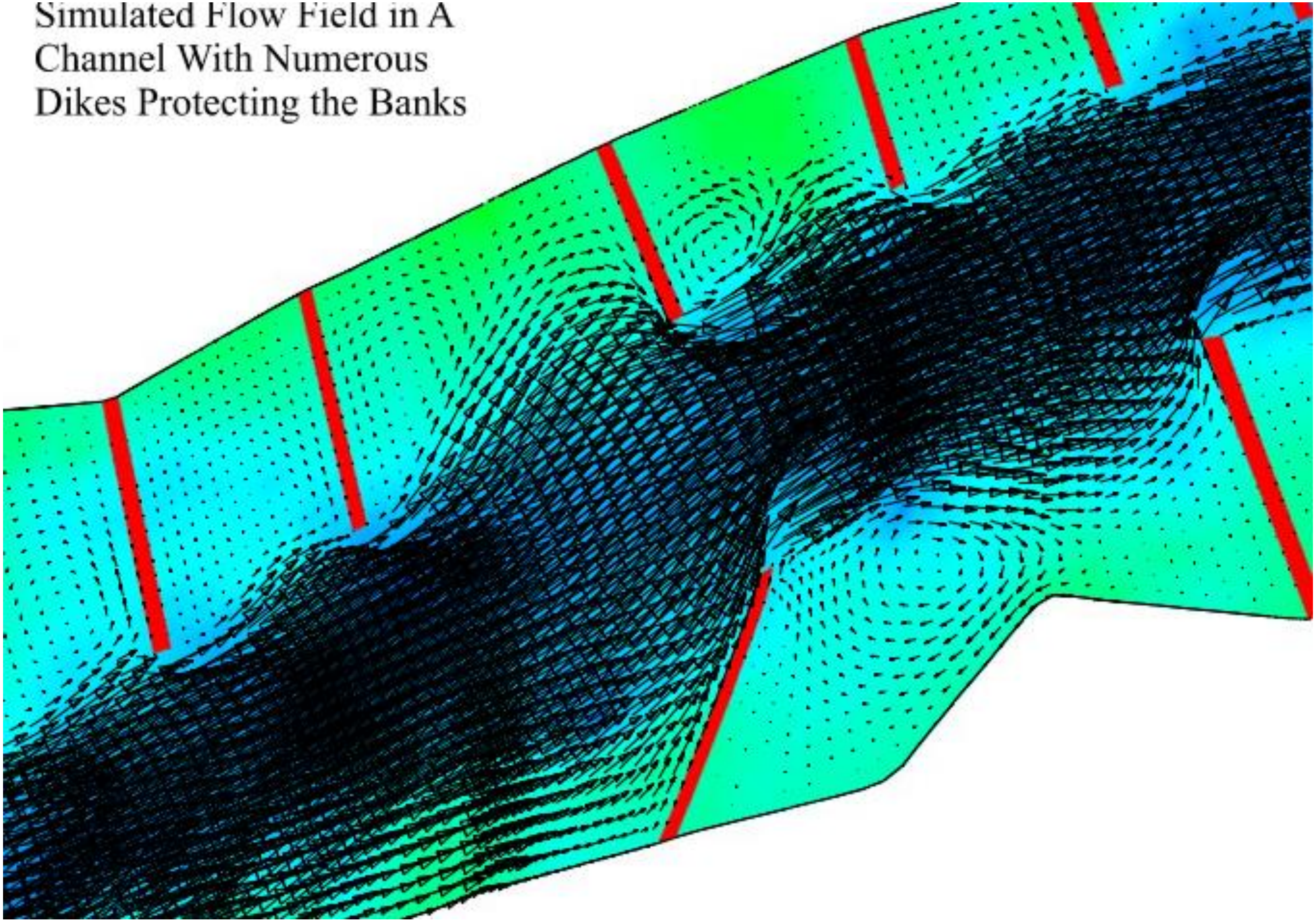
Technology of installation of Greenstick Walls



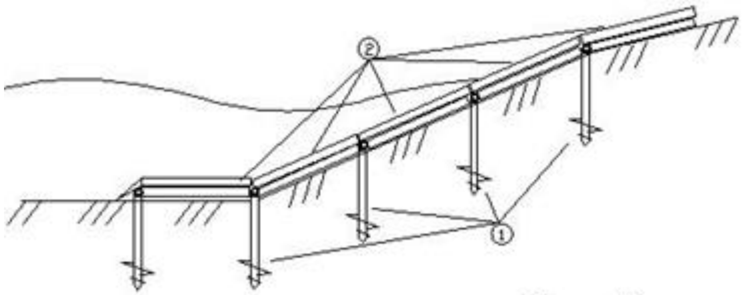
Greenstick underwater dum

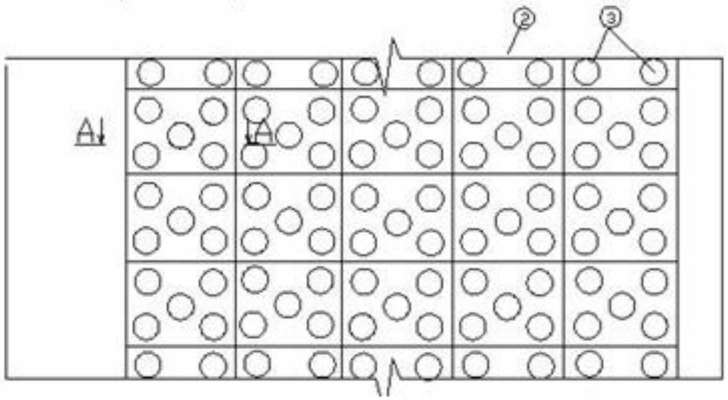


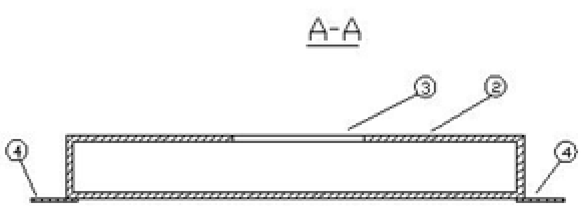
Decisions for underwater dums guiding the stream

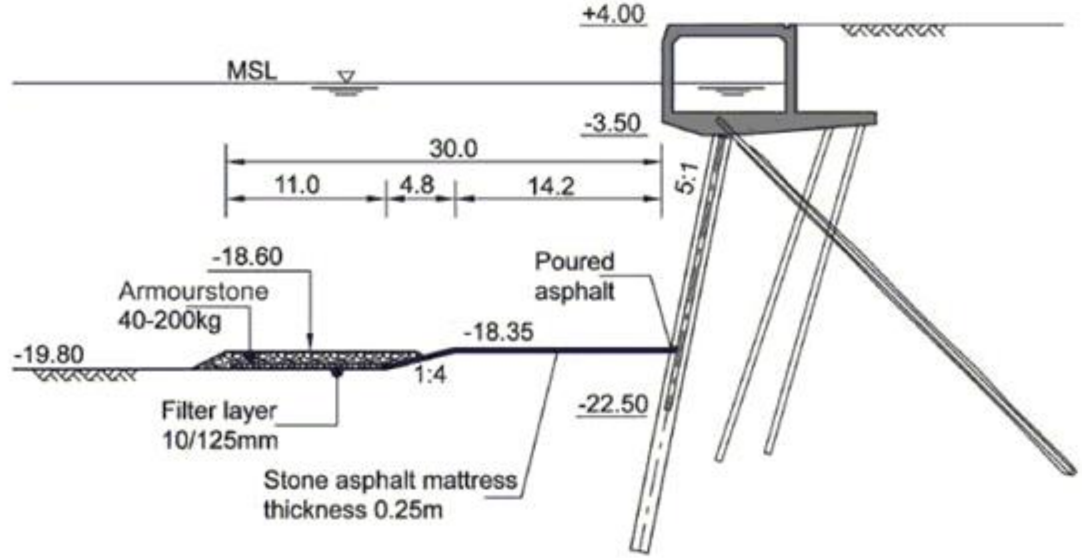


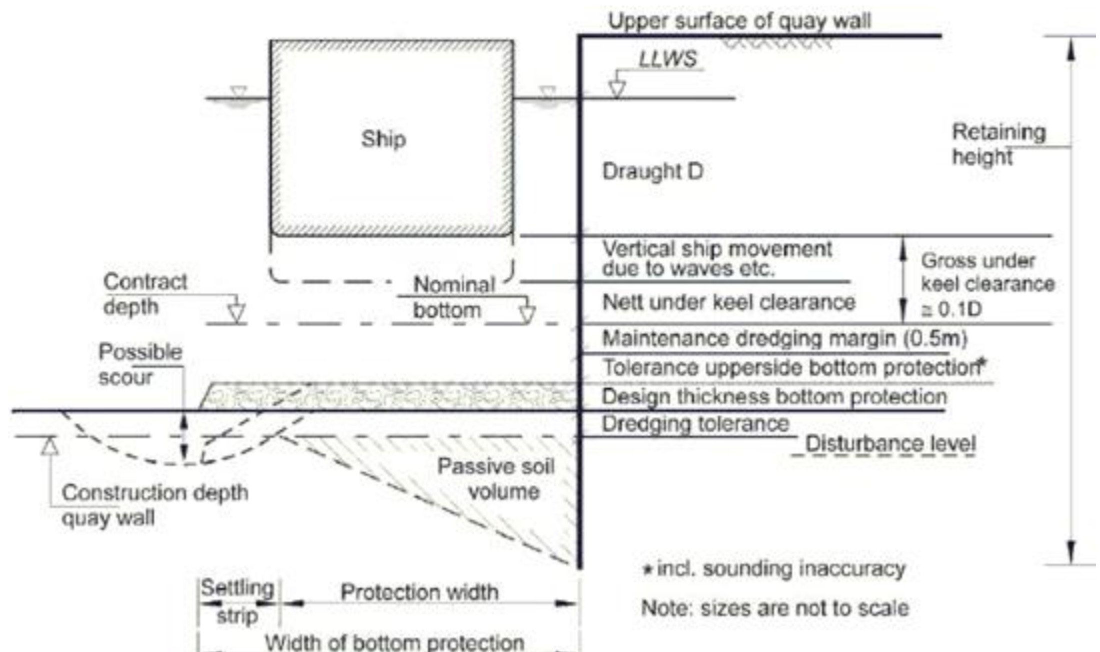
Greenstick bottom score protection

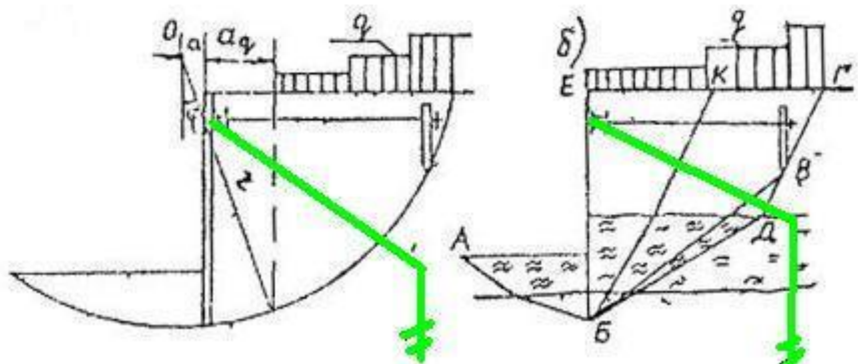


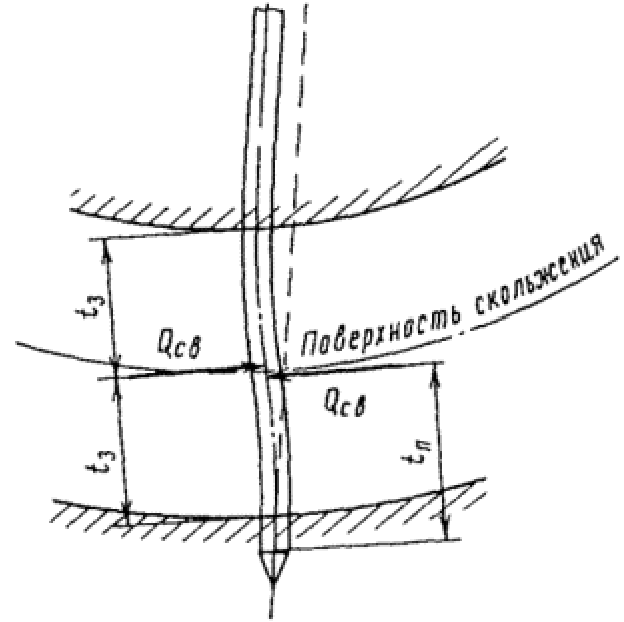












$$Q_{св i} = \frac{4M_{св}}{t_з};$$ [13]

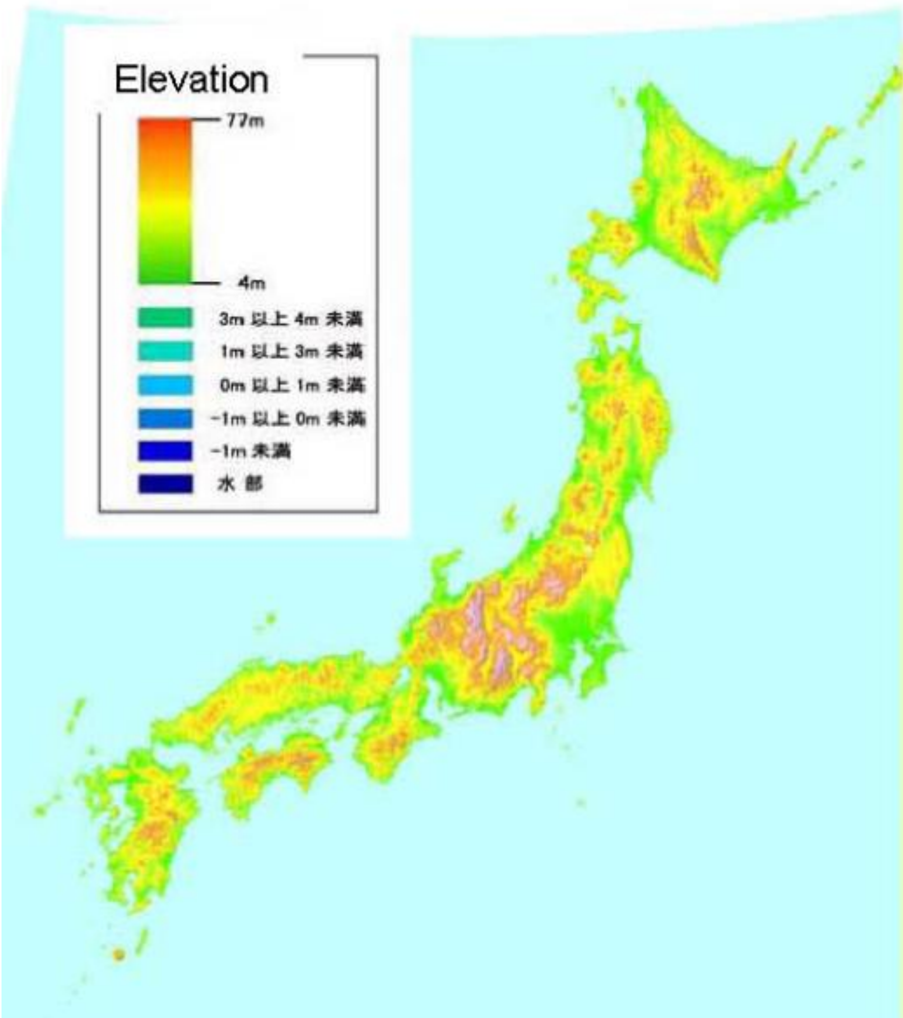
в расчет принимается меньшее из полученных значений;

$Q_{св\ i}$ - приведенная к 1 пог. м сооружения сила сопротивления сдвигу по поверхности скольжения за счет сопротивления излому свай, забитых ниже поверхности скольжения на глубину $t_п$, рекомендуется значение $Q_{св\ i}$ определять по Руководству к СНиП II-16-76; допускается определять $Q_{св\ i}$ по формуле

$$M_{св} = \frac{(\sigma_р - \sigma_а) l_c t_з^2}{8},$$ [12]

$M_{св}$ - изгибающий момент в свае ниже поверхности скольжения, значение которого принимается из двух условий: из условия прочности железобетонного сечения, определяемой по формуле СНиП II-56-77, или из условия защемления сваи ниже поверхности скольжения $t_з = t_п/1,25$ по формуле

About 50% of population
and about 75% of property
exist on about 10% of national land
lower than river water levels during flooding.



Topographical, geological, & meteorological characteristics of Japan

(i) Land:
A north-south stretch of land extending over a length of 2000 km

(ii) Four main islands:
Four main islands are separated from one another by straits. There are also numerous small islands.

(iii) Backbone mountain range:
Mountains run at the middle of the land.

(iv) Tectonic lines:
Median and Itoigawa-Shizuoka Tectonic Lines run from north to south.

(v) Plains:
Narrow plains are located along shorelines.

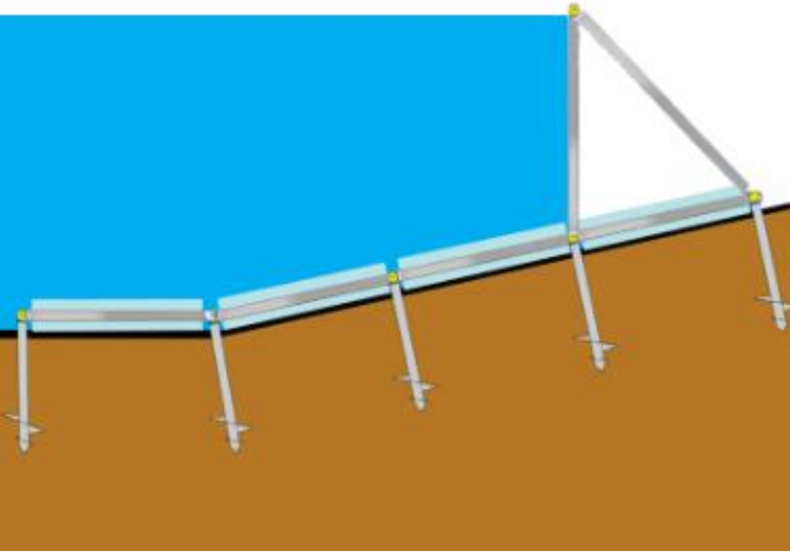
(vi) Weak soils:
Most large cities are located on weak soils.

(vii) Earthquakes:
About 10% of world's earthquakes occur in Japan.

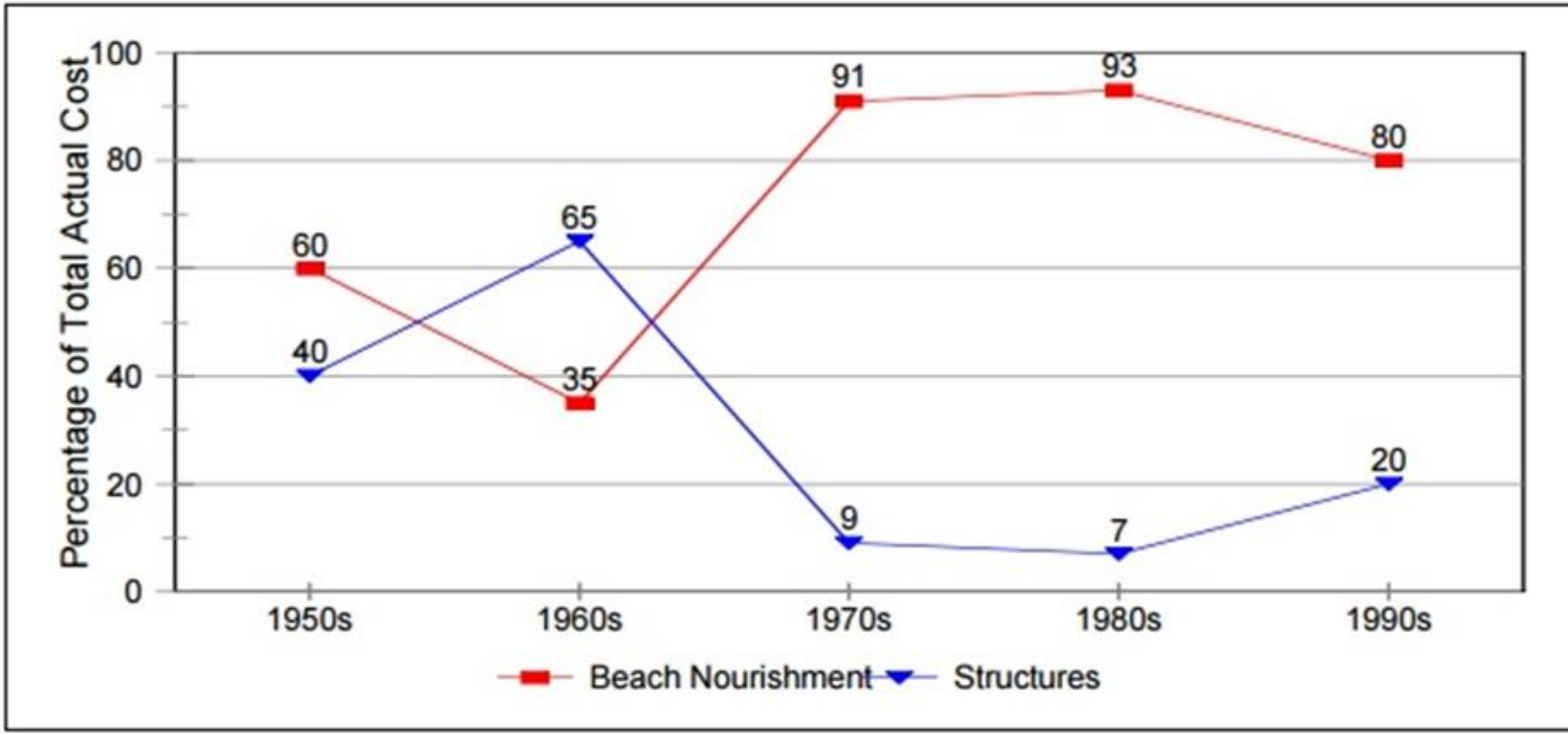
(viii) Heavy rains:
Japan is on the eastern edge of Monsoon Asian and is faced with the threats of heavy rains and typhoons. Rivers flow on steep slopes.

(ix) Snow cover:
Sixty percent of land is located in snowy and cold areas.

Greenstick Flood Wall



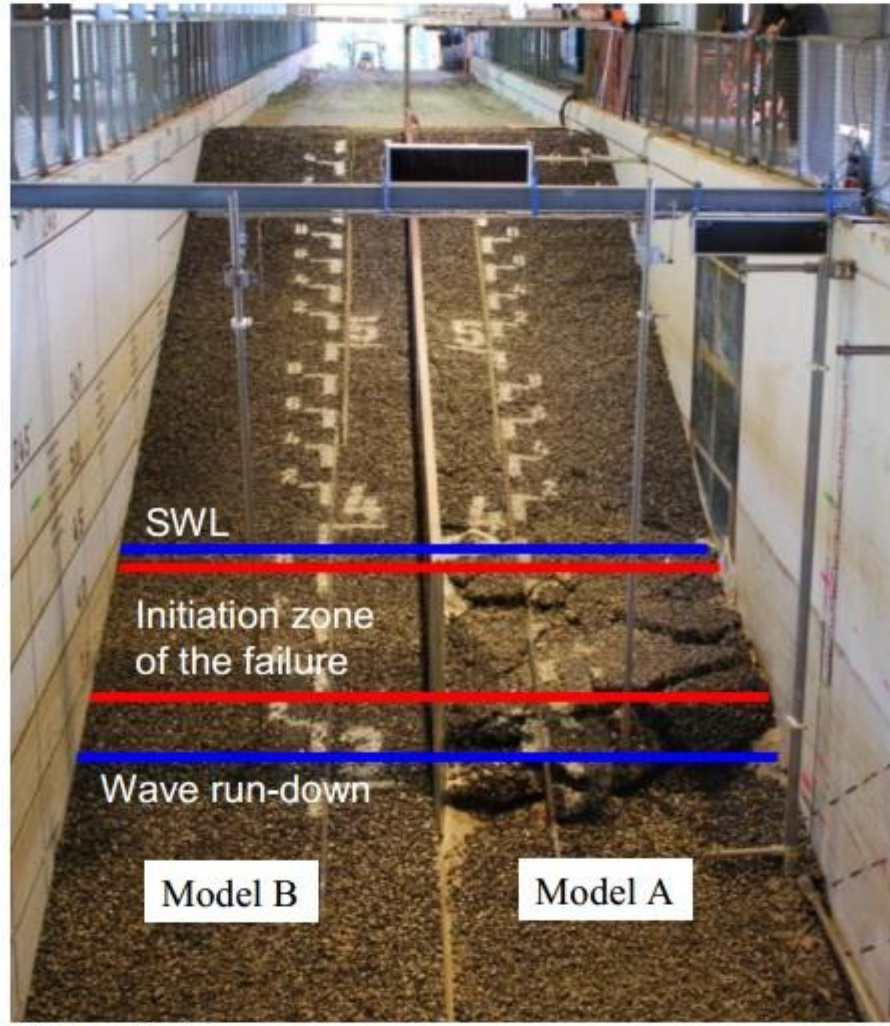

WATER transports sand over sill
SAND is retained behind sill
Original ground line
SANDBAGS
FILTER CLOTH to help retain sand on beach side of sill



Shift from hard (armored walls, groins, etc.) to soft (beach nourishment) alternatives by the Corps of Engineers (from Hillyer 1996)

Tests of Walls in Waves flume

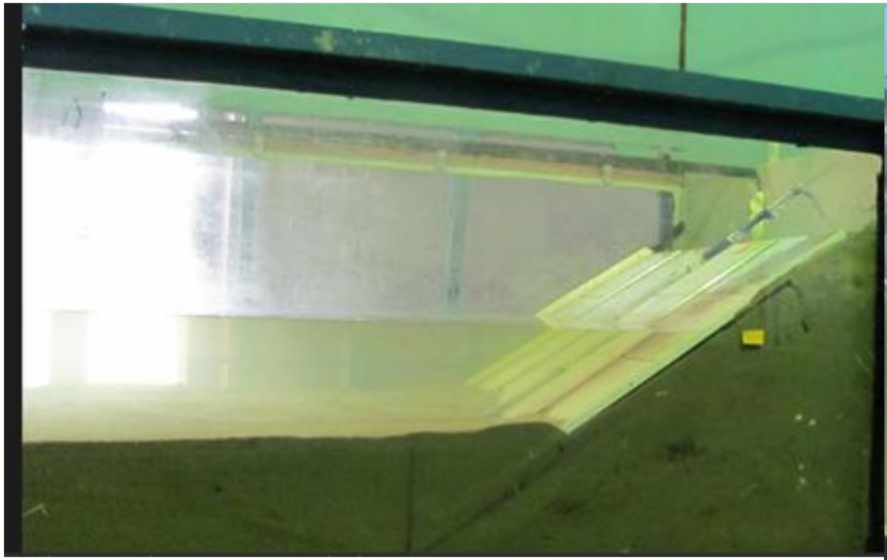
(a) Overall view

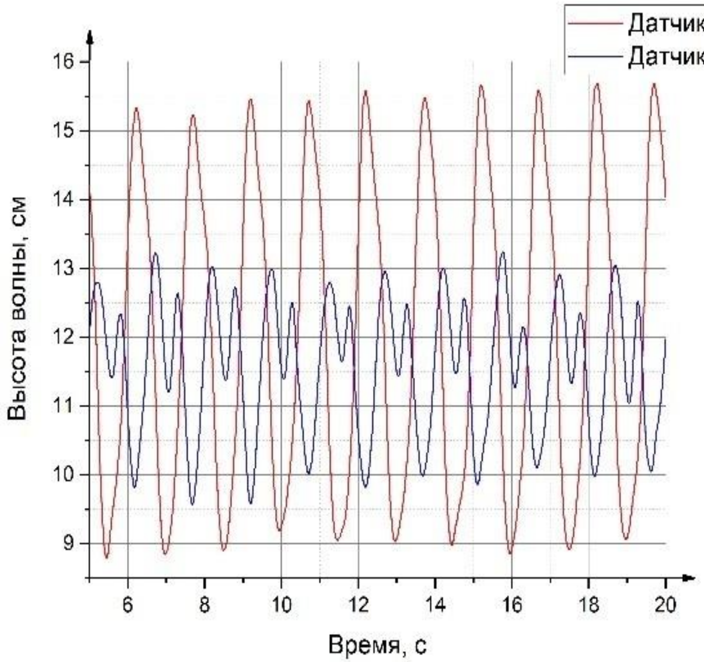


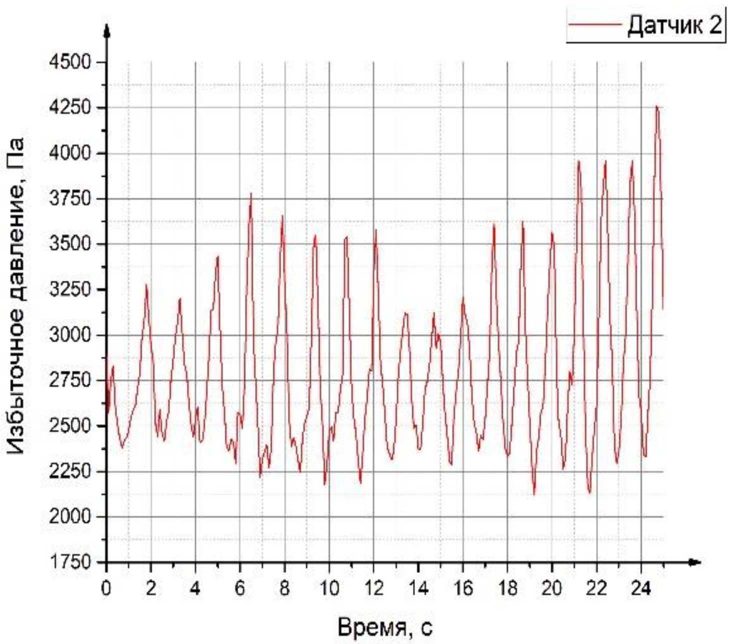
(b) Detailed view

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







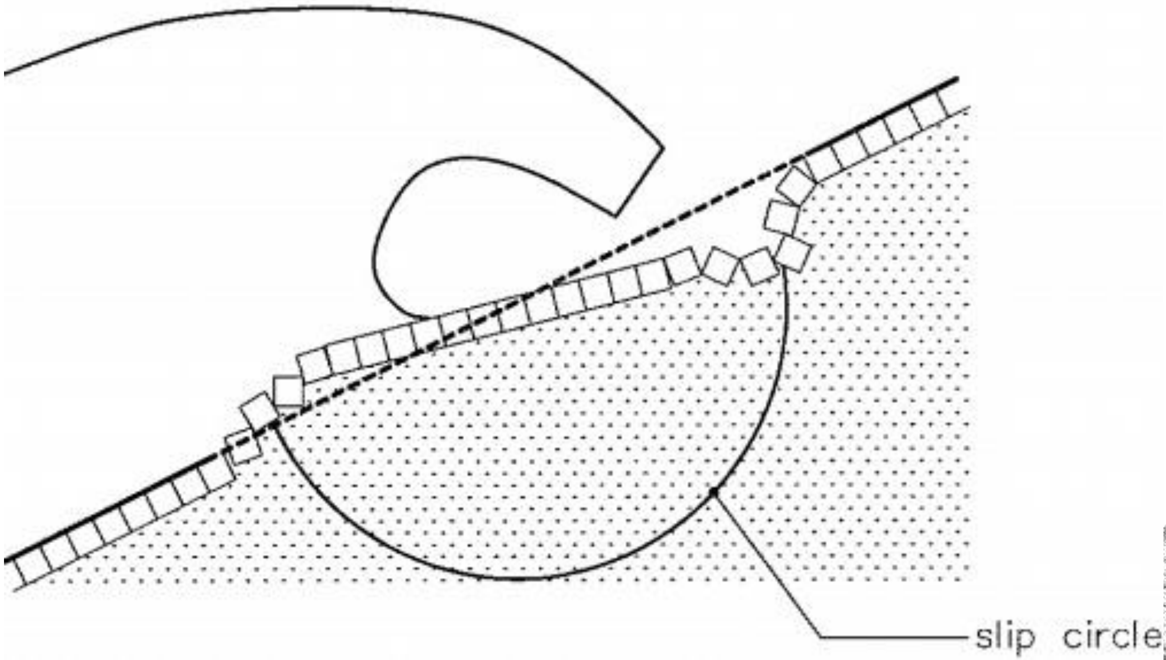
FRP(HCB) bridges http://innovativeglobal.net/products/hc-bridge

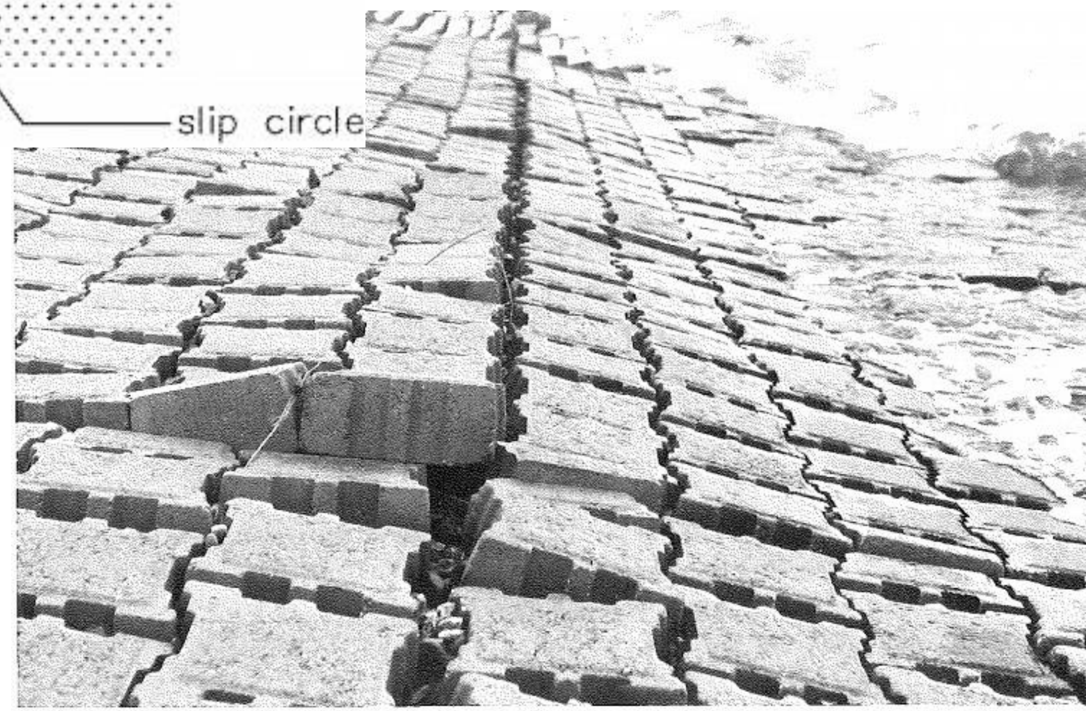
MARSHALL FORD MARINA
AUSTIN, TX

234 ft (71m) Breakwater

CREATIVE PULTRUSIONS

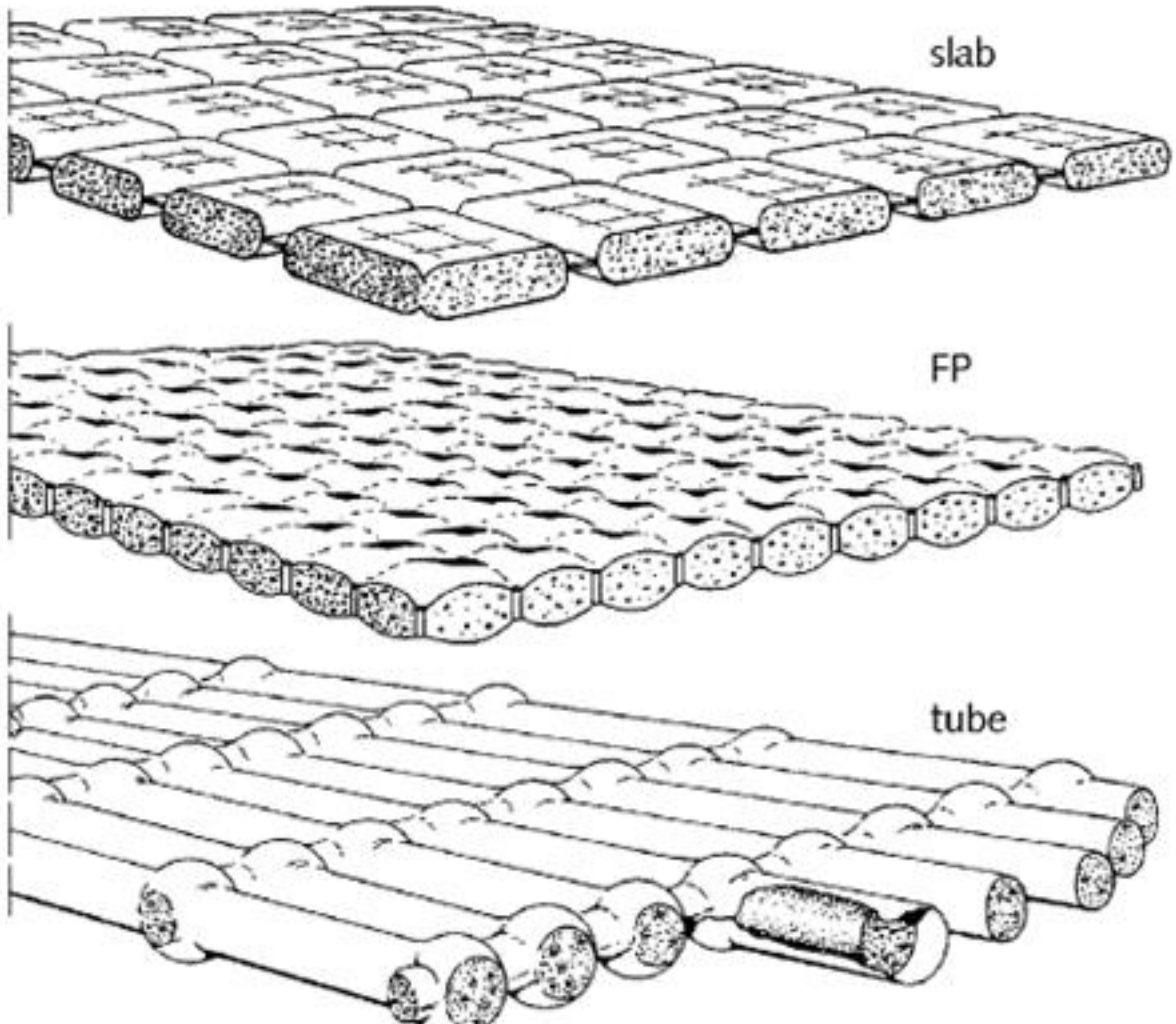
The distortion of an S-profile





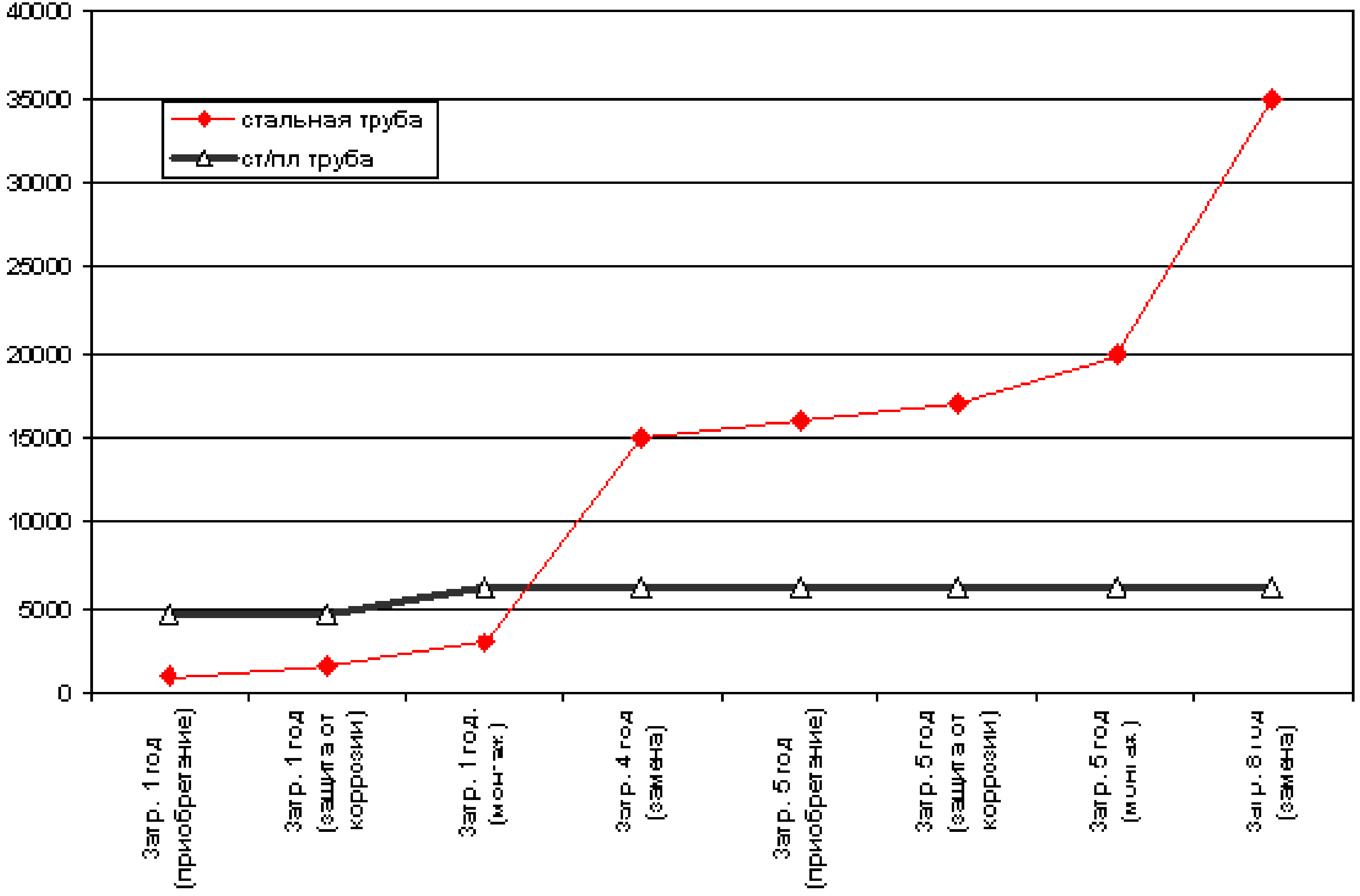
The turned-up corner of a mattress – test section near Lelystad.

Concrete-filled mattresses

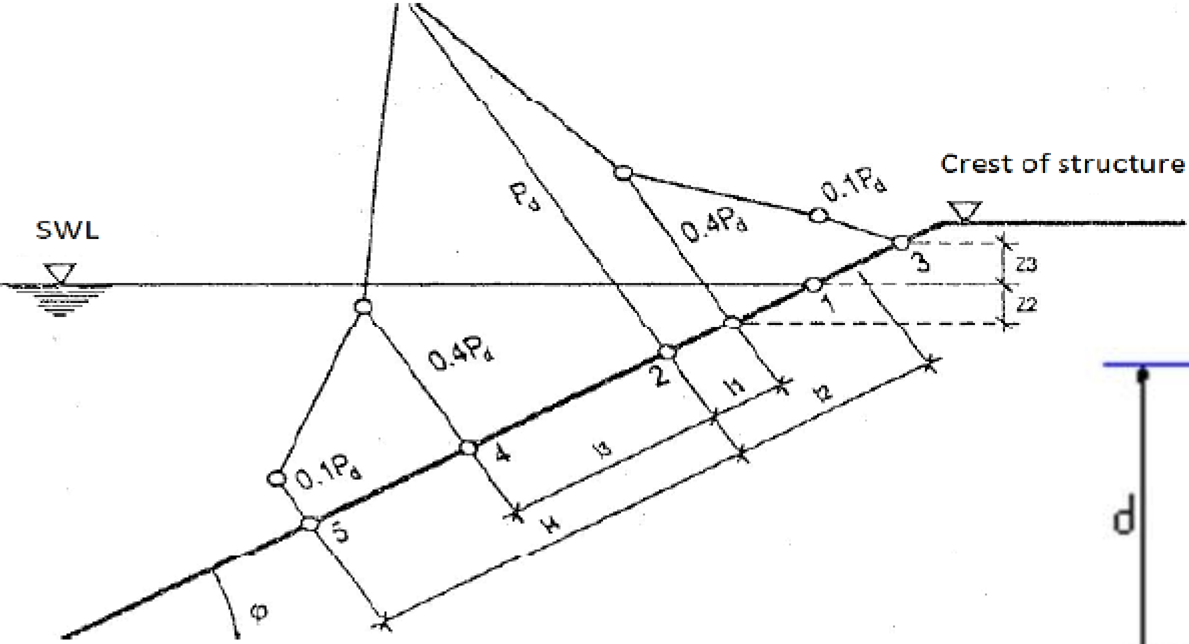


Danube river. Destruction of concrete matrasses

Price comparison of steel and FRP pipes



Wave pressure distribution on slope

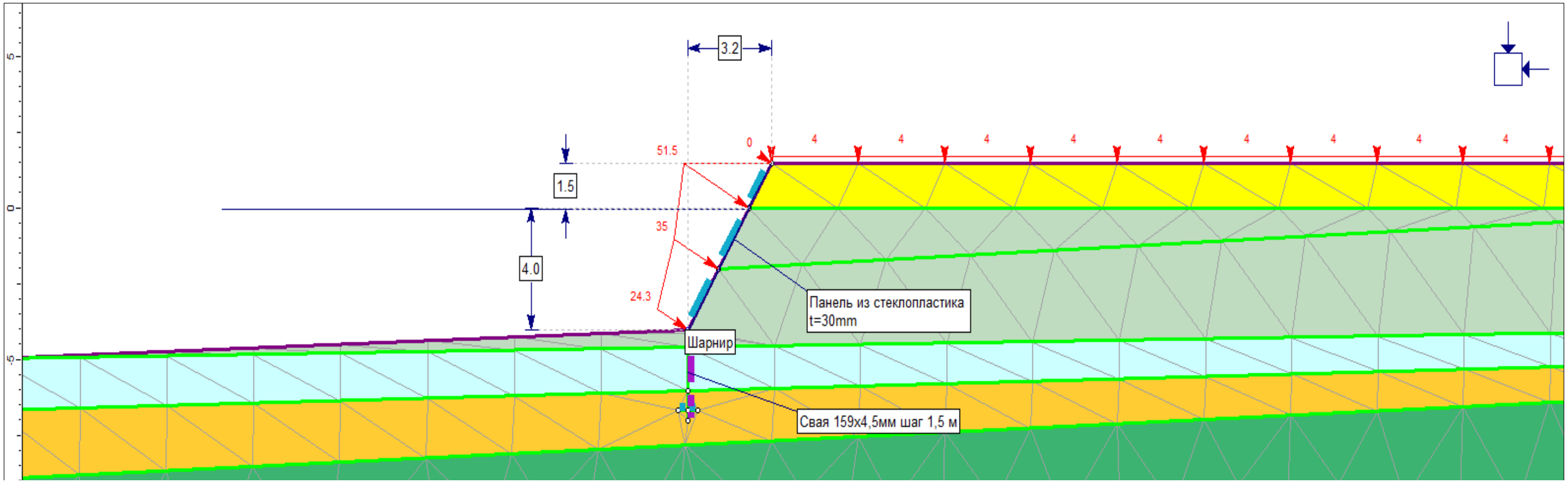


Scheme characteristics	Symbol	Quantity	Measure
Wind speed, 10m hight		15	m\sec
Bottom depth	(d)	2	m
Slope angle	(Fi)	44	°
Plates size	(bf)	30	m

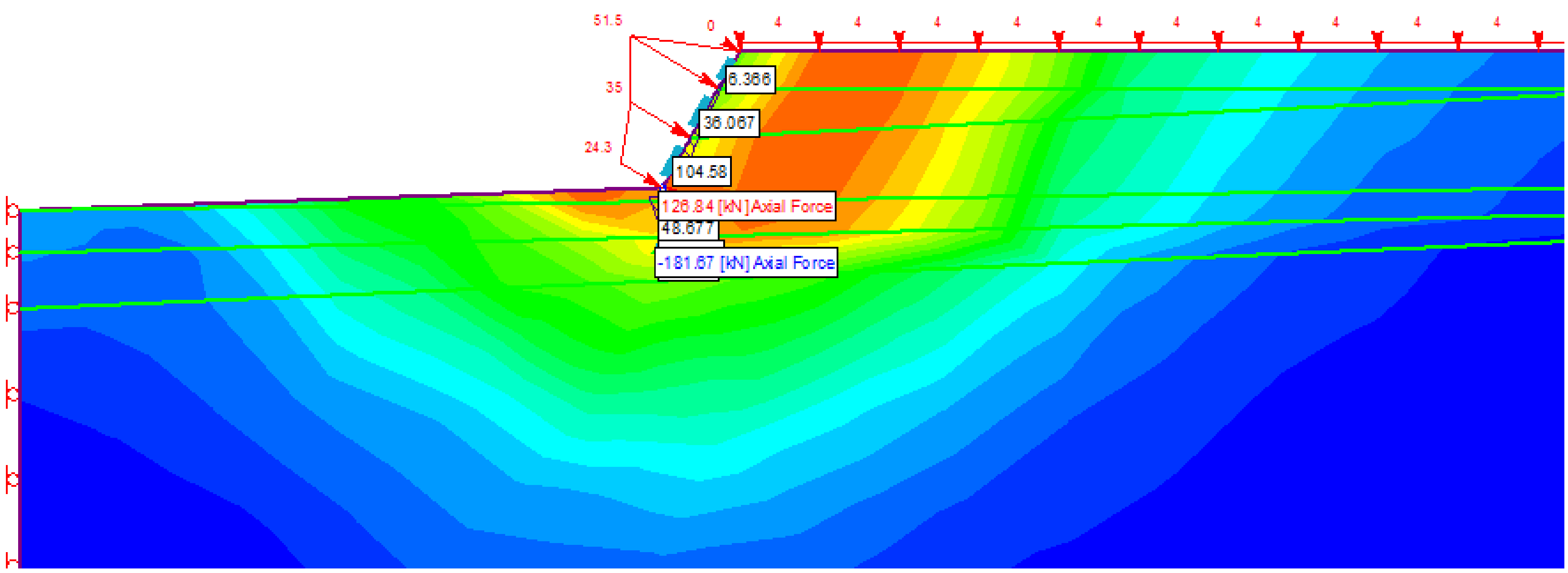
Waves loads calculations for Greenstick inclined wall

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

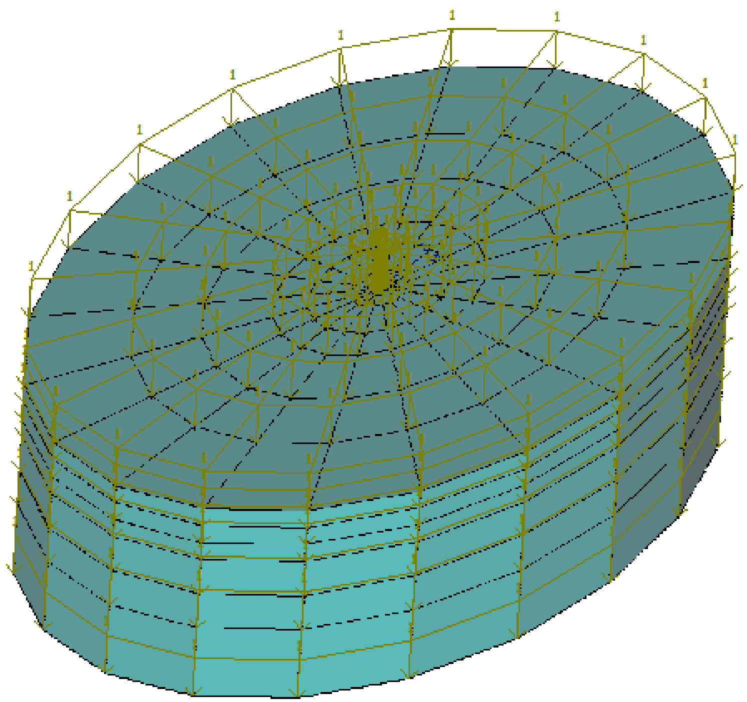
FEM calculations of Greenstick Wall

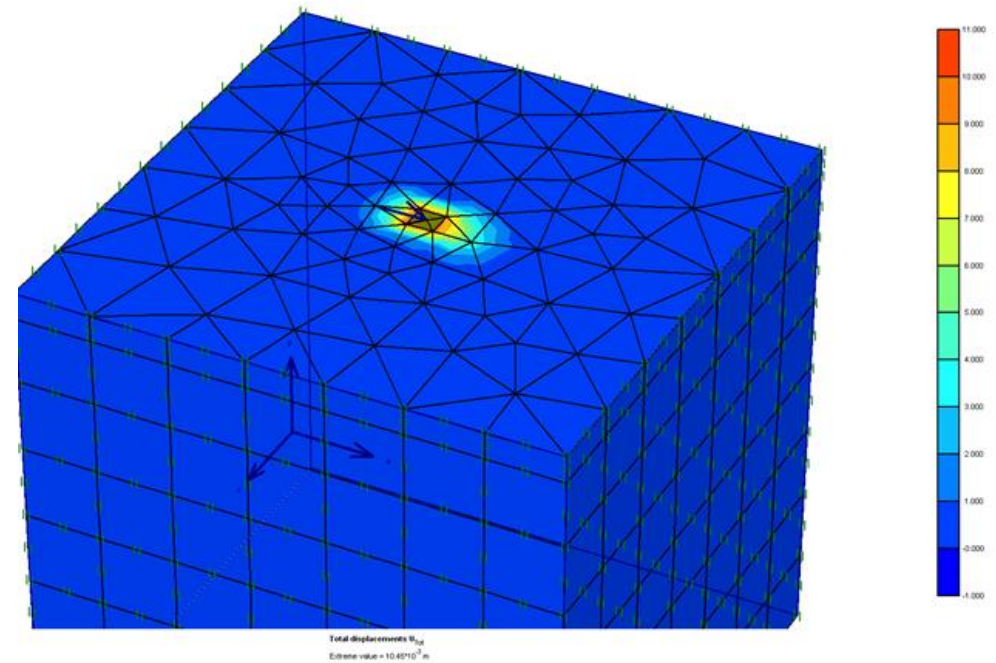


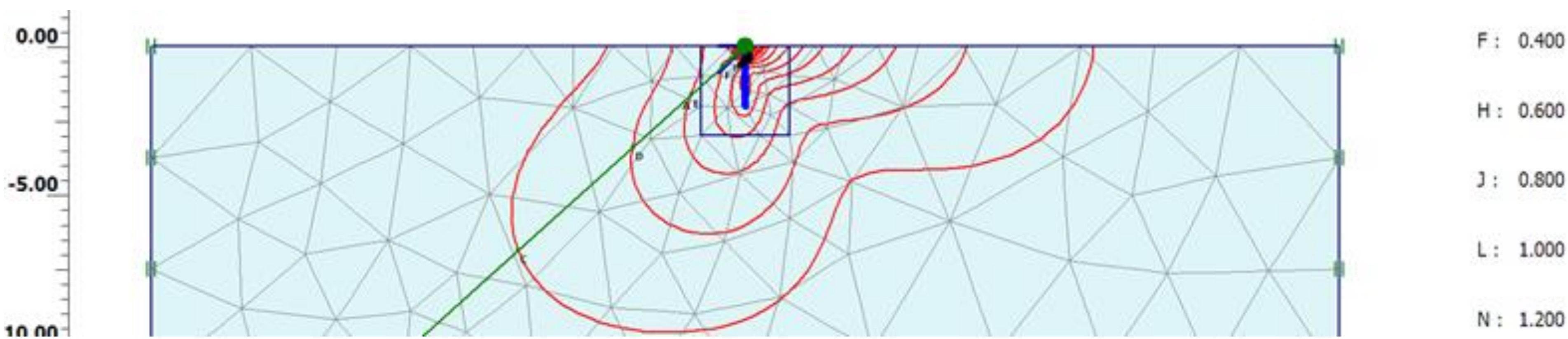
Critical SRF: 4.99



FEM Greenstick grip calculations

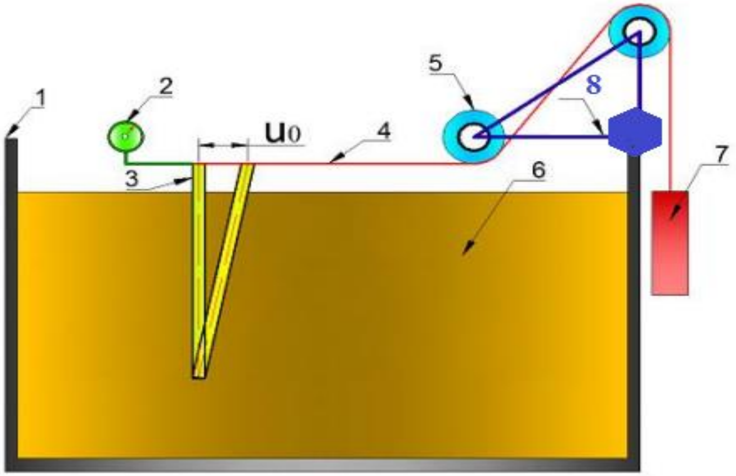






Tests of Greenstick grip in soil tray of BLASDARI

www.blasdari.com



Pile`s type	Anchorage aility, kg, for angle of inclined uplift force					
	Hori-zontal	20	30	45	60	Vertical
"Kriner" pile	42,40	57,49	26,34, 32	33,42,3 5	48	32
Screw pile	40	58,62	55,72	55,62	57,65	83,80,72

Vertical uplift capacity of "Krinner" 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 "Kriner" 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)

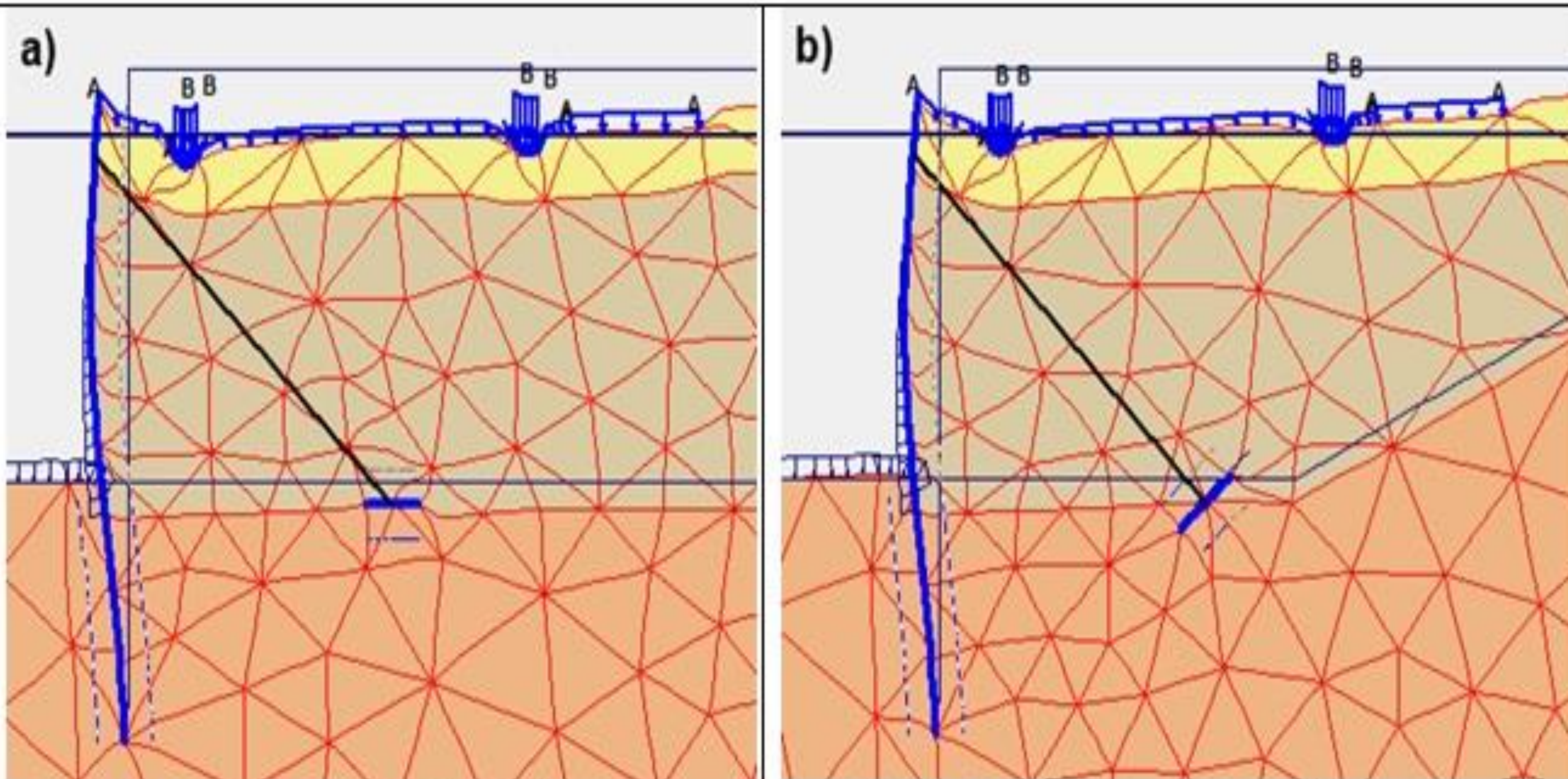


Figure *a*. Greenstick anchorage.

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 defense 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