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BERM BREAKWATER STRUCTURES
MAS2 – CT94 –0087

BERM BREAKWATER DESIGN
– influence of rock shape

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Aalborg University
October 1996

BERM BREAKWATER DESIGN - influence of rock shape

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The present report summarizes the test results obtained with a berm breakwater attacked by oblique waves. In the tests special attention is given to the influence of the rock shape on the longshore transport. Moreover, the reshaping berm profile and amount of wave overtopping is examined.

The tests were performed with a three-dimensional model during Jan.–Feb. 1996 in The Hydraulics & Coastal Engineering Laboratory, the Department of Civil Engineering, Aalborg University.

Description of the model tests

Figure 1 shows the lay-out and the cross section of the model. A breakwater geometry with uniform stone grading through the entire cross section was constructed on a plain bottom.

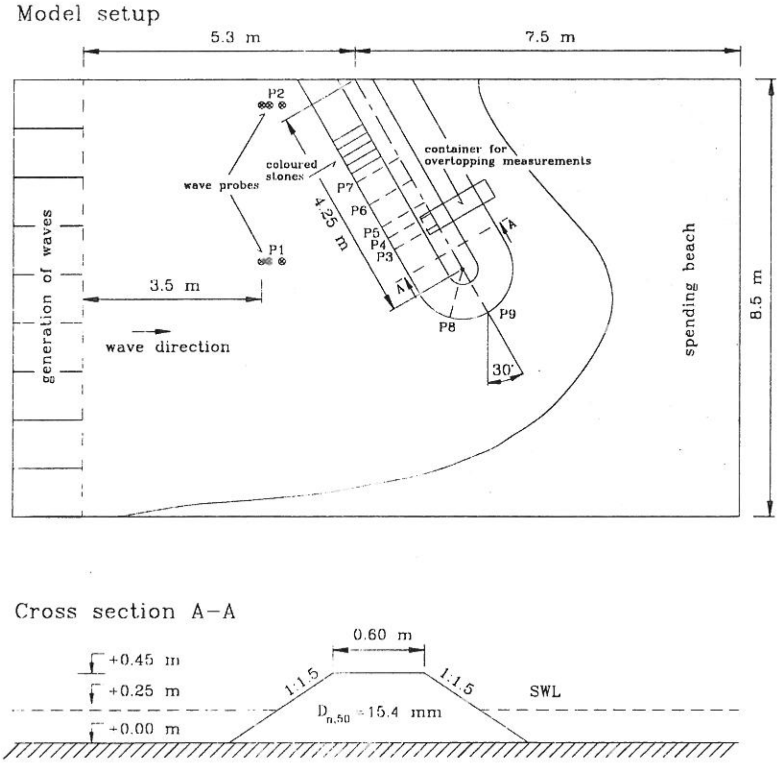

Figure 1: *Lay-out and cross section of the berm breakwater model.*

Materials

The berm breakwater model consists of one class of stones. Figure 2 shows the gradation curves of two samples.

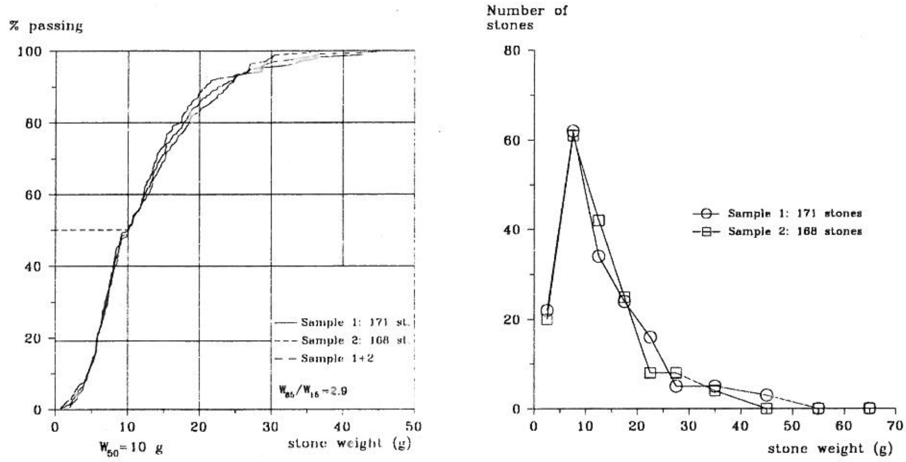

Figure 2: *Gradation curves of stone samples from the berm model.*

For the study of the longshore transport stones with a higher W_{50} were used. This class of stones consisted of four types by shape, all with exactly the same gradation curves, see figure 3.

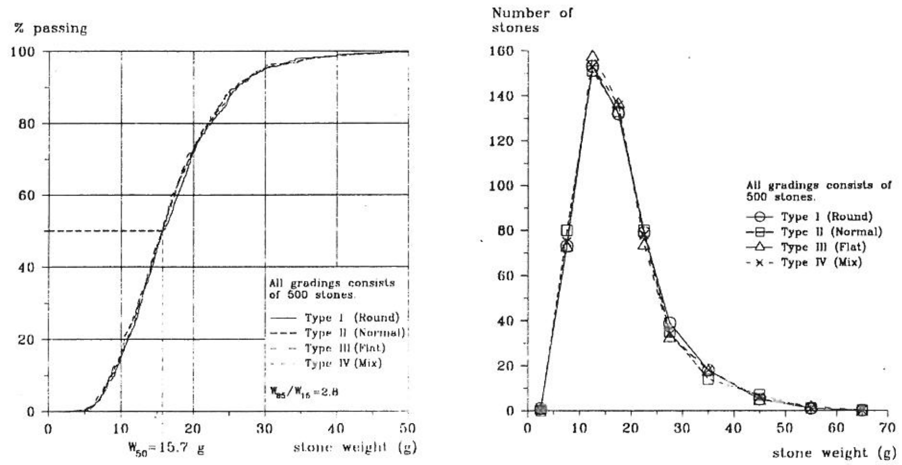

Figure 3: *Gradation curves of the four stone types used in the longshore transport study.*

Each gradation curve consists of the total number of stones used in the tests, that is approximately 4x500 stones.

The materials were chosen in order to obtain values of the stability number, $N_s = H_{m0} \Delta D_{n50}$ in the range of 2-4. Table 1-2 summarizes the rock material characteristics.

Table 1: *Berm breakwater material characteristics*

Mass density, ρ_s	2720 kg/m^3
Average stone mass, W_{50}	0.010 kg
Gradation ratio, W_{85}/W_{15}	2.9
Nominal diameter, $D_{n50} = W_{50}/\rho_s)^{1/3}$	0.0154 m
ΔD_{n50}, $\Delta = (\rho_s - \rho_W)/\rho_W$	0.0265 m

Table 2: *Char. of the stones in the transport study*

Mass density, ρ_s	2720 kg/m^3
Average stone mass, W_{50}	0.0157 kg
Gradation ratio, W_{85}/W_{15}	2.8
Nominal diameter, $D_{n50} = (W_{50}/\rho_s)^{1/3}$	0.0179 m
ΔD_{n50}, $\Delta = (\rho_s - \rho_W)/\rho_W$	0.0309 m
Round stones (red), length ratio l/b	1.0 - 1.5
Normal stones (blue), length ratio l/b	1.5 - 2.5
Flat stones (yellow), length ratio l/b	2.5 - 3.5
Mixed stones (green), length ratio l/b	1.0 - 3.5
Porosity, pore volume/total volume	0.41 to 0.46

The length ratios of the stones were defined as the longest side divided by the shortest side. The porosity of the *flat* stones is 0.46, and the porosity of the *round* and *normal* stones is 0.41. This yields a lower packing density of the flat stones.

Waves

In all the tests irregular waves were generated in accordance with a random phase JONSWAP-type spectrum (γ=3.3). Two arrays of three wave gauges were placed between the wave paddle and the berm breakwater, see figure 1. Both arrays of gauges were used to estimate incident and reflected spectra. The method of Mansard and Funke, 1980 was used, taking into account the direction of reflected waves. Due to the shallow water condition, h=0.25 m, the waves were limited by the water depth. Therefore non-linear effects were strong and were not accounted for with the adopted separation method of incident and reflected wave spectra.

Significant wave heights ranging from 0.05 m to 0.10 m were generated in the tests. The tests were distributed on six series. A characteristic steepness of 0.04 and an angle of wave attack of 30 degrees were used in all test series. In the enclosed appendix an overview of the applied wave characteristic is given. Figure 4 shows the target wave height against the actually measured incident wave height.

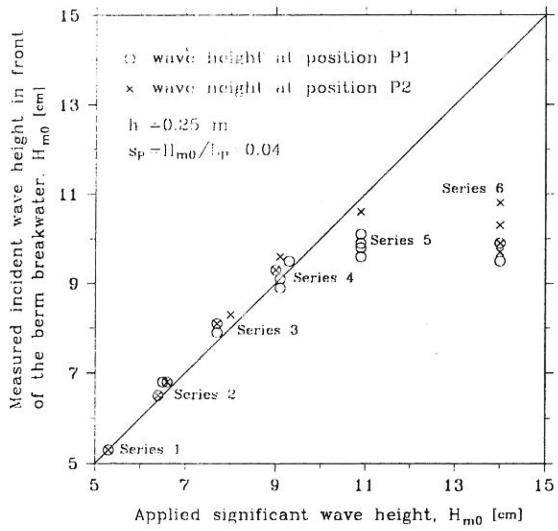

Figure 4: *Applied and measured significant wave height.*

For H_{m_0} bigger than approximately 0.09 m the influence of the water depth on the generated wave height becomes significant. Also, a difference in the measured incident wave height is seen at positions $P1$ and $P2$, respectively. This is mainly due to the presence of the wall near $P2$. Thus, the wave characteristics are determined on basis of the results measured at $P1$.

It seems that for relative large wave heights the wave breaking, due to the shallow water conditions, distorts the wave height distribution compared with the expected Rayleigh distribution. Figure 5 shows the respective measured spectra compared to the JONSWAP-spectra.

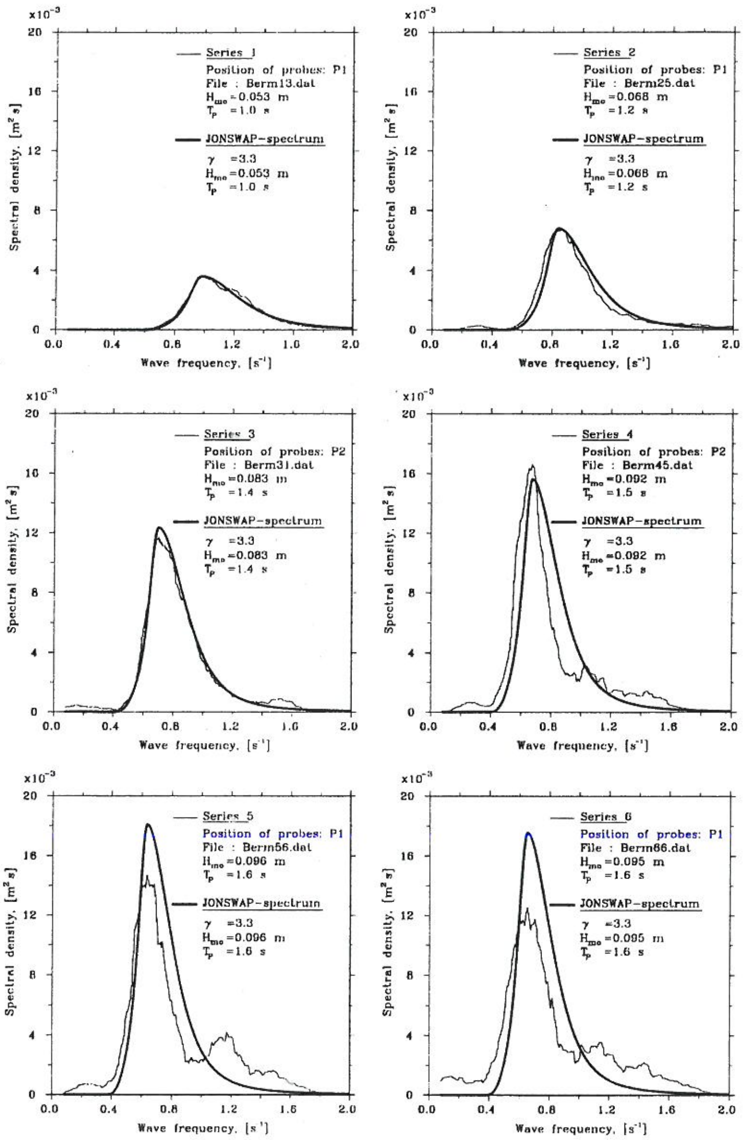

Figure 5: *Recorded spectra in each test series compared with the respective JONSWAP-spectra.*

The reflection coefficients, referring to the incident wave height and the reflected wave height, are shown in figure 6.

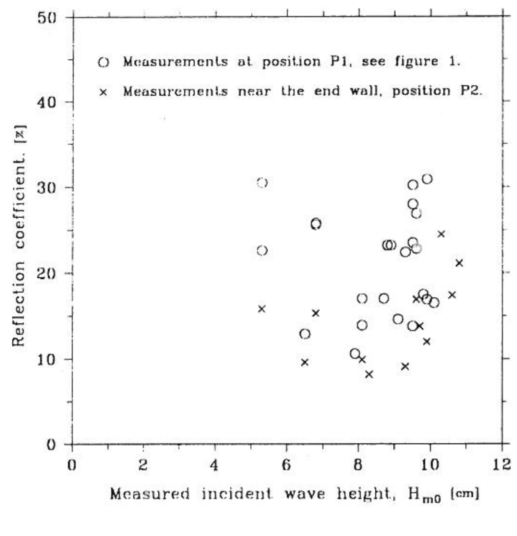

Figure 6: *Reflection coefficients measured at positions P1 and P2.*

The reflection coefficients are measured in the range of 10-30 %. The reflection tends to be higher at position P1.

Reshaped profiles

Five profiles, P3, P4, P5, P8, and P9 were measured at the trunk and the roundhead, see figure 1. The profiles P3, P4 and P5 were measured at the trunk. The profiles P8 and P9 were measured at the roundhead. Measurements were performed for each test series, which covers six wave heights. The reshaping period was defined in the range of 0-3000 waves (according to T_p), even though it was observed that the main reshaping took place during the first 200 waves. After 2000 waves no more reshaping was seen on the trunk section. For the roundhead reshaping still continued. Figure 7 and figure 8 show the profiles at the roundhead and trunk, respectively. The profiles at the trunk are an average of three profiles, even no significant difference was observed in the profiles depending on the position, see also the enclosed appendix.

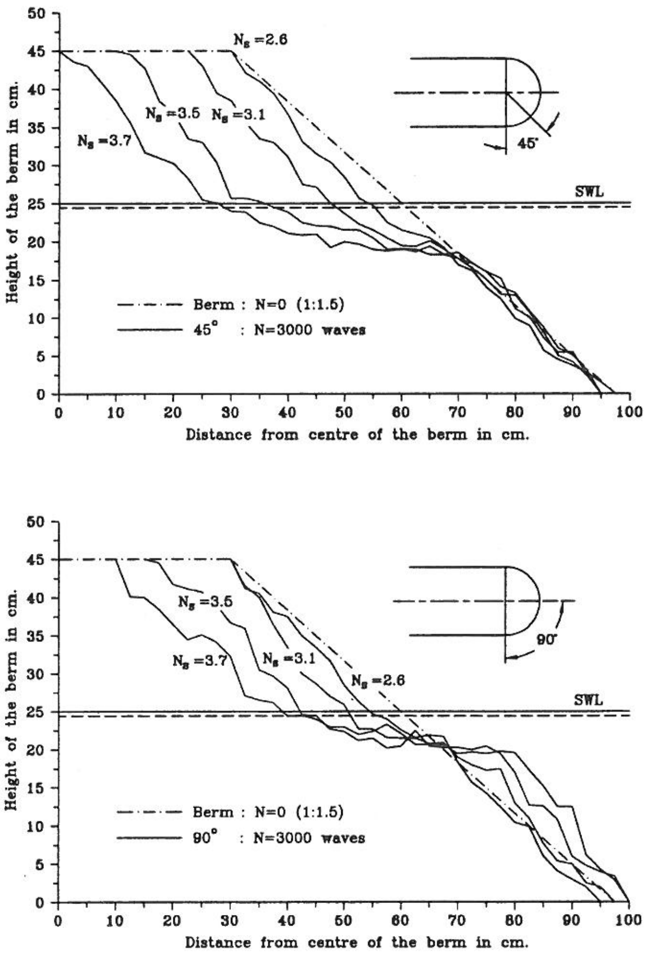

Figure 7: *Reshaped profile after 3000 waves at the roundhead.*

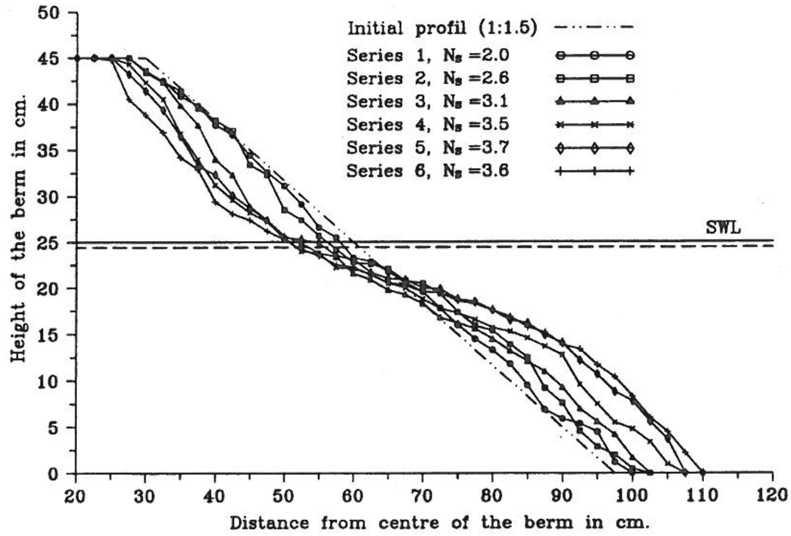

Figure 8: *Reshaped profile at the trunk.*

The larger wave height the more reshaping. The characteristic S-profile is clear for waves corresponding to stability numbers of $N_s > 3$.

Wave overtopping

Wave overtopping was measured during all the tests by collecting water in a 0.395 m wide container placed on the rear side of the breakwater, see Fig. 1. The container was moved during the tests following the recession of the berm. Figure 9 shows the amount of wave overtopping depending on the wave height.

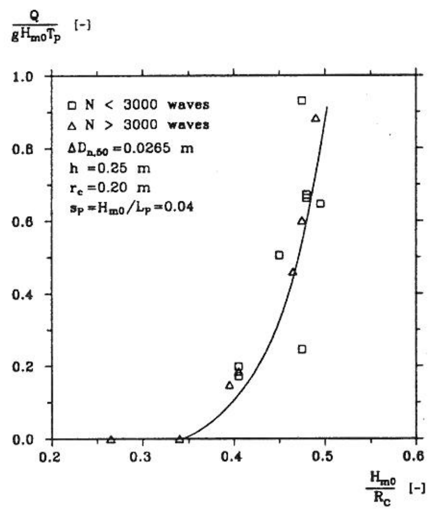

Figure 9: *Wave overtopping depending on the stability number.*

The wave overtopping was measured during reshaping and after reshaping as well. No wave overtopping was observed during the two first series, that is for N_s less than 3. No distinction of these two conditions can be made from figure 9. Two measurements do not fit the trend in figure 9. In the case of overtopping the highest waves are very important, especially when the freeboard is relative large. Looking at the analysed wave data in the appendix, the maximum recorded wave height in these two cases was not typical compared with the other tests.

Longshore transport

Four types of stone shapes were identified, round (red), normal (blue), flat (yellow) and a mix of these three (green). All the stones had exactly identical gradation curves. The coloured stones were placed in 4 separate 0.18 m wide bands in the armour layer of the berm. The thickness of the coloured stone layers was 3-4 stones. During reshaping (N = 0-3000 waves) the location and weight of every individual coloured stone were recorded. The number of waves applied in the transport test after reshaping were chosen in such a way, that the non-coloured stones upstream the coloured band did not pass the downstream coloured band. After reshaping location and weight recording was made. Thus the transport rates will be given as an average transport per sec. or wave through a cross section.

The results of the transport study are given in the appendix. Figure 10 shows the transported stones after reshaping as a function of the stability number. Moreover, the formula proposed for longshore transport both in shallow and in deep water conditions under oblique wave attack is shown (*Alikhani and Frigaard,* 1995).

$$S = \left[0.16 N_s \, s^{1/3} - \left(tan \frac{2\psi}{3}\right)^{-1/4}\right]^3 \qquad 0 < \psi \leq \; pi/4 \qquad (1)$$

where S is the transport in number of stones per wave, s is the steepness of the waves and ψ is the angle of wave attack.

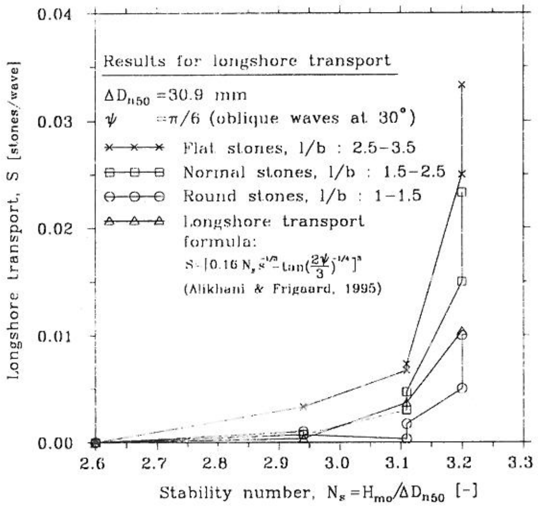

Figure 10: *Longshore transport after reshaping as a function of the stability number.*

Longshore transport was not identified for stability numbers lower than approximately 3. Clearly, the transport of the flat stones is more significant than the transport of the round stones, which shows the smallest transport rates. The transport suggested by eq. (1) is somewhat in between the measured transport of flat and round stones.

Having stones with two different stability numbers, non-coloured and coloured stones, created some problems of stabilising the downstream coloured band. This was done with a 25 cm wide band of stones with the same stability number as the coloured stones. Another problem was the covering of the upstream coloured band with non-coloured stones (see photos in the appendix). This was solved by placing first the green stones (mix) upstream, followed by the yellow, blue and red stones.

Also the transport of the non-coloured stones was recorded when the stones passed the most upstream coloured band. Figure 11 shows the results compared with the results obtained by Burcharth and Frigaard (1988).

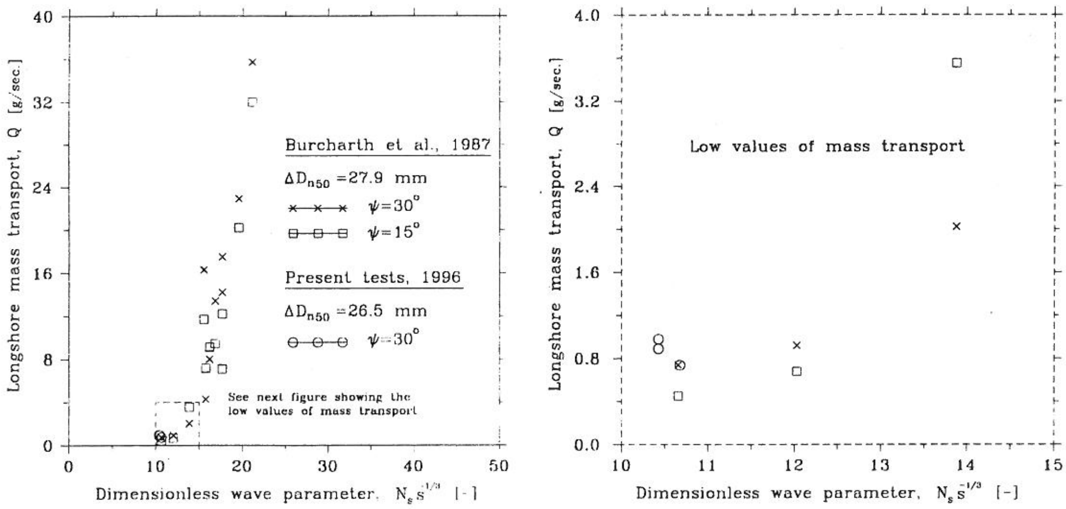

Figure 11: *Mass transport results compared with earlier results. Showed as function of dimensionless wave parameter after reshaping.*

The transport rates in the present tests seem to agree well with earlier tests, thus only three tests are performed. It is interesting that the agreement is confirmed close to the threshold value of longshore transport indicated by figure 11.

Conclusions concerning the influence of the rock shape

Any measurable differences in the profiles with different stone types were not observed in the tests.

It was not possible to quantify a difference in the amount of overtopping water. Though it seemed that the berm constructed of the flat stones, i.e. the smoothest slope after reshaping, was producing the most overtopping water. Thus this difference was believed to be insignificant.

A very significant longshore transport were measured for the different stone classes. Longshore transport rates for the flat stones were three to five times higher than the transport rates for the round stones.

Acknowledgement

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References

Alikhani, A. and Frigaard, P. (1995).
Governing Variables and Proposed Formula for Longshore Transport on Reshaping Breakwaters. Minutes of Meeting, Three-Dimensional Model Tests, Berm Breakwater Structures (MAS2–CT94–0087). DHI, January 1996.

Burcharth, H.F. and Frigaard, P. (1986).
On 3-Dimensional Study of Reshaping Breakwaters. Proc. 21th ICCE, Malaga, Spain, 1988.

Grønbech, J., Jensen, T. and Andersen, H. (1996)
Reflection Analysis with separation of cross modes. Proc. of 25th ICCE, Orlando, Florida, 1996.

Mansard, E.P.D. and Funke, E.R. (1980).
The measurement of incident and reflected spectra using least square method. Proc. 17th ICCE, Sydney, 1980, pp. 154-172.

Jensen, M.S. and Frigaard, P. (1996)
Results of berm breakwater tests with special attention to the influence of the rock shape on the longshore transport. Proc. 3rd workshop on Berm Breakwater Structures (MAS2–CT94–0087). Stavanger, Norway.

APPENDIX

WAVE DATA - BERM BREAKWATER TESTS '96

Filename / Series	H_{m0} [cm] (a*)	T_P [s] (a)	Pos.*	Time [s]	N	H_{m0} [cm] (m*)	T_P [s] (m)	Max* [cm]	Ref. - coeff. [%]	Remarks*	Date 96'
Berm11.dat/1	5.3	1.0	P1	300	300	5.3	1.0	10	23	R-O1(0-3000)	18-1
Berm12.dat/1	5.3	1.0	P2	300	300	5.3	1.0	10	16	R-O1(0-3000)	18-1
Berm13.dat/1	5.3	1.0	P1	1800	1800	5.3	1.0	9	31	R-O1(0-3000)	18-1
Berm21.dat/2	6.6	1.2	P1	300	250	6.8	1.2	11	26	T1-R-O2(0-3000)	22-1
Berm22.dat/2	6.6	1.2	P2	300	250	6.8	1.2	12	15	T1-R-O2(0-3000)	22-1
Berm23.dat/2	6.4	1.2	P1	300	250	6.5	1.2	11	13	T1-R-O2(0-3000)	22-1
Berm24.dat/2	6.4	1.2	P2	300	250	6.5	1.1	11	10	T1-R-O2(0-3000)	22-1
Berm25.dat/2	6.5	1.2	P1	1320	1100	6.8	1.2	10	26	T1-R-O2(0-3000)	22-1
Berm31.dat/3	8.0	1.4	P2	650	464	8.3	1.4	12	8	T1-R	26-1
Berm32.dat/3	7.7	1.4	P1	250	179	7.9	1.4	12	11	T1-R-O3(1000-2000)	26-1
Berm33.dat/3	7.7	1.4	P2	650	464	8.1	1.3	12	10	T1-R-03(1000-2000)	26-1
Berm34.dat/3	7.7	1.4	P1	1350	964	8.1	1.4	12	17	T1-R-04(2000-3000)	29-1
Berm35.dat/3	7.7	1.4	P1	1350	964	8.1	1.4	13	14	T2-S-O5(0-3500)	30-1
Berm41.dat/4	9.3	1.6	P1	750	469	9.5	1.6	14	14	T1-R-O7(0-3000)	2-2
Berm42.dat/4	9.1	1.6	P2	750	469	9.6	1.5	14	17	T1-R-O7(0-3000)	2-2
Berm43.dat/4	9.0	1.6	P1	1550	969	9.3	1.5	14	22	T1-R-O7(0-3000)	2-2
Berm44.dat/4	9.0	1.6	P2	1550	969	9.3	1.5	12	10	T1-R-O7(0-3000)	2-2
Berm45.dat/4	9.1	1.6	P1	1550	969	9.1	1.5	14	15	T2-S-O8(0-3000)	5-2
Berm46.dat/4	9.1	1.6	P1	1550	969	8.9	1.4	15	23	T2-S-O8(O-3000)	5-2
Berm51.dat/5	10.9	1.7	P1	850	500	9.9	1.7	13	17	T1-R	6-2
Berm52.dat/5	10.9	1.7	P1	338	199	10.1	1.7	13	17	T1-R-O9(500-3000)	6-2
Berm53.dat/5	10.9	1.7	P1	1700	1000	9.8	1.6	15	18	T1-R-O9(500-3000)	6-2
Berm54.dat/5	10.9	1.7	P2	1500	822	10.6	1.6	16	17	T2-S-O10(0-3100)	7-2
Berm55.dat/5	10.9	1.7	P1	2400	1412	9.6	1.5	15	27	T2-S-O11(0-3000)	8-2
Berm56.dat/5	10.9	1.7	P1	1650	971	9.6	1.6	16	23	T2-S-O11(0-3000)	8-2
Berm61.dat/6	14.0	1.8	P2	700	389	10.8	1.8	14	21	R-O12(0-3000)	8-2
Berm62.dat/6	14.0	1.8	P1	1320	733	9.5	1.7	14	30	R-O12(0-3000)	8-2
Berm63.dat/6	14.0	1.8	P2	2400	1333	10.3	1.8	15	25	R-O12(0-3000)	8-2
Berm64.dat/6	14.0	1.7	P1	840	494	9.9	1.7	14	31	T2-S-O13(0-1250)	11-2
Berm65.dat/6	14.0	1.7	P2	1160	682	9.7	1.6	14	14	T3-S-O14(0-2000)	12-2
Berm66.dat/6	14.0	1.7	P1	1160	682	9.5	1.6	16	24	T3-S-O14(0-2000)	12-2
Berm67.dat/6	14.0	1.7	P1	3360	1976	9.5	1.7	13	28	T3-S-O15(0-2000)	12-2
Berm68.dat/6	14.0	1.7	P2	3161	1859	9.9	1.7	14	12	T3-S	12-2

- **a**: Applied wave parameters.
- **m**: Measured wave parameters.
- **Pos.**: Position, see also Fig. 1.
- **Remarks**: R=reshaping, S=stable, T1=transport under reshaping (coloured stones), T2=transport after reshaping (coloured stones), T3=transport of non-coloured stones and O=overtopping (test no. and no. of waves included)
- **max.**: Maximum wave height determined by a zero-cross-down analysis.

OVERTOPPING DATA - BERM BREAKWATER TESTS '96

Overtopping test no. / Series	H_{m0} [cm] / T_P [s]	N_s^* [-]	Berm condition	Waves [-]	Time [s]	Overtopping in container [g]	Q x10^{-6} [m^3/m/s]	Date ('96)
1 / 1	5.3 / 1.0	2.0	R	0-3000	3000	0	0.00	18-1
2 / 2	6.8 / 1.2	2.6	R	0-3000	3600	0	0.00	22-1
3 / 3	7.9 / 1.4	3.0	R	1000-2000	1400	90	0.16	26-1
4 / 3	8.1 / 1.3	3.1	R	2000-3000	1400	106	0.19	29-1
5 / 3	8.1 / 1.4	3.1	S	0-3500	4900	368	0.19	30-1
6 / 3	8.1 / 1.4	3.1	S	500-3000	3500	301	0.22	1-2
7 / 4	9.3 / 1.5	3.5	R	0-3000	4800	1200	0.63	2-2
8 / 4	9.0 / 1.5	3.4	S	0-3000	4800	1272	0.67	5-2
9 / 5	9.8 / 1.6	3.7	R	500-3000	4250	2281	1.36	6-2
10 / 5	9.6 / 1.6	3.6	S	0-3100	5270	2090	1.00	7-2
11 / 5	9.6 / 1.5	3.6	S	0-3000	5100	1922	0.95	8-2
12 / 6	9.5 / 1.8	3.6	R	0-3000	5400	2163	1.01	8-2
13 / 6	9.9 / 1.7	3.7	S	0-1250	2125	897	1.07	11-2
14 / 6	9.5 / 1.6	3.6	S	0-2000	3400	1867	1.39	12-2
15 / 6	9.5 / 1.7	3.6	S	0-2000	3400	528	0.39	12-2

- N_s: Stability number for non-coloured stones, ΔD_{n50} =26.5 mm
- Q : Amount of overtopping water per metre berm per second.

PROFILE DATA - BERM BREAKWATER TESTS '96

Profile test no. / Series	H_{m0} [cm]	T_P [s]	N_s^* [-]	N	Time [s]	Date 96'
1 / 1	5.3	1.0	2.0	3000	3000	18-1
2 / 2	6.8	1.2	2.6	3000	3600	22-1
3 / 3	8.1	1.4	3.1	3000	4200	29-1
4 / 4	9.3	1.5	3.5	3000	4800	2-2
5 / 5	9.8	1.7	3.7	3000	5100	6-2
6 / 6	9.5	1.7	3.6	3000	5400	8-2

- N_s: Stability number for non-coloured stones, ΔD_{n50} =26.5 mm

LONGSHORE TRANSPORT - OBLIQUE WAVES AT 30° - BERM BREAKWATER TESTS '96

Wave data

Transport test no. / Series	H_{mo} [cm]	T_P [s]	s_P^* [-]	N_s^* [-]	N	Time [s]	Date 96'
1 / 4	9.1	1.5	0.042	2.94	3000	4800	5-2
2 / 4	9.1	1.5	0.042	2.94	3000	4800	5-2
3 / 5	9.6	1.6	0.041	3.11	3000	5100	7-2
4 / 5	9.6	1.6	0.041	3.11	3000	5100	8-2
5 / 6	9.9	1.7	0.039	3.20	600	1020	11-2
6 / 6	9.9	1.7	0.039	3.20	400	680	11-2

- s_P: Steepness of the waves, $s_P = H_{mo} / L_P$ where L_P is the wavelength after T_P.
- N_s: Stability number for coloured stones, ΔD_{n50} =30.9 mm.

Transport results

Transport test no.	Mix (green) stones / mass / aver. mass	Mix (green) transport: [st./wave] [g/s]	Round (red) stones / mass / aver. mass	Round (red) transport: [st./wave] [g/s]	Normal (blue) stones / mass / aver. mass	Normal (blue) transport: [st./wave] [g/s]	Flat (yellow) stones / mass / aver. mass	Flat (yellow) transport: [st./wave] [g/s]
1	15/314/21	$5.0 \cdot 10^{-3}$ $6.5 \cdot 10^{-2}$	2/34/17	$0.7 \cdot 10^{-3}$ $0.7 \cdot 10^{-2}$	2/31/16	$0.7 \cdot 10^{-3}$ $0.6 \cdot 10^{-2}$	10/179/18	$3.3 \cdot 10^{-3}$ $3.7 \cdot 10^{-2}$
2	8/178/22	$2.7 \cdot 10^{-3}$ $3.7 \cdot 10^{-2}$	3/69/23	$1.0 \cdot 10^{-3}$ $1.4 \cdot 10^{-2}$	2/36/18	$0.7 \cdot 10^{-3}$ $0.8 \cdot 10^{-2}$	10/191/19	$3.3 \cdot 10^{-3}$ $4.0 \cdot 10^{-2}$
3	9/134/15	$3.0 \cdot 10^{-3}$ $2.6 \cdot 10^{-2}$	1/15/15	$0.3 \cdot 10^{-3}$ $0.3 \cdot 10^{-3}$	9/140/16	$3.0 \cdot 10^{-3}$ $3.0 \cdot 10^{-3}$	20/311/16	$6.7 \cdot 10^{-3}$ $6.1 \cdot 10^{-2}$
4	10/146/15	$3.3 \cdot 10^{-3}$ $2.9 \cdot 10^{-2}$	5/103/21	$1.7 \cdot 10^{-2}$ $2.0 \cdot 10^{-2}$	14/265/19	$4.7 \cdot 10^{-2}$ $5.2 \cdot 10^{-2}$	22/359/19	$7.3 \cdot 10^{-3}$ $7.0 \cdot 10^{-2}$
5	19/350/18	$31.7 \cdot 10^{-3}$ $34.3 \cdot 10^{-2}$	6/158/26	$10.0 \cdot 10^{-2}$ $15.5 \cdot 10^{-2}$	14/229/16	$23.3 \cdot 10^{-2}$ $22.5 \cdot 10^{-2}$	20/330/17	$33.3 \cdot 10^{-3}$ $32.4 \cdot 10^{-2}$
6	12/223/19	$30.0 \cdot 10^{-3}$ $34.3 \cdot 10^{-2}$	2/55/28	$5.0 \cdot 10^{-2}$ $8.1 \cdot 10^{-2}$	6/104/17	$15.0 \cdot 10^{-2}$ $15.3 \cdot 10^{-2}$	10/161/16	$25.0 \cdot 10^{-3}$ $23.7 \cdot 10^{-2}$

Transport data - coloured stones

	Date: 5-2-96	H_{m0}=9.1 cm T_P=1.5 s	N=1200 Time:1920 s	Remarks : Observation
Distance [cm]	Green stones / weight [g]	Red stones / weight [g]	Blue stones / weight [g]	Yellow stones / weight [g]
0 - 9	6	1	2	9
9 - 18	-	1	-	1
18 - 27		-		-
27 - 36				
36 - 45				
45 - 54				
54 - 63				
63 - 72				
72 - 81				

	Date: 5-2-96	H_{m0}=9.1 cm T_P=1.5 s	N=2000 Time:3200	Remarks : Observation
Distance [cm]	Green stones / weight [g]	Red stones / weight [g]	Blue stones / weight [g]	Yellow stones / weight [g]
0 - 9	11	1	2	9
9 - 18	3	1	-	1
18 - 27	-	-		-
27 - 36				
36 - 45				
45 - 54				
54 - 63				
63 - 72				
72 - 81				

	Date: 5-2-96	H_{m0}=9.1 cm T_P=1.5 s	N=3000 Time:4800 s	Remarks : Observation & weight
Distance [cm]	Green stones / weight [g]	Red stones / weight [g]	Blue stones / weight [g]	Yellow stones / weight [g]
0 - 9	12 / 267	1 / 13	2 / 31	9 / 157
9 - 18	3 / 47	1 / 21	-	1 / 22
18 - 27	-	-		-
27 - 36				
36 - 45	(15 / 314 / 21)	(2 / 34 / 17)	(2 / 31 / 16)	(10 / 179 / 18)
45 - 54				
54 - 63				
63 - 72				
72 - 81				

	Date: 6-2-96	H_{m0}=9.1 cm T_P=1.5 s	N=1000 Time:1600 s	Remarks : Observation
Distance [cm]	Green stones / weight [g]	Red stones / weight [g]	Blue stones / weight [g]	Yellow stones / weight [g]
0 - 9	5	0	0	4
9 - 18	-	1	-	-
18 - 27		-		
27 - 36				
36 - 45				
45 - 54				
54 - 63				
63 - 72				
72 - 81				

	Date: 6-2-96	H_{m0}=9.1 cm T_P=1.5 s	N=2000 Time:3200 s	Remarks : Observation
Distance [cm]	Green stones / weight [g]	Red stones / weight [g]	Blue stones / weight [g]	Yellow stones / weight [g]
0 - 9	5	1	1	4
9 - 18	-	1	1	-
18 - 27		-	-	
27 - 36				
36 - 45				
45 - 54				
54 - 63				
63 - 72				
72 - 81				

	Date: 6-2-96	H_{m0}=9.1 cm T_P=1.5 s	N=3000 Time:4800 s	Remarks : Observation & weight
Distance [cm]	Green stones / weight [g]	Red stones / weight [g]	Blue stones / weight [g]	Yellow stones / weight [g]
0 - 9	6 / 136	1 / 15	1 / 17	10 / 191
9 - 18	1 / 22	2 / 54	1 / 19	-
18 - 27	0	-	-	
27 - 36	0			
36 - 45	1 / 20			
45 - 54	-			
54 - 63				
63 - 72	(8 / 178 / 22)	(3 / 69 / 23)	(2 / 36 / 18)	(10 / 191 / 19)
72 - 81				

	Date: 7-2-96	H_{m0}=9.6 cm T_P=1.6 s	N=500 Time:850 s	Remarks : Observation
Distance [cm]	Green stones / weight [g]	Red stones / weight [g]	Blue stones / weight [g]	Yellow stones / weight [g]
0 - 9	3	0	3	3
9 - 18	-	-	1	1
18 - 27			-	-
27 - 36				
36 - 45				
45 - 54				
54 - 63				
63 - 72				
72 - 81				

	Date: 7-2-96	H_{m0}=9.6 cm T_P=1.6 s	N=1000 Time:1700 s	Remarks : Observation
Distance [cm]	Green stones / weight [g]	Red stones / weight [g]	Blue stones / weight [g]	Yellow stones / weight [g]
0 - 9	4	0	5	5
9 - 18	-	-	2	1
18 - 27			-	-
27 - 36				
36 - 45				
45 - 54				
54 - 63				
63 - 72				
72 - 81				

	Date: 7-2-96	H_{m0}=9.6 cm T_P=1.6 s	N=2000 Time:3400 s	Remarks : Observation
Distance [cm]	Green stones / weight [g]	Red stones / weight [g]	Blue stones / weight [g]	Yellow stones / weight [g]
0 - 9	5	0	5	11
9 - 18	1	-	2	4
18 - 27	-		-	-
27 - 36				
36 - 45				
45 - 54				
54 - 63				
63 - 72				
72 - 81				

	Date: 7-2-96	H_{m0}=9.6 cm T_P=1.6 s	N=3000 Time:5100 s	Remarks : Observation & weight
Distance [cm]	Green stones / weight [g]	Red stones / weight [g]	Blue stones / weight [g]	Yellow stones / weight [g]
0 - 9	8 / 109	1 / 15	7 / 106	16 / 237
9 - 18	1 / 25	-	2 / 34	3 / 60
18 - 27	-		-	1 / 14
27 - 36				-
36 - 45	(9 / 134 / 15)	(1 / 15 / 15)	(9 / 140 / 16)	(20 / 311 / 16)
45 - 54				
54 - 63				
63 - 72				
72 - 81				

	Date: 8-2-96	H_{m0}=9.6 cm T_P=1.6 s	N=500 Time:850 s	Remarks : Observation
Distance [cm]	Green stones / weight [g]	Red stones / weight [g]	Blue stones / weight [g]	Yellow stones / weight [g]
0 - 9	5	2	8	7
9 - 18	-	1	1	2
18 - 27		-	-	1
27 - 36				0
36 - 45				1
45 - 54				-
54 - 63				
63 - 72				
72 - 81				

	Date: 8-2-96	H_{m0}=9.6 cm T_P=1.6 s	N=1000 Time:1700 s	Remarks : Observation
Distance [cm]	Green stones / weight [g]	Red stones / weight [g]	Blue stones / weight [g]	Yellow stones / weight [g]
0 - 9	7	2	9	9
9 - 18	-	1	1	1
18 - 27		-	-	2
27 - 36				0
36 - 45				1
45 - 54				-
54 - 63				
63 - 72				
72 - 81				

	Date: 8-2-96	H_{m0}=9.6 cm T_P=1.6 s	N=2000 Time:3400 s	Remarks : Observation
Distance [cm]	Green stones / weight [g]	Red stones / weight [g]	Blue stones / weight [g]	Yellow stones / weight [g]
0 - 9	9	3	11	11
9 - 18	0	1	1	2
18 - 27	1	-	-	3
27 - 36	-			0
36 - 45				1
45 - 54				-
54 - 63				
63 - 72				
72 - 81				

	Date: 8-2-96	H_{m0}=9.6 cm T_P=1.6 s	N=3000 Time:5100 s	Remarks : Observation & weight
Distance [cm]	Green stones / weight [g]	Red stones / weight [g]	Blue stones / weight [g]	Yellow stones / weight [g]
0 - 9	9 / 128	4 / 74	13 / 243	14 / 239
9 - 18	0	1 / 29	0	2 / 32
18 - 27	0	-	1 / 22	4 / 55
27 - 36	1 / 18		-	1 / 18
36 - 45	-			0
45 - 54				1 / 15
54 - 63				-
63 - 72	(10 / 146 / 15)	(5 / 103 / 21)	(14 / 265 / 19)	(22 / 359 / 16)
72 - 81				

	Date:12-2-96	H_{m0}=9.9 cm T_P=1.7 s	N=500 Time:850 s	Remarks : Observation & weight
Distance [cm]	Green stones / weight [g]	Red stones / weight [g]	Blue stones / weight [g]	Yellow stones / weight [g]
0 - 9	9 / 165	4 / 115	5 / 80	10 / 159
9 - 18	4 / 89	2 / 43	4 / 68	5 / 96
18 - 27	5 / 79	-	4 / 64	4 / 63
27 - 36	1 / 17		1 / 17	1 / 12
36 - 45	-		-	-
45 - 54	(19 / 350 / 18)	(6 / 158 / 26)	(14 / 229 / 16)	(20 / 330 / 17)
54 - 63				
63 - 72				
72 - 81				

	Date:12-2-96	H_{m0}=9.9 cm T_P=1.7 s	N=600 Time:1020 s	Remarks : Observation & weight
Distance [cm]	Green stones / weight [g]	Red stones / weight [g]	Blue stones / weight [g]	Yellow stones / weight [g]
0 - 9	6 / 114	1 / 29	3 / 49	6 / 99
9 - 18	5 / 95	1 / 26	2 / 34	3 / 51
18 - 27	1 / 14	-	1 / 21	1 / 13
27 - 36	-		-	-
36 - 45	(12 / 223 / 19)	(2 / 55 / 28)	(6 / 104 / 17)	(10 / 163 / 16)
45 - 54				
54 - 63				
63 - 72				
72 - 81				

Transport data - non-coloured stones

	Date: 12-2-96		N=2000 Time: 3400 s
Distance [cm]	Berm stones / tot. weight [g] / aver. weight [g]	Berm stones / tot. weight [g] / aver. weight [g]	Berm stones / tot. weight [g] / aver. weight [g]
0 - 9	121 / 1320 / 11	117 / 1193 / 10	156 / 1370 / 9
9 - 18	60 / 745 / 12	61 / 824 / 14	60 / 801 / 13
18 - 27	57 / 804 / 14	25 / 395 / 16	45 / 528 / 12
27 - 36	14 / 221 / 16	8 / 56 / 13	13 / 160 / 12
36 - 45	7 / 102 / 15	0	5 / 75 / 15
45 - 54	6 / 95 / 16	2 / 23 / 12	5 / 61 / 12
54 - 63	3 / 42 / 14	1 / 14 / 14	0
63 - 72	-	-	2 / 22 / 10
72 - 81	(268/3329/12.4)	(214/2505/11.7)	(286/3017/10.5)
H_{m0} [cm] T_P [s] s [-]	9.5 1.6 0.038	9.5 1.7 0.041	9.5 1.6 0.038

LONGSHORE TRANSPORT DURING RESHAPING

Transport data - coloured stones

	Date:26-1-96	H_{m0}=8.1 cm T_P=1.4 s	N=500 Time:700 s	
Distance [cm]	Green stones	Red stones	Blue stones	Yellow stones
0 - 9	3	0	2	6
9 - 18	-	-	-	4
18 - 27				-
27 - 36	(3)	(0)	(2)	(10)
36 - 45				
45 - 54				
54 - 63				
63 - 72				
72 - 81				

	Date:26-1-96	H_{m0}=8.1 cm T_P=1.4 s	N=1000 Time:1400 s	
Distance [cm]	Green stones	Red stones	Blue stones	Yellow stones
0 - 9	4	0	3	13
9 - 18	-	-	1	5
18 - 27			-	2
27 - 36				1
36 - 45				-
45 - 54	(4)	(0)	(4)	(21)
54 - 63				
63 - 72				
72 - 81				

	Date:26-1-96	H_{m0}=8.1 cm T_P=1.4 s	N=2000 Time:2800 s	
Distance [cm]	Green stones	Red stones	Blue stones	Yellow stones
0 - 9	4	0	5	18
9 - 18	-	1	5	9
18 - 27		-	-	1
27 - 36				4
36 - 45				1
45 - 54				-
54 - 63	(4)	(1)	(10)	(33)
63 - 72				
72 - 81				

	Date:26-1-96	H_{m0}=8.1 cm T_P=1.4 s	N=3000 Time:4200 s	
Distance [cm]	Green stones	Red stones	Blue stones	Yellow stones
0 - 9	9	0	8	26
9 - 18	1	1	4	10
18 - 27	-	-	1	4
27 - 36			-	6
36 - 45				5
45 - 54				3
54 - 63				1
63 - 72				-
72 - 81	(10)	(1)	(13)	(55)

Date: 2-3-96	H_{m0}=9.3 cm T_P=1.5 s	N=500 Time:800 s		
Distance [cm]	Green stones	Red stones	Blue stones	Yellow stones
0 - 9	3	4	2	3
9 - 18	1	1	-	-
18 - 27	-	1		
27 - 36		-		
36 - 45	(4)	(6)	(2)	(3)
45 - 54				
54 - 63				
63 - 72				
72 - 81				

Date: 2-3-96	H_{m0}=9.3 cm T_P=1.5 s	N=1000 Time:1600 s		
Distance [cm]	Green stones	Red stones	Blue stones	Yellow stones
0 - 9	4	8	3	3
9 - 18	1	2	-	-
18 - 27	-	1		
27 - 36		-		
36 - 45	(5)	(11)	(3)	(3)
45 - 54				
54 - 63				
63 - 72				
72 - 81				

Date: 2-3-96	H_{m0}=9.3 cm T_P=1.5 s	N=2000 Time:3200 s		
Distance [cm]	Green stones	Red stones	Blue stones	Yellow stones
0 - 9	9	9	3	5
9 - 18	2	4	-	-
18 - 27	-	3		-
27 - 36		-		
36 - 45	(11)	(16)	(3)	(5)
45 - 54				
54 - 63				
63 - 72				
72 - 81				

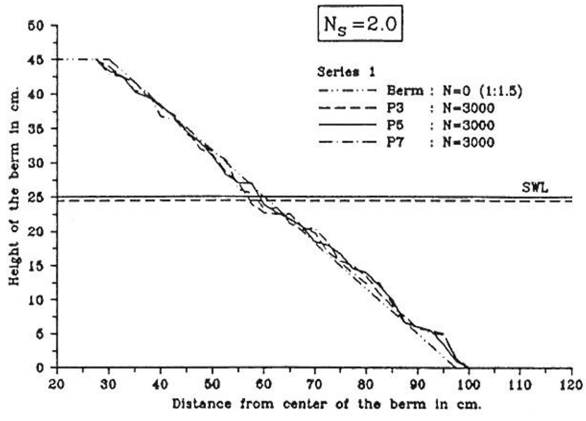
Date: 2-3-96	H_{m0}=9.3 cm T_P=1.5 s	N=3000 Time:4800 s		
Distance [cm]	Green stones	Red stones	Blue stones	Yellow stones
0 - 9	13	11	6	4
9 - 18	2	5	1	1
18 - 27	-	3	-	-
27 - 36		-		
36 - 45	(15)	(19)	(7)	(5)
45 - 54				
54 - 63				
63 - 72				
72 - 81				

Date: 6-3-96	H_{m0}=9.8 cm T_P=1.6 s	N=500 Time:850 s		
Distance [cm]	Green stones	Red stones	Blue stones	Yellow stones
0 - 9	5	1	1	7
9 - 18	6	1	-	3
18 - 27	1	-		-
27 - 36	-			
36 - 45	(12)	(2)	(1)	(10)
45 - 54				
54 - 63				
63 - 72				
72 - 81				

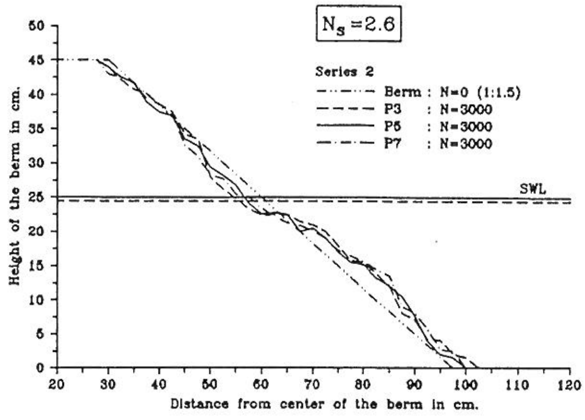
Date: 6-3-96	H_{m0}=9.8 cm T_P=1.6 s	N=1000 Time:1700 s		
Distance [cm]	Green stones	Red stones	Blue stones	Yellow stones
0 - 9	6	1	1	9
9 - 18	6	1	-	1
18 - 27	1	-		4
27 - 36	-			-
36 - 45	(13)	(2)	(1)	(14)
45 - 54				
54 - 63				
63 - 72				
72 - 81				

	Date: 6-3-96	H_{m0}=9.8 cm T_P=1.6 s	N=2000 Time:3400	
Distance [cm]	Green stones	Red stones	Blue stones	Yellow stones
0 - 9	8	1	3	8
9 - 18	6	1	-	2
18 - 27	1	-		3
27 - 36	-			1
36 - 45				-
45 - 54	(15)	(2)	(3)	(14)
54 - 63				
63 - 72				
72 - 81				

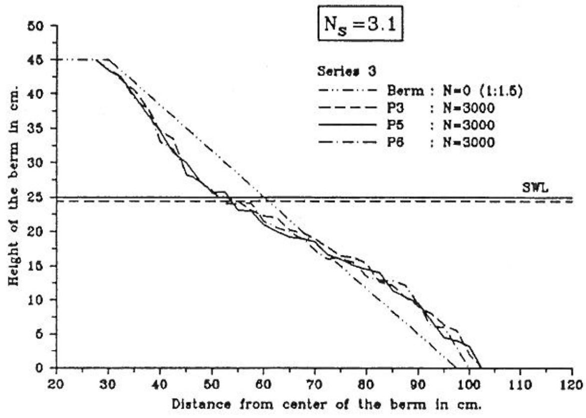
	Date: 6-3-96	H_{m0}=9.8 cm T_P=1.6 s	N=3000 Time:5100	
Distance [cm]	Green stones	Red stones	Blue stones	Yellow stones
0 - 9	10	1	3	10
9 - 18	5	1	1	4
18 - 27	2	1	1	2
27 - 36	-	-	-	2
36 - 45				-
45 - 54	(17)	(3)	(5)	(18)
54 - 63				
63 - 72				
72 - 81				



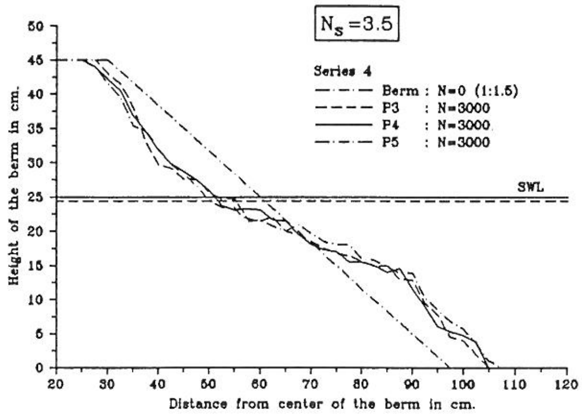
$N_s = 2.0$
Series 1
Berm : N=0 (1:1.5)
P3 : N=3000
P5 : N=3000
P7 : N=3000
SWL
Height of the berm in cm.
Distance from center of the berm in cm.



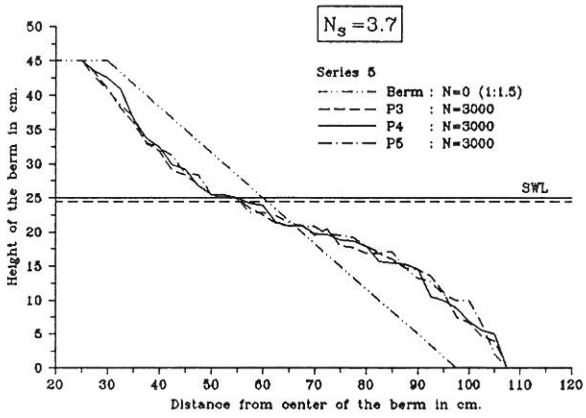
$N_s = 2.6$
Series 2
Berm : N=0 (1:1.5)
P3 : N=3000
P5 : N=3000
P7 : N=3000
SWL
Height of the berm in cm.
Distance from center of the berm in cm.



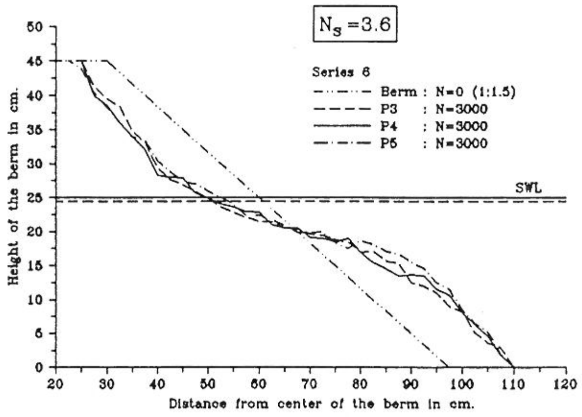
$N_s = 3.1$
Series 3
Berm : N=0 (1:1.5)
P3 : N=3000
P5 : N=3000
P6 : N=3000
SWL
Height of the berm in cm.
Distance from center of the berm in cm.



$N_s = 3.5$
Series 4
Berm : N=0 (1:1.5)
P3 : N=3000
P4 : N=3000
P5 : N=3000
SWL
Height of the berm in cm.
Distance from center of the berm in cm.



$N_s = 3.7$
Series 5
Berm : N=0 (1:1.5)
P3 : N=3000
P4 : N=3000
P5 : N=3000
SWL
Height of the berm in cm.
Distance from center of the berm in cm.



$N_s = 3.6$
Series 6
Berm : N=0 (1:1.5)
P3 : N=3000
P4 : N=3000
P5 : N=3000
SWL
Height of the berm in cm.
Distance from center of the berm in cm.

PROFILE DATA - BERM BREAKWATER TESTS 96'

PROFILE 1		N_s = 2.0		DATE:18-1-96		
Distance from center [cm]	Position P3 : 1.0 m [cm]	Kote [cm]	Position P5 : 1.5 m [cm]	Kote [cm]	Position P7 : 2.5 m [cm]	Kote [cm]
20.0	-	-	-	-	-	-
22.5	-	-	-	-	-	-
25.0	-	-	-	-	-	-
27.5	0.5	45.0	0.5	45.0	0.5	45.0
30.0	1.5	44.0	2.1	43.4	2.6	42.9
32.5	3.0	42.5	2.9	42.6	3.0	42.5
35.0	3.8	41.7	5.2	40.3	5.0	40.5
37.5	5.9	39.6	6.0	39.5	5.3	40.2
40.0	7.5	38.0	7.1	38.4	8.8	36.7
42.5	8.5	37.0	8.9	36.6	9.2	36.3
45.0	11.0	34.5	11.0	24.5	11.4	34.1
47.5	13.5	32.0	12.5	33.0	12.7	32.8
50.0	14.4	31.1	14.7	30.8	14.0	31.5
52.5	16.9	28.6	17.3	28.2	15.1	30.4
55.0	18.6	26.9	18.5	27.0	19.5	26.0
57.5	21.5	24.0	18.5	27.0	20.0	25.5
60.0	22.8	22.7	21.6	23.9	22.3	23.2
62.5	23.0	22.5	22.8	22.7	22.1	23.4
65.0	23.0	22.5	23.8	21.7	24.4	21.1
67.5	24.8	20.7	24.8	20.7	25.2	20.3
70.0	25.7	19.8	27.0	18.5	25.0	20.5
72.5	28.5	17.0	27.5	18.0	27.0	18.5
75.0	29.8	15.7	28.8	16.7	30.0	15.5
77.5	30.5	15.0	31.0	14.5	31.6	13.9
80.0	32.0	13.5	31.5	14.0	33.1	12.4
82.5	34.5	11.0	33.5	12.0	33.0	12.5
85.0	36.5	9.0	35.5	10.0	36.0	9.5
87.5	38.0	7.5	38.8	6.7	39.0	6.5
90.0	39.7	5.8	39.5	6.0	39.5	6.0
92.5	40.0	5.5	40.0	5.5	40.4	5.1
95.0	40.5	5.0	42.0	3.5	40.6	4.9
97.5	44.1	1.4	44.5	1.0	44.2	1.3
100.0	45.5	0.0	45.5	0.0	45.5	0.0
102.5	-	-	-	-	-	-
105.0	-	-	-	-	-	-
107.5	-	-	-	-	-	-

110.0	-	-	-	-	-	-

PROFILE 2		N_s = 2.6		DATE:22-1-96		
Distance from center [cm]	Position P3 : 1.0 m [cm]	Kote [cm]	Position P5 : 1.5 m [cm]	Kote [cm]	Position P7 : 2.5 m [cm]	Kote [cm]
20.0	-	-	-	-	-	-
22.5	-	-	-	-	-	-
25.0	-	-	-	-	-	-
27.5	0.5	45.0	0.5	45.0	0.5	45.0
30.0	1.6	43.9	1.5	44.0	2.6	43.0
32.5	3.4	42.1	3.0	42.5	3.0	42.5
35.0	4.8	40.7	3.8	41.7	5.0	41.7
37.5	5.4	40.1	6.6	38.9	5.3	39.4
40.0	6.9	38.6	8.0	37.5	8.8	38.6
42.5	8.0	37.5	8.6	36.9	9.2	37.0
45.0	11.3	34.2	12.0	33.5	11.4	32.6
47.5	12.0	33.5	13.0	32.5	12.7	31.0
50.0	17.5	28.0	16.1	29.4	14.0	28.2
52.5	19.3	26.2	17.3	28.2	15.1	27.7
55.0	20.7	24.8	18.7	26.8	19.5	25.5
57.5	22.1	23.4	21.3	24.2	20.0	25.1
60.0	23.1	22.4	22.9	22.6	22.3	23.4
62.5	23.0	22.5	22.7	22.8	22.1	22.4
65.0	23.0	22.5	23.0	22.5	24.4	21.3
67.5	24.0	21.5	25.4	20.1	25.2	20.9
70.0	24.5	21.0	25.0	20.5	25.0	20.1
72.5	25.4	20.1	26.4	19.1	27.0	19.0
75.0	27.6	17.9	28.5	17.0	30.0	17.3
77.5	29.7	15.8	30.0	15.5	31.6	16.4
80.0	30.0	15.5	30.3	15.2	33.1	15.6
82.5	31.6	13.9	32.3	13.2	33.0	14.5
85.0	33.5	12.0	33.4	12.1	36.0	13.5
87.5	37.4	8.1	35.0	10.5	39.0	9.0
90.0	38.4	7.1	37.8	7.7	39.5	8.1
92.5	41.3	4.2	41.5	4.0	40.4	5.7
95.0	41.4	4.1	43.5	2.0	40.6	2.7
97.5	43.5	2.0	44.0	1.5	44.2	2.5
100.0	44.0	1.5	45.5	0.0	45.5	0.0
102.5	45.5	0.0	-	-	-	-
105.0	-	-	-	-	-	-
107.5	-	-	-	-	-	-
110.0	-	-	-	-	-	-

PROFILE 3		N_s = 3.1		DATE:29-1-96		
Distance from center [cm]	Position P3 : 1.0 m [cm]	Kote [cm]	Position P5 : 1.5 m [cm]	Kote [cm]	Position P7 : 2.0 m [cm]	Kote [cm]
20.0	-	-	-	-	-	-
22.5	-	-	-	-	-	-
25.0	-	-	-	-	-	-
27.5	0.5	45.0	0.5	45.0	0.5	45.0
30.0	2.0	43.5	2.3	43.2	1.9	43.6
32.5	3.5	42.0	3.1	42.4	3.0	42.5
35.0	5.0	40.5	5.8	39.7	6.4	39.1
37.5	7.5	38.0	8.5	37.0	7.5	38.0
40.0	10.9	34.6	11.0	34.5	12.5	33.0
42.5	12.0	33.5	14.1	31.4	13.5	32.0
45.0	17.2	28.3	15.5	30.0	17.0	28.5
47.5	18.0	27.5	18.0	27.5	18.2	27.3
50.0	20.0	25.5	19.8	25.7	19.5	26.0
52.5	20.5	25.0	19.8	25.7	21.5	24.0
55.0	21.2	24.3	22.4	23.1	21.4	24.1
57.5	22.4	23.1	22.5	23.0	21.4	24.1
60.0	23.2	22.3	24.5	21.0	24.0	21.5
62.5	23.5	22.0	25.5	20.0	24.9	20.6
65.0	25.3	20.2	26.3	19.2	25.5	20.0
67.5	25.7	19.8	26.5	19.0	26.5	19.0
70.0	26.5	19.0	27.0	18.5	28.2	17.3
72.5	27.8	17.7	28.9	16.6	29.5	16.0
75.0	29.0	16.5	29.5	16.0	19.4	16.1
77.5	29.3	16.2	30.4	15.1	30.0	15.5
80.0	30.1	15.4	31.0	14.5	32.0	13.5
82.5	32.9	12.6	31.5	14.0	32.6	12.9
85.0	33.3	12.2	34.1	11.4	32.7	12.8
87.5	35.1	10.4	35.0	10.5	33.3	12.2
90.0	36.5	9.0	36.0	9.5	26.1	9.4
92.5	37.5	8.0	38.5	7.0	39.4	6.1
95.0	39.2	6.3	41.0	4.5	39.5	6.0
97.5	40.0	5.5	41.5	4.0	42.5	3.0
100.0	43.5	2.0	42.3	3.2	45.5	0.0
102.5	45.5	0.0	45.5	0.0	-	-
105.0	-	-	-	-	-	-
107.5	-	-	-	-	-	-
110.0	-	-	-	-	-	-

PROFILE 4			N_s = 3.5		DATE: 2-2-96	
Distance from center [cm]	Position P3 : 1.0 m [cm]	Kote [cm]	Position P4 : 1.25 m [cm]	Kote [cm]	Position P5 : 1.5 m [cm]	Kote [cm]
20.0	-	-	-	-	-	-
22.5	-	-	-	-	-	-
25.0	-	-	0.5	45.0	0.5	45.0
27.5	0.5	45.0	1.5	44.0	1.5	44.0
30.0	2.5	43.0	3.4	42.2	3.9	41.6
32.5	4.0	41.5	5.0	40.5	6.0	39.5
35.0	7.4	38.1	8.7	36.8	10.1	35.4
37.5	12.5	33.0	11.0	34.5	10.9	34.6
40.0	15.8	29.7	13.7	31.8	13.5	32.0
42.5	16.3	29.2	15.7	29.8	15.8	29.7
45.0	17.9	27.6	16.8	28.7	17.1	28.4
47.5	18.0	27.5	18.0	27.5	18.9	26.6
50.0	19.9	25.6	19.5	26.0	20.9	24.6
52.5	20.8	24.7	21.7	23.8	22.0	23.5
55.0	20.7	24.8	22.4	23.1	22.0	23.5
57.5	23.6	21.9	22.2	23.3	24.0	21.5
60.0	24.0	21.5	22.4	23.1	23.9	21.6
62.5	23.4	22.1	23.8	21.7	24.7	20.8
65.0	25.5	20.0	24.0	21.5	25.5	20.0
67.5	26.0	19.5	26.0	19.5	24.5	21.0
70.0	27.0	18.5	27.4	18.1	25.8	19.7
72.5	28.0	17.5	28.2	17.3	27.0	18.5
75.0	28.7	16.8	28.5	17.0	27.4	18.1
77.5	29.1	16.4	30.0	15.5	27.5	18.0
80.0	29.9	15.6	30.0	15.5	29.5	16.0
82.5	30.5	15.0	30.4	15.1	29.7	15.8
85.0	30.5	15.0	31.5	14.0	30.7	14.8
87.5	32.5	13.0	31.2	14.3	31.6	13.9
90.0	32.6	12.9	33.9	11.6	31.6	13.9
92.5	36.0	9.5	36.5	9.0	35.2	10.3
95.0	37.7	7.8	39.4	6.1	37.0	8.5
97.5	41.0	4.5	40.2	5.3	38.7	6.8
100.0	41.5	4.0	40.7	4.8	39.8	5.7
102.5	42.5	3.0	41.7	3.8	42.0	3.5
105.0	43.5	2.0	45.5	0.0	44.5	1.0
107.5	45.5	0.0	-	-	45.5	0.0
110.0	-	-	-	-	-	-

PROFILE 5			N_s = 3.7		DATE: 6-2-96	
Distance from center [cm]	Position P3 : 1.0 m [cm]	Kote [cm]	Position P4 : 1.25 m [cm]	Kote [cm]	Position P5 : 1.5 m [cm]	Kote [cm]
20.0	-	-	-	-	-	-
22.5	-	-	-	-	-	-
25.0	0.5	45.0	0.5	45.0	0.5	45.0
27.5	2.2	43.3	1.9	43.6	2.8	42.7
30.0	4.5	41.0	3.0	42.5	4.8	40.7
32.5	7.3	38.2	4.6	40.9	6.8	38.7
35.0	9.4	36.1	8.9	36.6	8.7	36.8
37.5	12.5	33.0	11.7	33.8	12.3	33.2
40.0	13.3	31.9	13.0	32.5	13.1	32.4
42.5	16.4	29.1	15.6	29.9	14.2	31.3
45.0	17.1	28.4	16.3	29.2	16.9	28.6
47.5	18.6	26.9	18.7	26.8	17.1	28.4
50.0	20.0	25.5	20.0	25.5	20.1	25.4
52.5	20.3	25.2	20.0	25.5	20.3	25.2
55.0	20.6	24.9	20.5	25.0	20.8	24.7
57.5	22.0	23.5	21.3	24.2	22.6	22.9
60.0	23.0	22.5	21.6	23.9	22.6	22.9
62.5	24.2	21.3	24.0	21.5	23.1	22.4
65.0	24.6	20.9	24.7	20.8	24.2	21.3
67.5	24.6	20.9	24.5	21.0	24.6	20.9
70.0	26.0	19.5	25.7	19.8	24.7	20.8
72.5	25.1	20.4	25.9	19.6	25.8	19.7
75.0	27.5	18.0	26.7	18.8	26.0	19.5
77.5	27.8	17.7	26.8	18.7	26.3	19.2
80.0	28.6	16.9	27.6	17.9	27.6	17.9
82.5	28.6	16.9	29.8	15.7	28.5	17.0
85.0	29.5	16.0	30.0	15.5	28.4	17.1
87.5	30.8	14.7	30.2	15.3	30.7	14.8
90.0	31.0	14.5	31.0	14.5	32.3	13.2
92.5	32.0	13.5	35.0	10.5	32.8	12.7
95.0	34.3	11.2	35.5	10.0	34.7	10.8
97.5	38.0	7.5	36.7	8.8	35.5	10.0
100.0	38.9	6.6	38.6	6.9	35.6	9.9
102.5	40.8	4.7	39.9	5.6	39.0	6.5
105.0	41.5	4.0	40.5	5.0	43.4	2.1
107.5	45.5	0.0	45.5	0.0	45.5	0.0
110.0	-	-	-	-	-	-

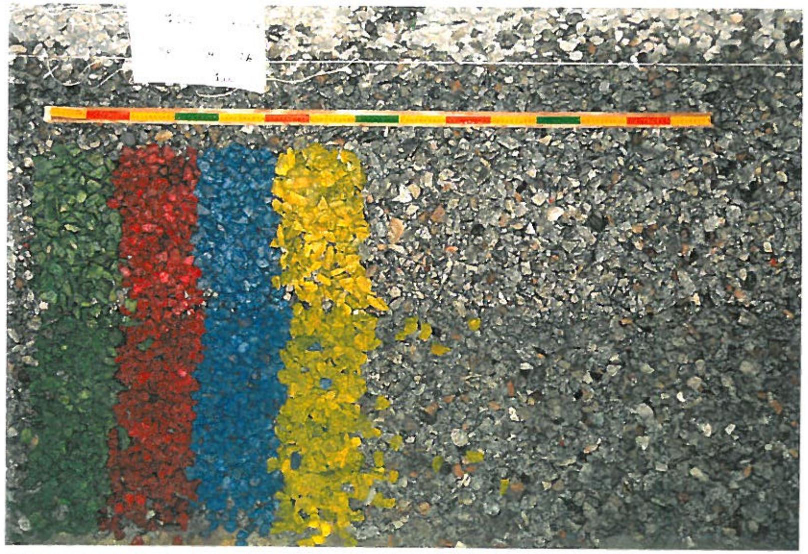
PROFILE 6			N_s = 3.6	DATE: 8-2-96		
Distance from center [cm]	Position P3 : 1.0 m [cm]	Kote [cm]	Position P4 : 1.25 m [cm]	Kote [cm]	Position P5 : 1.5 m [cm]	Kote [cm]
20.0	-	-	-	-	-	-
22.5	-	-	-	-	0.5	45.0
25.0	0.5	45.0	0.5	45.0	1.5	44.0
27.5	4.3	41.2	5.6	39.9	5.1	40.4
30.0	6.0	39.5	6.9	38.6	7.3	38.2
32.5	7.1	38.4	9.4	36.1	9.4	36.1
35.0	10.7	34.8	11.5	34.0	11.6	33.9
37.5	12.4	33.1	13.4	32.1	12.1	33.4
40.0	16.1	29.4	17.2	28.3	15.0	30.5
42.5	17.9	27.6	17.5	28.0	16.7	28.8
45.0	18.6	26.9	17.6	27.9	18.1	27.4
47.5	19.6	25.9	19.8	25.7	18.5	27.0
50.0	20.6	24.9	20.6	24.9	19.5	26.0
52.5	21.9	23.6	21.4	24.1	20.5	25.0
55.0	22.7	22.8	21.9	23.6	21.5	24.0
57.5	23.4	22.1	22.5	23.0	23.1	22.4
60.0	24.0	21.5	22.6	22.9	23.1	22.4
62.5	24.0	21.5	24.5	21.0	23.8	21.7
65.0	25.0	20.5	25.0	20.5	24.6	20.9
67.5	25.1	20.4	25.0	20.5	25.6	19.9
70.0	25.8	19.7	26.4	19.1	25.6	19.9
72.5	26.0	19.5	26.5	19.0	25.5	20.0
75.0	26.7	18.8	27.0	18.5	27.1	18.4
77.5	27.0	18.5	26.5	19.0	28.0	17.5
80.0	28.5	17.0	28.5	17.0	26.8	18.7
82.5	28.4	17.1	30.0	15.5	27.4	18.1
85.0	29.8	15.7	31.0	14.5	28.4	17.1
87.5	30.1	15.4	32.0	13.5	28.8	16.7
90.0	33.0	12.5	31.8	13.7	30.0	15.5
92.5	33.5	12.0	32.0	13.5	30.9	14.6
95.0	34.5	11.0	34.0	11.5	33.0	12.5
97.5	36.5	9.0	34.8	10.7	34.0	11.5
100.0	37.3	8.2	37.4	8.1	37.0	8.5
102.5	40.4	5.1	39.2	6.3	39.0	6.5
105.0	41.9	3.6	40.9	4.6	40.3	5.2
107.5	42.6	2.9	43.7	1.8	43.5	2.0
110.0	45.5	0.0	45.5	0.0	45.5	0.0

PROFILE 2		N_s = 2.6		DATE:22-1-96		
Distance from center [cm]	Profile at 45° (P8)	Kote [cm]	Profile at 90° (P9)	Kote [cm]		
0.0	-	-	-	-		
2.5	-	-	-	-		
5.0	-	-	-	-		
7.5	-	-	-	-		
10.0	-	-	-	-		
12.5	-	-	-	-		
15.0	-	-	-	-	8.7	36.8
17.5	-	-	-	-	12.3	33.2
20.0	-	-	-	-	13.1	32.4
22.5	-	-	-	-	14.2	31.3
25.0	-	-	-	-	16.9	28.6
27.5	-	-	-	-	17.1	28.4
30.0	0.5	45.0	0.5	45.0	20.1	25.4
32.5	3.4	42.1	4.3	41.2	20.3	25.2
35.0	4.5	41.0	5.0	40.5	20.8	24.7
37.5	6.1	39.4	7.4	38.1	22.6	22.9
40.0	8.8	36.7	8.0	37.5	22.6	22.9
42.5	12.4	33.1	10.5	35.0	23.1	22.4
45.0	14.0	31.5	12.0	33.5	24.2	21.3
47.5	15.1	30.4	13.8	31.7	24.6	20.9
50.0	17.1	28.4	17.0	28.5	24.7	20.8
52.5	19.8	25.7	19.2	26.3	25.8	19.7
55.0	20.8	24.7	20.8	24.7	26.0	19.5
57.5	23.0	22.5	21.5	24.0	26.3	19.2
60.0	24.0	21.5	22.9	22.6	27.6	17.9
62.5	24.5	21.0	23.9	21.6	28.5	17.0
65.0	25.0	20.5	23.6	21.9	28.4	17.1
67.5	26.3	19.2	23.8	21.7	30.7	14.8
70.0	28.5	17.0	27.1	18.4	32.3	13.2
72.5	29.3	16.2	29.8	15.7	32.8	12.7
75.0	31.5	14.0	31.2	14.3	34.7	10.8
77.5	33.0	12.5	33.0	12.5	35.5	10.0
80.0	35.6	9.9	35.2	10.3	35.6	9.9
82.5	36.5	9.0	35.6	9.9	39.0	6.5
85.0	39.8	5.7	39.4	6.1	43.4	2.1
87.5	41.0	4.5	41.4	4.1	45.5	0.0
90.0	41.8	3.7	42.5	3.0	-	-
92.5	42.7	2.8	43.5	2.0		
95.0	44.0	1.5	45.5	0.0		
97.5	45.5	0.0	-	-		
100.0	-	-	-	-		

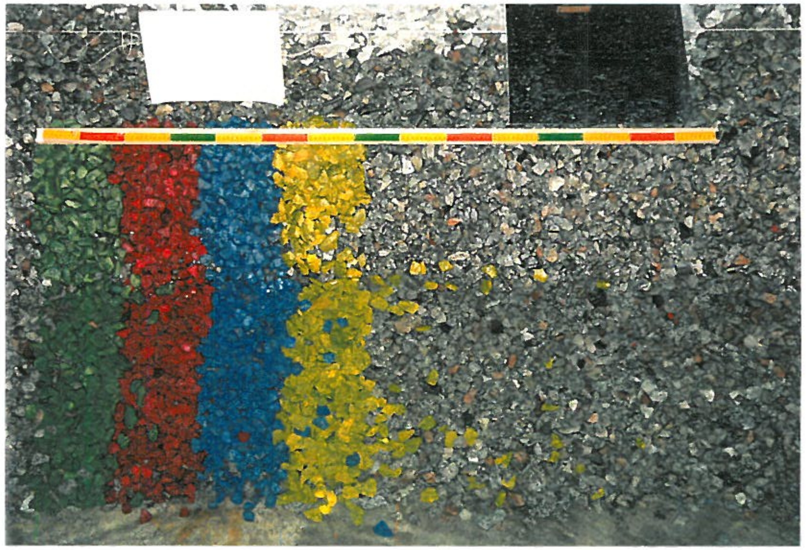
PROFILE 3		N_s = 3.1		DATE:29-1-96		
Distance from center [cm]	Profile at 45° (P8)	Kote [cm]	Profile at 90° (P9)	Kote [cm]		
0.0	-	-	-	-		
2.5	-	-	-	-		
5.0	-	-	-	-		
7.5	-	-	-	-		
10.0	-	-	-	-		
12.5	-	-	-	-		
15.0	-	-	-	-	8.7	36.8
17.5	-	-	-	-	12.3	33.2
20.0	-	-	-	-	13.1	32.4
22.5	0.5	45.0	-	-	14.2	31.3
25.0	2.5	43.0	-	-	16.9	28.6
27.5	6.0	39.5	-	-	17.1	28.4
30.0	7.0	38.5	0.5	45.0	20.1	25.4
32.5	9.8	35.7	4.0	41.5	20.3	25.2
35.0	12.0	38.5	5.5	40.0	20.8	24.7
37.5	12.5	33.0	9.0	36.5	22.6	22.9
40.0	14.4	31.1	12.0	33.5	22.6	22.9
42.5	18.0	27.5	15.5	30.0	23.1	22.4
45.0	18.4	27.1	16.8	28.7	24.2	21.3
47.5	20.5	25.0	18.5	27.0	24.6	20.9
50.0	21.8	23.7	19.6	25.9	24.7	20.8
52.5	23.2	22.3	22.8	22.7	25.8	19.7
55.0	24.0	21.5	22.8	22.7	26.0	19.5
57.5	25.0	20.5	23.9	21.6	26.3	19.2
60.0	26.0	19.5	24.0	21.5	27.6	17.9
62.5	26.1	19.4	24.0	21.5	28.5	17.0
65.0	25.4	20.1	24.7	20.8	28.4	17.1
67.5	26.5	19.0	24.6	20.9	30.7	14.8
70.0	27.7	17.8	26.5	19.0	32.3	13.2
72.5	28.4	17.1	27.5	18.0	32.8	12.7
75.0	29.4	16.1	28.2	17.3	34.7	10.8
77.5	30.3	15.2	28.0	17.5	35.5	10.0
80.0	34.3	11.2	32.5	13.0	35.6	9.9
82.5	35.4	10.1	34.5	11.0	39.0	6.5
85.0	38.2	7.3	37.8	7.7	43.4	2.1
87.5	40.1	5.4	40.1	5.4	45.5	0.0
90.0	40.0	5.5	40.5	5.0	-	-
92.5	43.0	2.5	43.0	2.5		
95.0	45.5	0.0	43.5	2.0		
97.5	-	-	45.5	0.0		
100.0	-	-	-	-		

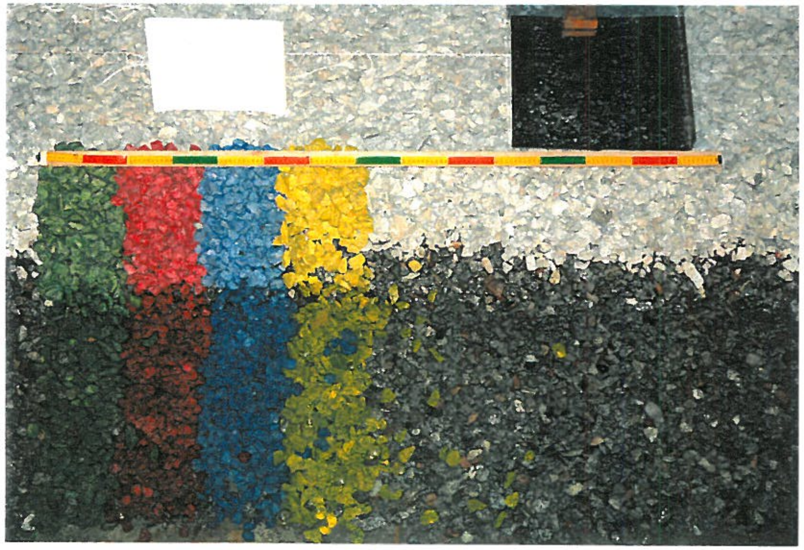
PROFILE 4		N_s = 3.5		DATE: 2-1-96		
Distance from center [cm]	Profile at 45° (P8)	Kote [cm]	Profile at 90° (P9)	Kote [cm]		
0.0	-	-	-	-		
2.5	-	-	-	-		
5.0	-	-	-	-		
7.5	-	-	-	-		
10.0	0.5	45.0	-	-		
12.5	1.0	44.5	-	-		
15.0	2.8	42.7	0.5	45.0	8.7	36.8
17.5	7.1	38.4	1.0	44.5	12.3	33.2
20.0	8.5	37.0	3.8	41.7	13.1	32.4
22.5	12.0	33.5	4.4	41.1	14.2	31.3
25.0	12.5	33.0	4.8	40.7	16.9	28.6
27.5	15.1	30.4	6.5	39.0	17.1	28.4
30.0	19.8	25.7	8.8	36.7	20.1	25.4
32.5	19.8	25.7	9.5	36.0	20.3	25.2
35.0	20.2	25.3	15.0	30.5	20.8	24.7
37.5	21.0	24.5	15.8	29.7	22.6	22.9
40.0	21.6	23.9	17.4	28.1	22.6	22.9
42.5	23.0	22.5	20.9	24.6	23.1	22.4
45.0	23.4	22.1	21.0	24.5	24.2	21.3
47.5	23.5	22.0	22.8	22.7	24.6	20.9
50.0	24.0	21.5	23.1	22.4	24.7	20.8
52.5	24.0	21.5	24.3	21.2	25.8	19.7
55.0	25.0	20.5	24.0	21.5	26.0	19.5
57.5	26.5	19.0	24.7	20.8	26.3	19.2
60.0	26.4	19.1	25.0	20.5	27.6	17.9
62.5	26.8	18.7	23.0	22.5	28.5	17.0
65.0	26.1	19.4	25.0	20.5	28.4	17.1
67.5	27.2	18.3	25.2	20.3	30.7	14.8
70.0	27.7	17.8	25.2	20.3	32.3	13.2
72.5	29.0	16.5	25.5	20.0	32.8	12.7
75.0	30.5	15.0	25.0	20.5	34.7	10.8
77.5	32.4	13.1	26.0	19.5	35.5	10.0
80.0	32.5	13.0	28.5	17.0	35.6	9.9
82.5	34.8	10.7	32.8	12.7	39.0	6.5
85.0	37.5	8.0	32.9	12.6	43.4	2.1
87.5	40.5	5.0	34.7	10.8	45.5	0.0
90.0	41.3	4.2	39.7	6.0	-	-
92.5	43.1	2.4	40.7	4.8		
95.0	45.5	0.0	41.5	4.0		
97.5	-	-	42.1	3.4		
100.0	-	-	45.5	0.0		

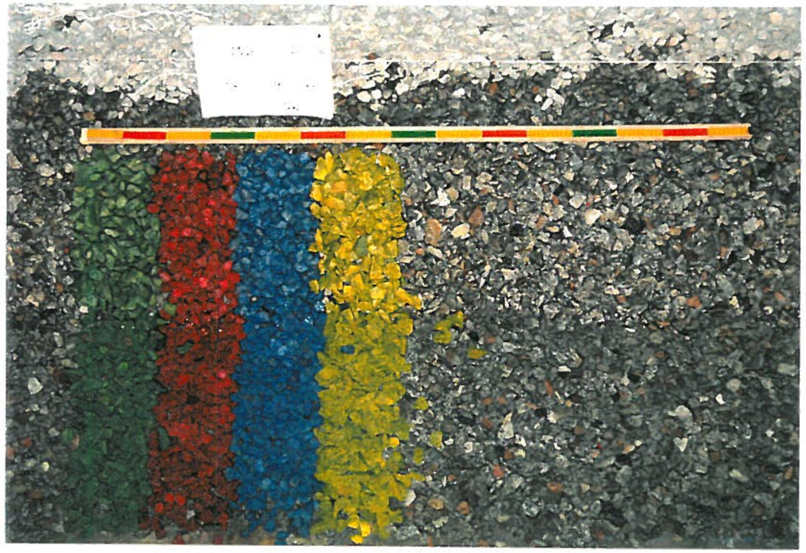
PROFILE 5		N_s = 3.7		DATE: 6-1-96		
Distance from center [cm]	Profile at 45° (P8)	Kote [cm]	Profile at 90° (P9)	Kote [cm]		
0.0	0.5	45.0	-	-		
2.5	1.9	43.6	-	-		
5.0	2.5	43.0	-	-		
7.5	4.7	40.8	-	-		
10.0	7.0	38.5	0.5	45.0		
12.5	10.0	35.5	5.4	40.1		
15.0	13.8	31.7	5.5	40.0	8.7	36.8
17.5	14.5	31.0	7.0	38.5	12.3	33.2
20.0	15.2	30.3	9.0	36.5	13.1	32.4
22.5	17.2	28.3	11.0	34.5	14.2	31.3
25.0	20.0	25.5	10.4	35.1	16.9	28.6
27.5	20.4	25.1	11.3	34.2	17.1	28.4
30.0	21.5	24.0	13.2	32.3	20.1	25.4
32.5	21.6	23.9	18.4	27.1	20.3	25.2
35.0	23.0	22.5	19.0	26.5	20.8	24.7
37.5	23.5	22.0	19.3	26.2	22.6	22.9
40.0	24.4	21.1	21.1	24.4	22.6	22.9
42.5	24.6	20.9	21.0	24.5	23.1	22.4
45.0	24.5	21.0	21.5	24.0	24.2	21.3
47.5	26.2	19.3	22.5	23.0	24.6	20.9
50.0	25.5	20.0	22.5	23.0	24.7	20.8
52.5	25.8	19.7	23.5	22.0	25.8	19.7
55.0	26.5	19.0	23.1	22.4	26.0	19.5
57.5	26.7	18.8	22.2	23.3	26.3	19.2
60.0	26.5	19.0	23.4	22.1	27.6	17.9
62.5	26.5	19.0	24.8	20.7	28.5	17.0
65.0	27.2	18.3	24.8	20.7	28.4	17.1
67.5	27.2	18.3	24.9	20.6	30.7	14.8
70.0	26.9	18.6	26.0	19.5	32.3	13.2
72.5	28.3	17.2	25.8	19.7	32.8	12.7
75.0	29.5	16.0	26.0	19.5	34.7	10.8
77.5	31.4	14.1	25.7	19.8	35.5	10.0
80.0	32.2	13.3	25.9	19.6	35.6	9.9
82.5	34.6	10.9	28.2	17.3	39.0	6.5
85.0	36.8	8.7	30.3	15.2	43.4	2.1
87.5	39.5	6.0	33.0	12.5	45.5	0.0
90.0	40.4	5.1	33.0	12.5	-	-
92.5	42.4	3.1	39.3	6.2		
95.0	45.5	0.0	41.2	4.3		
97.5	-	-	42.6	2.9		
100.0	-	-	45.5	0.0		

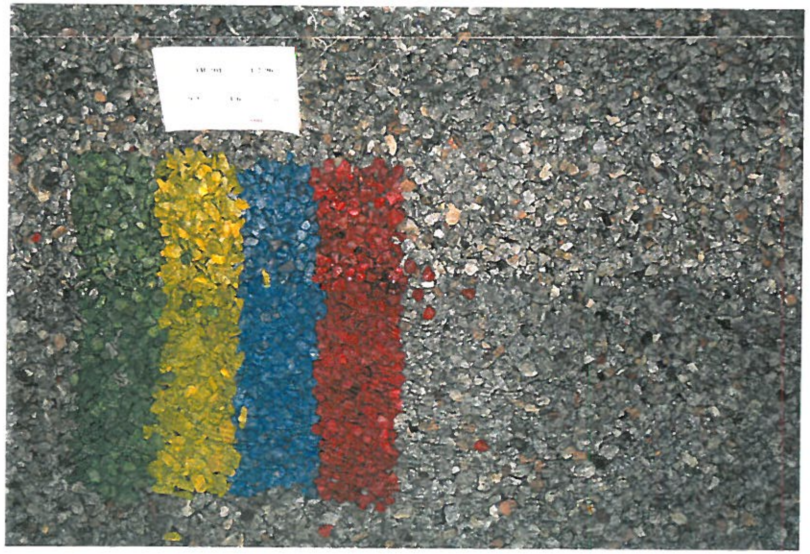


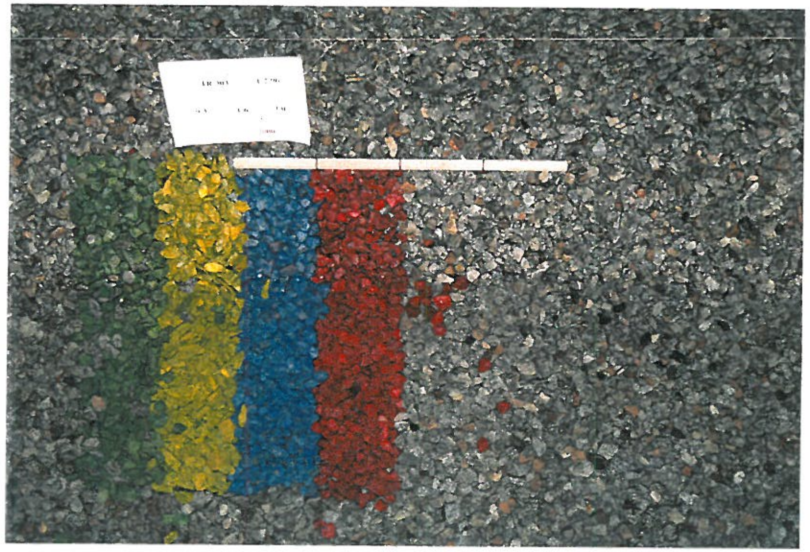
Transport during reshaping: Series 3, H_{m0} = 8,1cm, T_p = 1,4 sec.
N = 500, 1000, 2000 and 3000 waves.
The transport of the yellow stones is overestimated, thus no measurements were taken to deal with the meeting of the coloured and non-coloured stones.







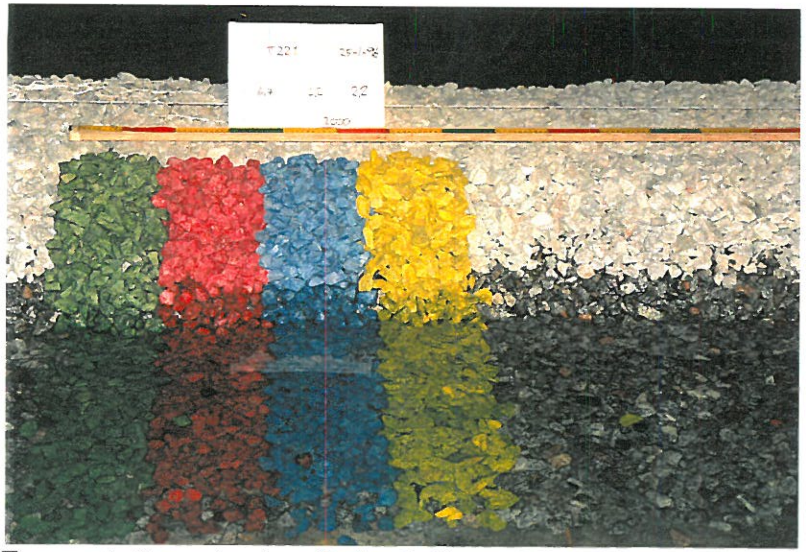




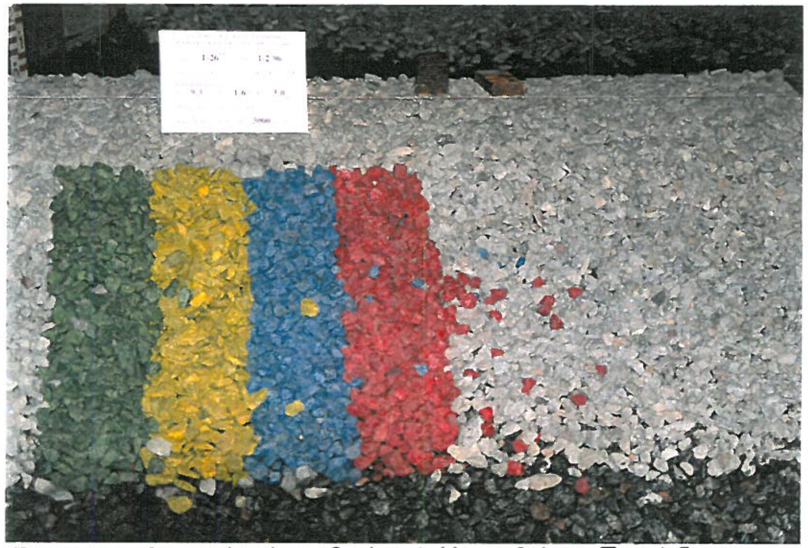
Transport during reshaping: Series 4, H_{m0} = 9,3 cm, T_p = 1,5 sec.
N = 500 and 2000 waves.
The red band is still not supported! This causes the red stones to move.

Transport during reshaping: Series 5, H_{m0} = 9,8cm, T_p = 1,6 sec.
N = 3000 waves.
Now, the red band has been supported with a 25cm wide band of non-coloured stones (to the right of the red band). Notice, no movement in the red band!

Rearranging of the coloured bands.

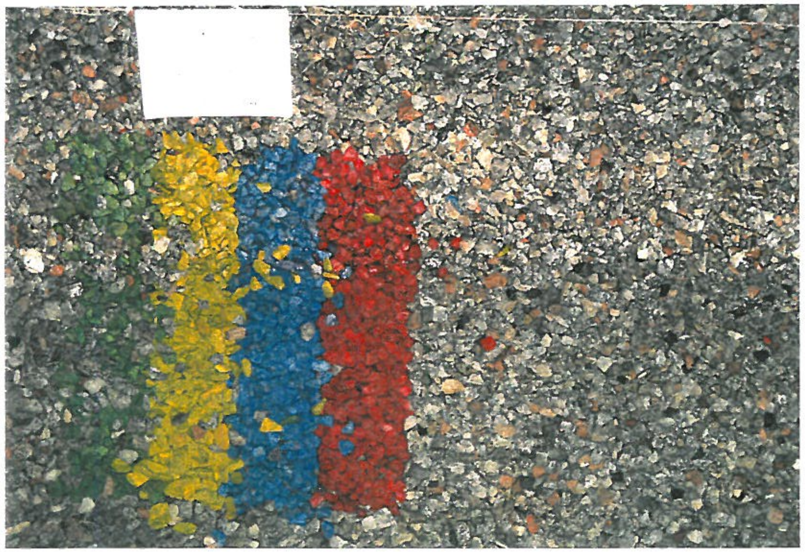


Transport after reshaping: Series 2, H_{m0} = 6,7cm, T_p = 1,2 sec.
N = 2000 waves.
No transport!

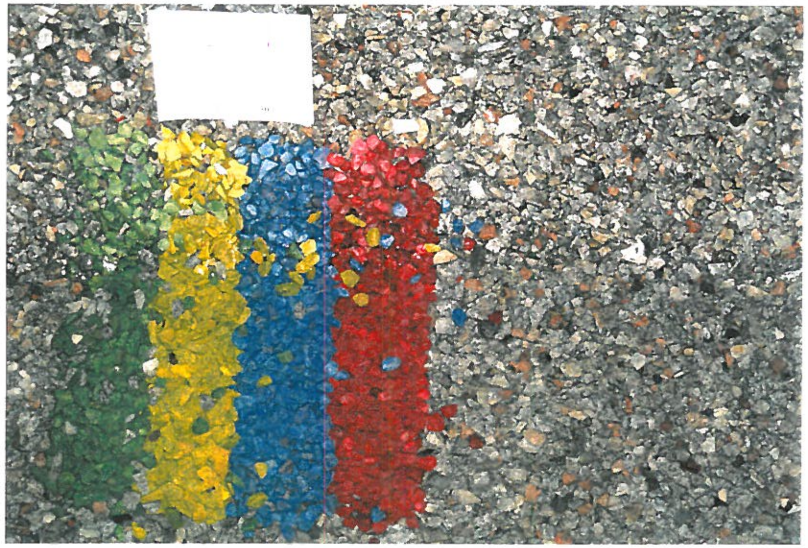


Transport after reshaping: Series 4, H_{m0} = 9,1cm, T_p = 1,5 sec.
N = 3000 waves.
Only transport in the red layer. This is due to the problem concerning the meeting of tow different stability-numbers (coloured stones ⇒ non-coloured stones).

Transport after reshaping: Series 5, H_{m0} = 9,6 cm, T_p = 1,6 sec.
N = 3000 waves.
The red band is now supported and no transport in the red band is showing! Notice, non-coloured stones in the yellow band.



Transport after reshaping: Series 5, H_{m0} = 9,6 cm, T_p = 1,6 sec.
N = 3000 waves.



Transport after reshaping: Series 6, H_{m0} = 9,9 cm, T_p = 1,7 sec.
N = 600 waves.

Transport after reshaping: Series 6, H_{m0} = 9,9 cm, T_p = 1,7 sec.
N = 400 waves.

Putting coloured stones in bands.

Putting coloured stones in bands.

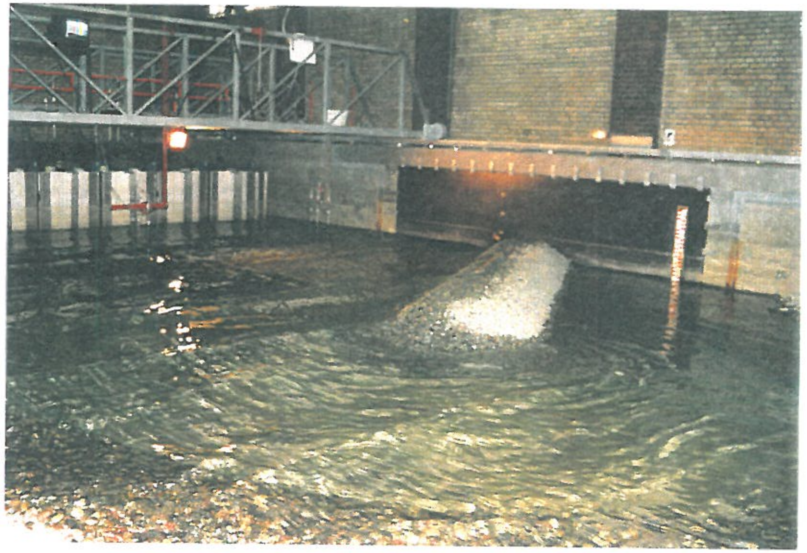
<u>Reshaping of trunk</u>: Series 2, H_{m0} = 6,8 cm, T_p = 1,2 sec.

<u>Reshaping of trunk</u>: Series 3, H_{m0} = 8,1 cm, T_p = 1,4 sec.

<u>Reshaping of trunk</u>: Series 3.

<u>Reshaping of trunk</u>: Series 3.

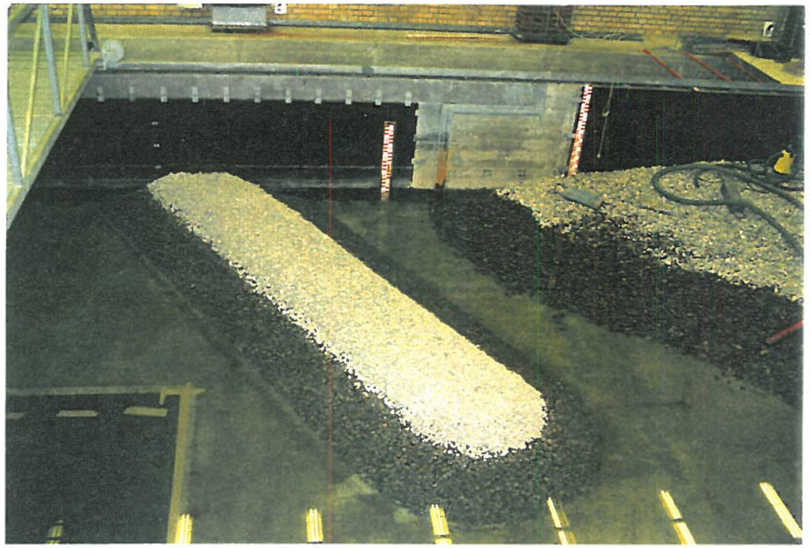

Refraction around roundhead.


Refraction around roundhead.

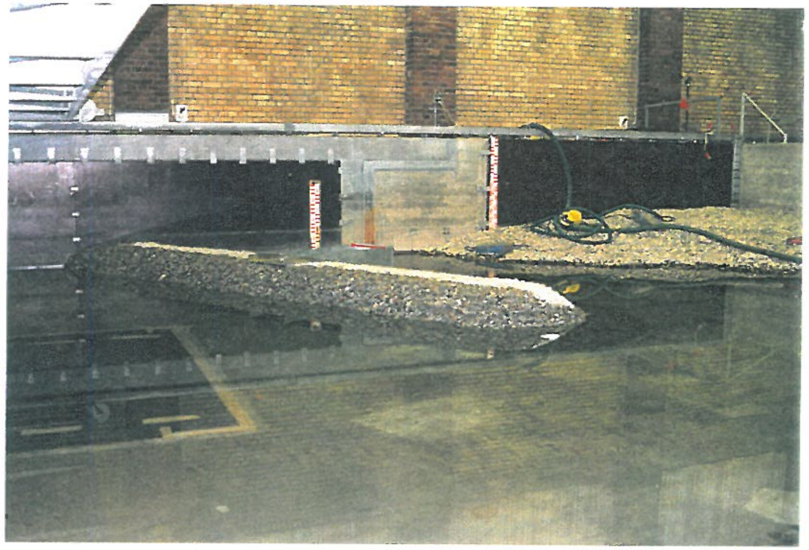

Reshaping of roundhead: Series 5, H_{m0} = 9,8 cm, T_p = 1,7 sec.

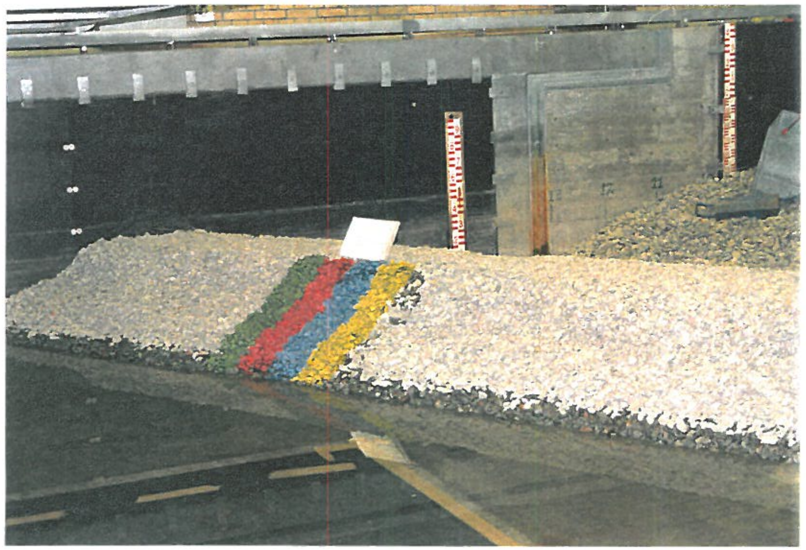
Reshaping of trunk and roundhead:
Series 6, H_{m0} = 9,5 cm, T_p = 1,7 sec.

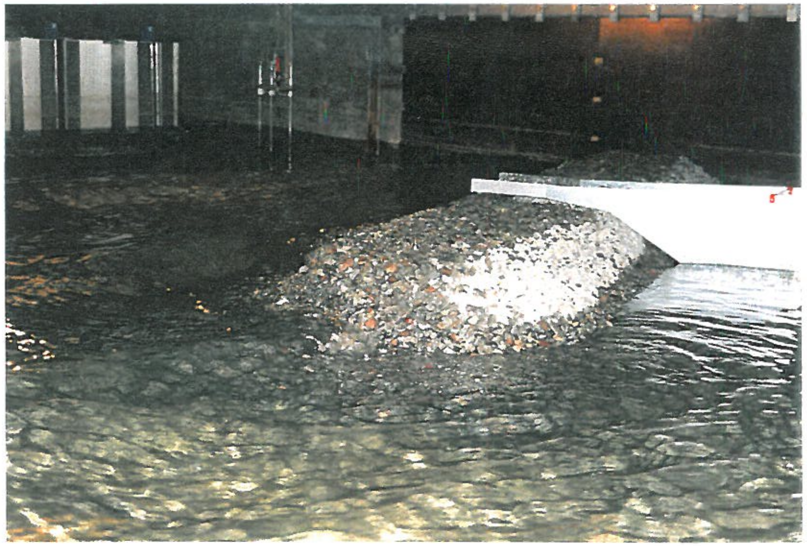
Reshaping of roundhead: Series 6, H_{m0} = 9,5 cm, T_p = 1,7 sec.



Initial profile.







Overtopping measurement.