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TEMPORAL VARIATIONS OF BED LOAD TRANSPORT RATE AND THE GRAIN SIZE DISTRIBUTION OF NON-UNIFORM SIZE SEDIMENT DURING A CONSTANT FLOW RATES

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Background (1)

- The existing sediment transport relations are rarely suitable for predicting changes in the size distribution of bed materials in river bed (the relations only predict total sediment discharge)
- Several empirical equations calibrated from different laboratory flume data sets have been proposed by many investigators with the assumptions that the sediment is homogeneous and non-cohesive
- Prediction methods of many existing published sediment transport rate relationships have therefore been developed using data from "uniform" sized sediment to allow the determination of the effects of the 'average' or 'representative' sediment size on transport rates

Background (2)

- The erosion and transport processes of non-uniform sediment are much more complex than those of uniform sediments, both respond very differently to the imposed fluid forces
- Calculation of highly non-uniform sediment transport rates using a single representative size of the bed material has been recognised as not appropriate
- It has been thought necessary to predict the transport rates of individual grain size fraction in the mixtures to get the total transport rate

Objectives

- To examine the behaviour of mixed grain size sediment transportation during constant flow rates
- To obtain the transport rate behaviour in correspond to time as well as the change in the composition of surface layer
- To understand the level of stability of each grains

Experimental Setup

- Experiments were carried out in a re-circulating glass sided tilting flume with the same constant flow rates of 34 l/s were applied in all tests
- A slot type sediment trap located 12.7 m from the flume inlet and positioned in the centre of the flume was provided to collect the material being transported as bedload
- The mixture of sediment was manufactured from three different grain size sediments to represent the natural sediment mixtures in many rivers

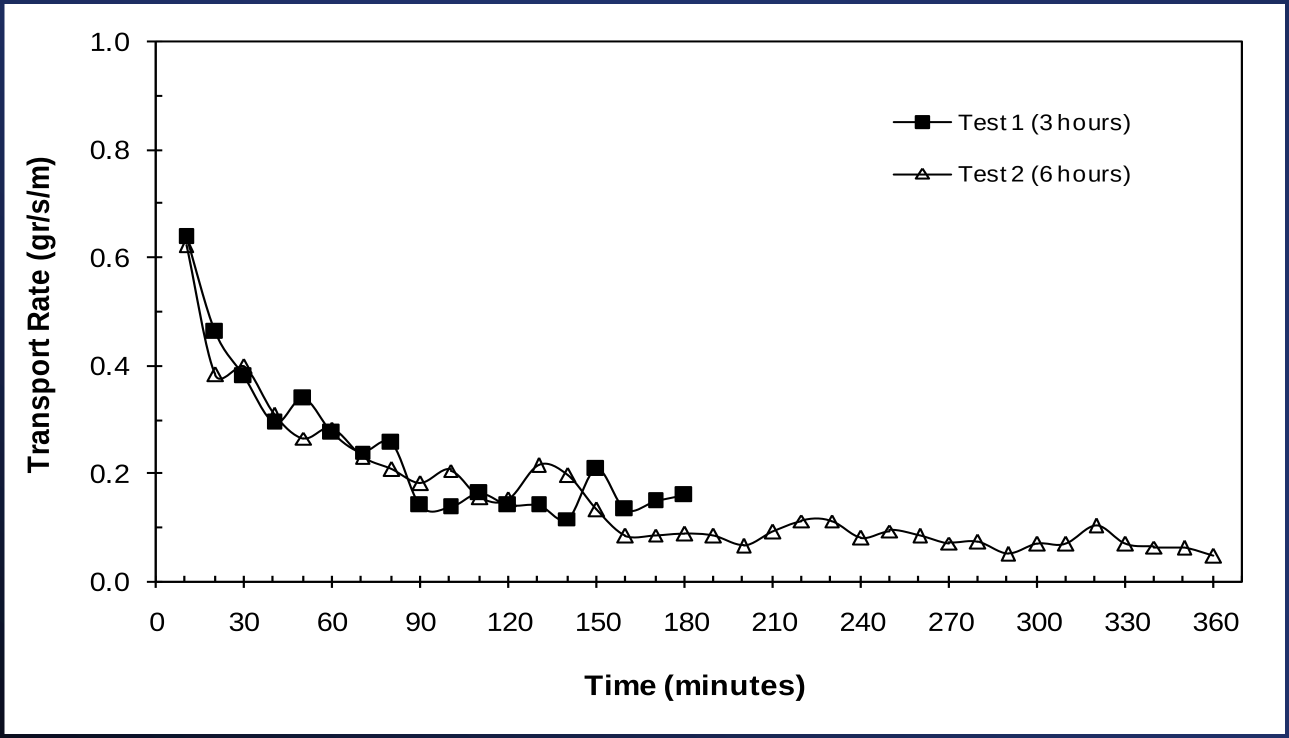
Experiment number	Discharge (l/s)	Flow duration (hours)	Sediment characteristic	
			τ_g	d_{50} (mm)
Test 1	34	3	3.42	5.19
Test 2	34	6	3.42	5.19

Results and Discussion [1]

- Observations indicate that during initial hours of constant flow rates, significant and rapid changes in bedload transport rates occurred
- During the first 60 minutes transport processes involved sporadic release of material as bed adjustment took place
- Both test experienced significant change in bedload transport rate during the initial stages (0.40 gr/s/m for Test 1 and 0.38 gr/s/m for Test 2)
- The rates drop rapidly within the course of one hour to a half than the bedload production in the preceding hour (0.18 gr/s/m for Test 1 and 0.19 gr/s/m for Test 2)

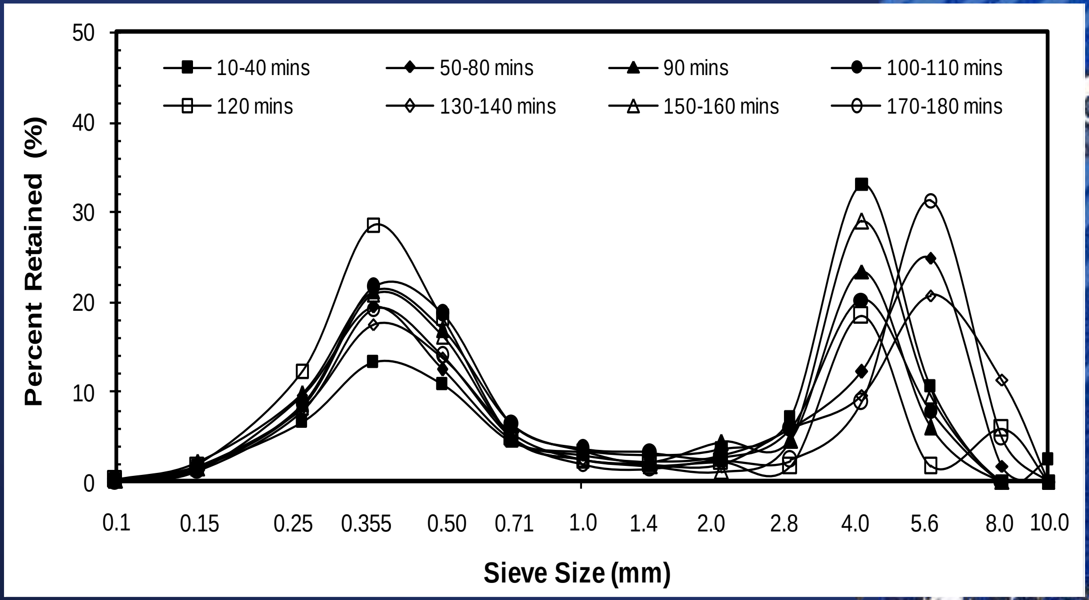
Results and Discussion (2)

- The rate fluctuated but continued to decrease in the third hour (0.15 gr/s/m for Test 1 and 0.13 gr/s/m for Test 2) before a much lower but constant rate during the remaining hours (0.09 gr/s/m to 0.07 gr/s/m)



Results and Discussion (3)

- Application of a relatively high constant discharge to freshly laid bimodal sediment beds has a different effect on the fine and the coarse mode of transported sediment
- Fine mode experience a similar pattern of transport throughout the 3 hours whilst the coarse mode shows variations , grain size of 0.355 mm was dominant in the fine mode for the whole duration of the test. In coarse mode, grain size of 4 mm was dominant during the very first part the test (i.e. time elapsed 10 -40 minutes)



Results and Discussion [4]

- Application of a relatively high constant discharge to freshly laid bimodal sediment beds has a different effect on the fine and the coarse mode of transported sediment

- Fine mode experience a similar pattern of transport throughout the 3 hours whilst the coarse mode shows variations , grain size of 0.355 mm was dominant in the fine mode for the whole duration of the test. In coarse mode, grain size of 4 mm was dominant during the very first part of the test (i.e. time elapsed 10 -40 minutes)

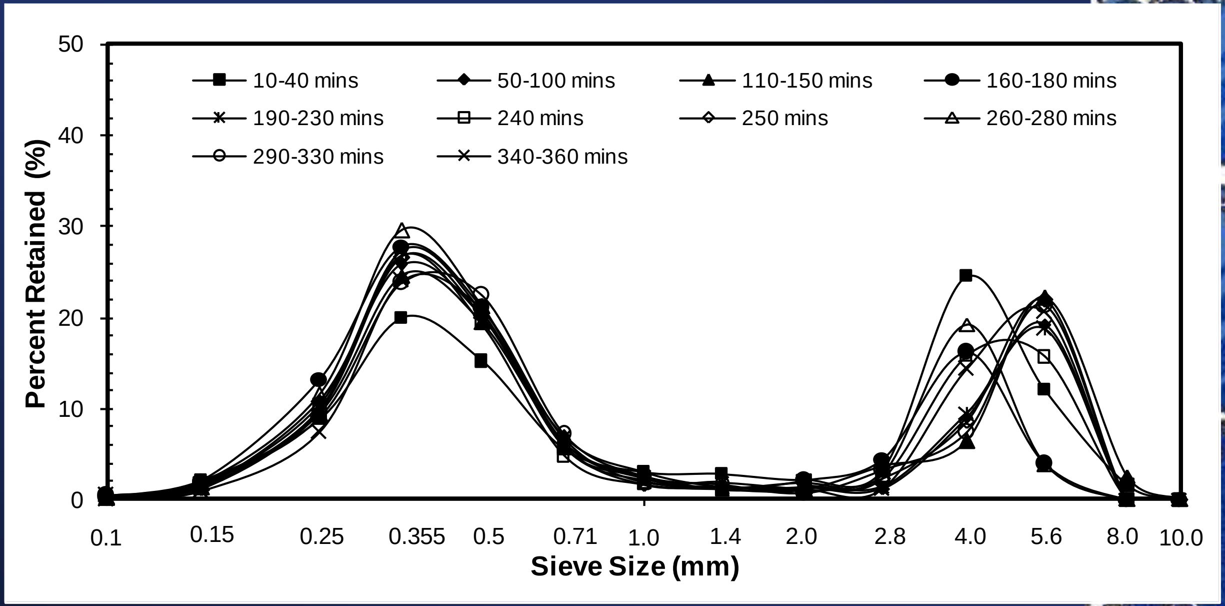
- It is evident that the grain sizes of 0.355 mm and 4.0 mm contributed quite significantly in transported bedload (estimated composition of both sizes left on the bed at the end of the test are less than the original composition of surface layer

Results and Discussion (5)

- More sediment was transported in the fine mode than in the coarse mode throughout the Test 2
- Fine mode also shows a similar pattern in grain size distribution with the modal size of fine grains was 0.355 mm for the whole duration of Test 2
- More interesting features are shown by the change in coarse mode where modal size of coarse grain shifts to the right from grain size of 4.0 mm to larger grain size suggesting that the level of exposure of larger grains increased with time

Results and Discussion (6)

- Although the percentage of finer grain transported during the test was dominant, it is not an indication that coarse mode was more stable but a reflection of the ability of the flow to continuously remove finer grains for the whole duration of the test



Results and Discussion [7]

- Bed surface composition at the end of the test can be estimated from the calculation of total transported bedload

Sieve size (mm)	Original composition of surface layer (%)		Fractional transported bedload (%)		Estimated composition of surface layer (%)	
	Test 1	Test 2	Test 1	Test 2	Test 1	Test 2
10.0	1.730	1.730	1.023	0.000	1.739	1.757
8.0	8.570	8.570	1.634	0.830	8.655	8.693
5.6	34.660	34.660	15.594	16.212	34.894	34.952
4.0	19.600	19.600	22.676	14.238	19.562	19.685
2.8	6.860	6.860	5.826	2.518	6.873	6.929
2.0	3.530	3.530	2.925	1.489	3.537	3.562
1.4	2.510	2.510	2.422	1.728	2.511	2.522
1.0	1.850	1.850	2.975	2.628	1.836	1.838
0.71	2.680	2.680	4.806	6.098	2.654	2.626
0.5	6.840	6.840	13.022	18.743	6.764	6.652
0.355	7.420	7.420	17.387	23.991	7.297	7.158
0.25	2.710	2.710	8.084	9.780	2.644	2.598
0.15	0.940	0.940	1.527	1.612	0.933	0.929
receiver	0.100	0.100	0.099	0.132	0.100	0.099

Results and Discussion (8)

- **The percentage of fine and coarse mode transported at the end of each test are 38 % and 40 % for Test 1 and 52% and 31 % for Test 2 respectively**

Experiment No.	Bedload transport		Mass and proportion of mode			
	Mass (gr)	Rate (gr/s/m)	Fine mode		Coarse mode	
			(gr)	(%)	(gr)	(%)
Test 1 (3 hours)	496.93	0.24	191.28	38.49	198.30	39.91
Test 2 (6 hours)	637.60	0.16	334.83	52.51	199.44	31.28
- First 3 hours	478.78	0.23	244.66	38.37	154.04	24.16
- Last 3 hours	158.82	0.08	90.16	14.14	45.34	7.12

Conclusion [1]

- A considerable amount of grains in both fine and coarse mode were transported during the initial stages of experiments. The amount of transported bedload during the first three hours is almost similar regardless of the total duration of the experiment. Intense degradational processes occurred during these periods with the proportion of grains in fine mode was more dominant than grains in coarse mode

- Stable armoured bed had been achieved after three hours of flow exposure. This clearly indicated by a considerable decrease in bedload transport during the second period of three hours in which a very low and constant transport rates took place. The grains in fine mode were better sheltered after three hours so that the rates dropped in the remaining hours. The diminishing supply reflects the bed stabilization as the armouring process continued

Conclusion (2)

- The coarsening process of bed surface occurred during the tests as indicated by the domination of grains in the fine mode in the total transported bedload. At the end of the tests the estimated compositions of surface layer were coarser than the original composition of bed surface

- The grain size distributions analysis of transported bedload at all time elapsed suggest that the proportion of fine mode was relatively stable and the modal grain size of this mode experienced a similar pattern throughout the tests whilst coarse mode was inconsistent and varied periodically

Recommendation

Experiment with longer duration of constant flow rates will hopefully provide information on whether the bed stability increases to some extent as the time progressed or may be destabilised and contribute to a considerable transport rate after long and continuous expose by the flow

Thank You