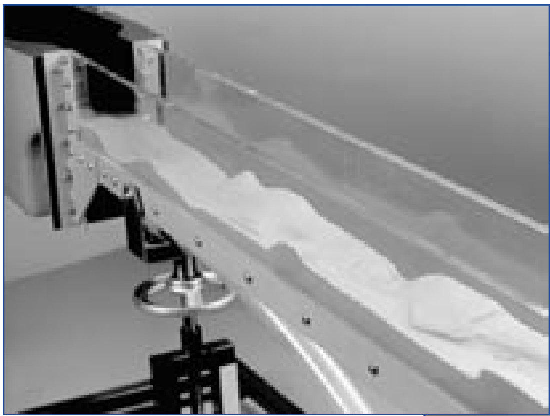
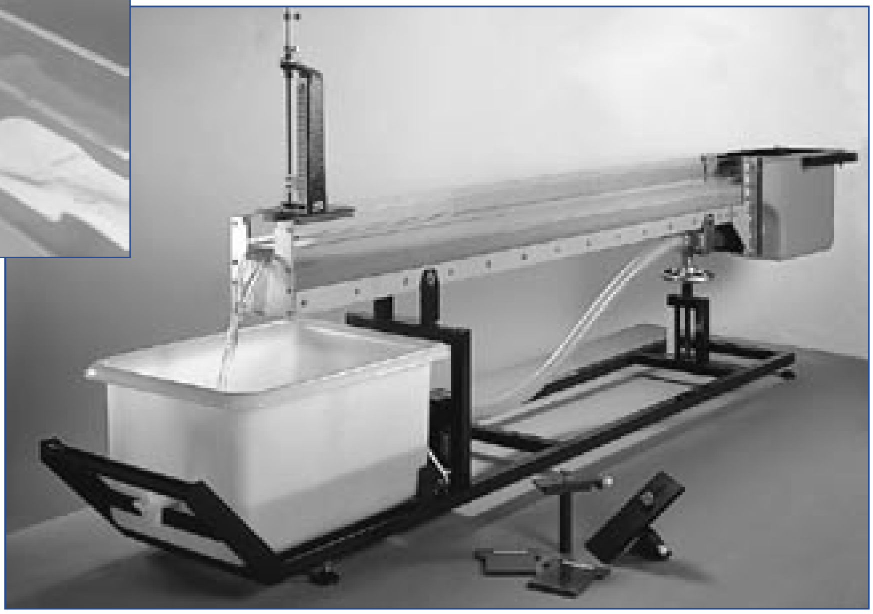
ISO 9001

SEDIMENT TRANSPORT DEMONSTRATION CHANNEL

S8MkII
issue 5



Plan view of drained dunes



This improved version of the Armfield sediment transport teaching facility allows demonstration of the full range of bedforms that arise in a mobile bed as the flow and/or slope are increased. The Channel can be used to perform most of the experiments and demonstrations usually undertaken in much larger laboratory flumes, but at much lower cost and without the need for technician back-up. The equipment is portable, and therefore may be used in the classroom as well as in the laboratory. Although too small for research applications, this demonstration flume can play a useful role in any course concerning the mechanics of open channel flow and sediment transport, including those in Departments of Civil Engineering, Geology and Physical Geography.

SUMMARY OF DEMONSTRATION TOPICS

- *Fixed, smooth bed flow*
- *Flow over a mobile sand-bed*
- *Mechanics of sediment transport*
- *Depositionary features and facies*
- *Local scour*
- *Flow structures*
- *Bedform hysteresis*
- *Computational work*
- *Flow over a fixed, gravel bed*

Applied Hydraulics and Hydrology

DESCRIPTION

The unit consists of an inclinable channel mounted on a frame, together with a discharge tank and recirculating pump. To commence a demonstration, sand is placed evenly along the channel bed, between the inlet tank and the overfall discharge weir. Water is circulated around the system at one of the three selectable flow rates. The channel slope is adjusted by means of a fine screw jack to which is attached an accurate slope indicator. The channel sides are transparent in order that bed profile changes can be readily observed, and a section of one side is provided with graphical grid markings to permit quantitative assessments to be made of bedform dynamics.

DEMONSTRATION CAPABILITIES

Fixed, Smooth Bed Flow:

The flume may be used without sediment on the bed to demonstrate the following flow phenomena and governing equations:

- *Tranquil, sub-critical flow - movement of surface waves upstream against flow*
- *Rapid, super-critical flow - dominance of intertial over gravity forces, 'shock waves' from flow obstructions*
- *Hydraulic jump - transition from super to sub critical flow, air entrainment, mixing*
- *Turbulence - flow visualisation for example by dye injection from a hypodermic syringe (not supplied)*
- *Flow measurement - using sharp crested weirs*
- *Governing equations of open channel flow - Reynolds' number, Froude number, continuity, Bernoulli's equation, weir equations*

Flow over a Mobile Sand Bed:

Sequence of bedforms associated with increasing flow intensity and sediment transport rate. The following bedforms are exhibited (as discharge and/or slope are increased):-

- ***Lower Regime:***
  - *plane-bed (no motion)*
  - *ripples*
  - *ripples and dunes*
  - *dunes*
  - *washed-out dunes*
- ***Upper Regime:***
  - *plane-bed (with motion)*
  - *standing waves*
  - *anti-dunes*
  - *breaking anti-dunes*
  - *chutes and pools*

Mechanics of Sediment Transport:

Starting from a plane-bed with no motion, the movement of grains can be observed with emphasis on the following:-

- *initiation of motion*
- *trajectory of initial motion*
- *movement by rolling and sliding (contact load)*
- *movement by hopping (saltation load)*

Depositional Features and Facies:

The deposition of sediment load can be observed and the resulting patterns of grains within the sand body (such as cross-bedding, foreset beds etc.) may be identified. The significance of such features when found in geological records can be discussed.

Local Scour:

Scour under boils and vortices in the flow is observed under both the lower and upper regime bedforms. Artificial obstructions may be introduced to represent bridge piers, revetments, sills or other man-made structures, and the resulting pattern of scour examined. Two such models are included.

Flow Structures:

The structure of turbulence in the flow may be examined using dye injection (dye injector <u>not</u> included). This is particularly interesting for the dune bedform configuration and clearly demonstrates separation on the lee face.

Bedform Hysteresis:

If the discharge in the flume changes quickly, there is insufficient time for bedforms to adjust to the new flow regime. Hence, if a flood hydrograph is simulated by increasing and then decreasing the discharge, different depths (stages) will occur for the same discharge on the rising and falling limbs. This effect is of major importance to gauging stations on sand-bed rivers. It is easily and clearly demonstrated in the flume.

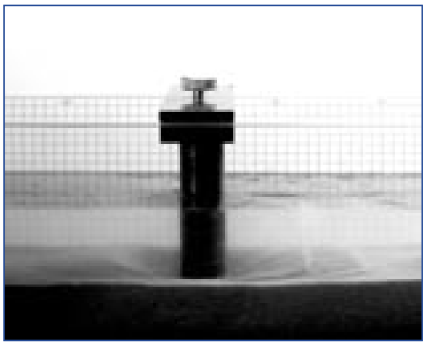
Computational Work:

In addition to illustrating flow and sediment phenomena, the flume can be used for basic data collection and numerical evaluation of the following:

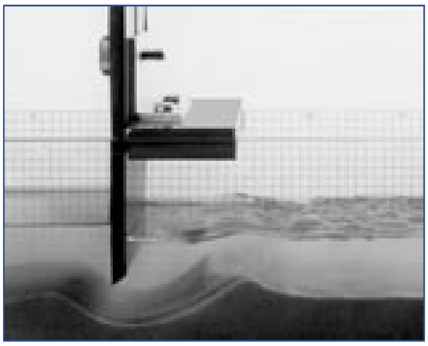
- ***Flow resistance:***
  - *Manning, Chezy and Darcy - Weisbach friction factors for various bedform configurations*
- ***Bedform prediction:***
  - *Hjulstrom Diagram (velocity)*
  - *Bogardi Diagram (Shields parameter)*
  - *Simons and Richardson Charts (Stream power)*
  - *Leeder Chart (Boundary shear stress)*
  - *movement by suspension (suspended load)*
- ***Initiation of Motion:***
  - *Hjulstrom's Curve*
  - *Shields Diagram*

Flow over a Fixed, Gravel-Bed:

The flume cannot transport gravel, but can be used to investigate flow resistance in gravel and polder-bed rivers. The flow resistance coefficients may be calculated using equations (such as those of Bray, Limerinos, Hey, Lacey, Thompson & Campbell and Bathurst) and the results compared to the actual values obtained by observation. It is recommended that users obtain actual gravel material from local sources, (Armfield cannot supply gravel).



Model bridge pier



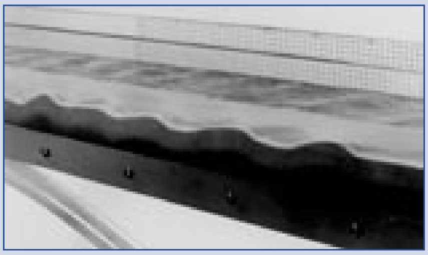
Undershot weir

A water level gauge is supplied to measure the head over the channel discharge weir to deduce flow rates from a calibration chart. Solid models of a bridge pier and an undershot weir are provided to demonstrate the scour effects on river beds of man-made structures.

BEDFORMS IN SAND

1 Ripples

2 Dunes and superimposed ripples

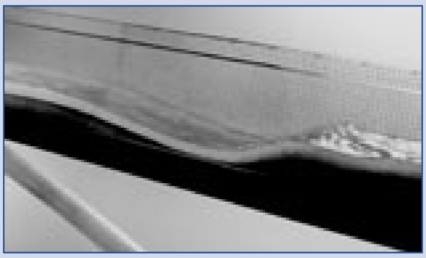


3 Dunes

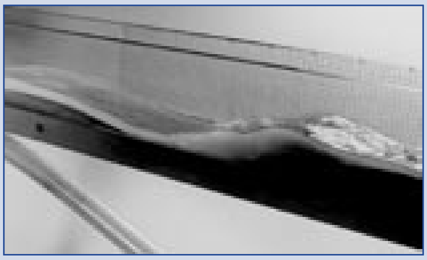
4 Transition dunes

5 Plane bed

6 Standing wave



7 Anti-dunes



8 Breaking anti-dunes

As water flows over sand in a river or on a beach it exerts a shear force on the bed. If the flow is strong enough, sand grains are lifted to roll and bounce along the bed. The shape of the bed responds to this motion by transforming into ripples. As the energy of the flow and transport rate of sand increase, the bedforms change. Ripples are replaced by larger dunes.

At higher energy still, the dunes are washed out to produced a flat bed and in extremely energetic flows anti-dunes appear.

Bedforms are important in affecting the flow of water and movement of sediment in rivers and on beaches. They also occur in deserts due to the movement of sand by the wind.

Bedforms are preserved when sand deposits are turned into sandstone by geological processes. They are used to reconstruct environments under which the sand was deposited.

ORDERING SPECIFICATION

- ***A transparent, inclinable flow channel through which water can be re-circulated by a pump over a mobile bed to demonstrate the whole range of bedforms from incipient particle movement to bed wash-out.***
- ***Three different discharge rates can be selected (and measured) within the range 0.2 to 0.6 litres/sec.***
- ***The channel slope can be adjusted within the range 0-10%.***
- ***The working section of the channel is 1.55m long, 78mm wide and 110mm deep.***
- ***The equipment is self-contained and may be bench-mounted in either the classroom or laboratory by virtue of its portability.***
- ***A model undershot weir and bridge pier are included for local erosion demonstrations.***
- ***A water level gauge is supplied to calibrate the overshot weir.***

TECHNICAL DETAILS

Channel working section:
Length: 1.55m
Width: 78mm
Depth: 110mm

Discharge rate:
3 fixed flow rates between 0.2 and 0.6 litres/sec, selected by switch on pump

Slope: *0 to 10%*

Sediment diameter: *0.1 to 0.3mm*

Weight of sand supplied: *15kg*

Weight (including sand and water):
S8MKII-A: *74kg*
S8MKII-B: *78kg*

SERVICES REQUIRED

First fill of water (approx. 22 litres)

Electrical supply:
S8MKII-A: *220-240V/1ph/50Hz*
S8MKII-B: *120V/1ph/60Hz*
S8MKII-G: *220V/1ph/60Hz*

OVERALL DIMENSIONS

Height: 1.1m (to top of point gauge)
Width: 0.4m
Length: 2.5m

SHIPPING SPECIFICATIONS

Volume: 0.6m³
Gross weight: 100kg

Armfield Limited
Bridge House West Street Ringwood
Hampshire England BH24 1DY
Tel: +44 (0)1425 478781
Fax: +44 (0)1425 470916
E mail: sales@armfield.co.uk
URL: http://www.armfield.co.uk

USA Office:
Armfield Inc.
436 West Commodore Blvd (#2)
Jackson NJ 08527
Tel: (732) 928-3332
Fax: (732) 928-3542
E mail: armfield@optonline.net

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