

CHAPTER 57

INSTRUMENT FOR LONG-TERM MEASUREMENT OF SUSPENDED MATTER (SILT GAUGE)

Harald Göhren

Hans Laucht

Strom- und Hafenbau
Hamburg, W. Germany

ABSTRACT

With financial support by the German Research Association (Deutsche Forschungsgemeinschaft) an instrument for automatic long-term measurement of suspended matter has been developed by the authors. It works on a settling method. A sample of 20 l of water is pumped into a conical settling bottle every hour. The suspended sediments settling in a measuring tube at the bottom of the bottle are recorded by a camera. The device called "Silt Gauge" is intended for long-term measurements in shallow coastal water.

INTRODUCTION

In estuaries as well as in the surf zone in front of sandy coasts the transport of material in form of "suspended load" is of great importance. Various instruments and methods to determine the concentration of suspended matter in water have been developed. Most of them are based on the analysis of weight or volume of the suspended sediment in a water sample, using filters, centrifuges or special settling receptacles. The samples are taken by pumping systems or bottle traps which have been constructed in

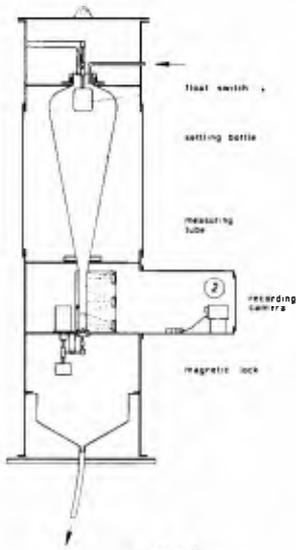


Fig. 1
SILT GAUGE



Fig. 2
SILT GAUGE

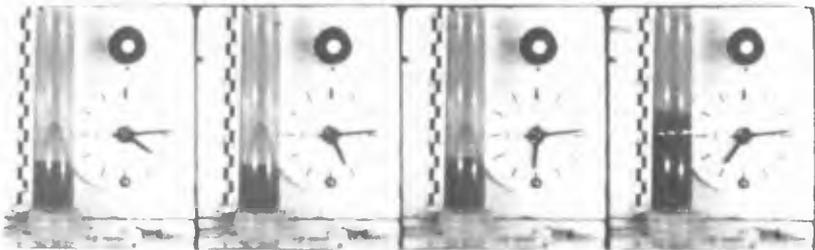


Fig. 3
SECTION OF A RECORD (orig. 8 mm film)

numerous variations. They all require manual handling and hence are not suitable for automatic long-term measurements. Another indirect method applies the effect that light is absorbed or scattered by the suspended particles. This principle provides a good basis for the construction of an automatic instrument, but unfortunately the absorption or scattering of light mainly depends on the grain diameter and not on the weight or volume. Another problem is the fouling of the optical windows which must be submerged into the liquid.

DESIGN AND CONSTRUCTION OF THE SILT GAUGE

The development of the Silt Gauge was started in 1967 after establishing the following principle: In regular time intervals 20 l of water are pumped into a settling bottle of 1 m height. The bottle is of conic shape, ending in a narrow measuring tube of 25 mm diameter. The slope of the bottle sides is designed that way that falling particles will slide off and settle in the tube. The settling bottle is manufactured from glass in order to have the walls as smooth as possible and to avoid any corrosion. After one hour settling time (which may be varied) the deposition is recorded by a camera. Then sediment and water are released through a magnetically operated lock (fig. 1 and 2). This cycle is reiterated hourly, controlled by an electronic unit. The recording set consists of a simple 8 mm camera and a magnetic trigger. The film capacity is sufficient for a two month's measuring time. The camera takes a picture of the measuring tube, a scale and a clockface, giving accurate time control. A special test lamp indicates whether the settling bottle is filled in the moment the foto is taken and provides a function check. Fig. 3 shows a section of a record.

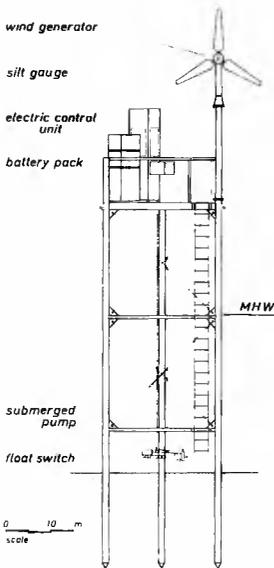


Fig. 4

SILT GAUGE PLATFORM FOR TIDAL FLAT



Fig. 5

THE PLATFORM FOR THE SILT GAUGE IS ERECTED



Fig. 6

THE WIND-MILL GENERATOR IS MOUNTED ON THE PLATFORM



Fig. 7

SUBMERGED PUMP AND FLOAT SWITCH

The Silt Gauge has been developed for investigations in the tidal flats of the southern North Sea coast. The complete instrument, installed in a steel box (dimensions 20 x 20 x 80 in.), is based on a threepod platform which easily can be set up by a vessel (fig. 4 to 6). A wind-mill generator in combination with a set of storage batteries provides an independent power supply. The submerged pump, fitted with an intake nozzle of 11 in. length and 0.6 in. diameter, is fastened at one of the platform legs (fig. 7). A special float switch is mounted on the pump, stopping it if the water level sinks below the switch.

CALIBRATION

Due to the "settling principle" the Silt Gauge can only measure the amount of suspended particles which sink down with a velocity ≥ 1 m per hour. Very fine stuff having a lower settling velocity is not recorded. The settling velocity mainly depends on grain size, specific weight and density of the liquid. This measuring principle may be a drawback in particular cases. But generally it seems to be advantageous since in all processes of coastal erosion and sedimentation only that part of suspended load is of importance that is able to sink down in calm water within a limited space of time. With regard to the dimension of the settling bottle and the "Stokes law" a theoretical deposition curve can be evaluated (fig. 8) indicating that a grain size of about 0.02 mm diameter confines the measuring range. However it is obvious that this theoretical boundary does not exist under natural conditions. Due to some complicate electrolytic, chemical and even biological effects fine suspended particles tend to generate flakes, these having a higher settling velocity in calm water than the single grains.

From a series of analyses using water samples taken in the tidal flat the deposition curve in fig. 9 has been

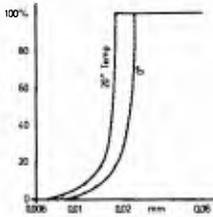


Fig. 8
RATE OF DEPOSITION
IN THE BOTTLE VERSUS
GRAIN SIZE (THEOR)

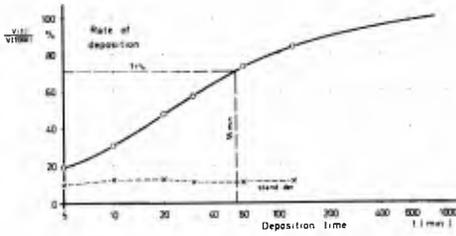


Fig 9
DEPOSITION IN THE TUBE VERSUS TIME
(EVALUATED BY TESTS UNDER NATURAL CONDITIONS)

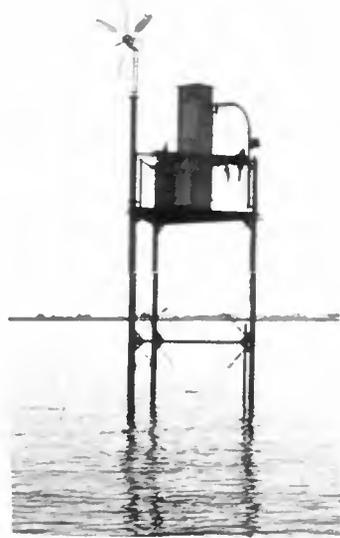


Fig. 10
SILT GAUGE STATION
IN THE TIDAL FLAT

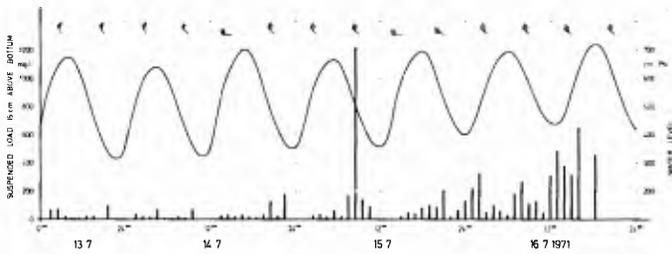


Fig 11
DATA OBTAINED FROM A "SILT GAUGE STATION" IN THE NEUWERK TIDAL FLATS,
INDICATING WIND INFLUENCE ON SUSPENDED LOAD

evaluated. An average rate of 70% of the suspended load can be expected to settle in the measuring tube during one hour.

EXPERIENCE

After having completed the device in 1968, a thorough test programme was performed which lead to several technical improvements. Particular difficulties were caused by the submerged pump (Type Benthos, 24 V D.C.). The pump, announced as "deep sea pump", was found to be not waterproof. After protracted trials in connection with the manufacturer to improve this type, which was most suitable because of its voltage and capacity, it was necessary to take another type of a submerged pump, operating with 220 V A.C. and thus requiring additional electric units.

After having accomplished all improvements, the device is operating with great reliability. It has been working on several stations in the tidal flats of the Elbe Estuary. The particular aim of these measurements is an investigation of the influence of waves and drift currents on suspended load in a tidal flat. As vessels cannot operate in the shoals at stormy weather, the employment of an automatic instrument is the only method to advance in that programme.

Fig. 10 shows the Silt Gauge in the tidal flat at high water. Records of currents and waves are taken simultaneously by a wave gauge and a current meter, both instruments likewise equipped for automatic long-term measurements.

Fig. 11 shows a section of a measurement carried out with the Silt Gauge. The increase of suspended load with increasing wind velocity gives an impression of the predominant wind influence on litoral transport in the shoals. It is intended to continue investigations of this kind over several years in order to obtain sufficient data

for a statistical evaluation of relationships between suspended load, currents, waves, water temperature and other parameters and in this way to enable trusty computations of suspended transport and its dependence on tide and weather variations.

REFERENCES

- Fairchild, J.C. (1965). Suspended sand sampler. Shore and Beach, Oct. 1965
- Göhren, H. and Laucht, H. (1972). Entwicklung eines Gerätes zur Dauermessung suspendierter Feststoffe. Deutsche Gewässerkundliche Mitteilungen, 16. Jg., H. 3, 1972
- Laucht, H. (1971). Entwicklung eines automatischen Schwebstoffmeßgerätes für den Brandungsbereich. Forschungsbericht - Sandbewegung im Küstenraum. Deutsche Forschungsgemeinschaft, 1971
- Nelson, M. and Bendict, C. (1950). Measurement and analysis of sediment load on streams. Am. Soc. Civ. Eng. Vol. 76, 1950
- Watts, G.M. (1953). Development and field test of a sampler for suspended sediment in wave action. Beach Erosion Board, Techn. Mem. 34