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A new method for measuring the impact energy of a piling hammer

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A photographic method for measuring the impact velocity of a ram is described. This enables the hammer’s efficiency to be quickly assessed. The method can be used during the day or night and in all weather conditions except dense fog. The equipment is easy to operate, and polaroid photography is used to obtain the results quickly. No physical attachments to the hammer are necessary, and hence no electrical cables between the hammer and work barge are required.

Introduction

ANY VARIATION in the hammer performance during pile driving will have a marked effect upon the rate of installation. However, pile driveability predictions assume the full rated energy to be produced by each hammer blow and any deviations from this may have a significant effect upon the interpretation of the blow-count record. Consequently, several methods for measuring the hammer efficiency have been devised, each based upon electrical transducers monitoring the motion of the hammer ram. However, these techniques have two basic disadvantages:

(1) A transducer is required to translate the ram velocity into an electronic signal. This transducer has to be robust enough to withstand the harsh, environmental working conditions. Any failure, mechanical or electrical, cannot be repaired unless piling is stopped.

(2) A hardwire link is required between the hammer transducer and the operator. On an offshore construction barge this can cause handling difficulties when pitching the hammer.

The apparatus used in the photographic technique described here is remote from the hammer. It can be positioned from 10m to 1 000m from the hammer.

The technique is based upon streak photography. In essence it records the displacement/time graph for the ram’s descent on a polaroid film. The film takes one minute to develop and a transparent overlay enables the impact velocity to be read directly.

The apparatus

The apparatus was built at Queen Mary College, and is shown in Fig. 1. It consists of a streak attachment (Fig. 2) which transports the polaroid film pack smoothly past a fixed slit. The attachment clips directly onto a Mamiya RB67 professional camera without modification to the camera body. The high quality lenses ensure that the recorded image is of exceptionally high resolution, and the range of focal length lenses available give a large image size (a maximum of 55mm × 50mm) for any range of distances between the camera and hammer.

The critical parts of the apparatus are labelled in the two figures. The camera lens contains the aperture control which is used to limit the light exposure. The mirror box enables the hammer image to be positioned and focussed using the "through the lens" facility on the Mamiya camera (the mirror is removed from the light path during exposure).

The streak attachment consists of two aluminium alloy plates. Plate 1 carries:

(a) the adaptor used to connect the attachment to the Mamiya camera. An alternative adaptor and minimal modifications would enable the attachment to be used with other types of medium-format camera;

(b) the vertical slit through which the hammer image is exposed to the film;

Fig. 1. Streak attachment mounted on a Mamiya RB67 camera

Fig. 2. The polaroid streak photography attachment

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(c) an LED (light emitting diode) which flashes at precisely 10.0 Hz. As explained later, this is used to provide the time base on the print; (d) a high-torque, 12 volt, d.c. motor. This moves the second plate through a rack and pinion drive; and (e) limit switches which control the movement of Plate 2.

It should be noted that no shutter is required because the method uses a constant exposure principle as described later.

The polaroid film pack is fixed rigidly to Plate 2, the entire unit being moved by the d.c. motor fixed to Plate 1. Friction between the two plates is minimised by providing PTFE runners. Light leaks to the film pack are reduced to a minimum by anodising all surfaces to a matt black finish and by using black velvet strips to bridge air gaps.

The motor is controlled from a remote box linked by a short, fixed cable. This control box also houses the electronics used to flash the LED every 100 milliseconds.

The principle

Streak photography uses an unshuttered, constant-exposure principle, i.e. the two-dimensional image of the ram's descent is continuously focussed on a fixed image plane. The arrangement used is shown in Fig. 3. Since the displacement of the ram is one-dimensional (i.e. vertical) this may be monitored by observing a single, vertical line in the observed image. The slit in Plate 1 allows the image of this vertical line to be exposed to the polaroid film. By moving the film horizontally, across the slit, the history of the slit's image is exposed to the film, and the horizontal dimension of the polaroid print is "time".

A useful analogy of the principle is provided by an X-Y pen plotter. The pen bar represents the slit, the paper replaces the polaroid film, and a pen attached to the bar corresponds to the image of the ram in the slit. As the paper is moved horizontally, the history of the pen's position on the bar is recorded. If the pen accelerates

(continued on page 48)