Geotextile Reinforcement in Full Scale Test Embankment on Soft Ground

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ABSTRACT: High-strength, non-woven geotextile was used as base reinforcement in a test embankment on soft Bangkok clay. Instrumentations for stress-strain measurements consisted of wire extensometers, Glotzl type high accuracy extensometers, special strain gages and dog-bone load cell. Wire extensometers were installed in both geotextile and surrounding soils in order to measure their relative displacements and global strains. Glotzl extensometers were attached in geotextile as redundant measurement to verify the reliability of wire extensometers. Strain in geotextile was also measured by means of strain gages. The comparable results of strain measurements from these different instruments have been obtained. Glotzl and wire extensometers gave reasonable data up to the strain larger than 10%. The strain gages yielded good results at strain levels lower than 3%. All of the strain gages ceased to function at strain levels less than to 5% both in the field and in the laboratory calibration tests.

1 INTRODUCTION

The use of synthetic polymer reinforcements in reinforced soil structures has become widely adopted in recent years. Due to the complicated behavior of geotextile confinement in soils, most of the designs carried out are based on limit equilibrium method with assumption of a "limiting strain" for determination of the mobilized tensile force in the reinforcement at failure of the system (Koerner et al, 1987). However, the prediction of load-strain behavior of the reinforcement under both operational and failure conditions has proven difficult (Mc Gown et al, 1992). To improve the understanding of the actual behavior of the geotextile reinforcement, the field measurements of the deformations (or strains) and the tensile loads, has become essentially necessary.

For the first time, a full scale, fully instrumented test embankment using high-strength woven-non woven geotextile (Polyfelt PEC200) has been constructed on soft Bangkok clay. The research project has been supported by the Polyfelt Geosynthetics Austria. This paper describes the instrumentation program for stress-strain measurements of geotextile reinforcement. Also presented are some initial measured data and discussions on the capacity of different instruments used for strain measurements in this research project.

2 INSTRUMENTATION

The instrumentation program consisted of 12 wire extensometers in geotextile, 10 wire extensometers in soil, 4 Glotzl extensometers, and 4 points of special strain gages and load cells with ordinary strain gages. The 21X micro datalogger together with a AM416 relay multiplexer were used for recording of strain gages and load cell measurements. The side view and layout of geotextile instrumentation are shown in Fig. 1. The installation and measurements are summarized in the following sections.

2.1 Strain gages

Special train gages of the type EP-08-40 CBY-120, manufactured by Micro Measurements Division, were used. These gages have a nominal resistance of 120 ohms, and are 10 cm long. The special strain gages were located on 0.5 m wide strip of geotextile, at 1 m spacing, and were in between the dog-bone load cell points. Two strain gages at both sides of the geotextile were installed at each point of strain measurement, and were connected in series to be a sensor of double resistance (Fig. 2). The strain gages were glued on geotextile at two ends using M-bond 200 adhesive. Then, the gages were covered by a thin layer of rubber silicon of about 2 mm thick by 30 mm

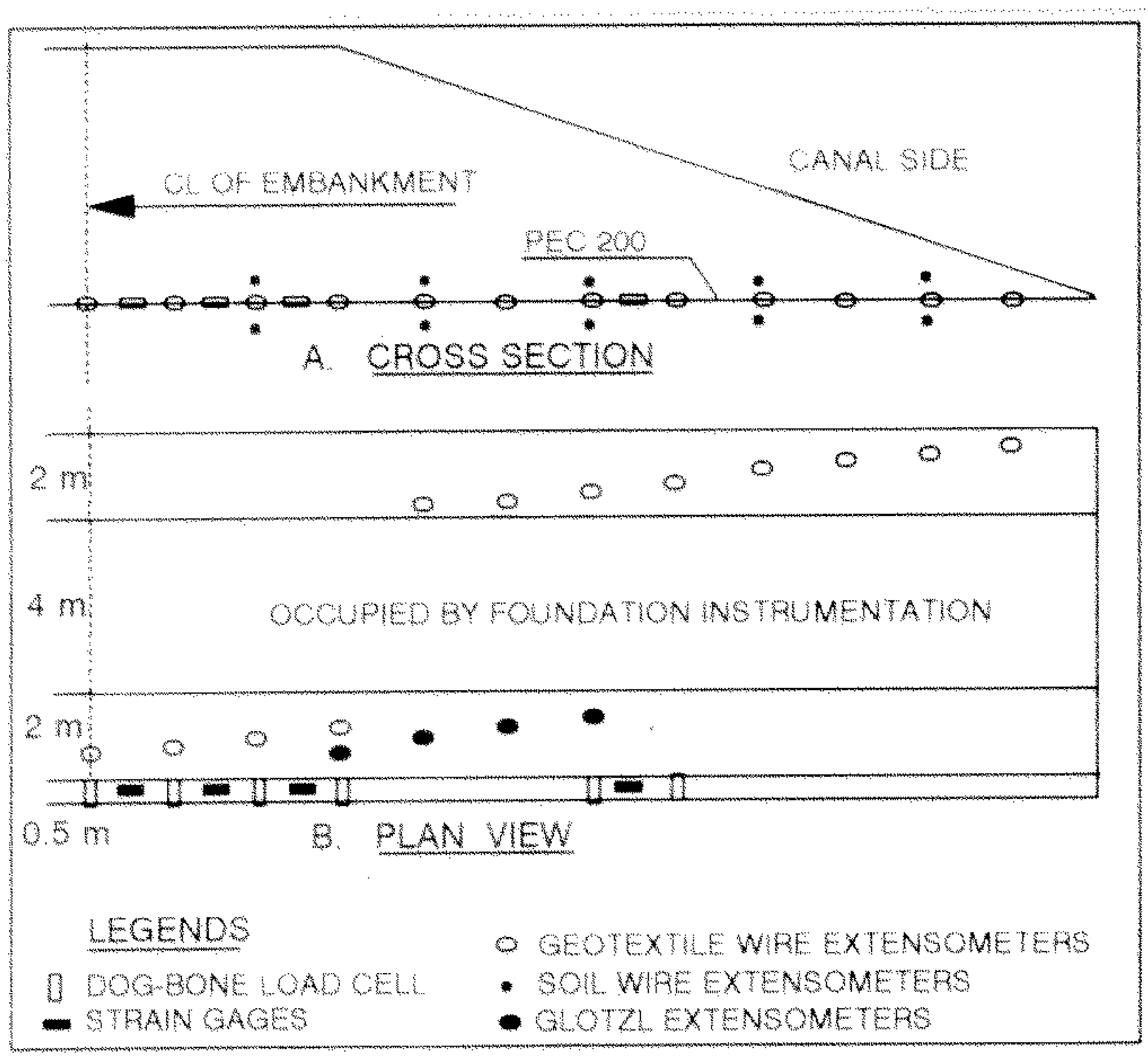

Fig. 1 Geotextile instrumentation of the test embankment

wide for moisture protection. Both laboratory calibration tests in-air (tension test) and in-soil (pullout test) yielded a linear relationship of Y = 1.05X where Y is the strain measured by LVDT, and X is the strain calculated from voltage change in strain gage .

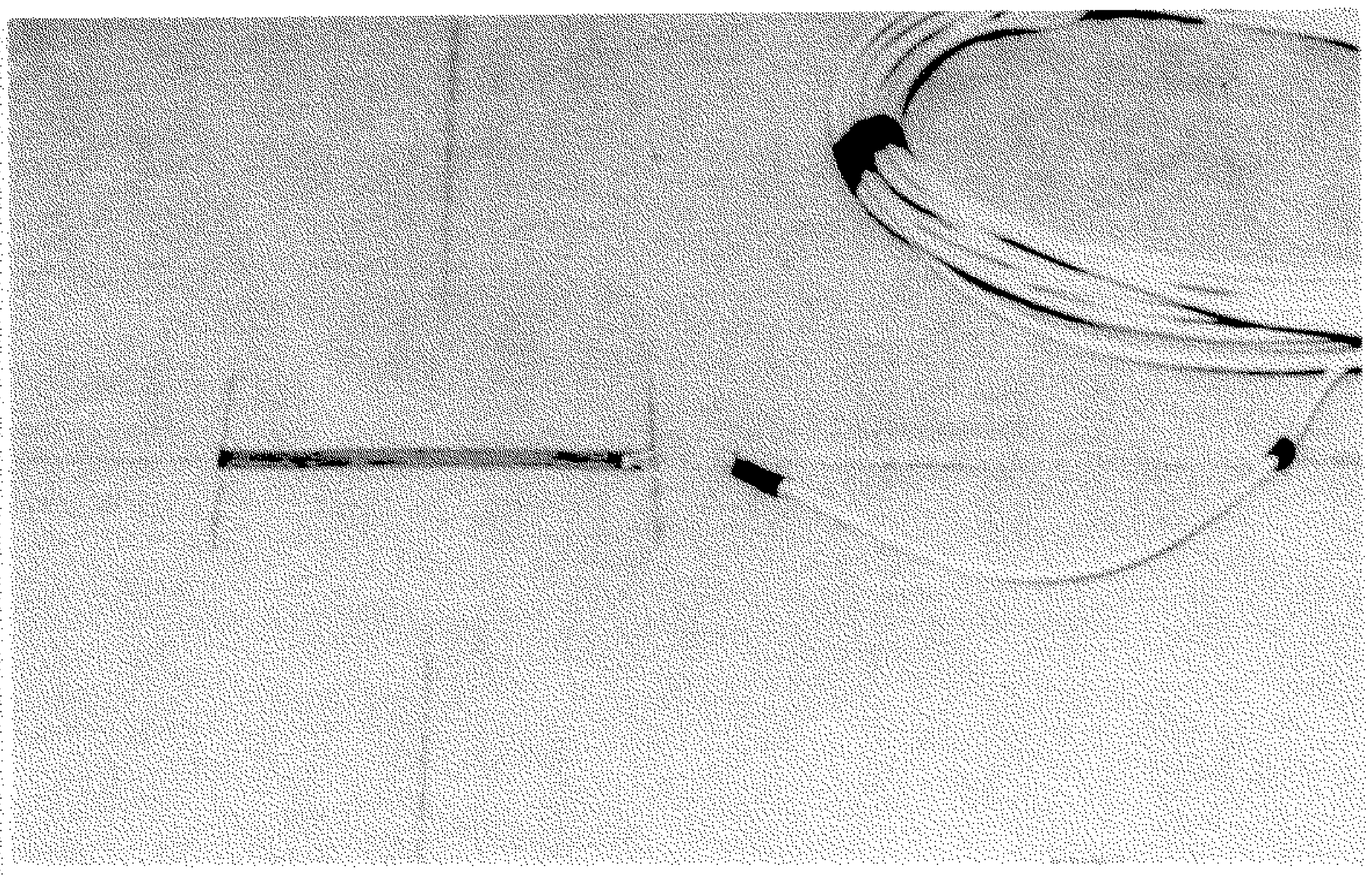

Fig. 2 Installation of strain gages in geotextile

2.2 Load cell

Dog-bone load cells were used to measure tensile forces in the geotextile. Manufactured in AIT, the dog-bone load cells consisted of a stainless steel rod installed with temperature compensated ordinary strain gages and an outer plastic tube for construction protection. The tensile force were measured indirectly using strain gage principle. In the field, the load cells were installed in pairs, and were connected to geotextile through clamps (Fig. 3).

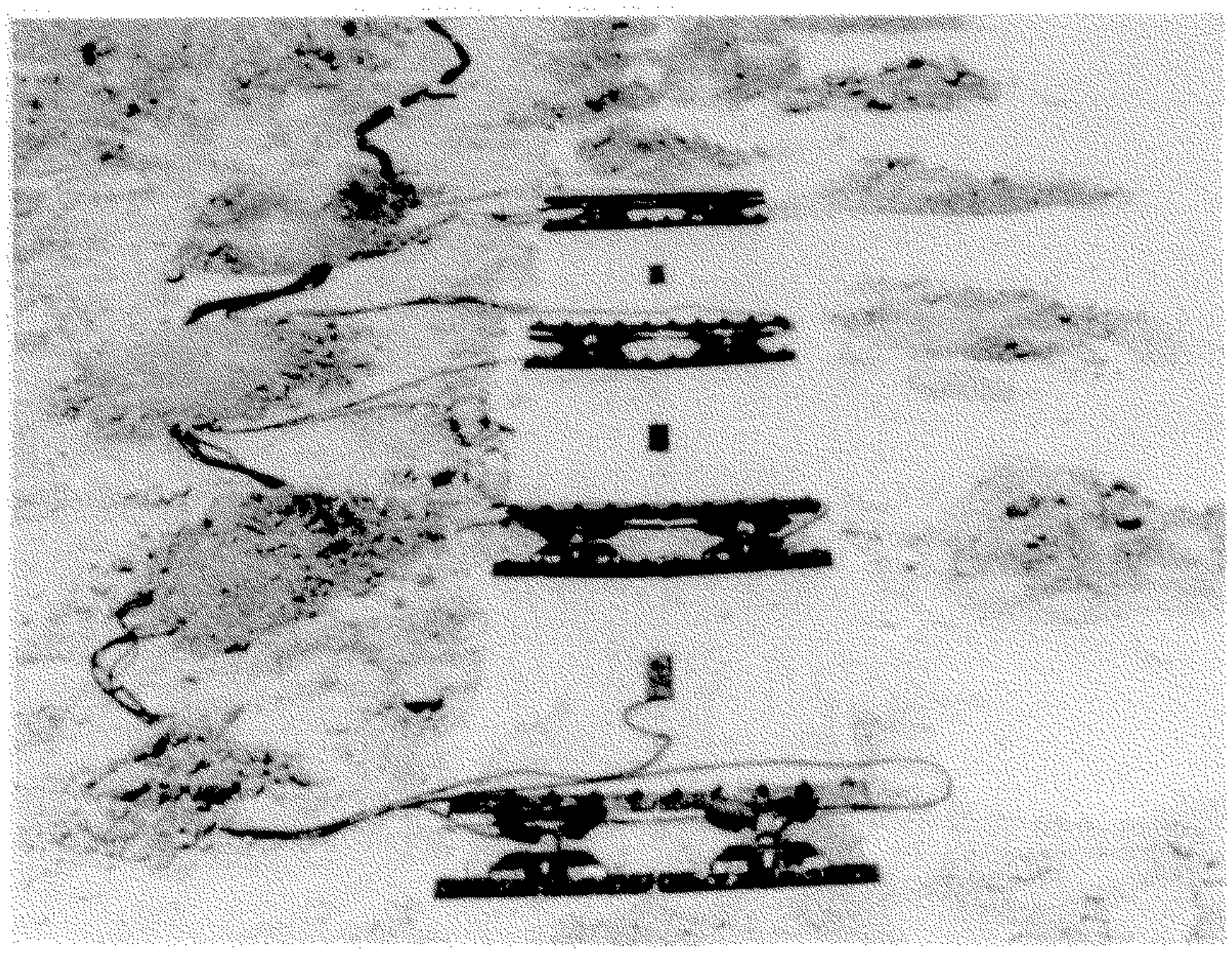

Fig. 3 Arrangement of strain gages and dog-bone load cells in the field

2.3 Wire extensometers

Wire extensometers were used to measure the displacements of geotextile and surrounding soils as well. The extensometer consists of an inner 2mm diameter high-strength stainless cable and an outer flexible PVC tube. The PVC tube, has 4mm inner and 6mm outer diameters, enabled the free moving of the inner wire. One end of the wire was fixed at the measured point. The other end connected to a counter weight of about 0.5 kg through a pulley system at the readout board. Figures 4 and 5 showed the installation of wire extensometers in the geotextile and in the surrounding soil, respectively.

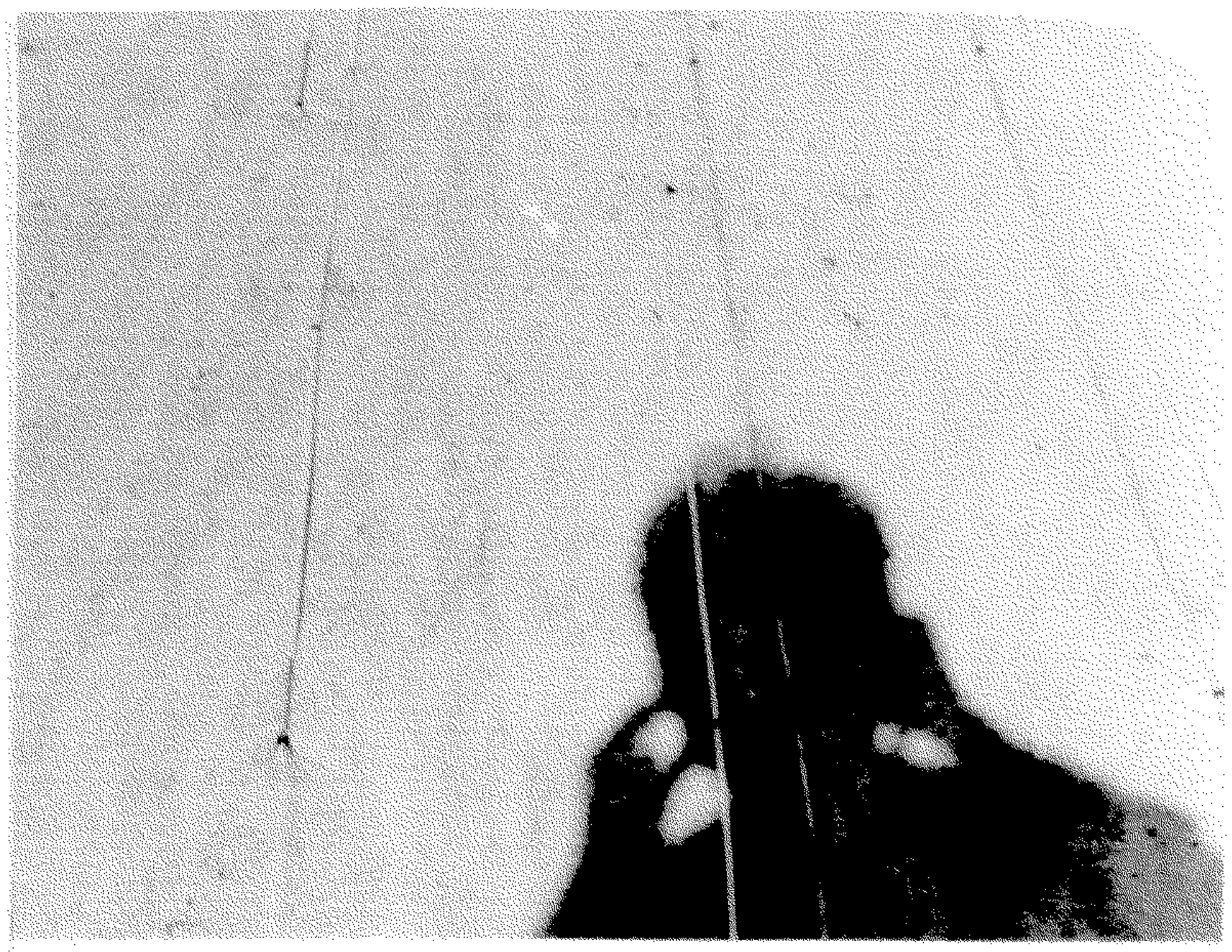

Fig. 4 Arrangement of wire extensometers in geotextile

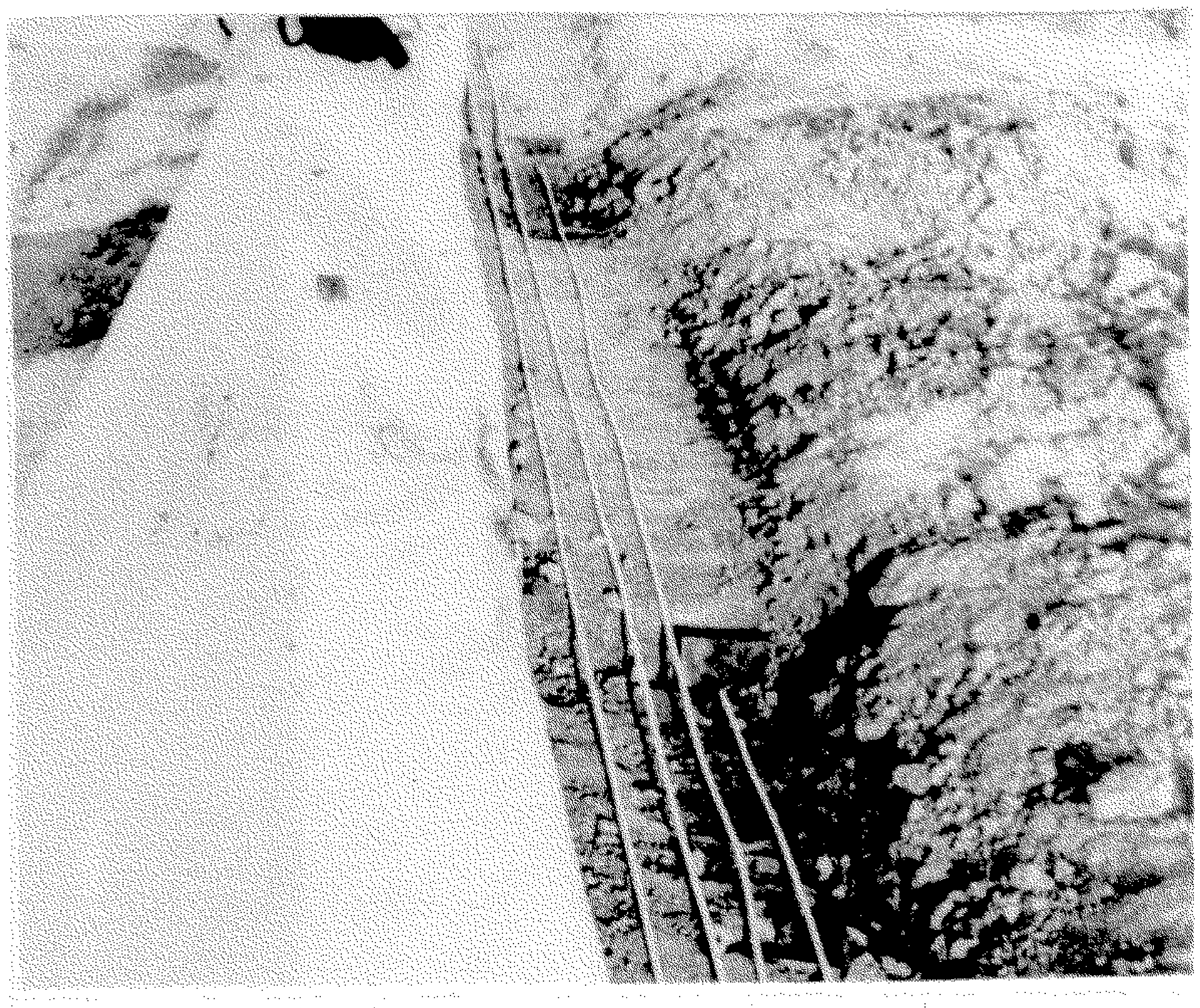

Fig. 5 Installation of wire extensometers in the soil

2.4 Glotzl extensometers

The other type of extensometer installed on geotextile was the precise Glotzl type extensometer. Glotzl extensometer consists of a 10.7 mm diameter inner rod made of glass fibre, an outer PVC tube with 12 mm inner diameter and 16 mm outer diameter. One end of the inner rod was attached in geotextile at the measured location as given in Fig. 6. The opposite end of the outer tube was fixed at the readout board. The extensometers were attached in the geotextile at 1 m intervals. Relative displacements of the inner rod and the fixed end of the outer tube yielded the relative displacements in the geotextile.

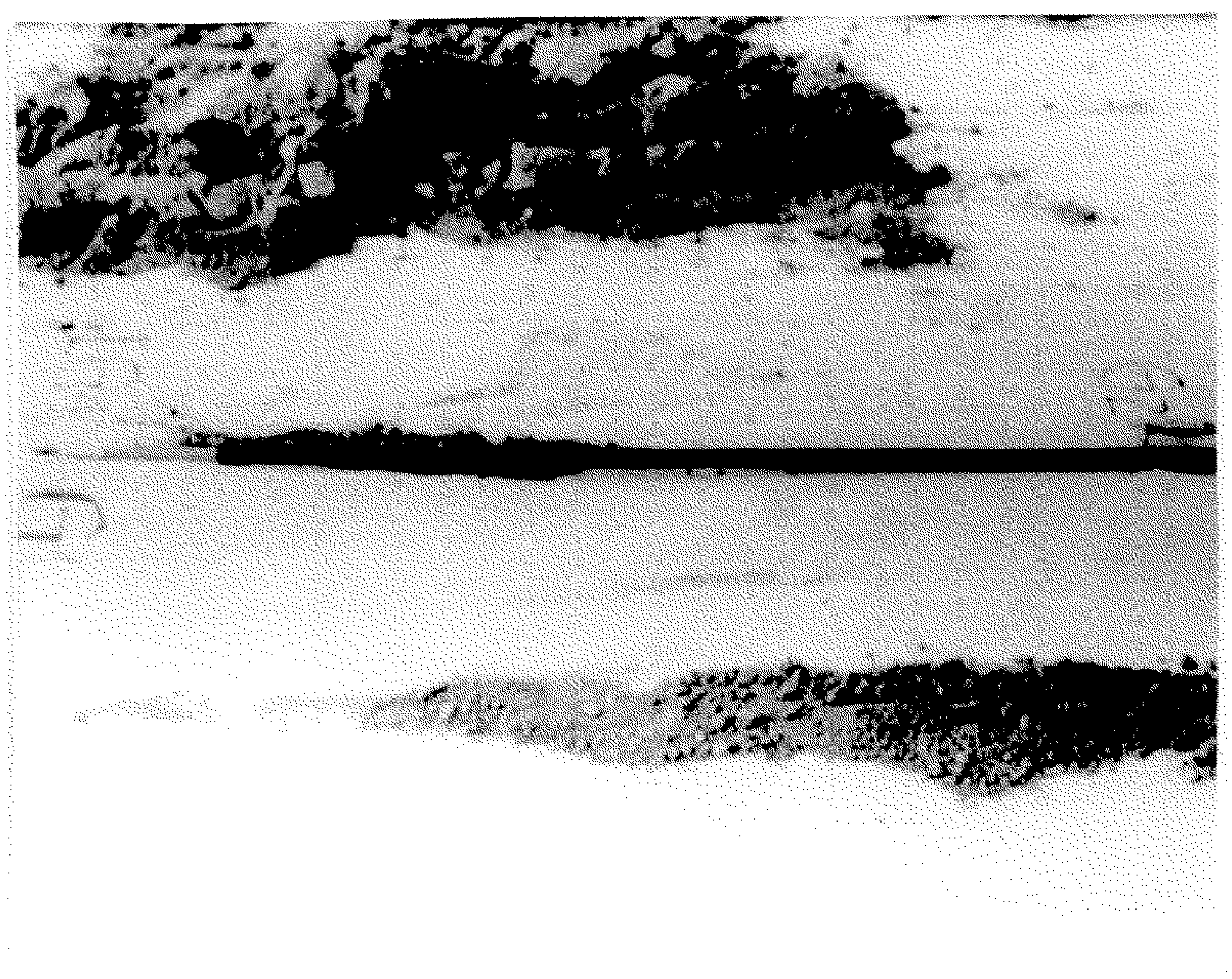

Fig. 6 Installation of Glotzl extensometers in the field

3 MEASURED DATA

Strain in geotextile measured by wire extensometers, Glotzl extensometers, and strain gages are plotted together in Figs. 7 and 8. There were no significant strains in geotextile at the embankment height of lower than 3 m. The strain of about 2 % to 3.5 % were obtained at the height of 4 m. Increasing of the embankment height, the maximum strain of about 13 % was measured before embankment failure at 6 m high.

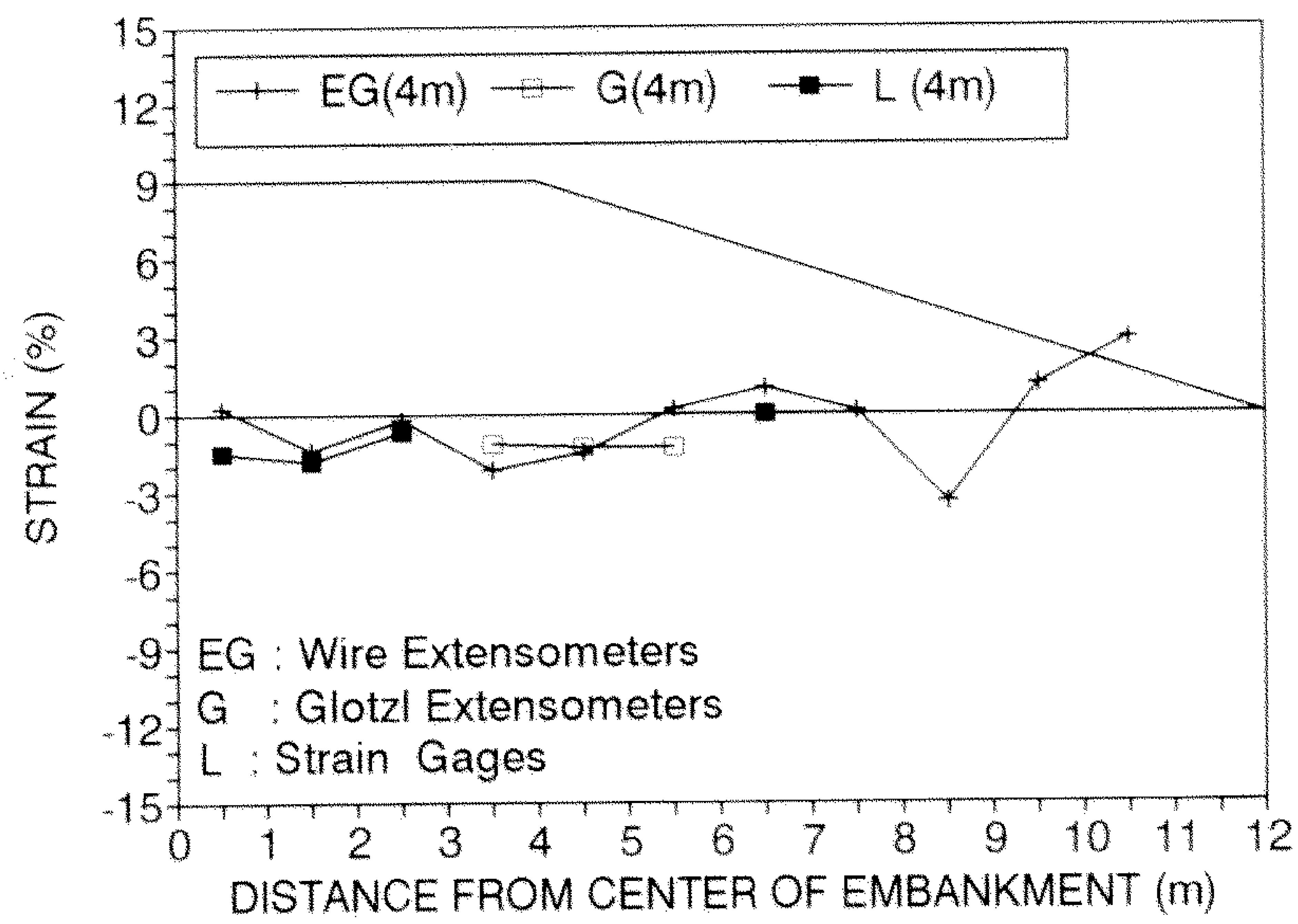

Fig. 7 Strains in geotextile measured by strain gages, wire and Glotzl extensometers, at embankment height of 4 m

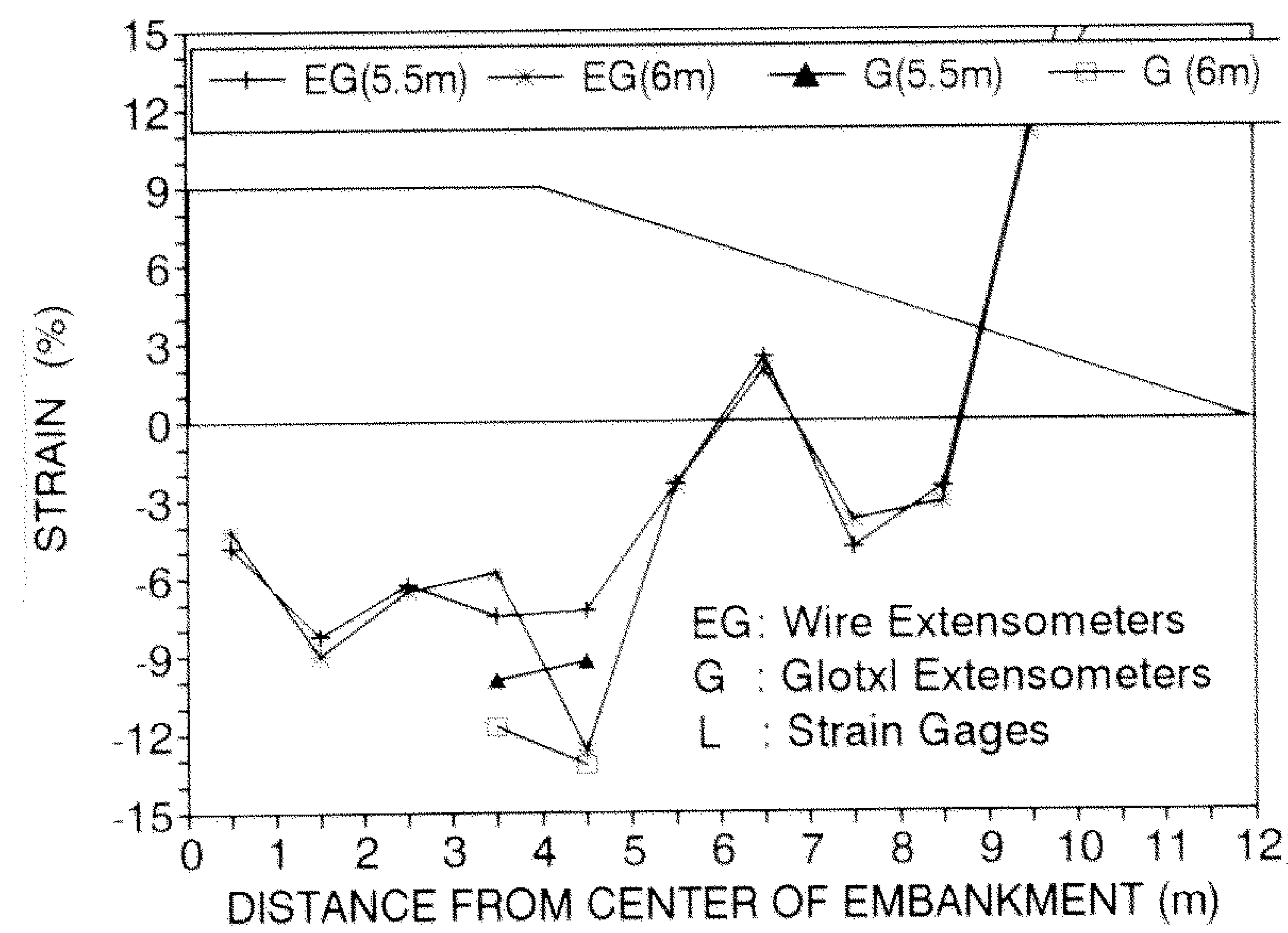

Fig. 8 Strains in geotextile measured by wire and Glotzl extensometers, at embankment heights of 5.5 m and 6 m

At the beginning of construction until about 4 m high, the peak strain occurred under the middle of slope. Increasing of embankment height, the second peak strain appeared and developed until failure of the embankment, at the location corresponding to the observed slip surface. Some compressions in geotextile were also recorded. Similar behavior was also reported by Delmas et al (1992).

In general, the strains calculated from the wire and Glotzl extensometers were comparable with the strains obtained from strain gages. The readings from Glotzl and wire extensometers have been recorded until the failure of embankment with the maximum strain in geotextile of about 13 %. The strain gages lost their electrical resistance at strain level of about 2% to 5% both in the field and in the laboratory calibration tests. The strain gages ceased to function mainly due to either the rupture of the lead-wires or the failure at the connection between the lead-wires and the strain gage foil.

The tensile forces measured from a dog-bone load cell were plotted in Fig. 9 together with the strains measured from the corresponding strain gages. Also shown in this figure is the stress-strain relationship of the geotextile obtained from in-air tension test. The measurements from dog-bone load cells showed some fluctuations as presented in Fig. 9. The reasons are due to the strain in the cells were too small to overcome the effects of temperature, noise, and the accuracy of the readout unit.

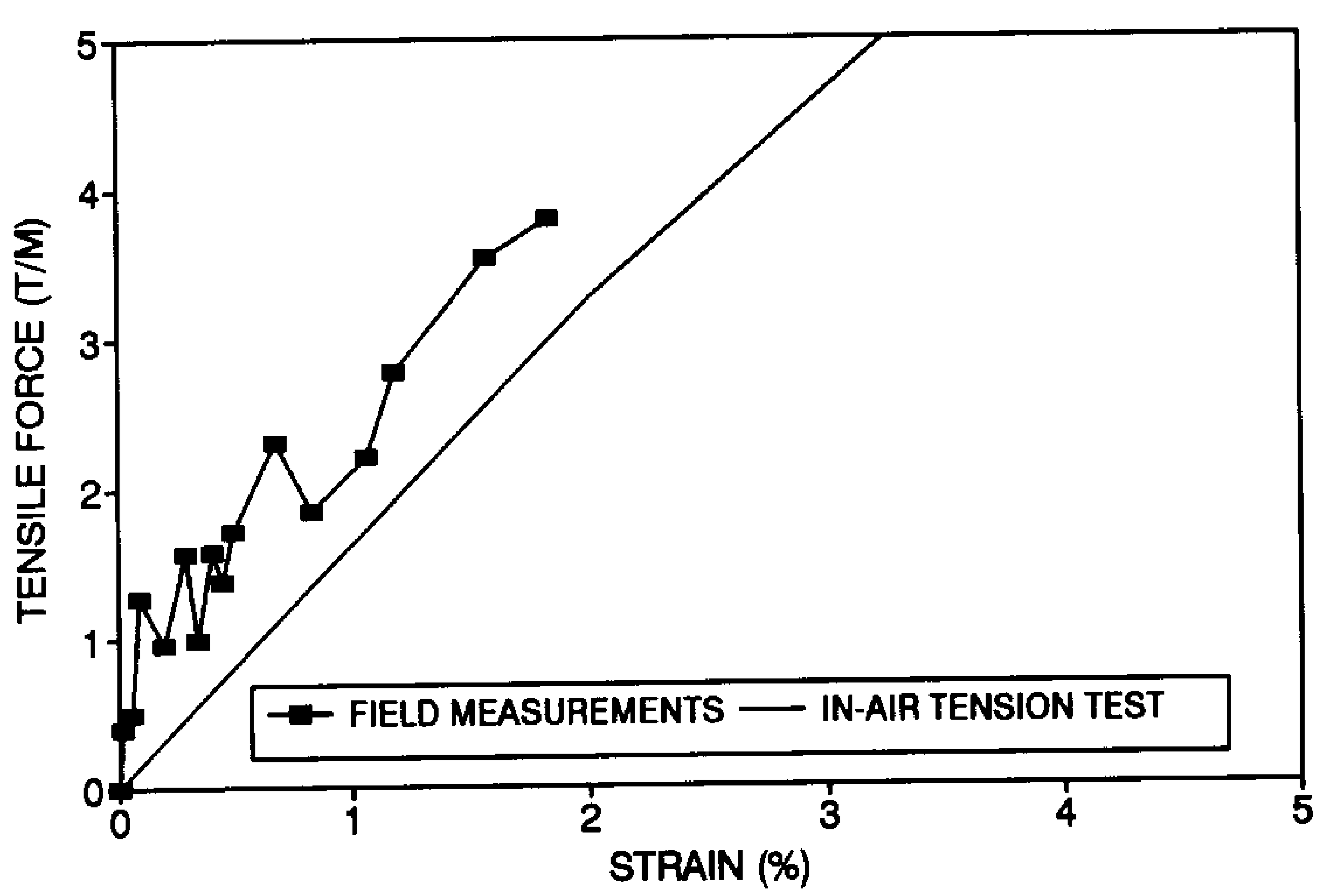

Fig. 9 Measured stress-strain in the field plotted together with the stress-strain curve from in-air tension test

4. CONCLUSIONS

From this instrumentation program, the following conclusions can be made:

1) Different types of instruments have been examined for strain measurements of geotextile in the field. The measured data indicated that the strain gages yielded good results at strain level smaller than 3%. The larger strains can only be measured by means of Glotzl or wire extensometers.
2) Wire extensometers seem suitable for geotextile strain measurement in terms of low cost, simple installation and monitoring, and longer life even at large deformation (more than 10% strain) of the system.
3) At early loading stage, the peak strain in geotextile occurred near the mid-slope. Increase of the embankment height, the localized strain appeared and developed to rupture at the location corresponding to the observed slip failure surface.

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