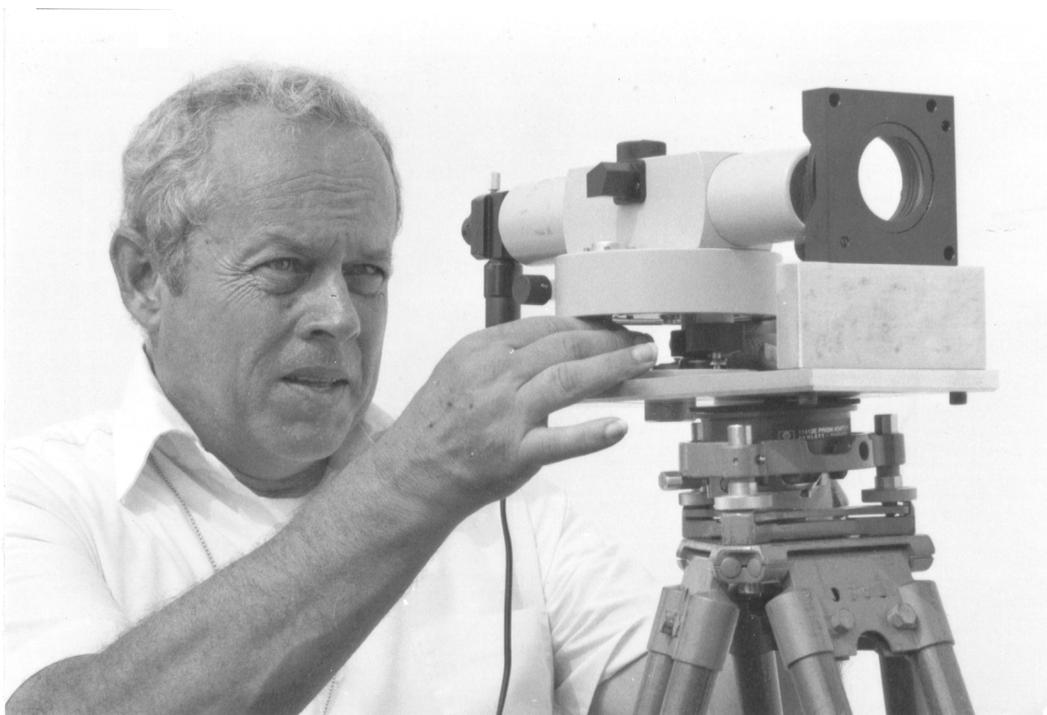




REMR TECHNICAL NOTE CS-ES-2.2
METHOD OF MEASURING
THE TILT OF LARGE STRUCTURES



PURPOSE: To describe an instrument and method for use in monitoring the tilt of large structures.

APPLICATION: Measurement of tilt of structures such as gallery walls in a dam or lock walls.

ADVANTAGES: The method and instrument are simple to use, inexpensive, and yield results of ± 2 seconds of arc.

LIMITATIONS: Manual operation and data recording are required. The instrument must be set up in an area where a standard survey tripod can be set up.

AVAILABILITY: Most of the equipment required is available from commercial suppliers. That which is not available can be manufactured at any machine shop. The Engineer Topographic Laboratories can assist any Corps of Engineers' Division or District Office with equipment purchase and installation as well as training personnel in the operation techniques and data reduction.

COSTS: The items required and their approximate cost are:

Zeiss NI2 level	\$2,000
Zeiss autocollimator	1,000
Optical vernier	2,400
Mirror installation (ea)	175
Total	<u>\$5,575</u>

Mirror installations are permanent. Therefore, the total cost for a specific site will be dependent on the number of mirrors required. The level, autocollimator, and vernier can all be stored at a central location and used at a number of sites.

FIELD PERFORMANCE: This system has been successfully tested at sites in several Corps Districts.

BACKGROUND: Normally, tilt measurements of structures are made through installation of a plumbline, an inverted plumbline, or an optical plummet. Tilt is inferred from the displacement and length of the plumbline. These installations are expensive, and normally only a few monoliths within a structure would be instrumented. The method of tilt measurement outlined in the reference uses modern survey equipment combined with some additional optical equipment to reliably measure long- or short-term tilt of a structure to ± 2 seconds of arc.

DESCRIPTION: The equipment used for this method of tilt measurement is an automatic level, an autocollimator, an optical vernier, and a mirror. The mirror is used as a sight and is mounted to the wall of a monolith or, for short-term measurements, could be mounted on a surveyor's tripod. The autocollimator will attach to the eyepiece of the automatic level, which will be mounted on a tripod. The automatic level maintains the projected line-of-sight normal to the gravitational force from one measurement to the next. The autocollimator is a device that projects a collimated beam of light onto the mirror. The reflected light re-enters the autocollimator, and the difference in angle between the projected light and reflected light may be measured. By passing the line-of-sight through an optical vernier, the displacement of the projected light rays can be measured precisely.

REFERENCE: An instrument to monitor the tilt of large structures.
K. Robertson. US Army Engineer Topographic Laboratories,
Ft. Belvoir, VA, Apr 1983. Technical Report ETL-0313.