Spot-on surveying at Humber Bridge

Reprinted from Highways & Road Construction. August, 1973

Spot-on surveying at Humber Bridge

Right on target with the Kern ME 3000 Mekometer

WHAT can only be described as almost perfect accuracy on short range surveying, now seems unrivalled with the "commercial" introduction of the Kern ME 3000 Mekometer. The Mekometer, which is not new, the birth of the prototype being some twelve years ago, works on electro-optical distance measurement. It was originally developed by the National Physical Laboratory as part of its velocity of light programme. Kern and Co, of Aarau, Switzerland, bought from the National Research Development Corporation (NRDC) the right to develop the instrument.

In brief, the Mekometer uses polarisation modulation at the ultra-high frequency of 500 Mhz (a 60 cm modulation wavelength) and the associated mechanical phase compensator is free from cyclical errors. To the stated accuracy, the instrument is unique, in that it is self-compensating for the effects of atmospheric refractivity which enables a fully corrected digital read out in metres, to be obtained.

The three main companies involved over the more recent years of the Mekometer's maturing, other than Kern themselves are, Survey and General Instrument Co Ltd, of Fircroft Way, Edenbridge, Kent, who are the sole agents in the UK for the ME 3000, and all other Kern equipment, Com-Rad Electronic Equipment Ltd, of Slough, who were completely responsible for all the electrical intricacies of the Mekometer, and Fairey Surveys Ltd, Reform Road, Maidenhead, Berkshire, who used the prototype Mekometer on several extensive jobs, notably the London Fleet Line, and the Manchester Rapid Transit System. Now, with the introduction of the "Mek" 3000 as a commercially viable instrument, Stuart Freeman, Sales Manager of Survey and General Instrument, and Peter Green, of Fairey Surveys Ltd, invited *Highways and Road Construction* to scrutinise the "newer" Mekometer on site at the Humber Bridge construction, to illustrate the versatility of the instrument.

Objective of the survey

The Humber River, at the bridge position, is about 1,800 m wide. The

On site at the Humber the ME 3000 in operation.

ends of the centreline of the bridge had been defined on each bank and a number of survey marks emplaced, from which it was intended to monitor the construction of the towers. The survey tasks involved, were to interpolate additional points on the centreline; measure the distance along the centreline; co-ordinate the additional survey points for monitoring the construction of the towers, together with some of the original survey points used in the initial design work; connect the levelling on the south bank to that on the north; and produce a set of co-ordinates on a local grid orientated on the centreline, with a transformation of the co-ordinates to National Grid for comparison with the original survey.

Interpolation

An approximate position for B4 (see diagram) was found by sighting N5 from B1 and guiding a man with a pencil onto the line by radio. The instrument was then set over this position and the true centreline found by trial and error, within the centreing

Close-up: the Kern ME 3000 Mekometer.

scope of the theodolite. The final position was transferred to the ground point using the optical plummet. Position N7 was found by swinging face right and left 180° angle at N5. The final centreline was checked to within second of arc by measurements with the theodolite at all points on it.

Centreline measurements

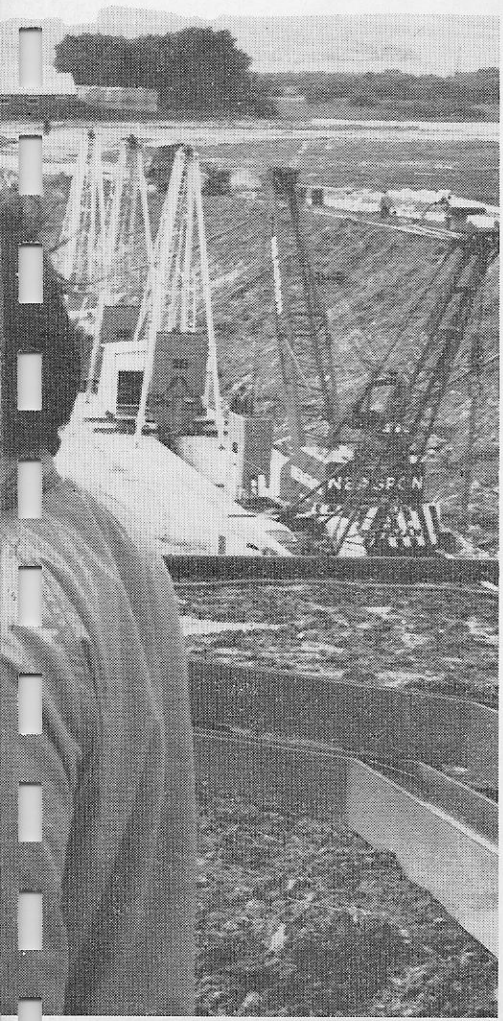
The Mekometer was used to measure the distances between B5, B1, B4, N6, N5 and N7 with the results shown on the facing diagram. Reduction to horizontal was achieved by using the levelled elevations of the ground marks and the measured heights of the instruments and reflectors. The main measurements were taken twice, from opposite ends of the lines, on successive days. Four reflectors were used and were individually calibrated.

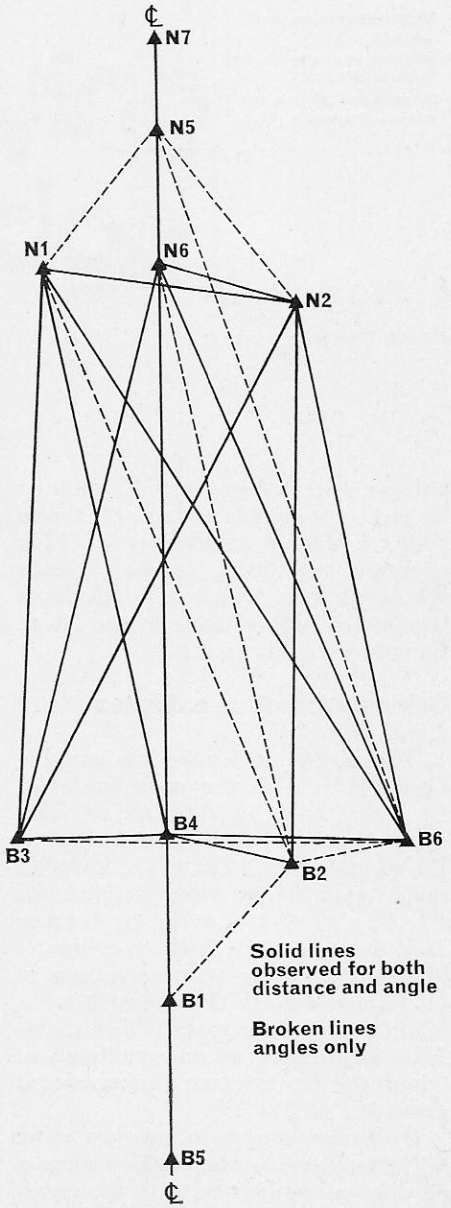
Mekometer distances were taken to provide a network across the river connecting the monitoring points, and theodolite angles were taken to provide a full triangulation of these points. All angles were measured with a one second theodolite on three zeros. Main angles were onto tripod mounted targets; some of the short lines were to nails set on the ground marks.

Connection of levels across the river

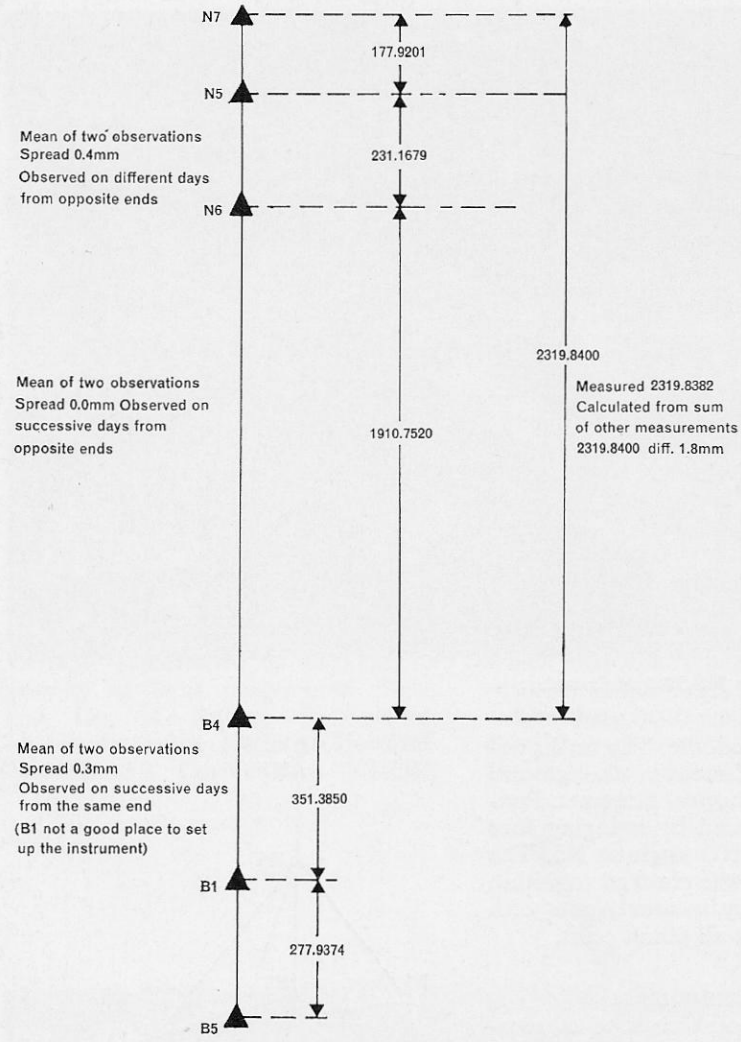
All survey points on both sides of the river had already been connected to the nearest Ordnance Survey Bench Marks. The river crossing excercise was to establish the relationship of the two systems.

Simultaneous vertical angles were taken across the river by theodolites set at survey points B6 and N2. Obser-





The Humber Bridge scheme.



Centre line measurement.

MEKOMETER DISTANCE MEASUREMENT

Job No. FD8 Name HUMBER BRIDGE

Date 19/6/73 Observer S.F.

At Station N2 VA/Inst.HT. 1·298

To Station N6 Refl.Ht. 1·1114 Refl.No MEK

Distance	86·6285	Fine Fwd.
	·7 7	
	·7 7	
	·8 2	
	·8 2	
	·7 7	Fine Reverse
	·7 7	
	·7 8	
	·7 7	
	·7 7	
Sum Fine Reading	·789	
Mean Fine Reading	·6279	
Reflector Constant ± +	·0013	
Final Slope Distance.	86·6292	

Distance measurement sheet.

vations were taken every 15 minutes by radio command between 11.00 and 13.00 hours in conditions of high overcast and light breeze. Results tabulated show that the South Bank levelling is high relative to the North Bank levelling by 16 mm.

Computation of co-ordinates

Local grid

The centreline is taken as running Grid North with the co-ordinates of B1 1000,0000E and1000,0000N. This gives a set of co-ordinates for points B5, B1, B4, N6, N5 and N7. Approximate co-ordinates were derived for B2, B3, B6, N1 and N2 by bearing and distance and final co-ordinates obtained by using all observations in an adjustment of the network by a method of least squares. The maximum adjustment on any one line was 9 mm, this representing a proportional error of 1 in 214,000.

By comparison, an adjustment using only the distance observations gives a far higher consistency, with the maximum residual only 1.3 mm and a maximum difference in co-ordinated position of 10.4 mm. The mean difference in co-ordinated position between the two adjustments is 2.5 mm. The reason for using the results from the adjustment using both angles and distance was that the network produced was very much stronger. The differences between the adjustment can be attributed to the fact that one second at the width of the Humber subtends one centimetre, so that the precision of a theodolite fix at these ranges is much lower than that of a Mekometer fix.

The Local Grid co-ordinates were converted to National Grid using the National Grid co-ordinates of B1 and the given bearing on the centreline of the bridge. As a check, the co-ordinates of the defunct north and south pins were computed, using the data provided by the main contractor of the scheme, John Howard and Co Ltd.

Comment

In total the entire survey took 13 days on the site, with previous days for preparation and some more time for calculations after completion in the field. A lot of time was lost because of bad communication on both sides of the river.

However, the Mekometer enabled a very precise figure to be obtained for the chainage along the centreline and good positions to be obtained for the monitoring survey points despite the poor shape of the feasible network. What is more, the ME 3000, once in position and set up, works quickly without hitch, and would certainly deal capably with the toughest of surveying jobs.

Acknowledgements

Highways and Road Construction would like to thank John Howard and Co Ltd, the main contractor for the substructure and tower of the Humber Bridge, for its kind co-operation, Freeman Fox and Partners, the consulting engineers, Survey and General Instruments and Fairey Surveys Ltd for their help.

Printed in Great Britain by Edward Wells & Sons Ltd., 143/5 Camberwell New Road, London, S.E.5