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Ibu Pejabat
Jabatan Ukur Dan Pemetaan
Jalan Semarak
50578 Kuala Lumpur

20 Januari, 1986

PEK. KETUA PENGARAH UKUR DAN PEMETAAN BIL. 3 TAHUN 1986
Penggunaan 'Alat Ukurjarak Elektronik (EDM) Untuk Ukur Kadastra

1. Tujuan

Pekeliling ini bertujuan untuk :-

(i) Membenarkan serta menggalakkan penggunaan alat ukurjarak elektronik (EDM) dalam ukur kadastra; dan

(ii) Mengujudkan Peraturan – Peraturan bagi ujian alat ukurjarak elektronik (field calibration of EDM).

2. Latarbelakang

Penggunaan EDM telah pun bermula lebih dari 2 dekad yang lalu dan teknologi dalam bidang ini pesat berkembang sehinggalah pada masa ini telah berjaya menghasilkan kejituan yang baik dan sesuai digunakan bagi ukuran kadastra.

Peraturan Ukur (Survey Regulation) ini menyentuh secara ringkas sahaja mengenai penggunaan alat EDM seperti ternyata di :

(a) Appendix II , 1.2, m.s. 37

(b) Appendix IA , 4.2, m.s. 32

(c) Appendix IA , 5, m.s. 33

3. Tapak Ujian EDM

Jabatan ini dengan kerjasama Lembaga Juruukur Tanah , Semenanjung Malaysia telah membina satu tapak ujian EDM yang pertama di negara ini bertempat di Wangsa Maju , Setapak, Kuala Lumpur.

Latarbelakang prinsip-prinsip teknikal mengenai :

(a) pembinaan ;

(b) ujian ;

(c) pembetulan dalam ujian EDM.

adalah seperti terkandung di **Lampiran A** dan **B** .

4. Penggunaan EDM Untuk Ukur Kadastra

4.1 Penggunaan alat EDM di Jabatan – Jabatan Ukur Negeri dalam ukur kadastra hendaklah menepati Peraturan seperti di **Lampiran D**.

4.2 Alat-alat EDM yang digunakan hendaklah terlebih dahulu didalam keadaan yang baik dan 'Constant error' nya tidaklah melebihi 10mm. Sila lihat para 6.4 di **Lampiran A**.

5. Buku Kerjaluar

Sehingga satu format Buku Kerjaluar yang baru diterbitkan , buku kerjaluar yang ada sekarang bolehlah digunakan.

6. Tafsiran

Bagi tujuan Pekeliling ini , perkataan EDM bermakna sistem EDM yang mengandungi satu alat EDM dan dua 'reflectors'. Jika salah satu daripada tiga komponan tersebut digantikan/diukur/'defective'/ jatuh atau rosak, maka keseluruhan sistem EDM tersebut hendaklah diuji semula.

7. Penggunaan Oleh Juruukur Tanah Berlesen

Penggunaan alat EDM bagi ukuran kadastra oleh Juruukur Tanah Berlesen hendaklah juga menepati seperti syarat – syarat terkandung di dalam Pekeliling ini.

8. Penggunaan oleh Lain-Lain Jabatan Kerajaan dan Badan-Badan Berkanun

Pengarah-Pengarah Ukur bolehlah menggunakan budibicara sendiri untuk

membenarkan lain-lain jabatan kerajaan dan badan-badan berkanun menggunakan tapak ujian EDM bagi tujuan ujian alat-alat EDM yang dipunyai oleh jabatan-jabatan kerajaan dan badan-badan berkanun berkenaan.

Prosidur di atas hendaklah dilaksanakan mulai dari tarikh Pekeliling ini.

Sekian.
" BERKHIDMAT UNTUK NEGARA"

(ABDUL MAJID BIN MOHAMED, JSM)

Ketua Pengarah Ukur & Pemetaan
Malaysia.

Edaran:
Semua Pengarah Ukur Negeri
Pengarah Ukur Topografi

Salinan Kepada :

Timbalan Ketua Pengarah Ukur dan Pemetaan

Pengarah Ukur Pemetaan

Pengarah Ukur Kadaster

Timbalan Pengarah Ukur Pemetaan

Timbalan Pengarah Ukur Kadaster

Setiausaha,
Lembaga Juruukur Tanah Semenanjung Malaysia

KUALA LUMPUR EDM TEST BASE
DEPARTMENT OF SURVEY & MAPPING

1. Purpose

The purpose of this paper is to propose the establishment of an EDM test base in Kuala Lumpur suitable for practical use by the Department of Survey & Mapping and also for the Licensed Land Surveyors.

2. Introduction

Modern visible and infra-red lightwave distance measuring instruments are capable of measuring to a very high degree of accuracy provided they are calibrated frequently and correctly. If such calibration are not done, large and undetected systematic errors may result. To avoid this and to make the best use of an EDM instrument, it is necessary to carry out a full scale calibration. This also applies to high precision instruments, such as the Mekometer, as well to standard engineering surveying distancers.

The systematic errors which may be determined by calibration are the zero error (instrument constant), the cyclic (periodic) error and the frequency (proportional) error. These three parameters may be determined by several different laboratory or field techniques. The laboratory procedures, which provide a quick way for determining these three calibration parameters, are the 'three-point' method for zero error, the 'graduated bar' for cyclic error and the direct electronic measurement of frequency. However, since it is difficult to separate the three parameters, it is usual and better to establish the latter two in the factory and to determine the former through a least square procedure or a linear regression applied to a series of measurements on a multi-pillar base line.

Moreover, such a base can be used for external frequency calibration, which is particularly useful in the case of modern EDM instruments, many of which are not provided with a direct frequency calibration socket. However, this can only be done if the base line, in turn, has been calibrated for scale. Lastly, a field calibration of an EDM instrument carried out on a multi-pillar base line, will lead to an estimate of the observational (a priori) standard error of the instrument.

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3. Systematic Instrumental Errors in EDM Systems

Systematic instrumental errors occuring in EDM systems include uncertainties in the position of the electrical centre of the transmitter, uncertainties in the effective centre of the reflectors, frequency drift, and instrument nonlinearity. The first two sources of error must be taken into account in all survey measurements, the third requires constant monitoring, and the fourth is critical only for measurements of high precision.

In EDM systems properly adjusted at the factory, the errors noted above will be very small and in a practical sense may be insignificant. However, it is important that users of these systems realize that periodic calibration of the instruments against a known distance is absolutely necessary to assure consistent results.

Uncertainties in the effective centre of the reflector are illustrated by reference to Fig. 1, which shows a cross-section through a corner-tube retro-reflector. The distance from the face of the cube to the back corner is t. The path within the cube is a+b+c=2t. Owing to the refractive properties of the glass in the cube, the equivalent travel in air of the ray path with the cube is 1.57 x 2t. Point D represents the effective centre of the corner cube and is literally the end of the line being measured. If it were possible to mount the reflector so that D coincided with the plumb line, the reflector offset would be zero. However, D is so far behind the face of the prism that such an arrangement would be unbalanced and difficult to manage in the field. Prisms are usually mounted so that c_R is from 28 to 40 mm. Some manufacturers eliminate c_R by making an adjustment in the transmitter to absorb the offset.

When slope distances are measured, light rays striking the reflector are not perpendicular to its front face of the reflector, thus altering the path of the rays within the reflector and changing the position of the effective centre. The amount of this change is a function of the degree of slope and varies from a few tenths of a millimetre at slopes of 4° to 6° to 7 to 14 mm at slopes from 30° to 40°. Given the angle of slope, corrections can be calculated to compensate for this error. Another option is to design the reflector with an adjustment allowing the front face of the reflector to be placed perpendicular to the incoming rays of light compensating for the error instrumentally. Details concerning the formulae for making

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corrections can be found in surveying text books. Corrections of this type would be necessary on surveys of high precision where slope angles are consistently large.

At the end of the line, if the plumb line does not coincide with the exact electrical centre of the electro-optical transmitter, an instrument offset exists.

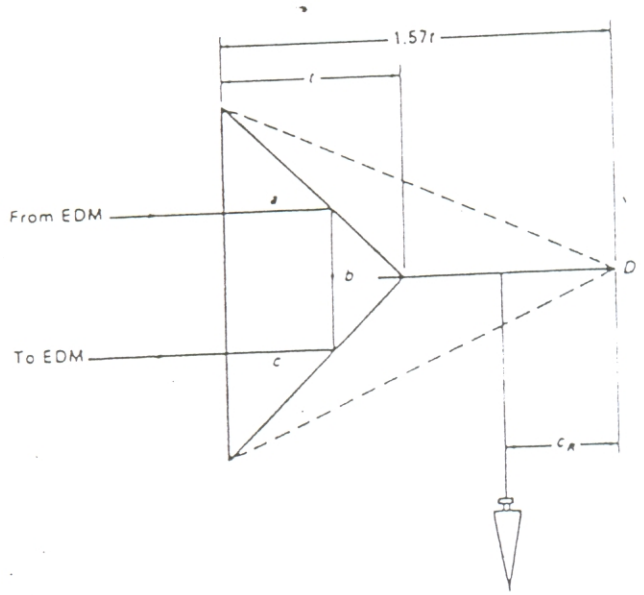

Fig. 1 Reflector Offset

4. EDM Calibration

The calibration involves the assessment of the three categories of systematic errors which are commonly encountered in EDM. These are:-

4.1 Scale error - deriving in this instance from incorrect pattern frequencies generated within the instrument.

4.2 Cyclic error - this produces errors that are a function of the point in the phase cycle where the measurement occurs and which consequently repeat over every wavelength of the measuring wave.

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4.3 *Constant or zero error - this takes into account the uncertainties in the position of the electrical centre of the transmitter and uncertainties in the effective centre of the reflector.*

It is to be noted that for practical purposes, the first two errors are not in any way significant. However, the third source, namely the constant or the zero error of the EDM should be calibrated to ascertain if the EDM is in acceptable working order.

5. *The Kuala Lumpur Test Base*

5.1 *The proposed Kuala Lumpur test base is to be sited in Wangsa Maju, Setapak. This area is chosen because it is unlikely to be disturbed by other developments and the location is such that the risk of vandalism is minimum.*

5.2 *This proposed test base is for practical use only. It does not entail complex mathematical model for the analysis of scale error and cyclic error.*

5.3 *The length of the test base is about 300 m because this is the maximum length of the boundary permitted from boundary stone to boundary stone as laid down in the Department Regulations, 1976.*

5.4 *The proposed pillar arrangement of the test base is as follows:-*

Pillar	1	2	3	4	5	6	7	8	9
2	5								
3	10	5							
4	49	44	39						
5	87	82	77	38					
6	125	120	115	76	38				
7	163	158	153	114	76	38			
8	201	196	191	152	114	76	38		
9	251	246	241	202	164	126	88	50	
10	300	295	290	251	213	175	137	99	49

...5/-

Each pillar is to be constructed as shown in Appendix B. The pillars are of reinforced concrete 1.2 m high with at least 1 cubic metre of foundation and 5/8 inch universal screw mounting to be set by 10"/2 mm tubular bubble. The pillar positions as shown above is an indication only and need not be exact.

5.5 However, distances between pillars must be measured with high precision satisfying the following limits:-

5.5.1 For distances below 100 metres invar tape is recommended to determine the most probable values of the base line with a M.S.E. ±0.5 mm.

5.5.2 For distances above 100 metres, high precision EDM (± 2mm +2ppm) is recommended for use to obtain the most probable value of the base line. Repeated measurements are necessary as illustrated below:-

Dist (m)	Setting Error (mm)	MSE for 10 EDM measurements with ± (2mm +2ppm)	Probable Error (mm)
125	±0.2	±0.67mm	±0.87
163	±0.2	±0.68mm	±0.88
201	±0.2	±0.68mm	±0.88
251	±0.2	±0.69mm	±0.89
300	±0.2	±0.70mm	±0.90

5.6 The EDM system should be tested periodically at 3 months interval.

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6. *Field Procedure & Treatment of Results*

6.1 *In the field, EDM readings suitably measured are compared directly with the established distances between pillars. If sufficient readings are taken, a regression analysis should be used to assess the zero correction and provide an estimate of uncertainty in the measurement process.*

6.2 *For a good estimation of the constant error of the EDM, it is recommended that at least 17 measurements are obtained as follows. However more measurements will be desirous if a better estimate of the zero error is required.*

Pillars	*Established known Length (From Test Base)*	*Measured Length*
1 - 2	L1	$l_1 + C$
1 - 3	L2	$l_2 + c$
1 - 4	L3	$l_3 + C$
1 - 5	L4	$l_4 + C$
1 - 6	L5	$l_5 + C$
1 - 7	L6	$l_6 + C$
1 - 8	L7	$l_7 + C$
1 - 9	L8	$l_8 + C$
1 - 10	L9	$l_9 + C$
2 - 3	L10	$l_{10} + C$
2 - 4	L11	$l_{11} + C$
2 - 5	L12	$l_{12} + C$
2 - 6	L13	$l_{13} + C$
2 - 7	L14	$l_{14} + C$
2 - 8	L15	$l_{15} + C$
2 - 9	L16	$l_{16} + C$
2 - 10	L17	$l_{17} + C$

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6.3 If 'C' is the constant error of the system, the following results apply:-

Pillars	Measured Length (A)	Known length (B)	Constant Error (C)
1 - 2	$l_1 + C$	L1	A-B
1 - 3	$l_2 + C$	L2	A-B
1 - 4	$l_3 + C$	L3	A-B
1 - 5	$l_4 + C$	L4	A-B
1 - 6	$l_5 + C$	L5	A-B
1 - 7	$l_6 + C$	L6	A-B
1 - 8	$l_7 + C$	L7	A-B
1 - 9	$l_8 + C$	L8	A-B
1 - 10	$l_9 + C$	L9	A-B
2 - 3	$l_{10} + C$	L10	A-B
2 - 4	$l_{11} + C$	L11	A-B
2 - 5	$l_{12} + C$	L12	A-B
2 - 6	$l_{13} + C$	L13	A-B
2 - 7	$l_{14} + C$	L14	A-B
2 - 8	$l_{15} + C$	L15	A-B
2 - 9	$l_{16} + C$	L16	A-B
2 - 10	$l_{17} + C$	L17	A-B
			(A-B)

Therefore constant error $C = \frac{(A-B)}{17}$

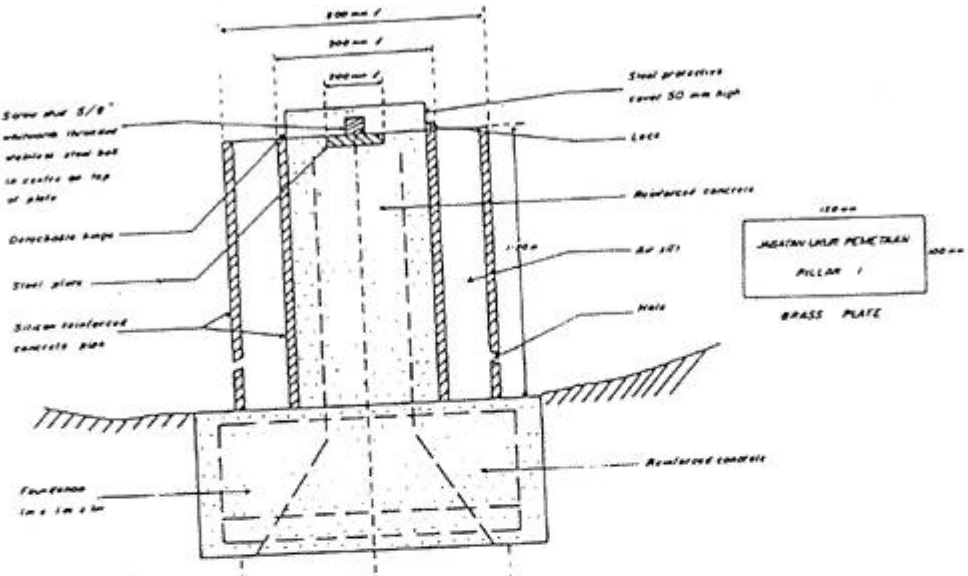
6.4 Magnitude of the constant error should not under any circumstance, exceed 10mm. If it exceeds 10mm, it is recommended that the EDM under test should be sent to factory for checking.

6.5 If the magnitude of the zero error of the EDM under test falls within the 10mm limit, then it can be considered as in acceptable good working condition. It is to be noted that the constant error (C) thus obtained is only an indication of its magnitude & is not to be applied to any of the field measurements.

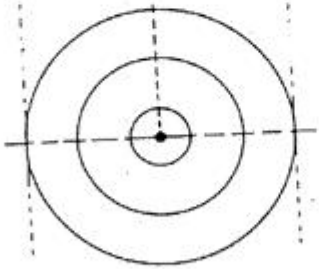
Department of Survey & Mapping, Malaysia
August, 1985.

LAMPIRAN B

EDM TEST BASE PILLAR



SIDE ELEVATION



PLAN VIEW

Specifications

PILLAR

Concrete : 28 Days 21 N / M²

Steel : 4 x Y 13, LINKS R 10 A 300 C/C

FOUNDATION

Concrete : 28 Days 21 N / M²

Steel : Top : R 10 at 300 C/C both ways

Bottom : Y 13 at 300 C/C both ways

BRASS PLATE is to be set only the pillar 1 meter from the base

Lampiran D

Peraturan Penggunaan EDM Untuk Ukur Kadaster

1. Semua Jabatan Ukur Negeri adalah dibenar dan digalakkan menggunakan EDM dalam kerja-kerja ukur kadastra.

2. Semua alat EDM yang akan digunakan hendaklah diuji sebagaimana syarat-syarat seperti berikut :-

   2.1 Semua alat EDM yang digunakan hendaklah diuji di Tapak Ujian EDM.

   2.2 Semua EDM yang digunakan hendaklah diuji tiap-tiap 3 bulan.

   2.3 Impak Ujian EDM adalah di bawah jagaan Pengarah Ukur Negeri. Oleh itu, semua pengguna tapak ujian tersebut perlu menghubungi pejabat beliau.

   2.4 Satu buku Rekod Ujian EDM hendaklah diadakan di Pejabat Pengarah Ukur Negeri supaya suatu rekod lengkap semua alat EDM yang digunakan dapat disimpan.

   2.5 Cara ujian serta cara-cara menggunakan data-data ujian adalah tertara di Perenggan 6 Lampiran A.

   2.6 Ujian EDM hendaklah dibuat di atas borang khas yang disediakan sebagaimana yang terkembar di Lampiran E. Borang tersebut hendaklah dikepilkan di mukasurat hadapan buku kerjaluar dan satu salinannya diserahkan kepada Pengarah Ukur Ngeri berkenaan.

   2.7 Contoh penggunaan borang Ujian EDM adalah seperti di Lampiran F.

   2.8 Cara-cara mengguna Tapak Ujian EDM serta penyelenggaraan dan penjagaannya adalah seperti di Lampiran C.