# THE COMPARISON OF SPEED, COST AND ACCURACY OF TRAVERSING USING EDM, ODM AND STEEL TAPE

BY

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A project submitted to the Postgraduate School, Ahmadu Bello University, Zaria in partial fulfillment of the requirements for the award of the degree of Master of Science in Land Surveying.

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June, 1937.

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## DECLARATION

I hereby declare that this project has been composed by myself and that it is a report and record of my own research work. It has not been accepted in any previous application for award of any higher degree. All sources of information are duly acknowledged by means of references.

Matthew Nnonyelu Onoh.

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## CERTIFICATION

The Project thesis entitled "the comparison of speed, cost and accuracy of traversing using steel tape, EDM and ODM" by Matthew Nnonyelu Onoh meets regulations governing the award of the degree of M.Sc (Land Surveying) of Ahmadu Bello University, and is approved for its contribution to knowledge and literary presentation.

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## DEDICATION

This work is dedicated to the born and unborn children of Nwonobele family.

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ABSTRACT

The Comparisonof Speed, cost and^accuracv of traversing

usinq EDM, ODM and Steel tape

A built-up area (Faculty of Enqineerinq) within the Ahmadi Bello University. Samaru Campus was traversed emplovinq theodolite with three methods of linear measurements. The obiective was to comparatively and statistically analyse the computed results of each of the three methods, in terms of speed, cost and accuracy.

The anqular measurements were made with theodolite and linear measurements were separately made with Steel tape, EDM (Eldi-1) and ODM (Self-reducinq tacheometer ).

The analyses of the results were done with regards to parameter of time for speed, manpower involved, equipment cost, overhead charqes etc were used for costing, and jr accuracy; the relative accuracy was the parameter used. Also, investiqations into dependency of time and method; cost and method; and accuracy and method were carried out.

The results showed that EDM has the highest cost and best accuracy, ODM has the shortest time and Steel tape is the cheapest and slowest of the three methods.

Hence, for high accuracv work, (over 1/20000). measure-ments of short or loner lines; EDM is recommended. For low order works (< 1/5000) . ODM should be used and Steel tape is recommended for accuracies greater than 1/5000, and on gentle topography.

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## Definitions of Abbreviations and Symbols

EDM - Electromagnetic Distance Measurement

ODM - Optical Distance Measurement

ST - Steel Taping.

$K_2$ - Measure of Overhead rates.

S - Observed distance in the field.

$\ell$ - Norminal length of tape

$\ell'$ - Standardised length of tape

C - Correction due to incorrect length of tape.

h - Difference in height

$C_h$ - Slope correction.

$\beta$ - Coefficient of expansion of steel tape.

$t_s$ - temperature of standardisation of the tape.

$t_f$ - Observed field temperature.

$C_t$ - Temperature correction.

$T_s$ - Standardisation tension.

$T_f$ - Observed field tension.

A - Cross-sectional area of the tape.

$E_2$ - Modulus of elasticity of the tape.

$C_T$ - Tension correction per tape length.

D - Horizontal distance.

$k_1$ - Multiplying constant in tacheometer.

$S_1$ - Staff intercept reading.

$n_g$ - refractive index of standard air.

$\lambda_c$ - Wavelength of carrier wave

$n_a$ - Refractive index different from standard air.

p - atmospheric pressure.

t - air temperature.

e - partial vapour pressure

$\sigma_e$ - Standard error in barometric pressure

$\sigma_t$ - Standard error in air temperature.

$\sigma_{n_a}$ - Standard error in regractive index of non-standard air.

$V_o$ - Velocity of infrared, wave in air

$C_s$ - Velocity of light in a Vaccuum.

$\phi$ - Angle of staff made with the vertical

E - Easting coordinate.

N - Northing coordinate.

$\sigma_{zo}$ - Zero error.

$e_i$ - error

n - number of stations

$\sigma$ - Standard error of the theodolite

$\bar{X}$=MPV- Most probable value

V - residual

X - Observed angles.

K - Number of rounds of zero

$E_1$ - allowable error.

$\alpha$ - Known bearings of lines.

$\Theta$ - External angles at respective stations.

$\sum_{i=1}^{5} D_i$ - Total distance of the traverse in kilometers.

$\sum$B.S - Sum of Back sights readings of levels.

$\sum$F.S - Sum of fore sights readings of levels.

$\alpha_1$ - Adjusted bearing of a line.

$\Delta E$ - Partial eastings.

$\Delta N$ - Partial Northings.

$e_{\angle}$ - Linear error in the traverse.

$e_E, e_N$ - respective cumulative errors in easting and northing coordinates of the last station.

$\not>$ not greater than.

$>$ greater than.

CHAPTER 1

## 1.1 INTRODUCTION

Traversing can be carried out by linear and angular measurements. The linear measurements are usually made with Steel tape or EDM or ODM while the angular measurements are made with compass or theodolite.

Traversing can be to demarcate boundaries of an area or to establish survey controls for detailing. This area could be an open or built-up area.

The methods of traversing have different performance in theory and practice in terms of speed cost and precision. This statement is yet to be confirmed.

Therefore, the main aim of this project is: To carry-out traversing employing theodolite with each of the three methods of distance measurements, then compare the speed, cost and accuracy of each method. Also to highlight the problems of traversing in a built-up area.

## 1.2 REVIEW OF LITERATURE

### 1.2.1 Speed

The speed of traversing is mostly affected by weather conditions (rain), the topography of the area, the experience of the surveyor, distance.

Also, the computing and survey checks stand out as sources of delay in speed of traversing. Dale (1976) writes that "in an average survey by numerical methods,

KASHIM

the time spent on computing is normally of the order of 30 to 40 percent of the overall time of the survey during which many survey assistants are often unproductively employed".

The subjection to rigorous checks to see whether at any stage there exists errors and whether the survey is efficient and makes full use of available resources and the least use of scarce increases the time delay and small productivity between the demand for a survey and the date at which all aspects of the work are completed. In many countries, Dale (1976) writes that "time saved can be profitably used to improve productivity and to extend the services of the surveyor to the wider fields of land information where his expertise is relevant and where the demand for information is growing"

In one way or the other, the accuracy required may determine the speed of work. For example, a survey of low accuracy will not undergo rigorous checks as above which implies that the survey work will be produced faster while a high accuracy required survey, undergoes these rigorous checks leading to delay in time.

Again, weight of instruments affects mobility in the field, Clark (1972) suggested that "it is incumbent on the surveyor to exercise considerable discretion in adjusting the methods to what can be considered, to be the necessities of the case with which the purpose is intended".

Bomford (1980) asserted that theoretical results provide that the speed of traversing increases in the following order - steel taping, ODM and EDM. Dale (1976) reported that "steel taping is most affected by the topography of the area being surveyed and therefore the slowest means of carrying out measurements"

### 1.2.2 Cost

Generally the cost of survey depends solely upon speed, labour and equipment used and in addition the accuracy required. Dale (1976) wrote that as a general rule;

> The cost of survey may be estimated from labour rates and the time spent on the survey and quotes 'sources' in many countries which suggest that the basic field and office costs of the people who actually carry out the work can be multiplied by three to give a fair approximation to the true overall cost of a survey.

In estimating, overheads should include the salaries of administrative and supervisory staff not directly concerned with the production process, the costs of maintaining buildings, heat, light, telephones, postage, the cost of amortisation of equipment, training and loss through sickness.

Dale (1976) particularly enumerated estimates of overhead to include:

> (a) Salaries including social insurance, cost of overtime, costs incured in recruitment and training programmes, bonuses and pension contributions, and payments of pensions or gratuities to retired personnel.
> (b) Equipment, including purchase costs, import duties, costs of installation, interest on capital, depreciation or rent of equipment, costs of maintainance.
> (c) Materials including purchase costs and allowance for wastage, transportation, including payments for use of private transport systems as well as running costs

and capital depreciation on organisational transport.
(d) Building, including purchase cost with loss of interest on capital used for the purchase, rent maintainance, heating, lighting, air conditioning, power supply.
(e) Other cost items, including research and development, public relations, costs incurred in acquiring work, the preparation of specifications and tenders, cost of employing consultants, including accountants, profit margin risk and insurance.

Of all these, the parameter of heating is not so relevant to Nigeria. Again, Dale (1976) asserts that "the *cost of a survey may be estimated from the formula:*

$$Cost = k_2 XY/1500 \quad \ldots\ldots\ldots\ldots\ldots \quad (1)$$

where $k_2$ is a measure of overhead rates which normally is in the region of 2.5 to 3.5, though it could be higher. X is the salary of any individual concerned and Y is the number of hours he spends on the job."

In Nigeria, some survey organisations such as Surveyors-General, Nigerian Institution of Surveyors have set various parameters which should be the determining factors in the costing of survey works called scale of fees. The Surveyors-General of Nigeria asserted that: 'apart from market trends on cost of materials, cost of equipment, cost of labour and services, the nature of the work i.e. traversing, triangulation, aeriel photography, accuracy requirements, the type of topography, size and coverage of land and transportation or accessibility should be considered".

In the process *of costing* /the Surveyors-General categorised the type of survey works to necessitate proper costing and recommended that cost of survey may be considered under any or some of the following types of terrain. I quote:

(a) Open or lines properly cleared by the client.
(b) Thick grass, orchard bush, light forest.
(c) Swamp land.
(d) Medium forest.
(e) Heavy forest with dense secondary growth and other factors as
(i) Investigation and searching fees.
(ii) Recce and beaconing fees.
(iii) Survey party charges.
(iv) Materials needed for survey.
(v) Transport costs.
(vi) Instrumentation costs.
(vii) What to deliver to client-presentation.
(viii) Clearing and cutting (where necessary).
(ix) Connections to government beacons.
(x) Overheads and contingencies.

On determination of the cost centres for a survey work, Lakanu (1978) wrote that cost of survey party is arrived at by an assessment of salaries payable to employed staff. For cost of equipment, he asserted that "arrival at the value of this cost centre could be through the assumption that the initial capital is loaned with interest acruing, and put a terminal point to the usuable life of the equipment. Cost per day or month can then be worked out".

He further said that :

> Materials/Operating cost should be calculated from consumable i.e. cement, fuels, hotel bills over time charges etc., and overhead would be a make up to cover the cost of the extra back up services like computation, ploting, administration etc. rend red at the head office to support the survey. Profit then is at normal investment level of any thing in the 10% to 20% range.

Again Lakanu (1978) asserted that "the practising surveyor would normally look at the scope of work, the standards demanded and the limit within which the job must be completed".

Hence, based on specifications for the project, one can determine the scope, methodology and place a time scale on the execution of the project.

### 1.2.3 Accuracy

The general specification of accuracy of EDM is expressed in the form ± pmm ± qmm/km. The p and q are both standard errors. But the overal standard error of measuremer is given by Bannister et. al. (1975) as

$$e_D^2 = p^2 + (D.q.10^{-6})^2 \quad \ldots\ldots\ldots \quad (2)$$

where D is the horizontal distance. For short distances such as 100 m or less, p is more relevant and q can be ignored but when D is very large then q becomes more important. Bannister and Raymond (1975) asserted that "this p is largely dependent or the sensitivity of the phase resolver and other electrical components and as such described to be a function of instrument design. The q is dependent on the accuracy of the modulation and on the accuracy of the val e used for the refractive index".

The short range instrument gives an automatic readout, with an expected accuracy of p = ± 5mm or less plus 10 ppm of the distance. Bomford (1930) explains this high fig re of 10 ppm as "due to the automatic readout which is designed to work with very little information about atmospheric condition". Uren and Price (1978) again gave a relative accuracy of up to 1 in $10^5$ except in short lines to be achieved witho t difficulty over longer ranges up to 100 km using the EDM methods.

The accuracy of ODM is very much dependent on the length of sight. Bannister and Reymond (1975) and Uren and Price (1978) were unanimous that "the accuracy of staff reading decreases

as sight length increases and recommended that maximum length of sight should never exceed 150 m and for most purposes never more than 100 m". That is , assuming a multiplying constant of 100 for each ± 1 mm uncertainty in the staff intercept, there will be ± 100 mm uncertainty in the horizontal distance.

Hence, Uren and Price(1978) asserts that "considering all the sources of error i.e. both instrumental and field errors, an overall accuracy is at best only 1 in 1000 but this could be improved upon".

The accuracy of steel tape is made as it is reasonably possible. Hence on measurements made on ground surfaces the maximum accuracy of 1 in 5000 (Uren and Price(1978)) is achievable if standardisation and slope corrections are applied. Bomford (1980) quotes this accuracy as admissible for making topographical maps and for property surveys. This accuracy can be further improved upon to 1 in 10000 if the tape is correctly tensioned and temperature variations taken into account.

On further application of sag corrections, the accuracy is increased to 1 in 20000.

### 1.2.4 Summary of Errors in Instruments

Errors in theodolite traversing: The errors are classifed as instrumental errors, natural errors and Random errors.

The non-elimination of parallax causes the inaccurate bisection of signal. The non-verticality of the target introduces error when the signal is bisected at the top. The in-

correct value of a division of the main scale and a divisio.. of the Venier, wrong estimation on the main scale, and incorrect finding of place of coincidence of graduations cause errors in the reading of the theodolite.

The setting up of instruments on unstable surfaces causes the displacements of pegs and signals and theodolite. Also touching and handling of instruments when observing dislevels the instrument and hence will introduce serious errors. Lack of care when booking readings introduces gross errors which are of random effect. All these are sources of instrumental errors(

The wind effect, high temperature and hazy atmosphere are sources of these natural errors. A strong wind can make impossible the performance of accurate work. The high tem-- peperature effect causes shimmer. This can also throw the instrument out of exact adjustment. A hazy atmosphere increases the probability of inaccurate bisection of the target.

The random errors are inevitable errors that occur during observations. They assume positive or negative values therefore impossible for the magnitude and signs to be predicted.

Errors in Steel taping: The errors to be discussed here are those that affect ground taping in particular. These errors can be grouped into two broad categories viz.

(a) Systematic errors and (b) Random errors.

The principal errors that fall under systematic errors

are:

(i) Incorrect length of tape: The difference between the nominal length and the standardised length introduces error in the measurement. If S is the recorded length of a line, $\ell$ the nominal length and $\ell'$ the standardised length. The correction to be computed is given thus:

$$C = S((\ell' - \ell)/\ell) \quad \ldots\ldots\ldots \quad (3)$$

The sign of the correction depends on the values of $\ell'$ and $\ell$.

(ii) Tape not horizontal along the line.

A tape assumed to be horizontal may actually be inclined, hence introducing an error. The amount of this error $C_h$ is computed by using the equation

$$C_h = \frac{h^2}{2S} \quad \ldots\ldots\ldots\ldots\ldots \quad (4)$$

where h is the difference in heights of end of lines being measured.

(iii) Fluctuations in the temperature of the tape.

As steel tapes contract and expand with temperatu variations, an error is int oduced in the measurements. Hence temperature of the tape is recorded during observations to carry out corrections in order to improve accuracy. Let $\beta$ be the coefficient of expansion of the tape ($\beta$ = 0.0000 112/$^0$C for steel), $t_3$ the temperature of standardisation (usually 20$^0$C), $t_f$ the field temperature ($^0$C) and S the observed length. The correction to S is given by

$$C = \beta S(t_f - t_s) \quad \ldots\ldots\ldots \quad (5)$$

and its sign is given by the magnitude of $t_f$ and $t_s$.

(iv) Incorrect tensioning.

A tape used in the field under a tension different from the standard tension used in calibration will change in length by a slight amount according to the relationship between stress and strain. A correction which is a function of the measured length, cross-sectional area of the tape and the modulus of elasticity of the material pf which the tape is made is computed to account for the difference in tension. The correction then is given by

$$C_T = \frac{T_f - T_s}{AE_2} S \quad \ldots\ldots\ldots \quad (6)$$

where $C_T$ is the correction per tape length, $T_f$ is the tension applied to the tape in the field (N). $T_s$ is the standardisation tension (N). A is the cross-sectional area of the tape ($mm^2$). $E_2$ is the modulus of elasticity of the tape material (for steel tapes, $E_2$ = 200000 XI $mm^{-2}$) and S is the observed length of the line(m). The sign of the correction depends on the magnitude of $T_f$ and $T_s$.

(v) Incorrect Alignment.

If the measurement comprises more than one tape length and the points marking the ends of the various lengths are not along a straight line, the measured length will be two great (Allan, *et. al.* (1968)), see figure 1 below.

(vi) Tape-not-straight.

The measured length will be two great if the tape is not stretched straight, as when it is being bent eithe horizontally or vertically around trees or bushes or is blown by a strong wind. This error is more preminent near the middle of the tape. See figure 1 below.

The magnitude of these errors (incorrect alignment and tape not straight) can be calculated thus

Effect of Incorrect alignment and tape not straight

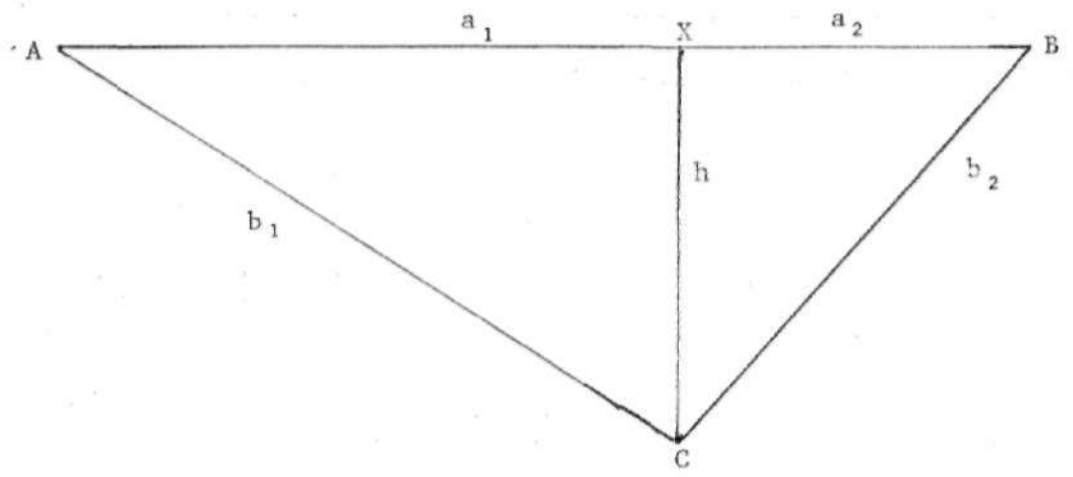



Fig 1

From figure 1, the line to be measured is AB, but due to incorrect alignment or tape not straight the lines AC and CD are measured. The error introduced is

$$(b_1 - a_1) + (b_2 - a_2) = \frac{h^2}{2b_1} + \frac{h^2}{2b_2} + \ldots . \qquad (7)$$

Suppose that $b_1 = b_2 = \frac{1}{2} S$, then

$$(b_1 - a_1) + (b_2 - a_2) \equiv 2h^2/S \quad \ldots\ldots \quad (8)$$

Errors in ODM: The error sources in ODM (self-reducing facility) are of two categories: (i) Instrumental and (ii) field errors.

The instrumental errors include :

(a) an incorrectly assumed value for $k_1$, the multiplying constant, that is an error in the diaphragm construction.

(b) Errors arising out of the assumption that modern telescopes are anallactic and that the stadia formula

$$D = k_1 s_1 + c \quad \ldots\ldots\ldots \quad (9)$$

is applicable when strictly, both $k_1$ and c are variable.

The field errors are errors due to

(a) incorrect reading of the staff intercept (b) non-verticality of the staff and (c) incorrect reading of the circle readings.

The effect of the non-verticality of the staff is shown figure 2 below

Effect of non-verticality of staff.

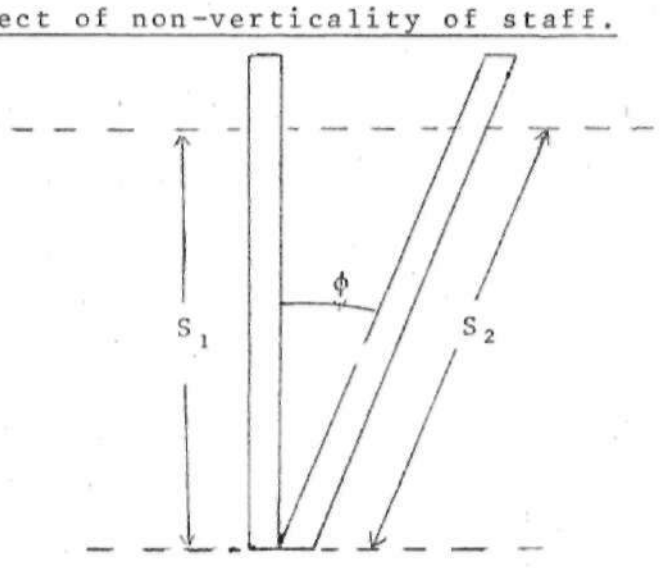



Fig 2.

The staff is held at an angle $\phi$ to the vertical and the reading is $S_2$ instead of $S_1$. The effect of this error is shown in the following equations

From the figure

$$S_1 = S_2 \cos \phi \equiv S_2 - \frac{1}{2} S_2 \phi^2 \quad \ldots\ldots \quad (10)$$

where $\phi$ is in radiens.

Hence, the error is

$$S_1 - S_2 = \frac{1}{2} S_2 \phi^2 \quad (11)$$

If $\phi = 2^0$ and $S_1 = 1.5$ m, the error is approximately 3 mm.

Errors in EDM

Errors can arise from two main sources namely internal and external factors. The internal sources of error are

(a). the accuracy of the standard cristal frequency

(b) the limit of phase resolution and

(c) Spurious phase shifts in the circuits and antenae.

The external sources of error are (a) uncertainties in the refractive index (b) uncertainties in the path length from curvature and zero error. (c) Ground swing effect from reflected signals.

Also the results of measurements is a slant range at some elevation above sea level. So corrections for slope, sea level, chord or arc and a projection scale factor may be required in standard surveying computations.

These errors are well described in Burnside (1971). But the refractive index uncertainties need be mentioned here. This can be computed for various carrier wave. Only that of infrared waves will be discussed here, because the instrument uses infrared waves.

For near-infrared modulated wave, the refractive index ($n_g$) of standard air (Moffitt, 1975) (i.e. dry air at $0^0$C, 760 mm of mercury pressure ( = 1013.250 mbar) and with 0.03% of $CO_2$) is given by

$$n_g = 1 + (287.604 + \frac{4.8864}{\lambda_c^2} + \frac{0.068}{\lambda_c^4})10^{-6} \quad \ldots (12)$$

where $\lambda_c$ is the wave length of the carrier wave in micrometers. For example, for a He - Ne laser, $\lambda_c$ = 0.6328 μm and $n_g$ = 1.000300.

For conditions departing from the standard air the refractive index $n_a$ is computed from

$$n_a = 1 + \frac{0.35947(n_g - 1)p}{273.2 + t} - \frac{1.5026\ e \times 10^{-5}}{273.2 + t} \quad \ldots (13)$$

where p is the atomospheric pressure in millibars, t is the air temperature in degrees celsius, and e is the partial vapour pressure in millibars (Blachut, et. el. 1979)

The last term in equation 13 is neglected, since humidity has very little effect on near-infrared waves. Hence

$$n_a = 1 + \frac{0.35947(n_g - 1)p}{273.2 + t} \quad \ldots\ldots \quad (14)$$

Differentiating partially to find the influence of errors $\sigma_p$ and $\sigma_t$ in barometric pressure and temperature, we obtain

the error propagation equation

$$\sigma^2_{n_a} = \left[ - \frac{0.35947(n_g - 1)\rho}{(243.2 + t)^2} \right]^2 \sigma^2_t + \left[ \frac{0.35947(n_g-1)}{273.2+t} \right]^2 \sigma^2_\rho \quad (15)$$

Also the velocity of infrared wave in air $V_a$ is relate to the velocity of light in a vaccuum by

$$V_a = C_s/n_a$$

where the approximate value $C_s$ is $300 \times 10^6$m/s.

### 1.2.5 Reduction of slope measurements

The distances measured with the EDM and steel tape are normally slope (slant) distances. They are reduced to horizontal distances by measuring the vertical angles and using the equation 16 below. Or by the difference in elevation.

In figure 3 below S is the length of the

Relation between D and S

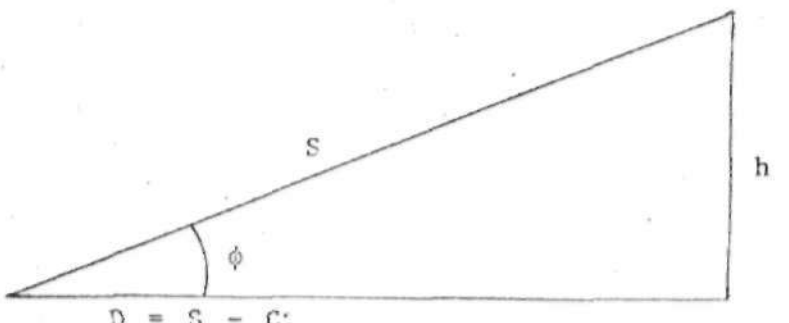



Figure 3

sloping line observed, h is the difference in elevation between the two ends and D is the horizontal distance

required.

From this right-angled triangle

$$D = S \cos \phi \quad \ldots\ldots\ldots\ldots \quad (16)$$

Also

$$D = (S^2 - h^2)^{\frac{1}{2}} \quad \ldots\ldots\ldots\ldots \quad (17)$$

Equation 17 is rearranged to give a correction that may be subtracted from the slope distance to give the horizontal distance. Expanding the right side of the equation by binomial series gives

$$D = S - h^2/2S - h^4/8S^3 - \quad \ldots\ldots\ldots \quad (18)$$

We have $C_h = S - D$, the correction, then is given by

$$C_h = h^2/2S + h^4/8S^3 + \quad \ldots\ldots\ldots \quad (19)$$

The second term of this equation is discarded as it is very small. Hence leaving us with the correction as

$$C_h = h^2/2S \quad \ldots\ldots\ldots \quad (20)$$

Therefore the horizontal distance is

$$D = S - C_h$$

i.e. $D = S - h^2/2S \quad \ldots\ldots\ldots \quad (21)$

1.2.6 Parameters of Comparison.

The mathematical models that relate parameters of the traverse are discussed. These are the relationship between bearings, distances, coordinates and Areas. These parameters can be subjected to statistical tests such as the F-test

statistics, $\chi^2$ test statistics and t - test statistics.

Coordinates, Distances and Bearings.

The mathematical relationship between these quantities can easily be visualised from the figure 4 below

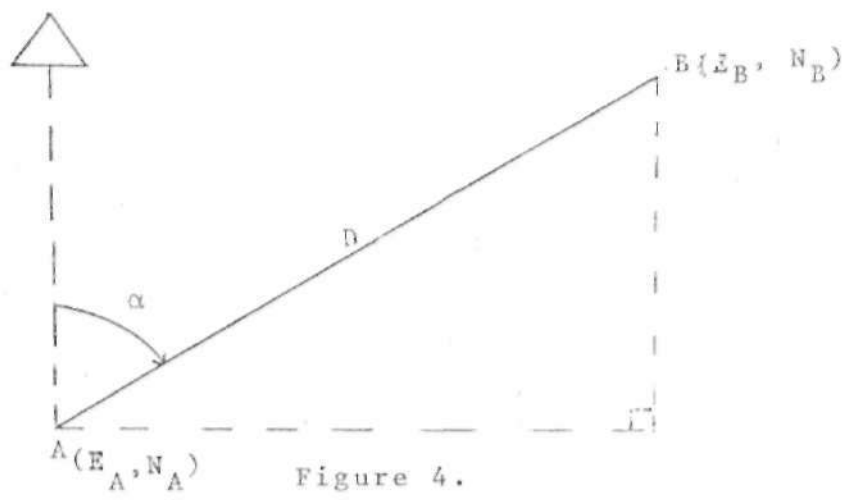



Figure 4.

Hence,

$$E_B = E_A + D \sin \alpha \quad \ldots\ldots\ldots \quad (21a)$$

$$N_B = N_A + D \cos \alpha \quad \ldots\ldots\ldots \quad (21b)$$

where $E_B$, $N_B$ are the easting and northing coordinates respectively of point B and D is the horizontal distance of line AB, $E_A$, $N_A$ are easting and northing coordinates of the point A( Shepherd (1957)).

Differentiating with respect to α and D we have

$$dE_B = D \cos \alpha d\alpha \text{ or } dE_B = \sin \alpha \, dD \quad \ldots\ldots \quad (22a)$$

and

$$dN_B = - D \sin \alpha d\alpha \text{ or } dN_B = \cos \alpha \, dD \quad (22b)$$

The combined effect of errors in length and bearing can be

investigated by differentiating the equations 21a, 21b partially, i.e.

$$dE_B = D \cos \alpha \, d\alpha + \sin \alpha \, dD \quad . . . \quad (23a)$$

$$dN_B = -D \sin \alpha \, d\alpha + \cos \alpha \, dD \quad . . . . . \quad (23b)$$

This mathematical model represents the effects of the systematic errors in the easting and northing coordinates of a station. The $d\alpha$ and $dD$ are the total standard errors in the angular and linear measurerments respectively.

Reciprocal effect

A reciprocal effect can be carried out by computing the distances and bearings from the coordinates, since some distortions in the bearings and distances exist. These are investigated mathematically as follows :

From Figure 4 ,

$$D^2 = (N_B - N_A)^2 + (E_B - E_A)^2 \quad . . . . . \quad (24)$$

Differentiating partially, we have

$$2DdD = 2\Delta N_{AB}(dN_B - dN_A) + 2\Delta E_{AB}(dE_B - dE_A) \quad . . .$$

$$dD = \frac{\Delta N_{AB}}{D}(dN_B - dN_A) + \frac{\Delta E_{AB}}{D}(dE_B - dE_A) \quad . . . (25)$$

where $\Delta N_{AB} = N_B - N_A$ and $\Delta E_{AB} = E_B - E_A$

The error introduced in the distance depends on the changes in the northing and easting cordinates.

Again for computed bearing

$$\tan \alpha = E_B - E_A / N_B - N_A \quad \ldots\ldots \quad (26a)$$

Differentiating partially.

$$(dN_B - dN_A)\tan \alpha + (N_B - N_A)\sec^2 \alpha d\alpha = dE_B - dE_A \quad \ldots(26b)$$

Multiplying through by $\cos^2\alpha/\Delta N_{AB}$, we have

$$d\alpha = \frac{\cos^2\alpha}{\Delta N_{AB}}(dE_B - dE_A) - \frac{\sin \alpha \cos \alpha}{\Delta N_{AB}}(dN_B - dN_A) \ldots \quad (26c)$$

$$d\alpha'' = \frac{\cos \alpha}{D \sin 1''}(dE_B - dE_A) - \frac{\sin \alpha}{D \sin 1''}(dN_B - dN_A) \quad \ldots \quad (26d)$$

Equation 26d shows that $d\alpha$ depends on the changes in coordinates.

Also, change in area is dependent on the variations in the easting and northing coordinates of stations. The following equation shows this by differentiating partially the area computation formula from coordinates.

$$\begin{aligned} dA = {} & dN_1(E_2 - E_o) + dN_2(E_3 - E_1) + dN_3(E_4 - E_2) + dN_4(E_5 - E_3) \\ & + dN_5(E_6 - E_4) + dN_6(E_7 - E_5) + dN_7(E_8 - E_6) + dN_8(E_9 - E_7) \\ & + dN_9(E_{10} - E_8) + dN_{10}(E_{11} - E_9) + dN_{11}(E_{12} - E_{10}) + dN_{12}(E_{13} - E_{11}) \\ & + dN_{13}(E_{14} - E_{12}) + dN_{14}(E_o - E_{13}) + dN_o(E_1 - E_{14}) + N_1(dE_2 - dE_o) \\ & + N_2(dE_3 - dE_1) + N_3(dE_4 - dE_2) + N_4(dE_5 - dE_3) + N_5(dE_6 - dE_4) \\ & + N_6(dE_7 - dE_5) + N_7(dE_8 - dE_6) + N_8(dE_9 - dE_7) + N_9(dE_{10} - dE_8) \\ & + N_{10}(dE_{11} - dE_9) + N_{11}(dE_{12} - dE_{10}) + N_{12}(dE_{13} - dE_{11}) + N_{13}(dE_{14} - dE_{12}) \\ & + N_{14}(dE_o - dE_{13}) + N_o(dE_1 - dE_{14}) \quad \ldots\ldots\ldots \quad (27) \end{aligned}$$

Different subscripts in the coordinates just illustrate the effect of the variations of coordinates on area.

CHAPTER 2

# PREPARATORY WORK

## 2.1 Reconnaissance

The reconnaissance involved the choice of the area, stations and thus the traverse lines. The area covered by control scheme of faculty of Engineering was chosen. This area is very ideal for the work because :

(a) It is tied to the campus Network, which in effect has also been tied to the National Network.

(b) It is a built-up area and therefore good to investigate the problems of traversing in built-up areas which is one of the objectives of the project.

The control points CP 13 and CP 12 located around the faculty of Engineering are available to the area. Their eastings and Northings coordinates are given as.

| Point | Easting (E) | Northing (N) |
|---|---|---|
| CP 12 | 17477.084 m | 9954.014 m |
| CP 13 | 17516.967 m | 9789.314 m |

Apart from these two points, the other points (stations) were buried in the ground. Hence new stations were established to follow the same line of the old scheme because the period of the work being dry season made the ground too hard and tiring to dig. Also the digging would have disturbed the positions of these stations.

The new stations are iron rods of 2 cm in diameter cut into lengths of 15 cm. The rods were nailed to assume level

with ground surface. Then these formed the stations of the traverse legs starting from CP 12 and ending on CP 13.

Short lines were established to avoid the numerious obstacles encountered since the area is a built-up one. The stations were established in such a way to avoid grazing rays, to eliminate shimmer or horizontal refraction which causes minor inaccuracies in observing the angles.

The stations were also on hard or firm level ground to give an unyielding support for the instrument. The sketch of the traverse is shown in figure 5 below.

The preliminary equipment and materials used for the reconnaissance were: prismatic compass, hammer, control scheme plan of the area, booking sheets and ranging poles.

## 2.2 Choice of equipment

The traverse is a theodolite traverse. Therefore for measurement of angles the instrument was the theodolite; model-Wild T2-140324 and for linear measurements, the equipment used were steel tape, Eldi-1 and self-reducing tacheometer. The other instruments used along with these were, sping balance, tape grip thermometer, reflector prism, tripods, vertical staff, ranging poles.

The choice of Eldi-1 came from some of the reasons given by Tomlinson (1976) and I quote:

> (a) It is primarily light, compact and well designed unit form coupled with accuracy claims and extreme simplicity in use and read out

SKETCH OF THE TRAVERSE

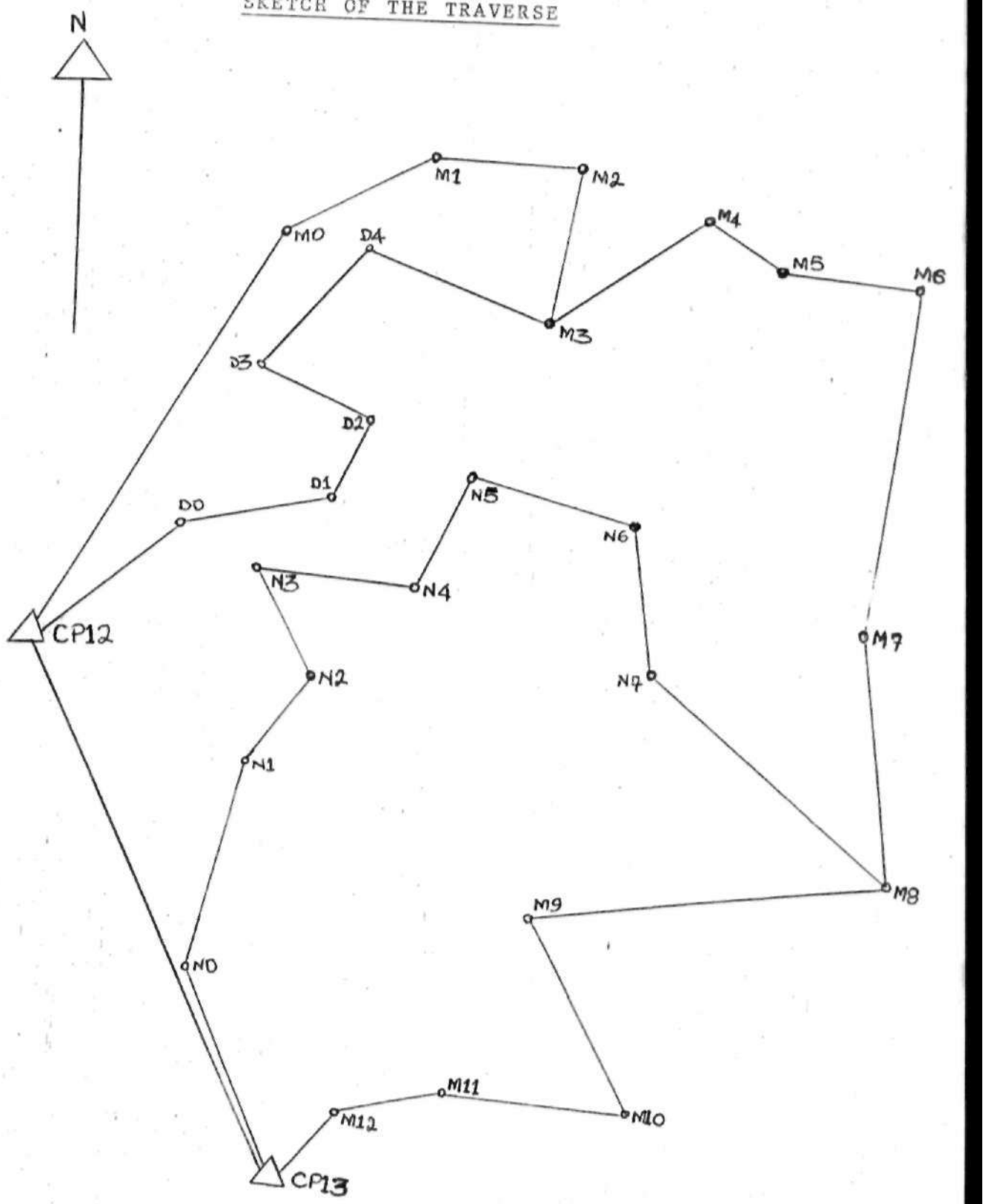



Figure 5.

(b) A total co-axial optics seem the logical design for such instruments, reducing size and weight of both instrument and reflector.
(c) The integral power source, and especially the lack of cables to get lost, cause drag, develop faulty contracts.
(d) Meteorological correction factor can be obtained from a graph on the side of the instrument and may be fed into the display.
(e) Digital display is clear and unambigous to 1 km with very rapid measuring/computing time.

From ODM, the choice of self-Reducing tacheometer was made in order to maintain comparability with other survey instruments used in the project for linear measurements.

The choice of steel tape is because the project aims at establishing the relative efficiences of the tape-theodolite, ODM-theodolite and EDM - theodolite traverses. The aim generally in deciding the necessary equipment is to balance relative accuracy at linear measurements.

## 2.3 Checks on the instruments

On the theodolite, a check for stability was carried ut, by mounting the theodolite on a rigid tripod and a point was sighted with all the clamps fixed. Then a gentle but firm, lateral pressure was applied on the eyepiece with finger.

The intersection of the hairs left the point, but returned exactly to it on removal of the pressure.

Also, the standard deviation of the theodolite was determine. This is shown in the next section.

The steel tape was checked by comparing the length with the official standard. This was done by using the 30 m baseline in the survey department. The tape was laid along the baseline and nominal length checked to see whether it corresponds to the 30 m baseline. The result showed a difference of 0.002 m, which is approximately 0.00002 m per 30m

The EDM (Eldi-1) was checked to see that all the parts were in order and in good condition. Then the dry cell battery was latter charged for 12 hours before the work took off. By touching the nuts and screws of the tripod, its was ascertained that the tripod was stable.

The EDM zero error was checked by carrying out calibration process to determine it. This is shown in section 2.5.

The vertical staff was checked against incorrect markings of readings which may be as result of loosenness of the staff by careful laying the staff on the ground and observing all the markings. By cleaning the viewing glasses of the telescope and the readings, it was made sure that the targets were clearly seen and the engraved readings were also clear to the eye.

## 2.4 Calibration and standardisation.

The 30 m base line on the floor between departments

of surveying and civil engineering buildings was used to standardise the steel tape and calibrate the Eldi-1 in order to determine zero error.

Hence, the standardised length of the steel tape is 29.998 at $20^0$C temperature and tension of 70 N.

For EDM (Eldi-1) the table 1 below shows the observed readings of distances from which the zero error was calculated by employing the formula.

$$\sigma_{z_o} = \left[ \frac{1}{n-1} \sum_{i=1}^{n} e_i^2 \right]^{\frac{1}{2}} \qquad \ldots\ldots \qquad (23)$$

where $e_i$ - error in each length combination.

$n$ - number of stations ($n = 4$).

In fact, four stations were established as A, B, C and D. The lines AB, AC, AD, BC, BD, CD were measured. See table 1 below.

Table 1 AD = 30 m Computation of zero error

| Lines | Observed Distances (m) | $D=S-h^2/2S$ | Adjusted Distances | Errors ($e_i$) | Zero error |
|---|---|---|---|---|---|
| AC | 16.897 | 16.897 | 16.899 | | |
| AB | 8.964 | 8.964 | 8.966 | AD-(AC+CD) = 0.002 | |
| BD | 21.032 | 21.032 | 21.033 | AD-(AB+BD) = 0.001 | 0.001 m |
| BC | 7.932 | 7.932 | 7.934 | | |
| | | | | AD-(AB+BC+CD)=0.001 | |
| CD | 13.096 | 13.096 | 13.099 | | |

Again, the standard deviation of the theodolite was determined after observing / horizontal angle ten times by using the formula :

$$\sigma = \left( \frac{\sum v^2}{n-1} \right)^{\frac{1}{2}} \quad \ldots\ldots\ldots\ldots\ldots \quad (29)$$

where the v is the residual and n is the number of time: the angle was observed (i.e. n = 10). The table below shows the readings obtained (X), the residuals, the most probable value ($\bar{X}$) and the standard deviation.

Table 2. Computation of standard deviation of th odolite.

| ° | X ′ | ″ | $v = \bar{X} - X$ | $v^2$ |
|---|---|---|---|---|
| 79 | 81 | 32.7 | 7.68 | 58.9824 |
| | | 42.5 | - 2.12 | 4.4944 |
| | | 36.5 | 3.88 | 15.0544 |
| | | 43.7 | - 3.32 | 11.0224 |
| | | 44.5 | - 4.12 | 16.9744 |
| | | 45.7 | - 5.32 | 28.3024 |
| | | 37.5 | + 2.88 | 8.2944 |
| | | 44.5 | - 4.12 | 16.9744 |
| | | 43.5 | - 3.12 | 9.7344 |
| | | 403.8 | 0.00 | 228.816 |

$\bar{X} = m\rho v = 79^{0}\ 01'\ 40''.38$

$\sigma = \left( \frac{\sum v^2}{n-1} \right)^{\frac{1}{2}} = 5''.04$

CHAPTER 3.

# DATA ACQUISITION

## 3.1 Methods

### 3.1.1 ODM

Much as this work is not concerned with details of instruments used, the general principle is as described in Olliver and Clendenning(1978). The instruments are: Zeiss Rta Self-Reducing tacheometer, the vertical staff, and one tripod.

The distance measurement principle of the instrument involves the clear bisection of the staff, then the staff intercepts of the distance curve and height curve relative to an index or zero curve and multiplying by the appropriate constants. The readings were done in face right and face left. For horizontal distance, the intercept is the difference between the zero curve and the distance cure (see figure 6 below). This was multiplied by 100 to give the distance on face left reading and 200 to give distance on face right reading. For height difference; the height curve readings on the staff were multiplied by 10. The horizontal circle readings were not taken since this project is concerned with the distances.

The form of booking sheets and readings for ODM distance measurement is as in the records of observation in Appendix D.

The field of view

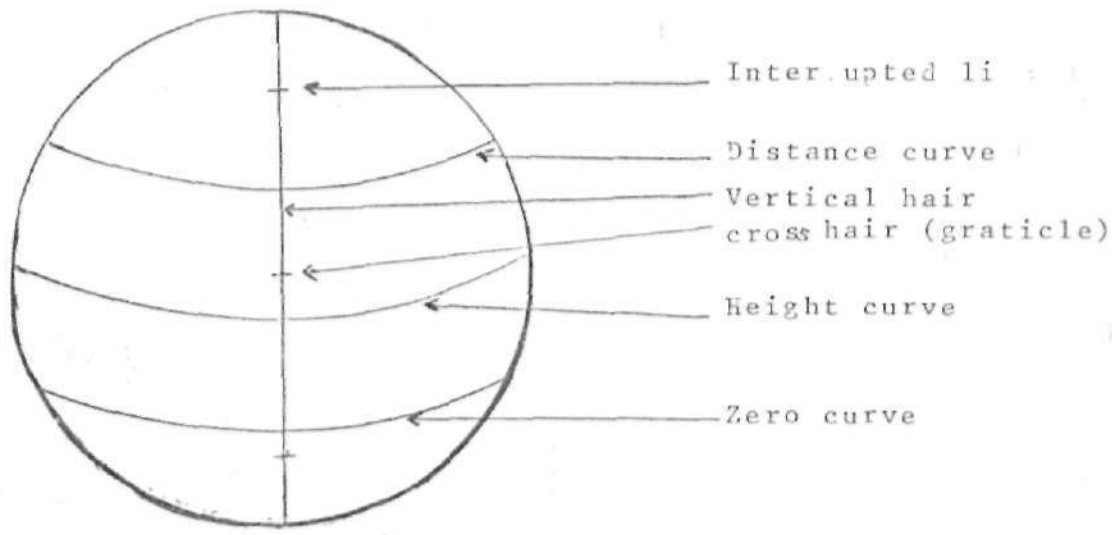



Figure 6

3.1.2 EDM - E1di-1

The general principle of EDM is found in Burnside '1971), while the measurement principle is as described by Tomlinson (1976).

In the field, after setting up, and pointing to bisect the reflector, range selection was set and meteorological correction code set. It was switched on, the signal intensity was balanced and switched to measure. The readings were displayed unambig ously. The interruption of signal reflector merely delays the display of readings. The readings are as booked in records of observation in Appendix D.

3.1.3 Ground taping

Steel tape. The tape was laid along the line formed with the ranging poles from one station to another station of the line being measured. The readings booked were

the length measured and the temperature. Each line was measured twice in opposite directions. The thermometer was on the ground near the tape and left about sixty to ninety seconds and then picked up and allowed to be steady before booking the reading. Before taking the readings, a tension of 70 N equivalent to the standardisation tension was applied.

For slope angles, they were not measured since the elevations of the stations are known. The readings are shown in the records of observations in Appendix D.

## 3.2 Field Checks

### 3.2.1 Check for angles:

The observed angles of the polygon traverse (see figure 5) were the external angles. Hence, the angular misclosure was found by comparing the sum of the observed angle with the theoretical value using the formula.

Sum of external angles = $(2n + 4)90^0$ where n is the number of stations in the traverse. In this case n = 15, therefore the theoretical value is $3060^0$.

### 3.2.2 Allowable error in angles:

After the check was made, a misclosure of magnitude 35" was found. The allowable error was found using the formula.

$$E_1 = \pm K\sigma(n)^{\frac{1}{2}} \quad \ldots\ldots \quad 30)$$

where n is the number of traverse stations and σ is the standard deviation of the theodolite in seconds. For the 1″ theodolite used, σ = 5.04″ (see table 2), n = 15 and K = 2, the number of rounds of zero. The allowable error ($E_1$)= 39.04″.

The misclosure was then compared with this allowable error to determine the precision of the measurement. The misclosure was within the allowable error which confirmed acceptable observations.

### 3.2.3 Linear measurement check:

Two independent distance measurement were carried out. These were done with the same precision and in opposite directions. These were also carried out at different times by the same people.

## 3.3 Precautions

### 3.3.1 Errors in angular observations:

The errors in angular observations viz. inaccurate bisection of the signal, non-verticality of the signal, errors of reading and errors due to displacement were eliminated by the following way during the process of observation:

(a) Inaccurate bisection of signal; Parallax was completely eliminated by adjusting eye piece until the cross hairs were in sharp forcus and clear bisection of the pole was made at the point of intersection of the lines as the vertical line might not be truely vertical.

(b) Non-verticality of signal: These error was minimized by sighting the ranging poles as for down as possible since

the foot was visible.

(c) Errors of reading: This error was avoided by repeating the measurements on different zero's of the circle and averaging.

(d) Errors due to displacement of pegs or signals: To offset the effects of this error, the instruments were set on chosen firm ground and pegs (stations) were firmly driven in

(e) Errors due to wrong booking was avoided by careful entering in the booking sheet and checking the figures again with the one being displayed in the theodolite.

For natural errors, the wind effect was not serious but careful centring was done by using the optical plumet. The high temperature effect was minimized by making the line of sight at all points above 30 cm from the ground. There was no hazy atmosphere, so targets were accurately bisected.

The random errors were minimized by being very cautious during the observations e.g. correct round off of all numbers to same number of decimals. Then relying on the compensatory nature of these errors.

### 3.3.2 Errors in ODM

In this project, the magnitudes of $k_1$ are 100 m and 200 m on face left and face right respectively and by knowing this, the incorrect assumption of value of $k_1$ was avoided. The constant $c$ is assumed to be zero.

The field errors were avoided by carrying out observations in face left and face right of the tacheometer and by checking the recorded readings. The non-verticality of the staff was

minimized by using the specially built staff which has a circular bubble. This circular bubble was used to position the staff vertically.

### 3.3.3 Errors in steel taping

The incorrect alignment of steel tape was catered for by using the ranging poles to align to the stations and a straight line was always created which is then measured.

The tape not being straight error was reduced to negli gible amount by proper straightening of the tape along the line being measured.

Also in order to correct for temperature effects, the field temperatures of the tape during observations were recorded using thermometer. Again extra caution was taken to apply the tension of 70 N in all measurements with spring balance.

CHAPTER 4

# DATA PROCESSING

## 4.1 Introduction.

The aim of this chapter is to carry out all the necessar standard computations as a means to processing the field data and also providing ground for the analyses of the results.

In all computations, the results are rounded off to even numbers.

## 4.2 Calculations of bearing from angles

The traverse started on the cadaster pillar CP 12 and terminated on pillar CP 13. The bearing of the line CP 13-CP 12 is known. So the bearings of the other lines in the traverse were calculated from the arithmetic means of observed external angles in the following procedures:

(a) Adding $180^0$ to the whole-circle bearing, and if the sum is above $360^0$, then $360^0$ is subtracted.

(b) Adding the external angle at the station to the val· above.

(c) If the sum is above $360^0$, then $360^0$ is again subtra· e

(d) The result is then the bearing of the line.

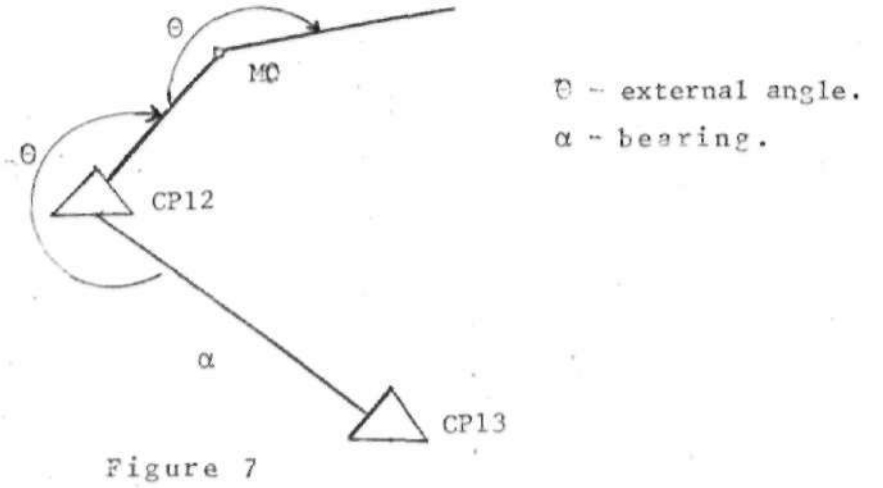



Figure 7

As a check, the external angles were added,

TABLE 3 TRAVERSE ANGLES (External)

| STATION | MEAN (Arithmetic) observed Angles (horizontal) | STATION | MEAN OBSERVED ANGLES (horizontal) | STATION | MEAN OBSERVED ANGLES (horizontal) |
|---|---|---|---|---|---|
| | ° ' " | | ° ' " | | ° ' " |
| CP 12 | 220 19 35 | CP 13 | 00 35 06 | CP 12 | 253 21 41 |
| M 0 | 193 49 21 | | | | |
| M 1 | 252 24 48 | NO | 197 09 02 | DO | 223 19 36 |
| M 2 | 246 57 52 | | | | |
| M 3 | 53 53 24 | N 1 | 226 31 40 | D 1 | 116 22 33 |
| M 4 | 257 32 19 | | | | |
| M 5 | 166 42 15 | N 2 | 127 31 53 | D 2 | 80 36 52 |
| M 6 | 280 17 38 | | | | |
| | | N 3 | 280 33 43 | | |
| M 7 | 171 49 40 | | | | |
| | | | | D 3 | 271 39 47 |
| M 8 | 227 41 46 | N 4 | 104 00 30 | | |
| M 9 | 92 05 06 | | | | |
| | | N5 | 259 18 28 | | |
| M 10 | 251 58 07 | | | D 4 | 267 26 47 |
| M 11 | 160 05 16 | N 6 | 243 16 17 | | |
| M12 | 122 34 56 | | | M 3 | 60 43 58 |
| | | N 7 | 154 57 30 | | |
| CP 13 | 331 48 32 | | | | |

since the traverse is a closed loop using the formula $(2n+4)90$ where n is the number of stations in the traverse.

4.2.1 Computation and adjustment of bearings.

The known stations are CP 12 and CP 13. Hence the traverse started from the given bearing of line CP 12 to CP 13. With this, the bearing of each line of the traverse was calculated. The last calculated bearing was the line CP 13 to CP 12. This bearing is known but the value calculated from the traverse is $+35''$ different from the known. This $(+35'')$ discrepancy was divided by 15 and the result subtracted cumulatively from the 15 calculated bearings to give the adjusted bearings. The first adjustment operation was the reduction of the first calculated bearing by $+02''$ the second by $+05''$ and continues cumulatively till the last one which was reduced was reduced by $35''$.

4.3 Reduction of slope measurements

The distances measured with the EDM and steel tape were slant distances. Hence they needed to be reduced to horizontal distances. This was done using the equation (21).

4.3.1 Reduction of elevations:

The height of collimation method was used in reducing the levels. This is based on collimation height being calculated for each instrument position. That is, instead of deducing rises and falls, the reduced level of each point was determined dir ctly by subtracting the staff reading at the point from the height of the line of collimation.

Date - 30/4/86. Observer & Booker - Matthew N. Onoh

Instruments- Quick Set tilting level, tripod, levelling staff.

LEVEL BOOKING SHEET

Table 4. Reduction of levels

| Station | Back sight (m) | Intermediate sight | Fore sight (m) | H P C (m) | Correction (m) | Elevation (m) | Remarks (m) |
|---|---|---|---|---|---|---|---|
| CP 12 | 1.470 | | | 669.757 | | 668.287 | CP 12 |
| A | 1.823 | | 1.215 | 670.365 | -0.001 | 668.342 | A 668.541 |
| B | 1.320 | | 1.182 | 670.503 | -0.001 | 669.183 | B 669.182 |
| M0 | 1.856 | | 1.234 | 671.125 | -0.002 | 669.269 | M0 669.267 |
| M1 | 1.330 | | 1.252 | 671.203 | -0.003 | 669.873 | M1 669.870 |
| M2 | 1.386 | | 1.685 | 670.904 | -0.003 | 669.518 | M2 669.515 |
| C | 1.368 | | 1.753 | 670.519 | -0.004 | 669.151 | C 669.147 |
| M3 | 1.480 | | 1.540 | 670.459 | -0.004 | 668.979 | M3 668.975 |
| D | 1.556 | | 1.280 | 670.735 | -0.005 | 669.179 | D 669.174 |
| M4 | 1.571 | | 1.420 | 670.886 | -0.006 | 669.315 | M4 669.309 |
| E | 1.650 | | 1.425 | 671.111 | -0.006 | 669.461 | E 669.455 |
| M5 | 1.502 | | 1.890 | 670.723 | -0.007 | 669.221 | M5 669.214 |
| M6 | 1.336 | | 1.815 | 670.244 | -0.008 | 668.908 | M6 668.900 |
| F | 1.370 | | 1.528 | 670.086 | -0.008 | 668.716 | F 668.708 |
| M7 | 1.202 | | 1.675 | 669.613 | -0.009 | 668.411 | M7 668.402 |
| G | 1.358 | | 1.789 | 669.182 | -0.009 | 667.824 | G 667.815 |
| M8 | 1.446 | | 1.590 | 669.038 | -0.010 | 667.592 | M8 667.582 |
| H | 1.442 | | 1.775 | 668.705 | -0.011 | 667.763 | H 667.252 |
| M9 | 1.390 | | 1.676 | 668.419 | -0.011 | 667.029 | M9 667.018 |
| M10 | 1.465 | | 1.715 | 668.169 | -0.012 | 666.704 | M10 666.692 |
| M11 | 1.506 | | 1.262 | 668.413 | -0.013 | 666.907 | M11 666.894 |
| M12 | 1.372 | | 1.538 | 668.247 | -0.013 | 666.875 | M12 666.862 |
| | | | 1.545 | | -0.014 | 666.702 | CP13 666.688 m |
| ∑BS = | 32.199 | | ∑FS 33.784 | | | - 0.014 | Misclosure |
| Check ∑FS - ∑BS = 1.585 = 668.287 - 66.702 | | | | | | | |

Then the following check was applied

(1) Apparent difference in levels as

$\sum$ B.S - $\sum$F.S = the difference in the reduced levels of start and finish stations.

= - 1.585.

(2) The accuracy of the misclosure was tested using the specification $\pm$ 24. 0 mm$\sqrt{\sum_{i=1}^{15} D_i}$, where $\sum_{i=1}^{15}$ is total distance covered in kilometers.

That is

misclosure = 0.014 m = - 14 mm (see table 4)

$\sum_{i=1}^{15} D_i$ = 994.476m = 0.994476 km

$\sum_{i=1}^{15} D_i$ = 992.925 = 0.992925 km

$\sum_{i=1}^{15} D_i$ = 994.269 = 0.994269 km

Hence

accuracy = 23.933mm, 23.915 mm and 23.931 mm

for the ST, ODM and EDM respectively. So the misclosure lies within the accuracy specifications, therefore the levelling was accepted.

### 4.3.2 Correction and Reduction of traverse distances from field book.

For the methods; ST, ODM and EDM used in measuring the distances, the arithmetic mean of the distances of a line

measured four times was taken. Then, the results of EDM and steel tape were corrected and reduced to horizontal distances by applying the appropriate corrections.

The distances measured with tacheometer were not corrected as they are actually the horizontal distances. The distances measured with steel tape and EDM (Eldi-1) were corrected for slope using equation (21).

The distances from steel tape were again corrected for temperature using equation (5)

The EDM (Eldi-1) has built - in compensators which outomatically correct the modulated wave length for local atmospheric conditions. Hence there was no measurement of temperature and barometric pressure at the station of the instrument for meteorological measurements. The assumption here was that the fully automatic correcting systems of the instrument gave accurate results believing the almospheric conditions along the measured line were the same as those at the instrument station.

Tables 5, 6 and 7 show the horizontal distances of the traverse lines as obtained from the tape, EDM and ODM respectively.

## 4.4 Computation of coordinates

### 4.4.1 Computation of station coordinates

The coordinates of known station CP 12 were entered in the appropriate columns of the standard traverse computation sheet (Appendix D), the partial eastings and northings to the next station was added algebraically and the results

Table 5. DISTANCES USING STEEL TAPE, $t_f$ = 20°C, $\rho$ = 0.00001 2/°C

| TRAVERSE LINE | MEAN MEASURED DISTANCE(m) (s) | HEIGHT DIFFERENCE (m) (h) | SLOPE CORRECTION (m) $-h^2/2S$ | TEMPERATURE CORRECTION (m) $\rho S(t_f - t_s)$ | HORIZONTAL DISTANCE (m |
|---|---|---|---|---|---|
| CP 12-Mo | 113.801 | -0.980 | -0.004 | 0.008 | 113.805 |
| MO-m1 | 60.366 | -0.603 | 0.003 | 0.005 | 60.368 |
| M1-M2 | 55.130 | 0.355 | 0.001 | 0.004 | 55.133 |
| M2-M3 | 68.670 | 0.540 | 0.002 | 0.006 | 68.674 |
| M3-M4 | 62.612 | -0.334 | 0.000 | 0.008 | 62.620 |
| M4-M5 | 56.182 | 0.095 | 0.000 | 0.010 | 56.192 |
| M5-M6 | 45.992 | 0.314 | 0.001 | 0.008 | 45.999 |
| M6-M7 | 73.814 | 0.498 | 0.002 | 0.010 | 73.822 |
| M7-M8 | 75.306 | 0.820 | 0.004 | 0.006 | 75.302 |
| M8-M9 | 91.792 | 0.564 | 0.002 | 0.011 | 91.801 |
| M9-M10 | 38.958 | 0.326 | 0.001 | 0.008 | 38.965 |
| M10-M11 | 51.080 | -0.202 | 0.000 | 0.014 | 51.094 |
| M11-M12 | 13.320 | 0.032 | 0.000 | 0.003 | 13.323 |
| M12-CP13 | 17.880 | 0.174 | 0.000 | 0.005 | 17.885 |
| CP13-CP12 | 169.450 | -1.599 | 0.008 | 0.051 | 169. 93 |
| CP13-NO | 38.308 | -0.030 | 0.000 | 0.004 | 38. 12 |
| NO-N1 | 35.016 | -0.128 | 0.000 | 0.003 | 35. 19 |
| N1-N2 | 18.290 | -0.501 | 0.006 | 0.002 | 18.286 |
| N2-N3 | 62.013 | -0.657 | 0.003 | 0.008 | 62.286 |
| N3-N4 | 33.770 | 0.354 | 0.002 | 0.012 | 33.780 |
| N4-N5 | 31.850 | -0.893 | 0.012 | 0.004 | 31.842 |
| N5-N6 | 47.069 | -0.072 | 0.000 | 0.005 | 47.074 |
| N6-N7 | 44.318 | 0.641 | 0.004 | 0.004 | 44.318 |
| N7-M8 | 64.928 | 0.392 | 0.001 | 0.007 | 64.934 |
| C 12-DO | 62.935 | -0.125 | 0.000 | 0.010 | 62.945 |
| O -D1 | 33.588 | -0.111 | 0.000 | 0.006 | 33.594 |
| 01 -D2 | 19.670 | -0.200 | 0.001 | 0.004 | 19.673 |
| 2 -D3 | 44.098 | -0.318 | 0.001 | 0.008 | 44.105 |
| 3-D4 | 35.518 | -0.414 | 0.002 | 0.008 | 35.524 |
| 4-M3 | 70.120 | -0.164 | 0.000 | 0.016 | 70.136 |

Table 6 DISTANCES USING EDM

| TRAVERSE LINE | MEAN MEASURED DISTANCE (m) | HEIGHT (A) DIFFERENCE (m) | CORRECTION $-h^2/2S$ (m) | HORIZONTAL DISTANCE $D=S-h^2/2S$ (m) |
|---|---|---|---|---|
| CP12-MO | 113.818 | -0.980 | 0.004 | 113.814 |
| MO -M1 | 60.386 | -0.603 | 0.003 | 60.383 |
| M1 - M2 | 55.138 | 0.355 | 0.001 | 55.137 |
| M2 - M3 | 68.673 | 0.540 | 0.002 | 68.671 |
| M3 - M4 | 62.612 | -0.334 | 0.000 | 62.612 |
| M4 - M5 | 56.180 | 0.095 | 0.000 | 56.180 |
| M5 - M6 | 45.988 | 0.314 | 0.001 | 45.987 |
| M6 - M7 | 73.845 | 0.498 | 0.002 | 73.843 |
| M7 - M8 | 75.315 | 0.820 | 0.004 | 75.311 |
| M8 - M9 | 91.822 | 0.564 | 0.002 | 91.820 |
| M9 - M10 | 38.969 | 0.326 | 0.001 | 38.968 |
| M10- M11 | 51.050 | -0.202 | 0.000 | 51.050 |
| M11- M12 | 13.289 | 0.032 | 0.000 | 13.289 |
| M12-CP13 | 17.754 | 0.174 | 0.000 | 17.754 |
| CP13-CP12 | 169.458 | -1.599 | 0.008 | 169.450 |
| CP13- NO | 38.272 | -0.030 | 0.000 | 38.272 |
| NO - N1 | 44.974 | -0.128 | 0.000 | 44.974 |
| N1 - N2 | 18.245 | -0.501 | 0.006 | 18.219 |
| N2 - N3 | 62.006 | -0.657 | 0.003 | 62.003 |
| N3 - N4 | 33.778 | 0.354 | 0.002 | 33.776 |
| N4 - N5 | 31.830 | 0.893 | 0.012 | 31.818 |
| N5 - N6 | 47.042 | 0.072 | 0.000 | 47.042 |
| N6 - N7 | 44.288 | 0.641 | 0.004 | 44.234 |
| N7 - M8 | 64.932 | 0.392 | 0.001 | 64.931 |
| CP12- DO | 62.934 | -0.125 | 0.000 | 62.934 |
| DO - D1 | 33.598 | -0.111 | 0.000 | 33.598 |
| D1 - D2 | 19.624 | -0.200 | 0.001 | 19.623 |
| D2 - D3 | 44.104 | -0.318 | 0.001 | 44.103 |
| D3 - D4 | 35.514 | -0.414 | 0.002 | 35.512 |
| D4 - M3 | 70.115 | -0.164 | 0.000 | 70.115 |

Table 7 DISTANCES USING SELF-REDUCING TACHEOMETER

| TRAVERSE LINE | MEAN HORIZONTAL DISTANCES (m) (S = D) | TRAVERSE LINE | MEAN HORIZONTAL DISTANCES (m) (S = D) | TRAVERSE LINE | MEAN HORIZONTAL DISTANCES(m) (S = D) |
|---|---|---|---|---|---|
| CP12-M0 | 113.775 | | | | |
| | | CP13-N0 | 38.225 | | |
| N0-M1 | 60.200 | | | CP12-00 | 62.850 |
| | | NO -N1 | 44.850 | | |
| M1-M2 | 55.000 | | | | |
| | | | | DO -D1 | 33.5 ) |
| M2-M3 | 68.525 | N1-N2 | 18.150 | | |
| M3-M4 | 62.475 | N2-N3 | 61.900 | D1- D2 | 19.5 ) |
| M4-M5 | 56.200 | | | | |
| | | N3-N4 | 33.750 | D2- D3 | 44.100 |
| M5-M6 | 45.925 | | | | |
| M6-M7 | 73.825 | N4-N5 | 31.825 | D3- D4 | 35.975 |
| M7-M8 | 75.100 | | | | |
| M8-M9 | 91.875 | N5-N6 | 46.850 | D4- M3 | 69.950 |
| M9-M10 | 38.850 | | | | |
| | | N6-N7 | 44.150 | | |
| M10-M11 | 50.950 | | | | |
| | | N7-M8 | 64.850 | | |
| M11-M12 | 13.250 | | | | |
| M12-CP13 | 17.700 | | | | |
| CP13-CP12 | 169.275 | | | | |

were the coordinates of a station.

The basic formulae of traverse computation for each leg of the traverse are :

$$\Delta E = D \sin \alpha_1 \quad \ldots\ldots \quad (31a)$$

$$\Delta N = D \cos \alpha_1 \quad \ldots\ldots \quad (31b)$$

where $\Delta E$, $\Delta N$ are the partial eastings and northings respectively, D is the horizontal distance and $\alpha_1$ is the adjusted forward bearing of a line.

After the $\Delta E$ and $\Delta N$ values have been computed for the whole traverse, the following checks were applied to the computation;

$$\sum \Delta E = 0 \quad \text{and} \quad \sum \Delta N = 0$$

because the traverse started and finished at the same point.

A final check was applied after all the coordinates had been calculated. That is the final and initial coordinates must be equal since they represent the same station.

4.4.2 Check computation.

A check was carried out to locate any possible gross error by carrying out back computation using the total coordinates obtained to compute the partial eastings and northings, distances and bearings.

They were computed using the following equation:

$$\Delta E = E_B - E_A \quad \text{and} \quad \Delta N = N_B - N_A$$

for partial eastings and northings respectively.

For distances

$$D = (\Delta E^2 + \Delta N^2)^{\frac{1}{2}} \qquad (32a)$$

and for bearings

$$\alpha_1 = \sin^{-1}(\Delta E/D) = \cos^{-1}(\Delta N/D) \quad . \quad . \quad . \quad . \quad . \qquad (32b)$$

This check employed was thorough and complete, whose standard of accuracy was not less or higher than the field work results.

4.5 Adjustment of the coordinates.

Due to accumulation of small unavoidable errors, the computed coordinates of CP 12 differed by - 0.108, 0.205, -0.032 and 0.067, 0.180, 0.027 for ST, ODM and EDM respectively. from the known values of the easting and northing coordinates respectively. Hence, a transit method of traverse adjustment (recommended by Federal Surveys) was carried out on the whole traverse so that the differences between the computed and the fixed coordinates of the end point were eliminated and the closing errors (see above) were distributed throughout the 15 stations of the traverse cumulatively. The corrections were applied directly to the total coordinates.

Transit Method :

$$\text{Correction to } \Delta E(\text{or } \Delta N) \text{ for one particular traverse leg} = e_E(\text{or } e_n) \times \frac{\Delta E(\text{or } \Delta N) \text{ of the traverse leg concerned}}{\text{absolute } \sum \Delta E(\text{or } \Delta N) \text{ for the traverse}} .$$

In this case, the corrections are proportional to the values of $\Delta E$ and $\Delta N$ for the various lines. The $e_E$ and $e_N$ are respectively cummulative errors in easting and northing coordinates

of the last station (of traverse computation sheet)

4.5.1 Re-adjustment of the coordinates.

The coordinates computed using the three methods were re-adjusted in order to assess the comparative accuracies of these three methods. These coordinates resulted in three sets of values and the weighted mean values of these were adopted as the final coordinates of a station. The computed coordinates of a station by each of the three methods were then readjusted for the misclosures on to the accepted position of the station.

In weighting the separate coordinates to determine the final position of a station, Olliver and Clendenning (1978) states; "assume that the random errors of distance measurement in a traverse are proportional to the square root of the distance".

Hence, using the above statement, and given the fact that the weight of an observed quantity is inversely proportional to the square of its standard error, then the weight of a traverse line is inversely proportional to its length. That is

$$\sigma = D^{\frac{1}{2}} \qquad (33a)$$

$$\omega = 1/\sigma^2 = 1/(D^{\frac{1}{2}})^2 = 1/D \quad \ldots\ldots \qquad (33b)$$

The re-adjusted coordinates of the stations are given by

$$E_a = \frac{\sum \omega E}{\sum \omega} \quad \text{(for easting coordinates)} \ldots. \qquad (33c)$$

Table 8 Re-adjusted Coordinates and proportional Misclosure

| INSTRUMENT | LINE | DISTANCES D(Km) | WEIGHT $\omega = \frac{1}{D}$ | STATION | COORDINATES | | COORDINATE MISCLOSURE | | RE-ADJ. COORDINATES | | PROPORTIONAL MISCLOSURE |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | EASTINGS E | NORTHINGS N | dE | dN | $E_A = \frac{\sum \omega E}{\sum \omega}$ | $N_A = \frac{\sum \omega N}{\sum \omega}$ | |
| ODM | | 0.113773 | 8.789 | | 17528.248 | 10055.613 | -0.001 | -0.040 | | | 1/2843 |
| TAPE | CP12-MO | 0.11805 | 8.787 | MO | 17528.252 | 10055.682 | 0.003 | 0.023 | 17528.249 | 10055.159 | 1/4906 |
| EDM | | 0.113.814 | 8.786 | | 17528.248 | 10055.676 | -0.001 | 0.017 | | | 1/6633 |
| ODM | | 0.060200 | 16.611 | | 17567.386 | 10101.359 | -0.072 | -0.138 | | | 1/386 |
| TAPE | MO-M1 | 0.060368 | 16.565 | M1 | 17567.493 | 10101.566 | 0.035 | 0.069 | 17567.458 | 10101.497 | 1/730 |
| EDM | | 0.060383 | 16.660 | | 17567.495 | 10101.566 | 0.037 | 0.069 | | | 1/771 |
| ODM | | 0.055000 | 18.182 | | 17618.053 | 10079.910 | -0.146 | -0.102 | | | 1/304 |
| TAPE | M1-M2 | 0.055133 | 18.138 | M2 | 17618.273 | 10080.072 | 0.074 | 0.055 | 17618.199 | 10080.017 | 1/598 |
| EDM | | 0.055137 | 18.136 | | 17618.271 | 10080.069 | 0.072 | 0.052 | | | 1/620 |
| ODM | | 0.068525 | 14.593 | | 17618.159 | 10011.369 | -0.146 | -0.021 | | | 1/465 |
| TAPE | M2-M3 | 0.068674 | 14.562 | M3 | 17618.379 | 10011.404 | 0.074 | 0.014 | 17618.305 | 10011.390 | 1/912 |
| EDM | | 0.068671 | 14.562 | | 17618.377 | 10011.396 | 0.072 | 0.006 | | | 1/950 |
| ODM | | 0.063475 | 16.006 | | 17668.593 | 10048.256 | -0.213 | -0.034 | | | 1/273 |
| TAPE | M3-M4 | 0.062620 | 15.969 | M4 | 17668.920 | 10048.390 | 0.114 | 0.050 | 17618.386 | 10048.340 | 1/503 |
| EDM | | 0.062612 | 15.971 | | 17668.905 | 10048.373 | 0.099 | 0.033 | | | 1/600 |
| ODM | | 0.056200 | 17.774 | | 17710.805 | 10011.126 | -0.099 | -0.087 | | | 1/254 |
| TAPE | M4-M5 | 0.056192 | 17.796 | M5 | 17711.118 | 10011.279 | 0.114 | 0.053 | 17711.004 | 10011.223 | 1/442 |
| EDM | | 0.056180 | 17.890 | | 17711.088 | 10011.363 | 0.084 | 0.040 | | | 1/603 |
| ODM | | 0.045925 | 21.774 | | 17751.353 | 9989.530 | 0.232 | -0.080 | | | 1/187 |
| TAPE | M5-M6 | 0.045999 | 21.740 | M6 | 17751.724 | 9989.656 | -0.139 | -0.046 | 17751.585 | 9989.610 | 1/314 |
| EDM | | 0.045987 | 21.745 | | 17751.679 | 9989.643 | -0.094 | 0.033 | | | 1/461 |
| ODM | | 0.073825 | 13.546 | | 17705.580 | 9931.608 | -0.221 | -0.061 | | | 1/322 |
| TAPE | M6-M7 | 0.073822 | 13.546 | M7 | 17705.944 | 9931.756 | 0.142 | 0.087 | 17705.801 | 9931.669 | 1/442 |
| EDM | | 0.073843 | 13.542 | | 17705.879 | 9931.718 | 0.078 | 0.049 | | | 1/802 |
| ODM | | 0.075100 | 13.316 | | 17667.858 | 9866.659 | -0.147 | 0.020 | | | 1/506 |
| TAPE | M7-M8 | 0.075302 | 13.280 | M8 | 17668.115 | 9866.657 | 0.110 | [illegible] | 8.005 | 9865.639 | 1/676 |
| EDM | | 0.075311 | 13.278 | | 17668.041 | 9866.601 | 0.036 | -0.038 | | | 1/1438 |

Table 8 Re-adjusted Coordinates and proportional Misclosure (Contd.)



| INSTPUMENT | LINE | DISTANCES D)Km) | WEIGHT $\omega = \frac{1}{D}$ | STATION | COPDINATES | | COORDINATS MISCLOSURE | | RE-ADJ. COORDINATES | | PROPOR-TIONAL MISCLO-SURE |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | EASTINGS E | NORTHINGS N | dE | dN | $E_A = \frac{\sum \omega E}{\sum \omega}$ | $N_A = \frac{\sum \omega N}{\sum \omega}$ | |
| ODM | M8-M9 | 0.091875 | 10.884 | M9 | 17578.075 | 9847.330 | -0.172 | 0.007 | 17578.247 | 9847.323 | 1/534 |
| TAPE | | 0.091801 | 10.893 | | 17578.386 | 9847.350 | 0.027 | 0.027 | | | 1/648 |
| EDM | | 0.091820 | 10.890 | | 17578.280 | 9847.289 | 0.033 | -0.034 | | | 1/1938 |
| ODM | M9-M10 | 0.038850 | 25.740 | M10 | 17584.862 | 9809.068 | 0.184 | -0.077 | 17585.046 | 9908.991 | 1/194 |
| TAPE | | 0.038965 | 25.664 | | 17585.191 | 9808.988 | 0.145 | 0.003 | | | 1/269 |
| | | 0.038968 | 25.662 | | 17586.086 | 9808.918 | 0.040 | 0.073 | | | 1/468 |
| ODM | M10-M11 | 0.050950 | 19.622 | M11 | 17533.958 | 9810.766 | -0.095 | 0.074 | 17534.053 | 9810.692 | 1/423 |
| TAPE | | 0.051094 | 19.571 | | 17534.135 | 9810.691 | 0.082 | 0.001 | | | 1/623 |
| EDM | | 0.051050 | 19.588 | | 17534.066 | 9810.620 | 0.013 | 0.072 | | | 1/698 |
| ODM | M11-M12 | 0.013250 | 75.472 | M12 | 17521.362 | 9806.671 | -0.057 | 0.085 | 1754.419 | 9806 | 1/123 |
| TAPE | | 0.013323 | 75.058 | | 17521.467 | 9806.574 | 0.048 | -0.012 | | | 1/269 |
| | | 0.013289 | 75.250 | | 17521.429 | 9806.513 | 0.010 | -0.073 | | | 1/180 |
| ODM | M12-CP13 | 0.017700 | 56.497 | CP13 | 17516.909 | 9789.536 | 0.037 | 0.158 | 17516.946 | 9789.378 | 1/109 |
| TAPE | | 0.017885 | 55.912 | | 17516.966 | 9789.266 | 0.020 | 0.112 | | | 1/157 |
| EDM | | 0.017754 | 56.325 | | 17516.962 | 9789.331 | 0.047 | | | | 1/358 |
| ODM | CP13-CP12 | 0.169275 | 5.908 | CP12 | 17477.284 | 9954.014 | 0.000 | 0.000 | 17477.087 | 9954.014 | |
| TAPE | | 0.169493 | 5.900 | | 17477.084 | 9954.014 | 0.000 | 0.000 | | | |
| EDM | | 0.169450 | 5.901 | | 17477.084 | 9954.014 | 0.000 | 0.000 | | | |

$$N_a = \frac{\sum \omega N}{\sum \omega} \quad \text{(for northing coordinates)} \ldots \quad (33d)$$

where $\omega$ is weight given in equation(33b) above, D is distance in km.

Table 8 shows these and the coordinates misclosures were computed using the equations below :

$$dE = E - E_a \quad \text{(for easting)} \quad \ldots\ldots \quad (33e)$$

$$dN = N - N_a \quad \text{(for northing)} \quad \ldots\ldots \quad (33f)$$

From these misclosures, the proportional misclosures were computed and are shown in last column of table 8.

4.6 Plotting of the traverse

The traverse plan area was plotted using the CYIACC Cybe. 72 main frame computer.
A fortran program (see appendix B) was written and was compiled using colcom p$_{\text{a}}$ plotting facilities in the Iya Abubakar Computer Centre, A.B.U., Zaria. The plotting was done off-line.

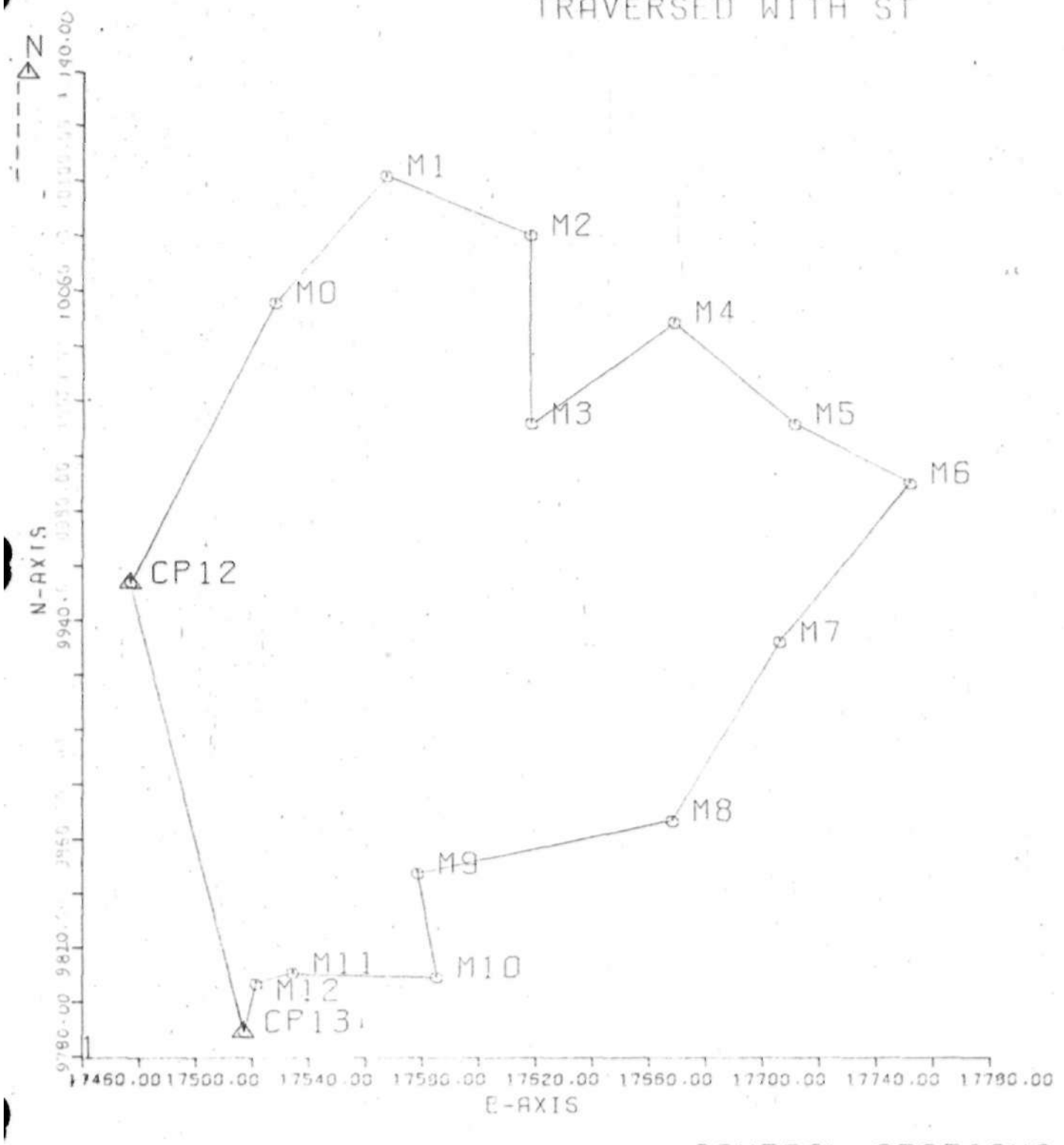
It was plotted at the scale 1 : 2000. The input data were the easting and northing coordinates obtained using steel tape, ODM and EDM. The figures 8 , 9 , and 10 , respectively show the plots. Choper and Kumar (1980) and MacCracken (1982) was referred to in writing the program.

4.7 Area Computation.

The coordinate method of area computation was used since the traverse area is a polygon. The method requires the computation of partial coordinate of the sides of closed traverse. So the formula used is given as

$$\text{Area} = \frac{1}{2}\left\{N_{mo}\left(E_{m_1} - E_{CP_{12}}\right) + N_{m_1}\left(E_{m_2} - E_{mo}\right) + N_{m_2}\left(E_{m3} - E_{m1}\right)\right.$$

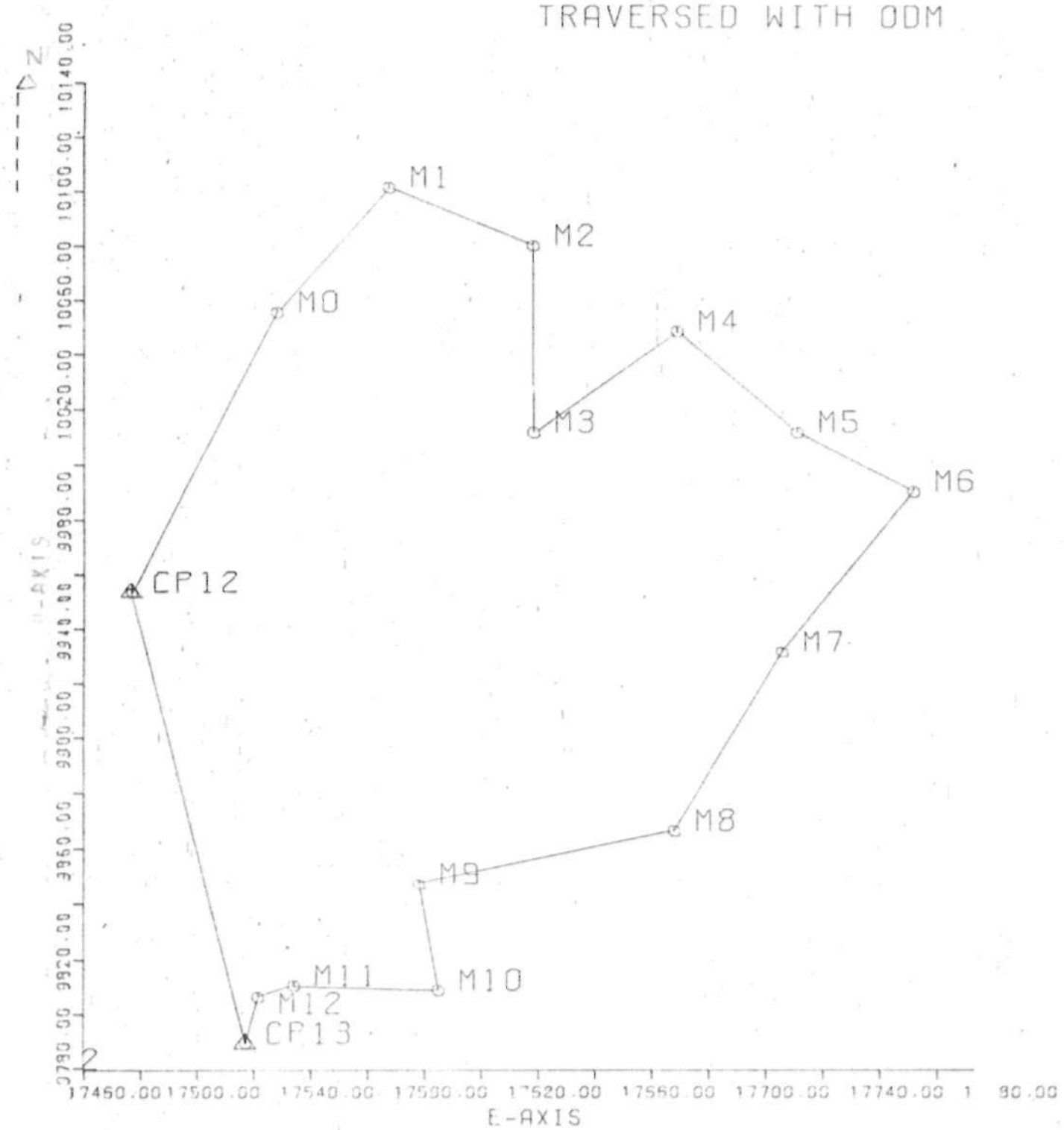
SCALE 1-2000 TRAVERSE PLAN AREA
TRAVERSED WITH ST




△-CONTROL STATIONS
O-NEW STATIONS

FIG.8

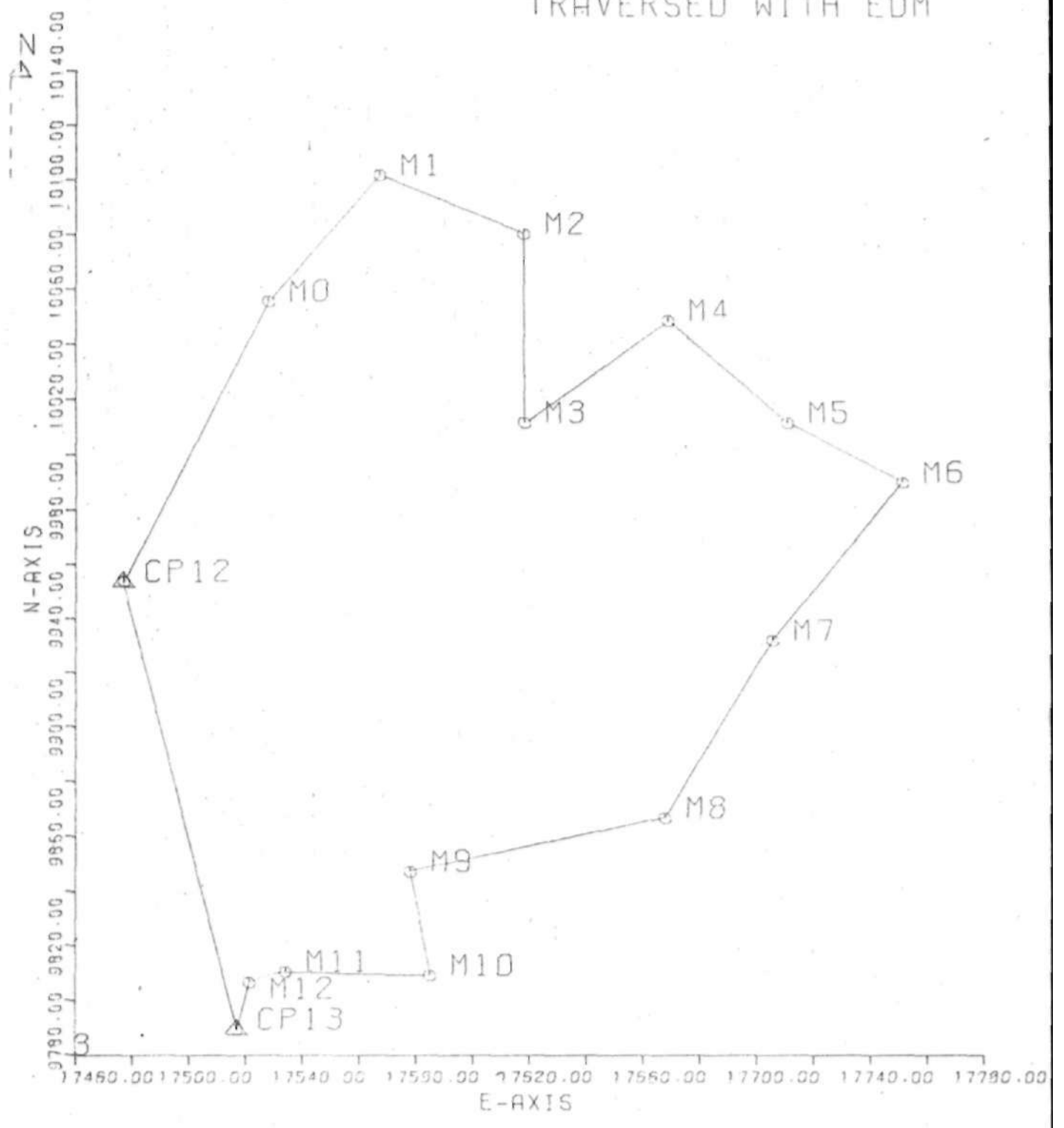
SCALE 1-2000 TRAVERSE PLAN AREA
TRAVERSED WITH ODM




△-CONTROL STATIONS
O-NEW STATIONS

FIG.9

SCALE 1-2000 TRAVERSE PLAN AREA
TRAVERSED WITH EDM




△-CONTROL STATIONS
O-NEW STATIONS

FIG.10

$$+ N_{m3}(E_{m4}-E_{m2}) + N_{m4}(E_{m5}-E_{m3}) + N_{m5}(E_{m6}-E_{m4})$$
$$+ N_{m6}(E_{m7}-E_{m5}) + N_{m7}(E_{m8}-E_{m6}) + N_{m8}(E_{m9}-E_{m7})$$
$$+ N_{m9}(E_{m10}-E_{m8}) + N_{m10}(E_{m11}-E_{m9}) + N_{m11}(E_{m12}-E_{m10})$$
$$+ N_{m12}(E_{cp13}-E_{m11}) + N_{cp13}(E_{cp12}) + N_{cp12}(E_{mo}-E_{cp13})\Big] \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (34a)$$

The formula was developed by projecting the traverse legs onto the northing rather than the easting axis. As a check, the formula was projected onto the easting axis and the area computed again. i.e.

$$\text{Area} = \frac{1}{2}\Big\{E_{mo}(N_{m1}-N_{cp12}) + E_{m1}(N_{m2}-N_{mo}) + E_{m2}(E_{m3}-E_{m1})$$
$$+ E_{m3}(N_{m4}-N_{m2}) + E_{m4}(N_{m5}-N_{m3}) + E_{m5}(N_{m6}-N_{m4})$$
$$+ E_{m6}(N_{m7}-N_{m5}) + E_{m7}(N_{m8}-N_{m6}) + E_{m8}(N_{m9}-N_{m7})$$
$$+ E_{m9}(N_{m10}-N_{m8}) + E_{m10}(N_{m11}-N_{m9}) + E_{m11}(N_{m12}-N_{m10})$$
$$+ E_{m12}(N_{cp13}-N_{m11}) + E_{cp13}(N_{cp12}-N_{m12}) + E_{cp12}(N_{m10}-N_{cp13})$$
$$\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (34b)$$

On evaluation of each term of the equations, equation (34a) gave a net positive area and equation (34b) gave a net negative area.

The process of the computation and the magnitude of the areas from the three methods are shown in tables 9, 10 and 11. Table 12 also shows the area computed from re-adjusted coordinates of the coordinates obtained from the three methods.

Table 9 AREA COMPUTATION FROM ODM (REDUCTION FACILITY) COORDINATOR

| POINTS | EASTING (E) (m) | NORTHINGS (N) (m) | DEPARTURE Δ E (m) | N X Δ E ($m^2$) |
|---|---|---|---|---|
| CP 12 | 17477.084 | 9954.014 | | |
| MO | 17528.248 | 10055.619 | 90.302 | 908042.506 |
| M1 | 17567.386 | 10101.369 | 89.805 | 907152.545 |
| M2 | 17618.053 | 10079.910 | 50.773 | 511787.240 |
| M3 | 17618.159 | 10011.369 | 50.540 | 505974.589 |
| M4 | 17668.593 | 10048.256 | 92.646 | 930930.7 |
| M5 | 17710.805 | 10011.126 | 82.760 | 828520.7 |
| M6 | 17751.353 | 9989.530 | - 5.225 | 52195.294 |
| M7 | 17705.580 | 9931.608 | 83.495 | -829239.610 |
| M8 | 17667.858 | 9866.659 | -127.505 | -1258048.356 |
| M9 | 17578.075 | 9847.330 | 82.996 | - 817289.000 |
| M10 | 17584.862 | 9809.068 | 44.117 | - 432746.653 |
| M11 | 17533.958 | 9810.766 | - 63.500 | - 622983.641 |
| M12 | 17521.362 | 9806.671 | - 17.049 | - 167193.934 |
| CP13 | 17516.909 | 9789.536 | 44.278 | - 433461.075 |
| CP12 | 17477.084 | 9954.014 | 11.339 | 112368.564 |
| MO | 17528.248 | 10055.619 | | |

$$\sum(N \times \Delta E) = 92118.296$$

$$AREA = \tfrac{1}{2} \sum(N \times \Delta E) = \tfrac{1}{2}(92118.296)$$

$$= 46059.148 \text{ m}^2$$

$$= 4.6059 \text{ hecteres}$$

CHECK Computation

$\sum(E \times \Delta N) = - 92118.296$

Area = 46059.148 $m^2$

= 4.6059 hectares

TABLE 10. AREA COMPUTATION FROM STEEL TAPE COORDINATES

| POINTS | EASTINGS (E) (m) | NORTHINGS (N) (m) | DEPARTURE Δ E (m) | N X Δ E ($m^2$) |
|---|---|---|---|---|
| CP12 | 17477.084 | 9954.014 | | |
| MO | 17528.252 | 10055.682 | 90.409 | 909124.153 |
| M1 | 17567.493 | 10101.566 | 90.021 | 909353.072 |
| M2 | 17618.273 | 10080.072 | 50.886 | 512934.544 |
| M3 | 17618.379 | 10011.404 | 50.647 | 507047.578 |
| M4 | 17668.920 | 10048.390 | 92.739 | 931877.640 |
| M5 | 17711.118 | 10011.279 | 82.804 | 828973. 46 |
| M6 | 17751.724 | 9989.656 | - 5.174 | - 51686..80 |
| M7 | 17705.944 | 9921.756 | - 83.609 | -830384.187 |
| M8 | 17668.115 | 9866.657 | -127.558 | -1258571.034 |
| M9 | 17578.386 | 9847.350 | - 82.924 | -816581.651 |
| M10 | 17585.191 | 9808.988 | - 44.251 | -434057.528 |
| M11 | 17534.135 | 9810.691 | - 63.724 | -625176.473 |
| M12 | 17521.467 | 9806.574 | - 17.169 | -168369.069 |
| CP13 | 17516.966 | 9789.266 | - 44.383 | -434476.992 |
| CP12 | 17477.084 | 9954.014 | 11.286 | 112341.002 |
| MO | 17528.252 | 10055.682 | | |

$$\sum(N \times \Delta E) = 92348.994$$

$$\text{Area} = \tfrac{1}{2} \sum(N \times \Delta E) = \tfrac{1}{2}(92348.994)$$

$$= 46174.497 \text{ m}^2$$

$$= 4.6174 \text{ hectares}$$

Check computation

$$\sum(E \times \Delta N) = - 92349.994$$

$$\text{Area} = 46174.497 \text{ m}^2$$

$$= 4.6174 \text{ hectaves.}$$

Table 11. AREA COMPUTATION FROM EDM COORDINATES

| POINTS | EASTINGS (E) (m) | NORTHINGS (N) (m) | DEPARTURE Δ E (m) | N X Δ E ($m^2$) |
|---|---|---|---|---|
| CP 12 | 177477.084 | 9954.014 | | |
| MO | 17528.248 | 10055.676 | 90.411 | 909143.922 |
| M1 | 17567.495 | 10101.566 | 90.023 | 909373.176 |
| M2 | 17618.271 | 10080.069 | 50.882 | 512894.070 |
| M3 | 17618.377 | 10011.396 | 50.634 | 506917.025 |
| M4 | 17668.905 | 10048.373 | 92.711 | 931594.709 |
| M5 | 17711.088 | 10011.263 | 82.774 | +828672.284 |
| M6 | 17751.679 | 9989.643 | - 5.209 | - 52036.050 |
| M7 | 17705.879 | 9931.718 | - 83.638 | -830669.030 |
| M8 | 12668.041 | 9866.601 | -127.599 | -1258968.421 |
| M9 | 17578.280 | 9847.289 | - 82.955 | -816881.859 |
| M10 | 17585.086 | 9808.918 | - 44.214 | -433691.500 |
| M11 | 17534.066 | 9810.620 | - 63.657 | -624514.637 |
| M12 | 17521.429 | 9806.513 | - 17.104 | -167730.598 |
| CP13 | 17516.962 | 9789.331 | - 44.345 | -434107.883 |
| CP12 | 17477.084 | 9954.014 | 11.286 | 112341.042 |
| MO | 17528.248 | 10055.676 | | |

$\sum(N \times \Delta E) = 92336.11$

Area = $\frac{1}{2} \sum(N \times N E) = \frac{1}{2}(92336.11)$

= 46168.055 $m^2$

= 4.6168 hectares

Check computation

$\sum(E \times \Delta N) = - 92336.11$

Area = 46168.055 $m^2$

= 46168 $m^2$

= 4.6168 hectares

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Table 12. AREA COMPUTATION FROM THE RE-ADJUSTED COORDINATES

| POINTS | EASTINGS (E) (m) | NORTHINGS (N) (m) | DEPARTURE Δ E (m) | N X (Δ E) ($m^2$) |
|---|---|---|---|---|
| CP12 | 17477.084 | 9954.014 | | |
| M0 | 17528.249 | 10055.659 | 90.374 | 908748.014 |
| M1 | 17567.458 | 10101.497 | 89.950 | 908629.655 |
| M2 | 17618.199 | 10080.017 | 50.847 | 512538.624 |
| M3 | 17618.305 | 10011.390 | 50.607 | 506646.414 |
| M4 | 17668.806 | 10048.340 | 92.699 | 931471.070 |
| M5 | 17711.004 | 10011.223 | 82.930 | 830230.723 |
| M6 | 17751.736 | 9989.610 | - 5.203 | - 51975.941 |
| M7 | 17705.801 | 9931.669 | -83.731 | -831588 .577 |
| M8 | 17668.005 | 9866.639 | -127.554 | -1258529.271 |
| M9 | 17578.247 | 9847.323 | - 82.959 | - 816924.068 |
| M10 | 17585.046 | 9808.991 | - 44.194 | - 433498.548 |
| M11 | 17534.053 | 9810.692 | - 63.627 | - 624224.900 |
| M12 | 17521.419 | 9806.586 | - 17.109 | - 167761.266 |
| CP13 | 17516.946 | 9789.373 | - 44.335 | - 434012.074 |
| CP12 | 17477.084 | 9954.014 | 11.303 | 112510.220 |
| MO | 17528.249 | 10055.659 | | |

$$\sum(N \times \Delta E) = 92255\ 025$$

$$\text{Area} = \tfrac{1}{2}(\sum N \times \Delta E) = \tfrac{1}{2}(92255.075)$$

$$= 46127.538\ m^2$$

$$= 4.6127 \text{ hectares.}$$

## 4.8 Closing Errors

Using $e_E$ and $e_N$ (the respective easting and northings coordinates cumulative errors of the last station of the traverse computation sheet) the linear error, $e_L$ was calculated by the formula

$$e_L = (e_E^2 + e_N^2)^{\frac{1}{2}} \quad \ldots\ldots\ldots\ldots \quad (35)$$

The linear error ($e_L$) was compared with the total length of the traverse legs, $\sum_{i=1}^{15} D_i$ to give the fractional linear error. i.e.

Fractional linear error = 1 in $\left(\sum_{i=1}^{15} D_i / e_L\right)$. This was done to compute the accuracy of the traverse (see table 13 below ):

Table 13. Fractional Linear error of the three methods

| Method | $e_E$ | $e_N$ | $e_L = (e_E^2 + e_N^2)^{\frac{1}{2}}$ | Fractional linear error = 1 in $\left(\sum_{i=1}^{15} D_i / e_L\right)$ |
|---|---|---|---|---|
| Steel taping | -0.108 | 0.067 | 0.1270944 | 1 in 7824.704 |
| ODM | 0.215 | 0.180 | 0.2804015 | 1 in 3541.083 |
| EDM | -0.032 | 0.027 | 0.0418688 | 1 in 23747.229 |

grasses.

Table 12, shows the time, instruments and field team for each method. It indicates that steel taping is the slowest of the three methods because it took longest time to carry out the measurements. From the table still, it shows that ODM has the shortest time.

On the average, to measure a line four times, it took 29 mins. 04 secs, 27 mins 20 secs and 23 mins 32 secs. using steel tape, ODM and EDM respectively.

The constant movement of vehicles contributed to high time recorded using steel tape. These movements seriously delayed measurements and the steel time is twice and 1.2 times more than ODM and EDM times respectively. Also many short lines in the traverse contributed to the increase in time or decrease in speed of traversing. It is a fact that, if the area is an open one at most only half of the lines would have bee required

Comparatively, the delay caused by movements (pedestrain and vehicular) in steel taping was comparable with the time involved in setting up of instruments on many stations for ODM and EDM methods.

The computation time was added to the recorded time in field using steel tape and EDM. This computation time is the time spent to reduce the distances using EDM and steel tape to horizontal distances.

Hence, on the whole, (5 hours 53 mins + 1 hour 40 mins =)

CHAPTER 5

# ANALYSES

## 5.1 Introduction

The aim of this chapter is to analyse comparatively the results of field data and computations of the three methods. This is to be done in terms of speed, cost and accuracy. For speed, the parameter of time is to be used, for cost, such parameters as overhead cost, equipment cost, recce and searching cost, accuracy etc are to be considered. The accuracy of each of the three methods will be studied using the parameters; distances, coordinates, bearings, Areas.

Then these parameters will be subjected to one-tailed statistical tests. The tests as we know is not fool-proof but is used here to concritize the results and provide guide lines. At each test, the hypothesis or consideration is stated (Lindgren et. al. (1978) and Francis (1979)).

The analyses is to be done on the major loop of the traverse which covers approximately 4.6 hectares.

## 5.2 Speed

The speed of traversing depends on such factors as; the topography, accuracy demanded and mobility in the field as regards the weight of equipment.

In this work, the area traversed has a gentle topography and also there was no need to clear the survey lines of

grasses.

Table 14, shows the time, instruments and field team for each method. It indicates that steel taping is the slowest of the three methods because it took longest time to carry out the measurements. From the table still, it shows that ODM has the shortest time.

On the average, to measure a line four times, it took 29 mins. 04 secs, 27 mins 20 secs and 23 mins 32 secs. using steel tape, ODM and EDM respectively.

The constant movement of vehicles contributed to high time recorded using steel tape. These movements seriously delayed measurements and the steel time is twice and 1.2 times more than ODM and EDM times respectively. Also many short lines in the traverse contributed to the increase in time or decrease in speed of traversing. It is a fact that, if the area is an open one at most only half of the lines would have been required

Comparatively, the delay caused by movements (pedestrain and vehicular) in steel taping was comparable with th time involved in setting up of instruments on many stations for ODM and EDM methods.

The computation time was added to the recorded time in field using steel tape and EDM. This computation time is the time spent to reduce the distances using EDM and steel tape to horizontal distances.

Hence, on the whole, (5 hours 53 mins + 1 hour 40 mins =)

Table 14. Summary of method, time, instruments and field team.

| Method | Time | | | | Instruments | | Field Team |
|---|---|---|---|---|---|---|---|
| | Angular observation | | Linear measurements | | Angular Observation | Linear Measurements | |
| OD | HRS | MINS | HRS | MINS | | | |
| | 14 | 45 | 6 | 50 | (i) T2-1" Theodolite<br>(ii) Two ranging poles with stands.<br>(iv) Tripod | (i) Self-reducing tacheometer<br>(ii) Vertical staff with built in circular buble.<br>(iii) One linen tape<br>(iv) Tripod | (i) One surveyor<br>(ii) Two Survey Assistants. |
| Steel taping | 14 | 45 | 7 | 16 | | (i) Steel tape | (i) One Surveyor |
| | | | 2 | 10 | ✓ | (ii) 3 ranging poles. | |
| | | | 9 | 26 | | (iii) thermo-meter<br>(iv) Spring balance<br>(v) roller (tape grip) | (ii) Two survey Assistants |
| EDM | 14 | 45 | 5. | 53 | | (i) Eldi-1 | (i) One Surveyor |
| Corrtation | | | 1 . | 40 | ✓ | (ii) Reflector prisms | |
| | | | 7 | 33 | | (iii) two tripods<br>(iv thermo-meter<br>(v) two lines tapes | (ii) two survey Assistants. |

7hours 25 mins gives the time spent to really obtain horizontal distance using EDM instrument. Also (7 hours 16 mins + 2 hours 10 mins = ) 9 hours 25 mins give the time using the steel tape.

Therefore, the ODM has the shortest time amongst the three methods. The time for observing the angles was the same in all the three methods, so also were the times for computations of traverse and areas.

### 5.2.1 t - test statistics:

In order to know the behaviour of time and methods, a t - test statistics was carried out on the observed times using the three methods. The considerations was, does time depend on the method.

To effectively carry out the test, a hypothetical table was constructed using the field time as a guide. The sample size is n = 4.

For the pair ODM and EDM,

$t_{test}$(ODM and EDM) = 23.76

but $t_{critical}$ (3, 95%) = 3.18

Therefore, the test is significant at 95% level which shows the evidence that time depends on the method. The (result) are the same in the pairs; ODM and steel tape, and steel tape and EDM.

## 5.3 ACCURACY

Three statistical tests were carried out on the accuracy.

to another statistical test to know if there are significa t differences between the coordinates obtained by each of th three methods.

A t - test statistics was used to test for any difference between pairs of coordinates. It was done for the pairs, ODM and steel tape, ODM and EDM and finally steel tape and EDM. Thus

$$t_{test}(\text{ODM and steel tape}) = 6.325$$

$$t_{test}(\text{ODM and EDM}) = 6.068$$

$$t_{test}(\text{steel tape and EDM}) = 3.732$$

But $t_{critical}(14, 95\%) = 1.76$

The test result then is significant at 95% level, so, there is significant difference between any two sets of coordinates from two methods of one measurement.

Again, from table 8 (last column), a t-test statisti s for the proportional misclosures were carried out. The considerations were that

(1) there is difference between the proportional misclosures of short and long distances measured by each method.

(2) there is difference between the proportional misclosures of short distances measured by each method in pairs of ODM and steel tape, steel tape and EDM, and finally ODM and EDM.

(3) there is difference between the proportional misclosures of long distances measured by each method in pairs as (2) above.

In conducting the t-test statistic; two paired random

samples of n = 3 were constructed. Thus the results of the considerations are :

(1) (i) $t_{test}$(ODM) = 4.71

(ii) $t_{test}$(steel tape) = 3.86

(iii) $t_{test}$(EDM) = 4.02

$t_{critical}$(2, 95%) = 4.30

(2) (i) $t_{test}$(ODM and steel tape) = 6.061,

(ii) $t_{test}$(steel tape and EDM) = 2.97

(iii) $t_{test}$(ODM and EDM) = 3.431

$t_{critical}$(2, 95%) = 4.30

(3) (i) $t_{test}$(ODM and steel tape) = 2.12

(ii) $t_{test}$(steel tape and EDM) = 2.12

(iii) $t_{test}$(ODM and EDM) = 2.83

$t_{critical}$(2,95%) = 4.30

Now, the t-test results in (1) are significant at 95% level, so there is essential difference between the proportional misclosures of short and long distances. The EDM method is better.

In 2(i) and 2(iii) the t-test results are significant, so we accept there is signicant difference between proportional misclosures for pairs of steel tape and ODM, EDM and ODM. It shows that the pair steel tape and ODM is better. In 2(ii) the t-test result is not significant, so there is no evidenc

of significant difference between pair of steel tape and EDM in short distances.

For 3(i) to 3(iii), the t-test results are not significant so we accept again that there is no evidence of essential difference in the pairs: ODM and steel tape, steel tape and EDM, EDM and ODM.

From the t - test results of the second and third considerations, we accept also that the accuracies of the methods depends on distances and the accuracies increases with increased distances in all the three methods.

This is even further illustrated in the accuracy against distance graph shown in figure 11. The graph was plotted using the Calcomp facilities in Iya Abubakar Computer Centre, A.B.U., Zaria. The graph shows that accuracies increases with increase in distance. Also amongst the three methods, the EDM follows this pattern more than ODM and steel tape by giving better accuracies than them.

Area: From tables 9, 10, 11, the area obtained using ODM is the least compared with EDM and steel tape areas. Also the computed area using steel tape has the highest magnitude.

Comparing tables 9, 10, 11 with 12, for ODM, the computed area differs from the area of readjusted coordinates by 0.0068 $m^2$, then steel tape and EDM by -0.0047 $m^2$ and -0.0041 $m^2$ respectively.

A proportional accuracy was computed by expressing the area of the readjusted coordinates over these differences ignoring their signs. The results obtained are 1/678, 1/981

ACCURACY VS DISTANCE

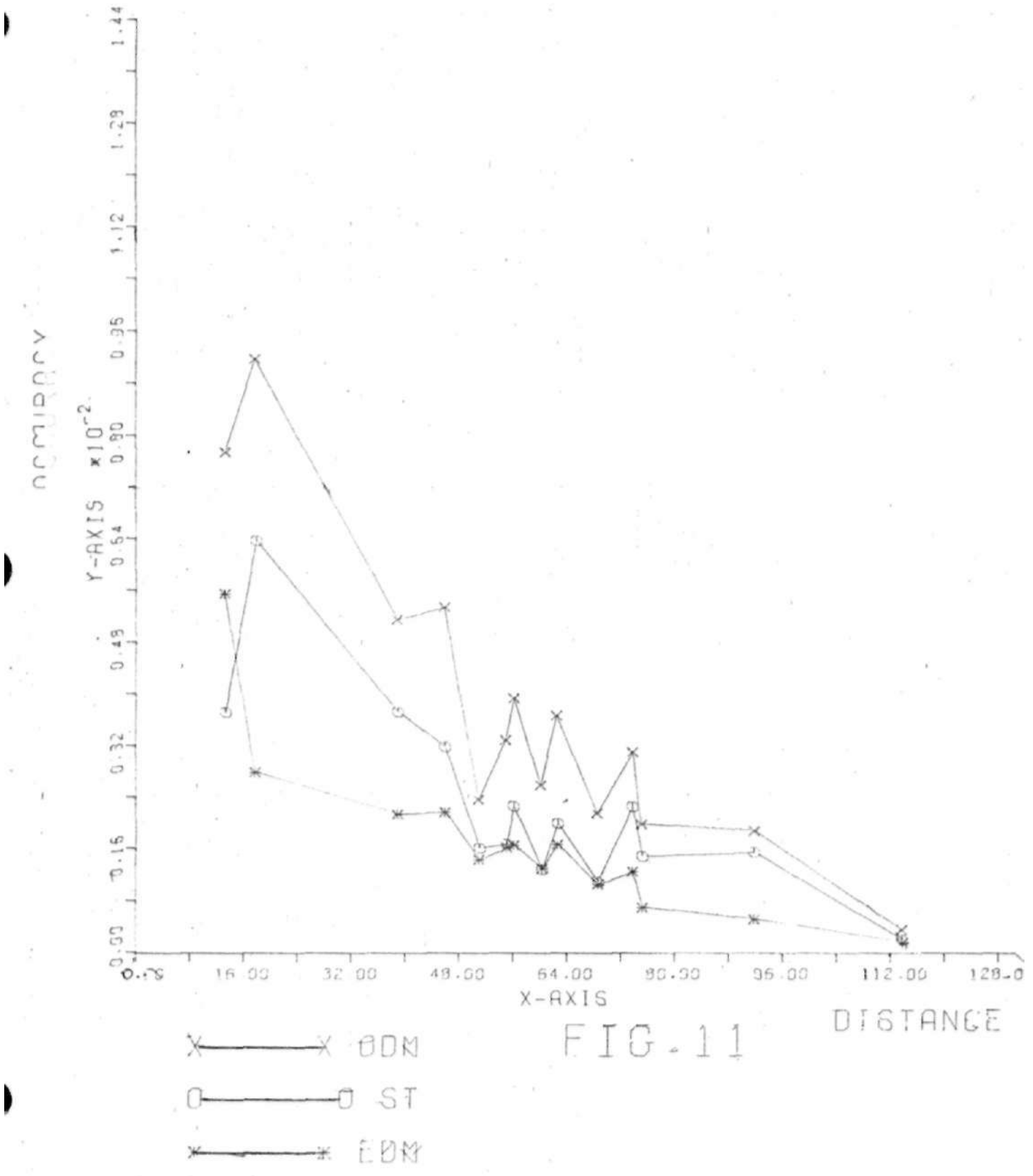



FIG. 11

and 1/1125 for ODM, steel tape and EDM respectively.

From this, we can infer that area obtained using EDM is better, then followed by steel tape area.

### 5.3.3 $\chi^2$ test statistics.

From a prepared contingency table, $\chi^2$ test was carried out to test whether the distance and method are independent of each other. The ODM, steel tape and EDM are the levels of method and short (0- 50 m), medium (50 - 70 m) and long (70-170) are levels of distances.

A random sample of n = 4 was taken the result is;

$$\chi^2_{test} = 0.0001$$

but

$$\chi^2_{95\%}(4) = 9.49$$

Therefore, the $\chi^2_{-test}$ value is very insignificant, hence, there is no evidence of dependence between method and distance.

### 5.3.4 Relative Accuracy:

After computation of traverse from measurements of the three methods, the relative accuracies of 1 in 8000, 1 in 24000 and 1 in 3500 were achieved for steel tape, EDM and ODM respectively. This shows that EDM is better than steel tape and ODM.

These accuracies are not the limit one can obtain. For example, accuracy greater than 1 in 10000 can be achieved with steel tape if other corrections such as tension, non-

alignment and tape-not-straight are applied. With EDM, accuracy of 1/50000 is possible if corrections like refraction, curvature, ground swing effect are also applied.

Equally, if errors due to non-verticality of staff, and error in the diaphragm construction are applied to ODM much better accuracies of over 1/5000 will be obtained.

## 5.4 COST

Based on the Surveyors-General scale of fees, the cost of carrying out this traversing is estimated by considering the cost centres: Survey party, reconnaissance, materials (iron Pillars, Drawing), Presentation (Supplying), Computation, transportation, equipment, Maintainance cost, Entertainments and Overheads and contingencies. See table 15.

In this case, the survey party was made up of one surveyor (the author) and two survey assistants. I^ the surveyor (the authory) is paid a salary of N9600.00 per annum and the two survey assistants each receives N4000.00 per annum. Hence the cost of hiring the survey party per day based on an average rate of pay is calculated to be N68.00. This is got by dividing the total by 260(the number of working days in a year). It should be recognised that this is not static as pay changes for a different survey team.

On the surface, the area is about 4.62 hectares, hence the total cost of traversing the area is N8893.50, for each of the three methods. This is based on the Surveyors-

Table 15. Comparative cost of the various methods in Naira

| | Cost centres | Steel tape | | ODM | | EDM | |
|---|---|---|---|---|---|---|---|
| | | N | K | N | k | N | K |
| (i) | Survey party per day (1 day) | 68 | 00 | 68 | 00 | 68 | 00 |
| (ii) | Reconnaissance and establishment (5 days). | 340 | 00 | 340 | 00 | 340 | 00 |
| (iii) | Materials | | | | | | |
| (a) | Iron Pillars (N1.50 each) | 24 | 00 | 24 | 00 | 24 | 00 |
| (b) | Computation (2 days) | 136 | 00 | 136 | 00 | 136 | 00 |
| (c) | Drawing (1 day) | 68 | 00 | 68 | 00 | 68 | 00 |
| (iv) | Presentation (supplying) (1 day) | 68 | 00 | 68 | 00 | 68 | 00 |
| (v) | Transportation | — | | 5 | 00 | 5 | 00 |
| (vi) | Cost of Equipment per day (1 day) | 12 | 50 | 96 | 00 | 154 | 00 |
| (vii) | Maintainnance cost | 6 | 00 | --- | | — | |
| (viii) | Calibration process (1 day) | | | --- | | 68 | 00 |
| (ix) | Entertainments (1 day) | 3 | 00 | 9 | 00 | 5 | 00 |
| (x) | Overheads and contingencies 331/3% | 241 | 80 | 271 | 30 | 312 | 00 |
| | Total | 967 | 30 | 1685 | 30 | 1248 | 00 |

General scale of fees where 4 hectares cost N7700.00. This, then, is very deficient because it does not properly take into considerations the cost of respective instruments and accuracies obtainable.

To take care of these factors, the method suggested by Lakanu (1978) is used. Now, for EDM (Eldi-1), the current cost is put at N40000.00 (Atlas (Nig.) Ltd., Kaduna). The quoted usuable life of the equipment is ten years, (Zeiss Information) and the accuring 10% interest is N4000 per annum. Hence, the cost of using the instrument per day is N154.00.

For self-Reducing Tacheometer at current price of N2500.00 (Atlas (Nig.) Ltd., Kaduna). The cost calculated per day using Lakanu (1978) method is N96.00. The quoted usuable life is over ten years (Zeise Information, Vol. 28). For steel tapes and other instruments (i.e., thermometer, spring balance, ranging poles etc.) the total cost is put at N5000.00 (LOM Survey Equipment). By Lakanu (1978), at 8% interest per annum, the cost per day is N12.50.

From table 15, the four parameters (cost centres) gave a common cost for each of three methods. Then, variation started from parameters (v) to (ix). Hence table 15 shows that EDM method is the most costly among the three methods, followed by ODM in executing the traverse.

On the whole, the total cost for the execution of the traverse seemed two small, this largely due to few survey team involved which lowered the cost of survey

party per day. So, also are the nearness of site and most importantly the gentle topography of the area. Again, such cost centres like hotel bills, hire of vehicles, were not considered. For example, for a very decent hotel, the bill for a Night is N45.00 (Zaria Hotels), hire of vehicles (Land Rover) costs N150.00 per day (Nkem Motors, Zaria).

In all, the practising surveyor should look at the scope of the work, standards demanded, the limit within which the job must be completed and then determine the methodology.

### 5.4.1 t-test statistics

A t-test was carried out to know whether there is significant dependence between cost and method. The null-hypothesis was if $t_{test} < t_{critical}$, then accept result.

The results of the test between the pairs are :

(a) $t_{test}$ (ODM and steel tape) = 1.65

(b) $t_{test}$ (EDM and steel tape) = 1.36

(c) $t_{test}$ (EDM) and ODM) = 1.43

(d) $t_{critical}$ = 1.83 at 95% level.

This shows a significant result, hence cost depends on method used. This confirms a view held by some practising Surveyors interviewed that the cost of survey work determines the method to use.

CHAPTER 6

# CONCLUSIONS AND RECOMMENDATIONS

## 6.1 Difficulties

The assistants aggreement to work within the official working hours made the work to go on several days and any other aggreement to work beyond the official hours was on overtime charges which increased the cost of the survey.

The movements on the area being traversed delayed observations and the effect lowered the speed of work.

The weather was really hot which caused some dis evell-ment in the instruments and also shimmer during the ork. But the hot weather made the ground to be covered with dying grasses which needed no clearing before the traverse commenced.

To make up for intervisibility, short lines were created and these increased the number of stations and decreased th. traverse speed.

## 6.2 Conclusion and Recommendations

In conclusion, the FDM gives the best accuracy, highest cost and has better speed. The ODM has the best speed, low accuracy and has higher cost. The author believes that the lower accuracy of ODM than steel tape is because of precision of measurement. While the readings of ODM are multiplied by 100 or 200 to give the distances to one place of decimal, the steel tape final readings are in three places of decimal. The steel tape has better accuracy, the cost is

low and has lowest speed.

Therefore, steel tape is the cheapest and most economical and hence most affordable for Cadastral Surveys.

In recommendation then, since each traverse survey is virtually a new problem, it would be difficult to make any general recommendation, if however we take a specific case of the project, we shall come out with the following :-

(i) Distances

Short lines (0 - 50)m - Steel tape or EDM is recommended for use.

Any of the three methods of linear measurement can be used for over 50 m.

(ii) In gentle topography where the distances are over 100m any of the three methods can be used.

(iii) Accuracy

$\neq$ 1/5000 - ODM is recommended

$\neq$ 1/15000 - Ground taping methods should be used.

$>$ 1/15000 - EDM is recommended.

(iv) Time

Over 35 mins per line - use steel tape.

Between 29 and 35 mins per line - use EDM

Less than 29 mins per line - use ODM.

(v) Costs.

To determine the method to be used, the approximate cost per day of manpower to be involved should be used.

Therefore for,

Low (₦100 - ₦180) - use steel tape,

High (₦180 - ₦300) - use steel tape, ODM.

Over (₦300) - use EDM

This project is not exhaustive and it is again suggested that further investigations should be narrowed down to specific instruments from each of the three methods i.e. steel taping ODM and EDM.

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APPENDIX A: Log Book

| | Activity | Date | Time |
|---|---|---|---|
| (1) | Angle Observations with theodolite | 6/2/86 | 8.02 am - 2.00 pm |
| (2) | Break | 6/2/86 | 2.00 pm - 2.30 pm |
| (3) | Angle Observations with theodolite | ✓ | 3.30 pm - 6.CC pm |
| (4) | Angle observations with theodolite | 7/2/86 | 8.00 am - 2.17 pm |
| (5) | Angle Observations with theodolite | 8/286 | 7.55 am - 1.36 p |
| (6) | Angle observations with theodolite. | 11/2/86 | 8.47 am - 12.11 a |
| (7) | Linear Measurements with ODM | 13/2/86 | 8.15 am - 12.30 a |
| (8) | Break | 13/2/86 | 12.30 pm - 3.07 pm |
| (9) | Linear Measurement with ODM | 13/2/86 | 3.07 pm - 5.35 pm |
| (10) | Linear measurement with ODM | 14/2/86 | 8.33 a.m. -12 pm |
| (11) | Linear measurement with ODM | 15/2/86 | 8.45 am - 10 56 am |
| (12) | Linear measurement with ODM | 22/2/86 | 8.59 am - 10.23 am |
| (13) | Linear measurement with EDM. | 8/3/86 | 9.30 am - 2.04 pm |
| (14) | Linear measurement with EDM | 12/3/86 | 8.32 am - 10.55 am |
| (15) | Linear measurement with EDM | 15/3/86 | 8.05 am - 12.56 |
| (16) | Linear measurement | 28/4/86 | 8.10 am - 3.26 p |
| (17) | Linear measurement with steel tape | 29/4/86 | 8.25 am - 1.53 p |
| (18) | Levelling | 30/4/86 | 8.30 am - 1.35 pm |
| (19) | Computations | 13/6/86 | |

APPENDIX B: PROGRAM THAT PLOTS THE TRAVERSE PLAN AREA

```
      THIS PROGRAM PLOTS THE TRAVERSE PLAN AREA USING CALCOMP FACILITIES
      THE PLOTTING IS DEFINED
      THE INPUT DATA:EASTINGS(E),NORTHINGS(N) CO-ORDINATES
      OUTPUT:SEE FIGURES 5,6,AND 11
      PROGRAMMER:MATTHEW N ONOH
      BLOCK DATA
      COMMON /BLK1/IBCD(16)
      DATA IBCD/"  CP12       M0       M1       M2       M3       M4
     1   M6       M7       M8       M5       M9       M10
     2M11         M12       CP13       CP12       "/
      END
      PROGRAM GEAA(DATAA,OUTPUT,TAPE5=DATAA,TAPE6=OUTPUT,TAPE1)
      DIMENSION X(18),Y(18)
      COMMON /BLK1/IBCD(16)
      CALL PLOTS(0,0,10)
      CALL PLOT(2.,5.,-3)
      DO 2 K=1,3
      READ(5,8) (X(J),Y(J),J=1,16)
    8 FORMAT(F9.3,9X,F9.3)
      WRITE(6,13) (X(J),Y(J),J=1,16)
   13 FORMAT(1LX,F9.3,9X,F9.3)
      CALL SCALE(X,15.,16,1)
      CALL SCALE(Y,15.,16,1)
      CALL AXIS(0.,0.,6HE-AXIS,-6,15.,0.,X(17),X(18))
      CALL AXIS(0.,0.,6HN-AXIS,+6,15.,90.,Y(17),Y(18))
      CALL LINE(X,Y,16,1,1,1)
      FK=K
      CALL SYMBOL(2.,20.,0.4,12HSCALE 1:2000,0.0,12)
      IF(K.EQ.1)CALL SYMBOL(5.,-3.,0.4,5HFIG.6,0.0,5)
      CALL PLOT(0.,0.,3)
      IF(K.EQ.2)CALL SYMBOL(5.,-3.,0.4,5HFIG.9,0.0,5)
      CALL PLOT(0.,0.,3)
      IF(K.EQ.3)CALL SYMBOL(5.,-3.,0.4,6HFIG.10,0.0,6)
      CALL NUMBER(999,999,0.4,FK,0.0,-1)
      CALL SYMBOL(8.,20.,0.4,18HTRAVERSE PLAN AREA,0.0,18)
      IF(K.EQ.1)CALL SYMBOL(8.,19.,0.4,17HTRAVERSED WITH ST,0.0,17)
      CALL PLOT(0.,0.,3)
      IF(K.EQ.2)CALL SYMBOL(8.,19.,0.4,18HTRAVERSED WITH ODM,0.0,18)
      CALL PLOT(0.,0.,3)
      IF(K.EQ.3)CALL SYMBOL(8.,19.,0.4,18HTRAVERSED WITH EDM,0.0,18)
      CALL PLOT(0.,0.,3)
      CALL SYMBOL(2.,-2.,0.4,16H -CONTRO. STATIONS,0.0,16)
      CALL SYMBOL(1.,-2.,0.4,2,0.0,-1)
      CALL SYMBOL(1.,-2.,0.4,1,0.0,-1)
      CALL SYMBOL(1.,-3.,0.4,14HO-NEW STATIONS,0.0,14)
      CALL SYMBOL(-1.,16.,0.4,7H------  ,90.0,7)
      CALL SYMBOL(-1.,18.,0.4,2,0.0,-1)
      CALL SYMBOL(-1.,18.3,0.4,1HN,0.0,1)
      CALL PLOT(0.,0.,3)
      DO 1 J=1,16
      IB=IBCD(J)
      X1=(X(J)-X(17))/X(18)
      Y1=(Y(J)-Y(17))/Y(18)
      IF(J.EQ.14)Y1=Y1-0.3
      WRITE(6,19)X1,Y1,X(J),Y(J),IB
   19 FORMAT(1X,F5.3,2X,F5.3,2X,F9.3,2X,F9.3,2X,A10)
      IF(J.EQ.1.OR.J.EQ.15)CALL SYMBOL(X1,Y1,0.4,2,0.0,-1)
      CALL SYMBOL(X1,Y1,0.4,IB,0.0,5)
    1 CONTINUE
      CALL PLOT(0.,0.,3)
      IF(K.EQ.1)CALL PLOT(0.,30.,-3)
      IF(K.EQ.2)CALL PLOT(26.,-30.,-3)
    2 CONTINUE
      WRITE(6,81)
   81 FORMAT(1EX,*TRAVERSE PLAN AREA*)
      STOP
      END
```

APPENDIX C: PROGRAM THAT PLOTS THE ACCURACY AGAINST DISTANCE

```
C
C
C     THIS PROGRAM PLOTS ACCURACY AGAINST DISTANCE USING CALCOMP FACILITIES
C     THE PLOTTING IS OFF-LINE.
C     INPUT:DISTANCE(X),ACCURACY(Y)
C     OUTPUT:PLOT FILE.
C     THE PLOTS ARE FOR ST.,DUM.,SNE LOW, MEASUREMENTS.
C     PROGRAMMER:MATTHEW N UNOH.
      PROGRAM GRAPH(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT,TAPE12
     *)
      DIMENSION X(15),Y(15)
      CALL PLOTS(,,12)
      READ(5,12)(X(I),Y(I),I=1,14)
   11 FORMAT(F7.3,4X,E10.6)
      WRITE(6,12)(X(I),Y(I),I=1,14)
   12 FORMAT(1X,F7.3,4X,E10.6)
      CALL SCALE(X,6.,14,1)
      CALL SCALE(Y,8.,14,1)
      CALL AXIS(0.,0.,5HX-AXIS,-5,15.,0.,X(15),X(16))
      CALL AXIS(0.,0.,5HY-AXIS,+5,15.,90.,Y(15),Y(16))
      DO 2 K=1,3
      READ(5,7)(X(J),Y(J),J=1,14)
    7 FORMAT(F7.3,4X,E10.6)
      WRITE(6,14)(X(J),Y(J),J=1,14)
   14 FORMAT(1X,F7.3,4X,E10.6)
      WRITE(6,22)(X(J),Y(J),J=1,14)
   22 FORMAT(1X,F7.3,2X,E7.3,2X,F7.3,2X,E10.6)
      IF(K.EQ.1)CALL LINE(X,Y,14,1,-1,1)
      CALL PLOT(2.,0.,-3)
      IF(K.EQ.2)CALL LINE(X,Y,14,1,-2,2)
      CALL PLOT(2.,0.,-3)
      IF(K.EQ.3)CALL LINE(X,Y,14,1,-3,3)
    2 CONTINUE
      CALL SYMBOL(6.,-6.,.16,6HF3,0.,2)
      CALL PLOT(0.,0.,3)
      CALL SYMBOL(1.,-2.,.14,24HX=======X 225,0.0,24)
      CALL SYMBOL(1.,-3.,.14,24H2-------2 225,0.0,24)
      CALL SYMBOL(1.,-4.,.14,24H3.......3 225,0.0,24)
      CALL SYMBOL(10.,-2.,.14,10HSTANDARD,0.0,8)
      CALL SYMBOL(-1.5,9.,.14,6HACCURACY,90.0,8)
      CALL SYMBOL(6.,15.,.14,24HACCURACY VS DISTANCE,0.0,22)
      CALL SYMBOL(6.,13.,.14,15HDF GRAPHICS,0.0,15)
      CALL PLOT(0.,0.,3)
      END(2,55)
   82 FORMAT(2X,*GRAPH OF ACC. VS. DIST.*)
      STOP
      END
```

TRAVERSE BOOKING SHEET

Date: 6/2/86 (Starting time) 8.02 am. Observer: Matthew Nicol

Instrument: Tx theodolite Booker:

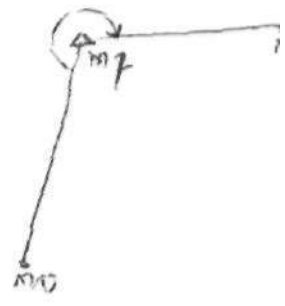
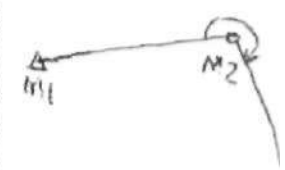
| Station | Sight | Face | Horizontal Circle Reading | Horizontal Angle | Mean Angle | Remarks |
|---|---|---|---|---|---|---|
| CP12 | CP13 | FL | 323° 25' 03" | | | |
| | MO | FL | 183 44 45.5 | 220° 19' 42 | | MO |
| | MO | FR | 03 44 48.5 | | | |
| | CP13 | FR | 143 25 08.5 | 220 19' 47 | | |
| | | | | | 220° 19' 35" | CP12 |
| CP12 | CP13 | FL | 337 26 03 | | | |
| | MO | FL | 194 56 29 | 220 19 26 | | |
| | MO | FR | 17 55 31 | | | |
| | CP13 | FR | 158 31 00 | 220 19 29 | | CP13 |
| | | | | | | |
| O | CP12 | FL | 35° 36 17 | | | |
| | M1 | FL | 229 26 40 | 193 49 23 | | |
| | M1 | FR | 49 26 37 | | | |
| | CP12 | FR | 215 36 12 | 193 49 09 | | |
| | | | | | 193 49 21 | M1 |
| MO | CP12 | FL | 01 33 27 | | | |
| | M1 | FL | 195 22 50 | 193 49 23 | | |
| | M1 | FR | 15 22 53 | | | MO |
| | CP12 | FR | 181 33 23 | 193 49 30 | | |
| | | | | | | CP12 |

# TRAVERSE BOOKING SHEET

Date: 6/2/86 Observer: Mathew N. Nyoh

Instrument: Tz theodolite Booker:

Two Ranging poles with stands.

| Station | Sight | Face | Horizontal Circle Reading ° ' " | Horizental Angle ° ' " | Mean Angle ° ' " | Remarks |
|---|---|---|---|---|---|---|
| M1 | M0 | FL | 131 13 41 | 252 25 00 | | |
| | M2 | FL | 63 38 41 | | | |
| | M2 | FR | 243 38 41 | 252 24 56 | | |
| | M0 | FR | 351 13 45 | | | |
| | | | | | 252 24 48 |  |
| M2 | M0 | FL | 132 08 57 | | | |
| | M2 | FL | 24 32 35 | 252 24 38 | | |
| | M2 | FR | 204 32 35 | 252 24 39 | | |
| | M0 | FR | 312 08 57 | | | |
| M2 | M1 | FL | 65 30 21 | | | |
| | M3 | FL | 312 28 15 | 247 57 54 | | |
| | M3 | FR | 132 28 14 | 247 57 50 | | Repeated. |
| | M1 | FR | 245 30 24 | | | |
| | | | | | 247 57 52 |  |
| M2 | M1 | FL | 30 57 50 | 246 57 52 | | |
| | M3 | FL | 294 55 42 | | | |
| | M3 | FR | 97 55 44 | 246 57 50 | | |
| | M1 | FR | 210 57 54 | | | |

Stopped for break. (2 00 - 3 30)

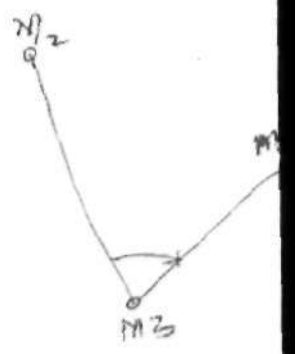
# TRAVERSE BOOKING SHEET

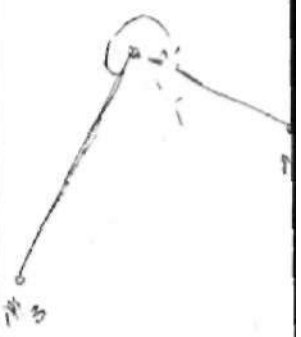
Date: 6/2/86 Observer: Matthew N. Smith

Instrument: TR theodolite Booker:

Two ranging poles with stands.

| Station | Sight | Face | Horizontal Circle Reading ° ' " | Horizental Angle ° ' " | Mean Angle ° ' " | Remarks |
|---|---|---|---|---|---|---|
| M3 | M2 | FL | 208 5 39 43 | | | |
| | M4 | FL | 262 53 16 | 53 53 22 | | |
| | M4 | FR | 82 53 38 | | | |
| | M2 | FR | 28 59 47 | 53 53 30 | | |
| | | | | | 53 53 24 | |
| M3 | M2 | FL | 175 2 3 15 | | | |
| | M4 | FL | 224 16 24 | 53 53 09 | | |
| | M4 | FR | 44 16 48 | | | |
| | M2 | FR | 350 23 14 | 53 53 26 | | |
| M4 | M3 | FL | 316 27 5 1 03 | 257 37 2 1 15 | | |
| | M5 | FL | 213 57 33 | | | |
| | M5 | FR | 33 57 42 | 257 37 2 22 | | |
| | M3 | FR | 136 27 5 20 | | | |
| | | | | | 257 37 2 19 24 | |
| M4 | M3 | FL | 299 43 10 | | | |
| | M5 | FL | 142 15 30 | 257 37 3 20 | | |
| | M5 | FR | 357 15 30 | | | |
| | M3 | FR | 99 43 13 | 257 37 2 17 | | |



# TRAVERSE BOOKING SHEET

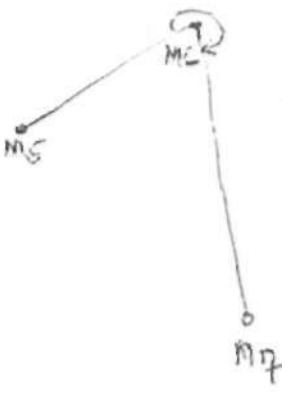
Date: 6/2/86 Observer: Matthew N. Grant

Instruments: T2 theodolite. Booker:

Two Ranging Poles with stands

| Station | Sight | Face | Horizontal Circle Reading | Horizental Angle | Mean Angle | Remarks |
|---|---|---|---|---|---|---|
| | | | ° ′ ″ | ° ′ ″ | ° ′ ″ | |
| M5 | M4 | FL | 125 59 27 | | | |
| | M6 | FL | 292 40 43 | 166 42 16 | | |
| | M6 | FR | 112 40 43 | | | |
| | M4 | FR | 305 59 25 | 166 42 08 | | |
| | | | | | 166 42 15 | |
| M5 | M4 | FL | 86 15 33 | | | |
| | M6 | FL | 252 57 46 | 166 42 13 | | |
| | M6 | FR | 72 57 49 | | | |
| | M4 | FR | 266 15 37 | 166 42 12 | | |
| M6 | M5 | FL | 187 59 47 | | | |
| | M7 | FL | 108 17 37 | 280 17 50 | | |
| | M7 | FR | 288 17 41 | | | |
| | M5 | FR | 07 59 47 | 280 17 54 | | |
| | | | | | 280 17 38 | |
| M6 | M5 | FL | 152 57 46 | | | |
| | M7 | FL | 73 12 11 | 280 17 24 | | |
| | M7 | FR | 253 12 16 | | | |
| | M5 | FR | 332 59 51 | 28 17 25 | | |




Stopped for the day (6.07pm)

# TRAVERSE BOOKING SHEET

Date: 7/2/86 (Starting time 8.00am) Observer: Mathew N. Emsh

Instrument: Tx theodolite Booker: Mathew N. Emsh

Two Ranging Poles with Stands

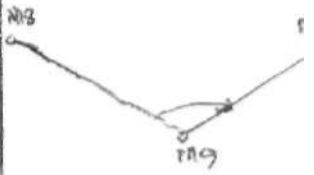
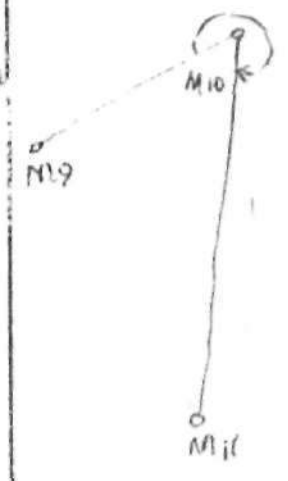
| Station | Sight | Face | Horizontal Circle Reading ° ' " | Horizental Angle ° ' " | Mean Angle ° ' " | Remarks |
|---|---|---|---|---|---|---|
| M7 | M6 | ~~FL~~ | 223 37 10 | | |  |
| | M8 | ~~FL~~ | 35 26 46 | 171 49 36 | | |
| | M8 | ~~FR~~ | 215 27 18 | | | |
| | M6 | ~~FR~~ | 43 37 40 | 171 49 33 | | |
| M7 | M6 | FL | 204 21 28 | | 171 49 40 | |
| | M8 | FL | 16 11 13 | 191 49 44 | | |
| | M8 | FR | 196 11 35 | | | |
| | M6 | FR | 24 21 48 | 191 49 47 | | |
| M8 | M7 | FL | 96 47 52 | | | |
| | M9 | FL | 324 34 09 | 227 48 17 | | |
| | M9 | FR | 144 24 20 | | | |
| | M7 | FR | 276 47 31 | 227 48 11 | | |
| | | | | | 227 47 46 | |
| M8 | M7 | FL | 65 53 39 | | | |
| | M9 | FL | 293 35 52 | 227 42 13 | | |
| | M9 | FR | 113 35 57 | | | |
| | M7 | FR | 245 57 06 | 227 41 57 | | |

# TRAVERSE BOOKING SHEET

Date: 7/2/86 Observer: Matthews N Crouch

Instrument: T2 Theodolite Booker:

Two Ranging Poles and 3 Stands.

| Station | Sight | Face | Horizontal Circle Reading ° ' " | Horizental Angle ° ' " | Mean Angle ° ' " | Remarks |
|---|---|---|---|---|---|---|
| M9 | M8 | FL | 22 07 31 | 92 05 04 | | |
| | M10 | FL | 114 12 35 | | | |
| | M10 | FR | 294 12 41 | | | |
| | M8 | FR | 202 07 41 | 92 05 00 | | |
| | | | | | 92 05 06 |  |
| M9 | M8 | FL | 330 58 31 | | | |
| | | | 330 47 26 | 92 05 17 | | |
| | M10 | FL | 272 90 27 6 43 | | | |
| | M10 | FR | 270 36 57 | 92 05 04 | | |
| | M8 | FR | 178 31 53 | | | |
| M10 | M9 | FL | 330 47 10 | 281 58 19 | | |
| | M11 | FL | 252 39 39 | | | |
| | M11 | FR | 72 39 19 | 281 58 14 | | |
| | M9 | FR | 150 41 25 | | | |
| | | | | | 281 58 07 |  |
| M10 | M9 | FL | 307 14 36 | | | |
| | M11 | FL | 229 14 34 | 281 57 58 | | |
| | M11 | FR | 49 12 50 | | | |
| | M9 | FR | 127 14 55 | 281 57 55 | | |

Report



TRAVERSE BOOKING SHEET

Date: 7/2/86 Observer: Matthew M. Cook

Instrument: T2 theodolite Booker:

Two Ranging poles with Stand.

| Station | Sight | Face | Horizontal Circle Reading ° ' " | Horizental Angle ° ' " | Mean Angle ° ' " | Remarks |
|---|---|---|---|---|---|---|
| $M_{11}$ | $M_{10}$ | FL | 224 03 49 | | | |
| | $M_{12}$ | FL | 24 14 91 | 160 05 42 | | |
| | $M_{12}$ | FR | 204 13 57 | 160 05 17 | | |
| | $M_{10}$ | FR | 44 08 40 | | | |
| | | | | | 160 05 16 17 | |
| $M_{11}$ | $M_{10}$ | FL | 196 20 48 | | | |
| | $M_{12}$ | FL | 356 36 04 | 160 05 16 | | |
| | $M_{12}$ | FR | 176 35 59 | 160 05 17 | | |
| | $M_{10}$ | FR | 16 30 42 | | | |
| $M_{12}$ | $M_{11}$ | FL | 69 00 34 | | | |
| | CP13 | FL | 191 35 16 | 122 34 52 | | |
| | CP13 | FR | 11 35 38 | 122 34 58 | | |
| | $M_{11}$ | FR | 249 00 40 | | | |
| | | | | | 122 34 57 | |
| $M_{12}$ | $M_{11}$ | FL | 41 30 25 | | | |
| | CP13 | FL | 164 05 31 | 122 34 56 | | |
| | CP13 | FR | 344 05 55 | 122 34 59 | | |
| | $M_{11}$ | FR | 221 30 56 | | | |

# TRAVERSE BOOKING SHEET

Date: 9/2/86 Observer: [illegible]

Instrument: TZ Theodolite Booker: [illegible]

Two Ranging Poles and 2 Bands

| Station | Sight | Face | Horizontal Circle Reading ° ' " | Horizental Angle ° ' " | Mean Angle ° ' " | Remarks |
|---|---|---|---|---|---|---|
| CP13 | M12 | FL | 261 20 13 | 331 48 27 | | |
| | CP12 | FL | 233 08 40 | | | |
| | CP12 | FR | 53 08 30 | 331 48 56 | | |
| | M12 | FR | 81 20 34 | | | |
| | | | | | 331 48 32 | |
| CP13 | M12 | FL | 282 36 57 | 331 48 37 | | |
| | CP12 | FL | 204 25 31 | | | |
| | CP12 | FR | 24 25 36 | 331 48 43 | | |
| | M12 | FR | 52 36 53 | | | |

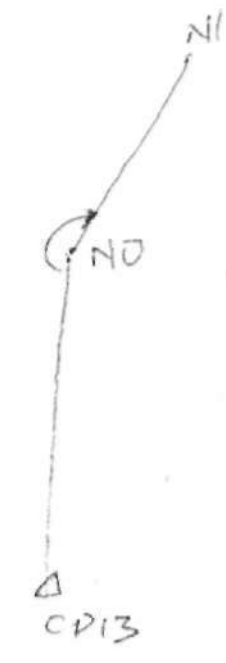



Stopped (2.19 p.m)

# TRAVERSE BOOKING SHEET

Date: 8/2/86 (Started - 7.55 a.m) Observer: Mathew N. Ono

Instrument: ..... Booker: .....

| Station | Sight | Face | Horizontal Circle Reading ° ' " | Horizental Angle ° ' " | Mean Angle ° ' " | Remarks |
|---|---|---|---|---|---|---|
| CP13 | CP12 | FL | 234 58 25 | 00 35 13 | |  |
| | ND | FL | 235 33 38 | | | |
| | ND | FR | 55 33 54 | 00 35 05 | | |
| | CP12 | FR | 54 58 34 | | | |
| | | | | | 00 35 06 | |
| CP | CP12 | FL | 210 35 28 | 00 35 04 | | |
| | ND | FL | 211 10 32 | | | |
| | ND | FR | 31 10 32 | | | |
| | CP12 | FR | 30 35 30 | 00 35 02 | | |
| ND | CP13 | FL | 131 03 38 | | |  |
| | N1 | FL | 328 02 50 | 197 09 12 | | |
| | N1 | FR | 148 12 59 | | | |
| | CP13 | FR | 311 03 42 | 197 09 17 | | |
| | | | | | 197 09 02 | |
| | CP13 | FL | 111 39 1: | | | |
| N0 | N1 | FL | 308 47 3: | 197 09 20 | | |
| | N1 | FR | 128 47 30 | | | |
| | CP13 | FR | 291 39 1: | 197 08 18 | | |

# TRAVERSE BOOKING SHEET

Date: 8/2/86 Observer: Matthew N Omoh

Instrument: Booker:

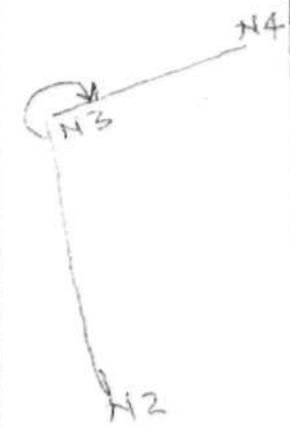
| Station | Sight | Face | Horizontal Circle Reading ° ′ ″ | Horizental Angle ° ′ ″ | Mean Angle ° ′ ″ | Remarks |
|---|---|---|---|---|---|---|
| N1 | N0 | FL | 44 28 25 | | |  |
| | N2 | FL | 271 00 03 | 226 31 38 | | |
| | N2 | FR | 91 00 03 | | | |
| | N0 | FR | 274 28 27 | 226 31 40 | | |
| | | | | | 226 31 40 | |
| N1 | N0 | FL | 09 36 20 | | | |
| | N2 | FL | 236 08 04 | 226 31 44 | | |
| | N2 | FR | 56 08 09 | | | |
| | N0 | FR | 189 36 33 | 226 37 36 | | |
| N2 | N1 | FL | 171 51 43 | | |  |
| | N3 | FL | 299 23 36 | 127 31 53 | | |
| | N3 | FR | 119 23 38 | | | |
| | N1 | FR | 351 51 48 | 127 31 50 | | |
| | | | | | 127 31 53 | |
| N2 | N1 | FL | 148 27 46 | | | |
| | N3 | FL | 275 59 42 | 127 31 56 | | |
| | N3 | FR | 95 59 43 | | | |
| | N1 | FR | 328 27 49 | 127 31 54 | | |

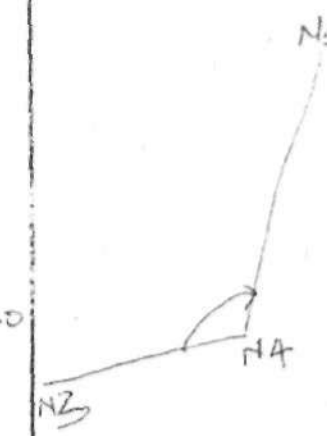
# TRAVERSE BOOKING SHEET

Date: 8/2/86 Observer: Matthew N Smith

Instrument: ..... Booker: .....

| Station | Sight | Face | Horizontal Circle Reading ° ' " | Horizental Angle ° ' " | Mean Angle ° ' " | Remarks |
|---|---|---|---|---|---|---|
| N3 | N2 | FL | 339 11 27 | | | |
| | N4 | FL | 259 45 05 | 280 33 38 | | |
| | N4 | FR | 79 45 06 | | | |
| | N2 | FR | 159 11 31 | 280 33 35 | | |
| | | | | | 280 33 43 | |
| N3 | N2 | FL | 323 02 19 | | | |
| | N4 | FL | 243 36 08 | 280 33 49 | | |
| | N4 | FR | 63 36 12 | | | |
| | N2 | FR | 143 02 23 | 280 33 49 | | |
| N4 | N3 | FL | 90 11 52 | | | |
| | N5 | FL | 194 12 40 | 104 00 43 | | |
| | N5 | FR | 14 12 38 | | | |
| | N3 | FR | 270 12 00 | 104 00 38 | | |
| | | | | | 104 00 30 | |
| | N3 | FL | 67 35 03 | | | |
| N4 | N5 | FL | 171 35 25 | 104 00 22 | | |
| | N5 | FR | 351 35 25 | | | |
| | N3 | FR | 247 35 07 | 104 00 18 | | |



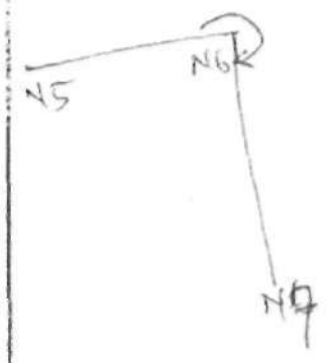
# TRAVERSE BOOKING SHEET

Date: 8/2/86 Observer: Matthew N. Omoh

Instrument: ..... Booker: .....

| Station | Sight | Face | Horizontal Circle Reading ° ' " | Horizental Angle ° ' " | Mean Angle ° ' " | Remarks |
|---|---|---|---|---|---|---|
| NS | N4 | FL | 214 18 20 | | | |
| | N6 | FL | 113 36 54 | 259 18 34 | | |
| | N6 | FR | 293 36 58 | | | |
| | N4 | FR | 34 18 31 | 259 18 27 | | |
| | | | | | 259 18 28 | |
| | N4 | FL | 188 19 47 | | | |
| NS | N6 | FL | 87 38 16 | 259 18 29 | | |
| | N6 | FR | 267 38 18 | | | |
| | N4 | FR | 08 19 57 | 259 18 21 | | |
| | NS | FL | 42 44 5/45 | | | |
| N6 | N7 | FL | 286 01 9/10 | 243 16 1/75 | | |
| | N7 | FR | 106 01 11 | | | |
| | NS | FR | 222 44 53 | 243 16 18 | | |
| | | | | | 243 16 18 | |
| | NS | FL | 17 57 32 | | | |
| N6 | N7 | FL | 261 13 51 | 243 16 19 | | |
| | N7 | FR | 81 04 01 | | | |
| | NS | FR | 197 57 41 | 243 16 20 | | |



TRAVERSE BOOKING SHEET

Date: 8/2/86 Observer: Matthew N. Onoh

Instrument: Booker:

| Station | Sight | Face | Horizontal Circle Reading ° ' " | Horizental Angle ° ' " | Mean Angle ° ' " | Remarks |
|---|---|---|---|---|---|---|
| N7 | N6 | FL | 110 42 02 | | |  |
| | | | | 154 57 26 | | |
| | N8 | FL | 265 39 28 | | | |
| | N8 | FR | 85 29 45 | | | |
| | N6 | FR | 290 42 16 | 157 57 29 | | |
| | | | | | 154 57 30 | |
| N7 | N6 | FL | 83 08 24 | | | |
| | N8 | FR | 238 06 02 | 154 57 38 | | |
| | N8 | FR | 58 06 02 | | | |
| | N6 | FR | 263 08 36 | 157 57 26 | | |
| | | ~~FR~~ | Typed (1.36 p.m) | | | |

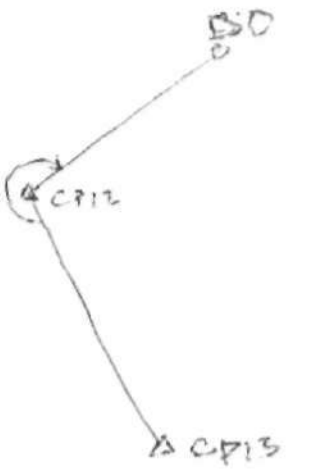
# TRAVERSE BOOKING SHEET

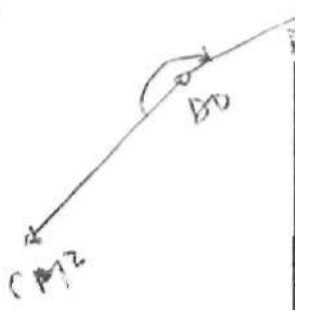
Date: 11/2/86 (Start: 8.47 a.m.) Observer: Matthew N. Finch.

Instrument: Tx Theodolite Booker:

Two ranging poles with flags.

| Station | Sight | Face | Horizontal Circle Reading | Horizental Angle | Mean Angle | Remarks |
|---|---|---|---|---|---|---|
| | | | ° ' " | ° ' " | ° ' " | |
| CP12 | CP13 | FL | 26 23 16 | 253 21 46 | | |
| | DO | FL | 279 45 02 | | | |
| | DO | FR | 99 45 08 | 253 21 40 | | |
| | CP13 | FR | 206 23 38 | | | |
| | | | | | 253 21 41 | |
| CP12 | CP13 | FR | 09 47 53 | | | |
| | DO | FL | 263 09 33 | 253 21 40 | | |
| | DO | FR | 83 09 36 | | | |
| | CP13 | FR | 189 47 58 | 253 21 38 | | |
| DO | CP12 | FL | 59 53 23 | | | |
| | D1 | FL | 283 13 09 | 223 19 46 | | |
| | D1 | FR | 103 13 05 | | | |
| | CP12 | FR | 239 53 22 | 223 19 43 | | |
| | | | | | 223 19 43 | |
| DO | CP12 | FL | 43 03 ~~359~~ 01 | | | |
| | D1 | FL | 266 23 15 | 223 19 ~~46~~ 18 | | |
| | D1 | FR | 86 23 15 | | | |
| | CP12 | FR | 223 03 31 | 223 19 39 | | |



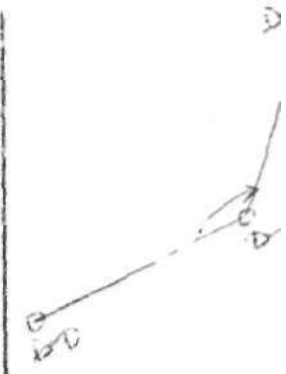
# TRAVERSE BOOKING SHEET

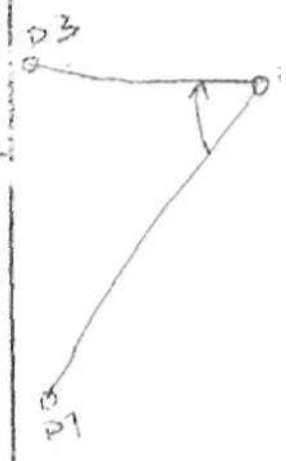
Date: 11/2/86 Observed: Mathew N C

Instrument: T2 theodolite Booker:

Two Ranging poles with Flags

| Station | Sight | Face | Horizontal Circle Reading ° ′ ″ | Horizental Angle ° ′ ″ | Mean Angle ° ′ ″ | Remarks |
|---|---|---|---|---|---|---|
| D1 | D0 | FL | 194 49 04 | | | |
| | D2 | FL | 291 11 34 | 116 22 26 | | |
| | D2 | FR | 111 11 30 | 116 22 18 | | |
| | D0 | FR | 354 49 12 | | | |
| | | | | | 116 22 33 | |
| D1 | D0 | FL | 148 33 49 | | | |
| | D2 | FL | 264 55 34 | 116 22 45 | | |
| | D2 | FR | 84 55 37 | | | |
| | D0 | FR | 328 33 54 | 116 22 41 | | |
| D2 | D1 | FL | 40 03 10 | | | |
| | D3 | FL | 120 39 58 | 80 36 48 | | |
| | D3 | FR | 300 40 00 | 80 36 52 | | |
| | D1 | FR | 220 03 08 | | | |
| | | | | | 80 36 52 | |
| D2 | D1 | FL | 17 07 17 | | | |
| | D3 | FL | 97 41 08 | 80 36 51 | | |
| | D3 | FR | 277 41 31 | | | |
| | D1 | FR | 197 07 25 | 80 36 52 | | |



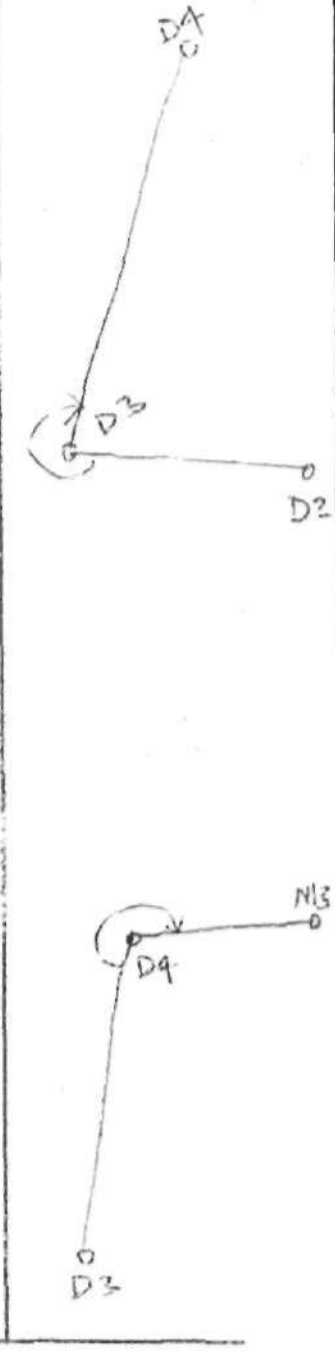
# TRAVERSE BOOKING SHEET

Date: ~~Date~~ 11/2/36 Observed: Mathews N. (Jnr).

Instrument: Th. Theodolite. Booker: .....

Two Ranging Rods with Numbers.

| Station | Sight | Face | Horizontal Circle Reading | Horizontal Angle | Mean Angle | Remarks |
|---|---|---|---|---|---|---|
| | | | ° ′ ″ | ° ′ ″ | ° ′ ″ | |
| D3 | D2 | FL | 257 07 52 | | | |
| | D4 | FL | 268 47 44 | 291 39 46 | | |
| | D4 | FR | 88 47 45 | 291 39 46 | | |
| | D2 | FR | 177 07 59 | | | |
| | | | | | 291 39 47 | |
| D2 | D2 | FL | 332 20 39 | | | |
| | D4 | FL | 244 00 21 | 291 39 42 | | |
| | D4 | FR | 64 00 23 | | | |
| | D2 | FR | 152 20 39 | 291 39 54 | | |
| D4 | D3 | FL | 220 22 31 | | | |
| | M3 | FL | 128 49 23 | 267 26 52 | | |
| | M3 | FR | 308 49 33 | | | |
| | D3 | FR | 40 22 49 | 267 26 44 | | |
| | | | | | 267 26 48 | |
| D4 | D3 | FL | 199 32 18 | | | |
| | M3 | FL | 106 59 07 | 267 26 49 | | |
| | M3 | FR | 286 59 21 | | | |
| | D3 | FR | 19 32 32 | 267 26 49 | | |



# TRAVERSE BOOKING SHEET

Date: 11/2/86 Observer: Matthew N[illegible]

Instrument: Te theodolite Booker:

Two Ranging pole - north

Stations

| Station | Sight | Face | Horizontal Circle Reading | Horizental Angle | Mean Angle | Remarks |
|---|---|---|---|---|---|---|
| | | | ° ' " | ° ' " | ° ' " | |
| M3 | DA | FL | 253 45 07 | | | |
| | M2 | FL | 54 28 59 | 60 43 52 | | |
| | M2 | FR | 234 29 16 | | | |
| | DA | FR | 173 45 13 | 60 44 03 | | M2 |
| | | | | | 60 43 58 | |
| M3 | DA | FL | 333 44 07 | | | |
| | M2 | FL | 29 28 05 | 60 43 58 | | |
| | M2 | FR | 209 28 20 | | | |
| | DA | FR | 153 44 33 | 60 43 57 | | M3 |

Stopped (12.11 p.m)

TRAVERSE BOOKING SHEET

Date 13/2/86 (Starting 8.15am) Observer: Matthew K. Omoh

Instruments Self-Reducing tacheometer Booker

Vertical Staff, One linen tape, One tripod.

Instrument ht = 1.56m

| STATION | Sight | Face | Horizontal Angle | Horizontal Distance | Vertical Angle | Height Diff | Remarks |
|---|---|---|---|---|---|---|---|
| CP12 | CP13 | FL | | 1.695 x100 | | | |
| | | FR | | 0.849 x200 | | | |
| | M0 | FL | | | | | |
| | | FR | | 1.136x100 | 89 03.0 | 0.090x10 | +10 |
| | | | | 0.578x200 | 271 04.0 | 0.090x10 | |
| M0 | CP12 | FL | | 1.139 x100 | | 0.090 x10 | −10 |
| | | FR | | 0.590 x200 | | 0.090x10 | |
| | M1 | FL | | 0.602x100 | 88 58.1 | 0.061x10 | +10 |
| | | FR | | 0.301x200 | 271 09.0 | 0.061x10 | |
| M1 | M0 | FL | | 0.602 x100 | | 0.062x10 | −10 |
| | | FR | | 0.297 x200 | | 0.061x10 | |
| | M2 | FL | | 0.550x100 | 89 54.2 12.0 | 0.033x10 | −10 |
| | | FR | | 0.275 x200 | 270 58.0 03.0 | 0.033x10 | |
| M2 | M1 | FL | | 0.550x100 | | 0.033x10 | +10 |
| | | FR | | 0.275x200 | | 0.033x10 | |
| | M2 | FL | | 0.656x100 | 90.02.2 | 0.060x10 | −10 |
| | | FR | | 0.342x200 | 270 04.2 | 0.060x10 | |

# TRAVERSE BOOKING SHEET

Date 13/2/86 Observer: Matthew A Omoh

Instruments Self reducing Tacheometry Booker

Vertical Staff, One line at 1.5m & One at 1.6m

Instrument ht = 1.57m

| STATION | Sight | Face | Horizontal Angle | Horizontal Distance (M) | Vertical Angle | Height Diff (m) | Remarks |
|---|---|---|---|---|---|---|---|
| M1 | M2 | FL | | 0.687 x100 | 89 28.0 | 0.059x10 | +10 |
| | | FR | | 0.342x200 | 271 03.2 | 0.059x10 | |
| | M4 | FL | | 0.625x100 | 89 14.0 | 0.03 24 | +10 |
| | M4 | FR | | 0.312x200 | 270 62.7 | 0.03 32 | |
| M4 | M3 | FL | | 0.626x100 | 89 52.0 | 0.034x10 | −10 |
| | | FR | | 0.312x200 | 270 14.5 | 0.034x10 | |
| | M5 | FL | | 0.562x100 | 89 39.7 | 0.012x10 | −10 |
| | | FR | | 0.281x200 | 270 24.0 | 0.012x10 | |
| M5 | M4 | FL | | 0.562x100 | 89 26.4 | 0.012x10 | +10 |
| | | FR | | 0.281x200 | 270 40.0 | 0.013x10 | |
| | M6 | FL | | 0.460x100 | 89 58.2 | 0.035x10 | −10 |
| | | FR | | 0.229x200 | 270 10.4 | 0.034x10 | |

Shifted for Break at 12.30pm.

Resumed after break at 3.00 p.m.

TRAVERSE BOOKING SHEET

Date 13/2/86 Observer: Matthew N. Owoh

Instruments Self reducing tacheometer Booker

Vertical staff, One tripod, One. instrument hts = 1.5
measuring tape.

| STATION | Sight | Face | Horizontal Angle | Horizontal Distance | Vertical Angle | Height Diff | Remarks |
|---|---|---|---|---|---|---|---|
| M6 | M5 | FL | | 0·459×100 | 89 09·0 | 0·034×10 | |
| | | FR | | 0·230×200 | 270 54·5 | 0·034×10 | +10 |
| | M7 | FL | | 0·739×100 | 89 56·0 | 0·050×10 | |
| | | FR | | 0·369×200 | 270 10·8 | 0·051×10 | −10 |
| M7 | M6 | FL | | 0·738×100 | 89 10·8 | 0·050×10 | |
| | | FR | | 0·369×200 | 270 50·5 | 0·050×10 | −10 |
| | M8 | FL | | 0·752×100 | 90 11·0 | | |
| | | FR | | 0·375×200 | 269 35·5 | 0·052×10 | |
| M8 | M7 | FL | | 0·752×100 | 88 55·5 | 0·054×10 | |
| | | FR | | 0·375×200 | 271 11·1 | 0·054×10 | +10 |
| M9 | FL | | | 0·920×100 | 89 54·0 | 0·059×10 | |
| | FR | | | 0·466×200 | 270 12·5 | 0·060×10 | −10 |

# TRAVERSE BOOKING SHEET

Date: 13/2/86 Observer: Matthew N. Omoh

Instruments: Self-reducing tacheometer, Booker
Vertical staff, One linen tape, One

Instrument = I.com

| STATION | Sight | Face | Horizontal Angle | Horizontal Distance | Vertical Angle | Height Diff | Remarks |
|---|---|---|---|---|---|---|---|
| M9 | M8 | FL | | 0·915×100 | 89 12·0 | 0·058×10 | |
| | | FR | | 0·460×200 | 270 14·5 | 0·059×10 | +10 |
| | M10 | FL | | 0·389×100 | 90 13·9 | 0·035×10 | |
| | | FR | | 0·194×200 | 270 12·9 | 0·034×10 | −10 |
| M10 | M9 | FL | | 0·389×100 | 89 02·0 | 0·035×10 | |
| | | FR | | 0·194×200 | 271 04·9 | 0·035×10 | +10 |
| | M11 | | | 0·510×100 | 89 15·0 | 0·029×10 | |
| | | | | 0·255×200 | 270 48·5 | 0·029×10 | +10 |
| M11 | M10 | FL | | 0·510×100 | 89 48·0 | 0·025×10 | |
| | | FR | | 0·254×200 | 270 18·0 | 0·025×10 | −10 |
| | M12 | FL | | 0·133×100 | 89 41·0 | 0·003×10 | |
| | | FR | | 0·066×200 | 270 25·5 | 0·003×10 | −10 |

# TRAVERSE BOOKING SHEET

Date 13/2/86 Observer: Matthew N. Omoh

Instruments Self-reducing tacheometer, Booker.
Vertical staff, One linen tape, One

Instrument = 1.56 m

| STATION | Sight | Face | Horizontal Angle | Horizontal Distance | Vertical Angle | Height Diff | Remarks |
|---|---|---|---|---|---|---|---|
| M9 | M8 | FL | | 0·915 x100 | 89 12·0 | 0·058x10 | |
| | | FR | | 0·460 x200 | 270 14·5 | 0·059x10 | +10 |
| | M10 | FL | | 0·389 x100 | 90 13·9 | 0·025x10 | |
| | | FR | | 0·194 x 200 | 270 12·9 | 0·024x10 | -10 |
| M10 | M9 | FL | | 0·389 x100 | 89 02·0 | 0·025x10 | |
| | | FR | | 0·194 x200 | 271 04·4 | 0·025x10 | +10 |
| | M11 | | | 0·510 x100 | 89 18·0 | 0·024x10 | |
| | | | | 0·255 x200 | 270 48·5 | 0·025x10 | +10 |
| M11 | M10 | FL | | 0·510 x100 | 89 48·0 | 0·025x10 | |
| | | FR | | 0·254 x200 | 270 18·0 | 0·025x10 | -10 |
| | M12 | FL | | 0·133 x100 | 89 41·0 | 0·003x10 | |
| | | FR | | 0·066 x200 | 270 25·5 | 0·004x10 | -10 |

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# TRAVERSE BOOKING SHEET

Date 13/2/86 Observer: Matthew A. Quach

Instruments Self-reducing tacheometer, Booker .....

Vertical Staff. One 30m Tape, One

Instrument height = 1.56m

| STATION | Sight | Face | Horizontal Angle | Horizontal Distance | Vertical Angle | Height Diff | Remarks |
|---|---|---|---|---|---|---|---|
| M12 | M11 | FL | | 0.133 x100 | 89 26.2 | 0.003x10 | |
| | | FR | | 0.066 x200 | 270 40.3 | 0.003x10 | +10 |
| | CP13 | FL | | 0.177 x100 | 90 06.5 | 0.019x10 | |
| | | FR | | 0.062 x200 | 270 02.0 | 0.019x10 | -10 |
| CP13 | M12 | FL | | 0.179 x100 | 88 58.0 | 0.013x10 | |
| | | FR | | 0.059 x200 | 271 10.0 | 0.019x10 | +10 |
| | CP12 | FL | | 1.692 x100 | 89 01.0 | 0.155x10 | |
| | | FR | | 0.845 x200 | 271 06.0 | 0.159x10 | +10 |

Stopped (5 0.357 m).

# TRAVERSE BOOKING SHEET

Date 14/2/86 (Starting at 8.33 a.m.) Observer: Mather & Smith.

Instruments Self-reducing tacheometer, Booker

Vertical staff, Dumpy level, One ipod.

Instrument ht = 1.55 m.

| STATION | Sight | Face | Horizontal Angle | Horizontal Distance | Vertical Angle | Height Diff | Remarks |
|---|---|---|---|---|---|---|---|
| CP12 | CP13 | FL | | 1693 x 100 | 90° 05' 17" | 0.159 x 10 | −1 |
| | | FR | | 0.846 x 200 | 270 01 4 | 0.158 x 10 | |
| | D0 | FL | | 0.629 x 100 | 89 26 9 | 0.009 x 10 | +10 |
| | | FR | | 0.314 x 200 | 270 40.2 | 0.010 x 10 | |
| D0 | CP12 | FL | | 0.629 | 89 39.5 | 0.010 x 10 | −10 |
| | | FR. | | 0.314 | 270 27 4 | 0.009 x 10 | |
| | D1 | FL | | 0.331 | 89 21.0 | 0.010 x 10 | +10 |
| | | FR | | 0.168 | 270 46 0 | 0.011 x 10 | |
| D1 | D0 | FL | | 0.332 x 100 | 89 45.1 | 0.015 x 10 | −10 |
| | | FR | | 0.167 x 200 | 270 21.6 | 0.014 x 10 | |
| | D2 | FL | | 0.195 x 100 | 88 52.7 | 0.020 x 10 | +10 |
| | | FR | | 0.098 x 200 | 271 10.3 | 0.021 x 10 | |

# TRAVERSE BOOKING SHEET

Date 14/2/86 Observer: Matthew N. Onoh

Instruments Self-reducing tacheometer Booker

Vertical Staff, One linen Tape, One iron rod.

Instrument ht. = 1.55 m.

| STATION | Sight | Face | Horizontal Angle | Horizontal Distance | Vertical Angle | Height Diff | Remarks |
|---|---|---|---|---|---|---|---|
| D2 | D1 | FL | | 0.195×100 | 90 09.0 | 0.021×10 | |
| | | FR | | 0.098×200 | 269 58.3 | 0.021×10 | −10 |
| | D3 | FL | | 0.440×100 | 89 09.0 | 0.031×10 | |
| | | FR | | 0.220×200 | 270 55.0 | 0.032×10 | +10 |
| D3 | D2 | FL | | 0.441×100 | 89 57.0 | 0.030×10 | |
| | | FR | | 0.221×200 | 270 09.8 | 0.02×10 | −10 |
| | D4 | FL | | 0.355×100 | 89 23.4 | 0.018×10 | |
| | | FR | | 0.178×200 | 270 43.3 | 0.010×10 | +10 |
| D4 | D3 | FL | | 0.354×100 | 89 42.5 | 0.010×10 | |
| | | FR | | 0.178×200 | 270 24.2 | 0.010×10 | −10 |
| | M3 | FL | | 0.700×100 | 89 40.9 | 0.018×10 | |
| | | FR | | 0.349×200 | 270 26.0 | 0.018×10 | −10 |

# TRAVERSE BOOKING SHEET

Date 14/2/86 Observer: Matthew N Onoh

Instruments Self-reducing tacheometer Booker

Vertical staff, ~~Other~~ linen tape, One prism pole. Instrument hts = 1.57m

| STATION | Sight | Face | Horizontal Angle | Horizontal Distance | Vertical Angle | Height Diff | Remarks |
|---|---|---|---|---|---|---|---|
| M3 | D4 | FL | | 0.700×100 | 89 25·1 | 0·018×10 | +10 |
| | | FR | | 0·350×200 | 270 41·6 | 0·049×10 | |
| | M2 | FL | | 0·687×100 | 89 28·0 | 0·059×10 | −10 |
| | | FR | | 0·343×200 | 271 03·1 | 0·065×10 | |

Stopped (2.18pm)

# TRAVERSE BOOKING SHEET

Date 15/2/86 (Started: 8.45 am) Observer: Matthew N. Crouch

Instruments Self-reducing tacheometer, Booker

Vertical Staff, One linen tape, One

Weather Instrument ht = 1.55m

| STATION | Sight | Face | Horizontal Angle | Horizontal Distance | Vertical Angle | Height Diff | Remarks |
|---|---|---|---|---|---|---|---|
| CP13 | CP12 | FL | | | | | |
| | | FR | | | | | |
| | N0 | FL | | 0·382×100 | 89 30·5 | 0·000 | |
| | | FR | | 0·191×200 | 270 36·9 | 0·000 | |
| N0 | CP13 | FL | | 0·449×100 | 89 24·0 | 0·012(N0) | +10 |
| | | FR | | 0·224×200 | 270 43·2 | 0·012(N0) | |
| | CP13 | FL | | 0·383×100 | 89 36·1 | 0·000 | |
| | | FR | | 0·191×200 | 270 31·0 | 0·000 | |
| N1 | N0 | FL | | 0·449×100 | 89 42·9 | 0·013(N0) | −10 |
| | | FR | | 0·224×200 | 270 24·5 | 0·012(N0) | |
| | N2 | FL | | 0·182×100 | 87 57·0 | 0·051(N0) | +10 |
| | | FR | | 0·091×200 | 272 10·0 | 0·051(N0) | |

# TRAVERSE BOOKING SHEET

Date 15/2/86 Observer: Matthew N Omoh

Instruments Self-reducing tacheometer, Booker: .....

Vertical staff, One invar tape, One prod. Instrument ht 1.55m

| STATION | Sight | Face | Horizontal Angle | Horizontal Distance (m) | Vertical Angle | Height Diff (m) | Remarks |
|---|---|---|---|---|---|---|---|
| N2 | N1 | FL | | 0·182×100 | 91 09·1 | 0·052×10 | −10 |
| | | FR | | 0·090×200 | 268 57·8 | 0·051×10 | |
| | N3 | FL | | 0·620×100 | 88 57·0 | 0·065×10 | +10 |
| | | FR | | 0·309×200 | 271 10·0 | 0·065×10 | |
| N3 | N2 | FL | | 0·620×100 | 90 09·4 | 0·066×10 | −10 |
| | | FR | | 0·309×200 | 269 57·2 | 0·065×10 | |
| | N4 | FL | | 0·338×100 | 90 10·5 | 0·04 ×10 | −10 |
| | | FR | | 0·168×200 | 269 56·1 | 0·044×10 | |
| N4 | N3 | FL | | 0·338×100 | 88 56·3 | 0·047×10 | +10 |
| | | FR | | 0·169×200 | 271 10·2 | 0·047×10 | |
| | N5 | FL | | 0·319×100 | 87 52·0 | 0·091×10 | +10 |
| | | FR | | 0·159×200 | 272 11·0 | 0·096×10 | |

TRAVERSE BOOKING SHEET

Date 15/2/86 Observer: Matthew N Smith

Instruments Dalgety reading Instruments Booker

Vertical Staff, One Invar tape, One pole

Instrument h.h. = 1.55m.

| STATION | Sight | Face | Horizontal Angle | Horizontal Distance (m) | Vertical Angle | Height Diff (m) | Remarks |
|---|---|---|---|---|---|---|---|
| N5 | N4 | FL | | 0·318×100 | 91 11 1 | 0·050×10 | |
| | | FR | | 0·159×200 | 268 55 5 | 0·090×10 | -10 |
| | N6 | FL | | 0·419×100 | 89 28 1 | 0·001×10 | |
| | | FR | | 0·234×200 | 270 32 5 | 0·071×10 | +10 |

Stopped (10·56 a.m)

USM LINEAR MEASUREMENTS

TRAVERSE BOOKING SHEET

Date 22/2/86 Started 8:39 a.m. Observer: Matthew A Smith

Instruments Self-reducing tacheometer Booker:

Vertical staff, One linen tape, One [illegible] Instrument Ht. = 1.55 m

| STATION | Sight | Face | Horizontal Angle | Horizontal Distance (m) | Vertical Angle | Height Diff (m) | Remarks |
|---|---|---|---|---|---|---|---|
| N6 | N5 | FL | | 0.469×100 | 89 38·5 | 0.042×10 | −10 |
| | | FR | | 0.334×200 | 270 28·5 | 0.030×10 | |
| | N7 | FL | | 0.442×100 343 16. | 90 23·3 | 0.045×10 | −10 |
| | N7 | FR | | 0.220×200 | 269 43·0 | 0.024×10 | |
| N7 | N6 | FL | | 0.442×100 | 88 43·2 | 0.04+ | +10 |
| | | FR | | 0.221×200 | 271 24·0 | 0.065 | |
| | M8 | FL | | 0.649×100 | 89 54·2 | 0.042×10 | −10 |
| | | FR | | 0.324×200 | 270 13·0 | 0.040×0 | |
| M8 | N7 | FL | | 0.649×100 | 89 12·0 | 0.040×10 | +10 |
| | | FR | | 0.324×200 | 270 54·0 | 0.039×10 | |

Started (10.23 a.m.)

Traverse Booking Sheet (Distance measurement) (EDM)

Time started) = 9.30 a.m.

D Date: 8/3/86 Observer: Matthew N. Onoh.

Instruments: Eldi 1, DNO reflectorless Booker:

Prisms, two tripods, two levelling staves, thermometer

| Stations from | Stations To | Distances (M) | Mean Dist. (M) | Temp. °C | Slope Angle | Tension | Remarks |
|---|---|---|---|---|---|---|---|
| CP12 | CP13 | 169.458 | 169.458 | 32°C | | | height of instrument 1.42m |
| CP12 | CP12 | 169.458 | | | | | temp. 32°C |
| CP12 | MD | 113.819 | 113.818 | 33°C | | | |
| CP12 | MD | 113.818 | | | | | |
| MI | MD | 60.386 | 60.386 | 34°C | | | ht = 1.44m. |
| MI | MD | 60.386 | | | | | |
| MI | M2 | 55.137 | 55.138 | 37. | | | ht = 1.61m |
| MI | M2 | 55.139 | | | | | |
| M3 | M2 | 68.693 | 68.672 | 34 | | | ht. 1.61m |
| M3 | M2 | 68.671 | | | | | |
| M3 | M4 | 62.613 | 62.613 | 34.9 | | | ht = 1.61m. |
| M3 | M4 | 62.613 | | | | | |
| M5 | M4 | 56.180 | 56.180 | 34.9 | | | ht = 1.61m |
| M5 | M4 | 56.181 | | | | | |
| M6 | M6 | 45.987 | 45.988 | 35.6 | | | |
| M | M6 | 45.990 | | | | | |

Traverse Booking Sheet (Distance measurement) (EDM)

Time (stopped) 2.04pm

D Date: 8/3/86 Observer: [illegible]

Instruments: ELdi 1, One reflector Booker: [illegible]

Prism, Theo tripod's, two linen tapes
thermometer

| Stations From | TO | Distances | Mean Dist. | Temp. °C | Slope Angle | Tension | Remarks |
|---|---|---|---|---|---|---|---|
| M07 | M6 | 73.847 | 73.844 | 34.0 | | | Iht. = 1.[illegible]m. |
| M7 | M6 | 73.845 | | | | | |
| M7 | M8 | 75.314 | 75.315 | 32.0 | | | Iht = 1.60 m. |
| M7 | M8 | 75.316 | | | | | |
| M9 | M8 | 91.821 | 91.822 | 31.0 | | | Iht = 1.60m. |
| M9 | M8 | 91.822 | | | | | |
| M9 | M10 | 38.970 | 38.969 | 33.0 | | | Iht = 1.60 m |
| M9 | M10 | 38.968 | | | | | |
| M11 | M10 | 51.061 | 51.050 | 34.0 | | | Iht. 1.60 m |
| M11 | M10 | 51.049 | | | | | |
| M11 | M12 | 13.289 | 13.284 | 35.5 | | | Iht = 1.60 m. |
| M11 | M12 | 13.280 | | | | | |
| GP13 | M12 | 17.757 | 17.754 | 35.0 | | | Iht = 1.60m |
| GP13 | M12 | 17.755 | | | | | |
| GP13 | M6 | 38.273 | 38.272 | 35.0 | | | Iht. 1.60 m. |
| GP13 | M6 | 38.271 | | | | | |

Traverse Booking Sheet (Distance measurement)(EDM)

D Date: 8/3/86 Observer: Matthew N O'Neill

Instruments: Eldi 1, One reflector prisms, two linen tapes, two tripods, thermometer Booker:

| Stations From | Stations To | Distances (m) | Mean Dist. (m) | Temp. °C | Slope Angle | Tension | Remarks |
|---|---|---|---|---|---|---|---|
| N1 | N0 | 44.975 | | | | | |
| N1 | N0 | 44.974 | 44.974 | 34.8 | | | I.ht = 1.60m |
| N1 | N2 | 18.245 | | 34.2 | | | |
| N1 | N2 | 18.246 | 18.246 | | | | I.ht = 1.60m. |
| N3 | N2 | 62.006 | | 34.5 | | | |
| N3 | N2 | 62.005 | 62.006 | | | | I.ht = 1.59 m |
| N3 | N4 | 33.778 | | 34 | | | I ht = 1.59m |
| N3 | N4 | 33.777 | 33.778 | | | | |
| N5 | N4 | 31.831 | | 34 | | | |
| N5 | N4 | 31.831 | 31.831 | | | | I ht = 1.60m |
| N5 | N6 | 47.041 | | | | | |
| N5 | N6 | 47.041 | 47.041 | 33 | | | I ht = 1.60m |
| N7 | N6 | 44.289 | 44.288 | 33 | | | I ht = 1.60m |
| N7 | N6 | 44.288 | 44.288 | | | | |
| N7 | N8 | 64.932 | | 33.5 | | | |
| N7 | N8 | 64.932 | 64.932 | | | | I.ht = 1.60m |

Skipped (2.042m)

Traverse Booking Sheet (Distance measurvement) (EDM)

D Date: 12/3/86 (Start 8.32 a.m) Observer: Matthew N. Omoh

Instruments: Eldi 1, Dumpy level Booker:

Prisms, two tripods, 30m tape, Thermometer

| Stations From | Stations To | Distances (m) | Mean Dist. (m) | Temp. °C | Slope Angle | Tension | Remarks |
|---|---|---|---|---|---|---|---|
| CP12 | D0 | 62.933 | | | | | I.ht = 1.50 |
| CP12 | D0 | 62.934 | 62.934 | 32° | | | |
| D1 | D0 | 33.599 | | 31.9° | | | I.ht = 1.51 m |
| D1 | D0 | 33.599 | 33.599 | | | | |
| D1 | D2 | 19.625 | | | | | I.ht = 1.51 m |
| D1 | D2 | 19.624 | 19.624 | 31.9° | | | |
| D3 | D2 | 44.097 | | | | | |
| D3 | D2 | 44.098 | 44.098 | 33.0 | | | I.ht = 1.58 m |
| D3 | D4 | 35.514 | | | | | |
| D3 | D4 | 35.514 | 35.514 | 33.5 | | | I.ht = 1.58 m |
| D3 | D4 | ~~70.116~~ | | ~~33.0~~ | | | I.ht = 1.58 m. |
| D3 | D4 | 70.115 | 70.116 | 23.0 | | | |

Traverse Booking Sheet (Distance measurvement)(ドレベル)

Date: 13/3/81

Observer: [illegible]

Instruments: Eldi 1, One reflector prism, two tripods, two level tapes. Booker: [illegible]
Thermometer

| Stations FROM | Stations TO | Distances (m) | Mean Dist. (m) | Temp. °C | Slope Angle | Tension | Remarks |
|---|---|---|---|---|---|---|---|
| D4 | M3 | 70.11 4/4 | | | | | |
| D4 | M3 | 70.116 | 70.115 | 34.0 | | | I.ht = 1.55m |
| D4 | D3 | 35.51 3/4 | | | | | |
| D4 | D3 | 35.513 | 35.513 | 35.0 | | | I.ht = .8m |
| D2 | D3 | 44.111 | | | | | |
| D2 | D3 | 44.111 | 44.111 | 35.0 | | | I.ht = 1.60m |
| D2 | D1 | 19.623 | | | | | |
| D2 | D1 | 19.623 | 19.623 | 35.5 | | | I.ht = 1.60m |
| D0 | D1 | 33.598 | | | | | |
| D0 | D1 | 33.598 | 33.598 | 35.6 | | | I.ht = 1.60m |
| D0 | CP12 | 62.929 | | | | | |
| D0 | CP12 | 62.928 | 62.928 | 35.9 | | | I.ht = 1.60m |

Height of D0 = 10.55 m

Traverse Booking Sheet (Distance measurement) (EDM)

D Date: 15/3/86 (started · 8.05) Observe: Mathew N. Onoh

Instruments: Eldi 1 (the reflector prism, two tripods, two linen tapes, barometer) Booker:

| Stations From | Stations TO | Distances (m) | Mean Dist. | Temp. °C | Slope Angle | Tension | Remarks |
|---|---|---|---|---|---|---|---|
| ~~PM12~~ | | | | | | | height of instrument = 1.60m |
| PM12 | CP13 | 17.755 | 17.755 | 31°C | | | |
| M12 | CP13 | 17.755 | | | | | |
| M12 | M11 | 13.288 | 13.289 | 31°C | | | |
| M12 | M11 | 13.290 | | | | | |
| M10 | M11 | 51.052 | 51.051 | 32°C | | | |
| M10 | M11 | 51.050 | | | | | |
| M10 | M9 | 38.970 | 38.969 | 32.5°C | | | |
| M10 | M9 | 38.968 | | | | | |
| M8 | M9 | 91.822 | 91.822 | 33°C | | | |
| M8 | M9 | 91.822 | | | | | |
| M8 | M7 | 75.315 | 75.316 | 34°C | | | |
| M8 | M7 | 75.316 | | | | | |
| M6 | M7 | 73.845 | 73.846 | 33°C | | | |
| M6 | M7 | 73.847 | | | | | |

Traverse Booking Sheet (Distance measurement) (EDM)

Date: 15/3/86 Observe: Matthew N. O'Neill

Instruments: Eldi 1, One reflector, Booker:
prisms, two tripods, two linen tapes
thermometer

| Stations From | TO | Distances (m) | Mean Dist. (m) | Temp. °C | Slope Angle | Tension | Remarks |
|---|---|---|---|---|---|---|---|
| N0 | CPB | 38.272 | | | | | height of |
| N0 | CPB | 38.272 | 38.272 | 34°5C | | | Instruments |
| N0 | N1 | 44.973 | | | | | |
| N0 | N1 | 44.974 | 44.974 | 34°6C | | | = 1.60m |
| N2 | N1 | 18.245 | | | | | |
| N2 | N1 | 18.245 | 18.245 | 34°8C | | | |
| N2 | N3 | 62.007 | | | | | |
| N2 | N3 | 62.005 | 62.006 | 34.5C | | | |
| N4 | N3 | 33.777 | | | | | |
| N4 | N3 | 33.779 | 33.778 | 34°3C | | | |
| N4 | N5 | 31.830 | | | | | |
| N4 | N5 | 31.829 | 31.830 | 34°6C | | | |
| N6 | N5 | 47.042 | | | | | |
| N6 | N5 | 47.043 | 47.042 | 34°2C | | | |
| N6 | N7 | 44.288 | | | | | |
| N6 | N7 | 44.290 | 44.289 | 34°0C | | | |
| N8 | N7 | 64.932 | | | | | |
| N8 | N7 | 64.932 | 64.332 | 33.9°C | | | |

Stopped (12.56 p.m)

Traverse Booking Sheet (Distance measurement) (EDM)

Date: 5/3/86 Observe: Matthew N. Smith

Instruments: Eldi1, two reflector prisms, two tripods, two linen tapes, thermometer. Booker:

| Stations from | Stations to | Distances (m) | Mean Dist. (m) | Temp. °C | Slope Angle | Tension | Remarks |
|---|---|---|---|---|---|---|---|
| M6 | M5 | 45.988 | | | | | height of instrument 1.50m. |
| M6 | M5 | 45.989 | 45.988 | 33°C | | | |
| M4 | M5 | 56.179 | | | | | |
| M4 | M5 | 56.178 | 56.179 | 34°C | | | |
| M4 | M3 | 62.610 | | | | | |
| M4 | M3 | 62.612 | 62.611 | 34°C | | | |
| M2 | M3 | 68.675 | | | | | |
| M2 | M3 | 68.674 | 68.674 | 34°C | | | |
| M2 | M1 | 55.138 | | | | | |
| M2 | M1 | 55.138 | 55.138 | 34°C | | | |
| M0 | M1 | 60.387 | | | | | |
| M0 | M1 | 60.387 | 60.387 | 33°C | | | |
| M0 | CP12 | 113.816 | | | | | |
| M0 | CP12 | 113.820 | 113.818 | 33°C | | | |
| CP13 | CP12 | 169.458 | | | | | |
| CP13 | CP12 | 169.458 | 169.458 | 34°C. | | | |

Traverse Booking Sheet (Distance measurvement) (Steel tape ranging)

D Date: 28/4/93 (Starting 8:10am) Observer: [illegible]

Instruments: Steel tape, Ranging rods, thermometer, Spring balance and roller grip. Booker: [illegible]

| Stations from | TO | Distances (M) | Mean Dist.(m) | Temp. °C | Slope Angle | Tension | Remarks |
|---|---|---|---|---|---|---|---|
| CP12 | MO | 113.800 | | | | | Standard Temperature of the Steel tape = 27°C |
| CP12 | MO | 113.802 | | 26°C | | | |
| MO | CP12 | 113.801 | 113.801 | | | | |
| MO | CP12 | 113.801 | | | | | |
| MO | M1 | 60.365 | | | | | Standard Tension of the Steel tape = 7kN. |
| MO | M1 | 60.364 | | | | | |
| M1 | MO | 60.369 | 60.366 | 28°C | | | |
| M1 | MO | 60.368 | | | | | |
| M1 | M2 | 55.129 | | | | | |
| M1 | M2 | 55.130 | | | | | |
| M2 | M1 | 55.132 | 55.130 | 27°C | | | |
| M2 | M1 | 55.132 | | | | | |
| M2 | M3 | 68.671 | | | | | |
| M2 | M3 | 68.670 | | 28°C | | | |
| M3 | M2 | 68.669 | 68.670 | | | | |
| M3 | M2 | 68.668 | | | | | |

Traverse Booking Sheet (Distance measurement) (Sec. : ~~Expt~~ Point)

D Date: 28/4/87

Observer: [illegible]

Instruments: Steel tape, Ranging Poles, thermometer, spring balance and roller grip. Booker: [illegible]

| Stations from | Stations To | Distances | Mean Dist. | Temp. | Slope Angle | Tension | Remarks |
|---|---|---|---|---|---|---|---|
| M3 | M4 | 62.611 | | | | | |
| M3 | M4 | 62.613 | | | | | Standard temperature = 20°C |
| M4 | M3 | 62.615 | 62.612 | 32°C | | | |
| M4 | M3 | 62.612 | | | | | |
| M4 | M5 | 56.179 | | | | | |
| M4 | M5 | 56.181 | | | | | |
| M5 | M4 | 56.185 | 56.182 | 37°C | | | Standard tension = Dt |
| M5 | M4 | 56.183 | | | | | |
| M5 | M6 | 45.986 | | | | | |
| M5 | M6 | 45.990 | | | | | |
| M6 | M5 | 45.995 | 45.992 | 35°C | | | |
| M6 | M5 | 45.996 | | | | | |
| M6 | M7 | 73.795 | | | | | |
| M6 | M7 | 73.830 | | | | | |
| M7 | M6 | 73.830 | 73.814 | 33°C | | | |
| M7 | M6 | 73.830 | | | | | |

Traverse Booking Sheet (Distance measurement) (Steel taping)

D Date: 28/4/87 Observer: Matthew N. Onoh

Instruments: Steel tape, Ranging Rods, thermometer, spring balance and Roller grip. Booker:

| Stations From | Stations TO | Distances | Mean Dist. | Temp. | Slope Angle | Tension | Remarks |
|---|---|---|---|---|---|---|---|
| ~~M7~~ | M8 | ~~75.305~~ ~~75.308~~ | | 28°C. | | | ~~Standard temperature~~ = 20°C. |
| M7 | M8 | 75.303 | | ~~28°C~~ | | | |
| M8 | M7 | 75.309 | 75.306 | | | | |
| M8 | M7 | 75.310 | | | | | |
| M8 | M9 | 91.790 | | | | | Standard Tension = 50N |
| M8 | M9 | 91.796 | | 31°C | | | |
| M9 | M8 | 91.789 | 91.792 | | | | |
| M9 | M8 | 91.791 | | | | | |
| M9 | M10 | 38.955 | | 40°C | | | |
| M9 | M10 | 38.959 | | | | | |
| M10 | M9 | 38.963 | 38.958 | | | | |
| M10 | M9 | 38.957 | | | | | |
| M10 | M11 | ~~51.080~~ | | 46°C | | | |
| M10 | M11 | 51.079 | | | | | |
| M11 | M10 | 51.079 | 51.080 | | | | |
| M11 | M10 | 51.080 | | | | | |

Traverse Booking Sheet (Distance measurement) Steel tape (prism)

D Date: 28/4/83 Observer: Matthew

Instruments: Steel tape, hanging poles, thermometer, spring balance and roller grip. Booker:

| Stations From | Stations To | Distances | Mean Dist. | Temp. | Slope Angle | Tension | Remarks |
|---|---|---|---|---|---|---|---|
| M11 | M12 | 13.375 | | | | | Standard temperature = 20°C |
| M11 | M12 | 13.320 | | | | | |
| M12 | M11 | 13.319 | 13.320 | 42°C | | | |
| M12 | M11 | 13.319 | | | | | |
| M12 | CP13 | 17.880 | | | | | Standard tension = 7kg |
| M12 | CP13 | 17.879 | | 47°C | | | |
| CP13 | M12 | 17.882 | 17.880 | | | | |
| CP13 | M12 | 17.882 | | | | | |
| CP13 | CP12 | 169.459 | | | | | |
| CP13 | CP12 | 169.461 | | | | | |
| CP12 | CP13 | 169.460 | 169.460 | 47°C | | | |
| CP12 | CP13 | 169.462 | | | | | |

Started (3.26 p.m)

Traverse Booking Sheet (Distance measurement) (Steel taping)

D Date: 29/4/86 (Starting 8.25am) Observer: Mathew N.

Instruments: Steel tape, Ranging Rods, thermometer, Spring balance and roller grip. Booker:

| Stations From | Stations TO | Distances | Mean Dist. | Temp. | Slope Angle | Tension | Remarks |
|---|---|---|---|---|---|---|---|
| CP13 | N0 | 38.310 | | | | | |
| CP13 | N0 | 38.310 | | | | | Standard |
| N0 | CP13 | 38.305 | 38.308 | 30°C | | | temperature |
| N0 | CP13 | 38.305 | | | | | = 30°C |
| N0 | N1 | 35.020 | | | | | |
| N0 | N1 | 35.020 | | | | | |
| N1 | N0 | 35.010 | 35.016 | 28°C | | | Standard |
| N1 | N0 | 35.015 | | | | | tension |
| | | | | | | | = 7kN |
| N1 | N2 | 18.290 | | | | | |
| N1 | N2 | 18.290 | 18.290 | 28°C | | | |
| N2 | N1 | 18.290 | | | | | |
| N2 | N1 | 18.290 | | | | | |
| N2 | N3 | 62.015 | | | | | |
| N2 | N3 | 62.013 | 62.013 | 32°C | | | |
| N3 | N2 | 62.012 | | | | | |
| N3 | N2 | 62.012 | | | | | |

Traverse Booking Sheet (Distance measurement) (Red tape)

D Date: 29/4/81 Observer: [illegible]

Instruments: Steel tape, Ranging rods, thermometer, Spring balance and roller grip. Booker: [illegible]

| Stations From | Stations To | Distances | Mean Dist. | Temp. | Slope Angle | Tension | Remarks |
|---|---|---|---|---|---|---|---|
| N3 | N4 | 32.770 | | | | | |
| N3 | N4 | 33.774 | | 33°C | | | Standard temperature = 20°C |
| N4 | N3 | 33.769 | 33.770 | | | | |
| N4 | N3 | 33.767 | | | | | |
| N4 | N5 | 31.850 | | | | | |
| N4 | N5 | 31.851 | 31.850 | 30°C | | | |
| N5 | N4 | 31.849 | | | | | |
| N5 | N4 | 31.849 | | | | | Standard tension = 70N |
| N5 | N6 | 47.078 | | 30°C | | | |
| N5 | N6 | 47.069 | 47.069 | | | | |
| N6 | N5 | 47.069 | | | | | |
| N6 | N5 | 47.068 | | | | | |
| N6 | N7 | 44.320 | | | | | |
| N6 | N7 | 44.316 | 44.318 | 25°C | | | |
| N7 | N6 | 44.320 | | | | | |
| N7 | N6 | 44.320 | | | | | |

Traverse Booking Sheet (Distance measurement) (Steel taping)

D Date: 29/4/86 Observer: Matthews Alfred

Instruments: Steel tape, Ranging Rods, Thermometer, Spring balance and roller grip Booker:

| Stations From | Stations To | Distances | Mean Dist. | Temp. | Slope Angle | Tension | Remarks |
|---|---|---|---|---|---|---|---|
| NQ | M8 | 64.930 | | | | | Standard temperature = 20°C |
| NQ | M8 | 64.930 | | | | | |
| N8 | NQ | 64.926 | 64.928 | 30°C | | | |
| N8 | NQ | 64.928 | | | | | |
| CP12 | DO | 62.935 | | | | | |
| CP12 | DO | 62.933 | 62.935 | 35°C | | | Standard tension = 70N. |
| DO | CP12 | 62.935 | | | | | |
| DO | CP12 | 62.934 | | | | | |
| DO | D1 | 33.585 | | 39°C | | | |
| DO | D1 | 33.588 | | | | | |
| D1 | DO | 33.590 | 33.588 | | | | |
| D1 | DO | 33.590 | | | | | |
| D1 | D2 | 19.~~728~~ 65 | | 39°C | | | |
| D1 | D2 | 19.~~728~~ 65 | | | | | |
| D2 | D1 | 19.~~742~~ 68 | 19.670 | | | | |
| D2 | D1 | 19.~~742~~ 68 | | | | | |

Traverse Booking Sheet (Distance measurement) (Steel Tape)

Date: 29/4/86 Observer: [illegible]

Instruments: Steel tape, Ranging Booker: [illegible]
Poles, thermometer, Spring balance,
and roller grip.

| Stations From | To | Distances (m) | Mean Dist. (m) | Temp. | Slope Angle | Tension | Remarks |
|---|---|---|---|---|---|---|---|
| D2 | D3 | 44.099 | | | | | Standard temperature = 20°C |
| D2 | D3 | 44.097 | 44.098 | 38°C | | | |
| D3 | D2 | 44.099 | | | | | |
| D3 | D2 | 44.100 | | | | | |
| D3 | D4 | 35.520 | | | | | Standard tension = 7kg |
| D3 | D4 | 35.519 | 35.518 | 40°C | | | |
| D4 | D3 | 35.518 | | | | | |
| D4 | D3 | 35.518 | | | | | |
| D4 | M3 | 70.119 | | | | | |
| D4 | M3 | 70.120 | 70.120 | 40°C | | | |
| M3 | D4 | 70.121 | | | | | |
| M3 | D4 | 70.122 | | | | | |

Stopped (1.53 p.m)

## COMPUTATION OF TRAVERSE CO-ORDINATES

Survey: TRAVERSING. Town: Zwia
Traverse of: TERMSWOOD District: A.B.U
Field Book No.: Province:
Observed Azimuth from: ... to ...
Deducted Azimuth from: CP13 to CP12
Closing Error for: 17 Stations 1.5' per Station 0.1'
Page:
Date: 13 | 6 | 1986
Surveyor: Matthew N. Onoh
Computer:

| From Station A | Back Bearing Observed Angle Forward Bearing | Correction to Bearing | Corrected Bearing | EDM True Horizontal Length | Cos Bearing | Sin Bearing | ΔN − | ΔN + | ΔN Arithmetic Sum | ΔE + | ΔE − | ΔE Arithmetic Sum | Origin ... C. or T.N. Uncorrected Co-ords. Correction Final Co-ords. (in Red) N | Final Co-ords. (in Red) E | To Station B |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ° ' " | " | ° ' " | (m) | | | | | | | | | | | |
| CP13 | 306 03 10 | | | | | | | | | | | | | | |
| | 126 | | | | | | | | | | | | | | |
| | 220 19 36 | | | | | | | | | | | | 9954.014 | 17459.014 | CP12 |
| CP12 | 26 42 20 | -02 | 26 42 48 | 113.814 | | | | | | | | | 10055.680 | 17625.346 | |
| | 206 | | | | | | 101.660 | | 101.666 | 51.162 | | 51.162 | - 0.006 | + 0.002 | |
| | 192 49 21 | | | | | | | | | | | | 10155.674 | 17572.764 | TP10 |
| MD | 40 32 11 | -05 | 40 32 06 | 60.352 | | | | | | | | | 10101.592 | 17587.490 | |
| | 220 | | | | | | 45.792 | | 149.458 | 30.248 | | 80.456 | - 0.006 | + 0.005 | |
| | 352 24 48 | | | | | | | | | | | | 10101.586 | 17587.495 | M1 |
| M1 | 112 56 59 | -02 | 112 56 52 | 66.142 | | | | | | | | | 10059.075 | 17618.268 | |
| | 292 | | | | | | 21.495 | 149.953 | 60.734 | | 141.134 | | - 0.006 | + 0.009 | |
| | 206 56 50 | | | | | | | | | | | | 10059.069 | 17618.277 | M2 |
| M2 | 100 59 51 | -09 | 100 59 42 | 68.691 | | | | | | | | | 10011.405 | 17618.849 | |
| | 359 | | | | | | 68.670 | 332.936 | 0.106 | | 141.285 | | - 0.007 | + 0.007 | |
| | 93 58 24 | | | | | | | | | | | | 10011.398 | 17618.856 | M3 |
| M3 | 53 48 10 | -12 | 53 47 58 | 82.512 | | | | | | | | | 10048.283 | 17668.992 | |
| | 233 | | | | | | 34.998 | 274.080 | 49.534 | | 191.811 | | 0.010 | + 0.010 | |
| | 287 32 19 | | | | | | | | | | | | 10047.393 | 17669.002 | M4 |
| M4 | 121 20 32 | -14 | 121 20 20 | 62.120 | | | | | | | | | 10011.295 | 17691.095 | |
| | 311 | | | | | | 37.102 | 311.811 | 42.188 | | 233.991 | | - 0.012 | + 0.013 | |
| | 166 42 15 | | | | | | | | | | | | 10011.283 | 17691.082 | M5 |
| M5 | 118 02 49 | -16 | 118 02 33 | 45.983 | | | | | | | | | 9989.665 | 17751.663 | |
| | 298 | | | | | | 21.620 | 338.461 | 40.588 | | 274.839 | | - 0.012 | + 0.016 | |
| | 280 17 38 | | | | | | | | | | | | 9989.653 | 17751.679 | M6 |
| M6 | 218 20 22 | -10 | 218 20 02 | 96.848 | | | | | | | | | 9934.253 | 17705.861 | |
| | 38 | | | | | | 57.022 | 391.325 | 45.802 | | 320.881 | | - 0.015 | + 0.018 | |
| | 191 49 40 | | | | | | | | | | | | 9934.238 | 17705.879 | M7 |
| M7 | 210 10 02 | -21 | 210 09 41 | 95.311 | | | | | | | | | 9886.619 | 17668.021 | |
| | 30 | | | | | | 15.114 | 602.441 | 37.898 | 358.221 | | | - 0.018 | + 0.020 | |
| | 222 41 46 | | | | | | | | | | | | 9886.601 | 17668.041 | M8 |
| M8 | 252 51 53 | -22 | 252 51 30 | 91.820 | | | | | | | | | 9846.309 | 17638.255 | |
| | 90 | | | | | | 10.342 | 495.399 | 89.776 | 449.901 | | | - 0.018 | + 0.023 | |
| | 92 05 06 | | | | | | | | | | | | 9846.291 | 17638.278 | M9 |
| M9 | 169 26 59 | -26 | 169 26 33 | 38.968 | | | | | | | | | 9808.958 | 17685.080 | |
| | | | | | | | 38.340 | 524.148 | 6.806 | | 482.992 | | - 0.020 | + 0.026 | |
| | | | | | | | | | | | | | 9808.918 | 17685.106 | M10 |

EDT. 1119

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COMPUTATION OF TRAVERSE CO-ORDINATES

KST-009

Page

Survey TRAVERSING
Traverse of PHOTOGRAPHIC
Field Book No.

Town Zeria
District A·B·U
Province

Observed Azimuth from ... to ...
Deducted Azimuth from CP13 to CP12
Closing Error for 15 Stations 59" per Station 02"

Date 13/6/1986
Surveyor
Computer Matthew N. Owuor

| From Station A | Back Bearing Observed Angle Forward Bearing | Correction to Bearing | Corrected Bearing | Adopted True Horizontal Length (M) | Cos Bearing | Sin Bearing | ΔN + | ΔN − | ΔN Arithmetic Sum | ΔE + | ΔE − | ΔE Arithmetic Sum | Origin Uncorrected Co-ords. Correction Final Co-ords. (in Red) C or T.N N | C or T.N E | To Station B |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 340 ° ' " | ° ' " | ° ' " | | | | | | | | | | | | |
| | 281 58 01 | | | | | | | | | | | | | | |
| CP12 | 021 56 00 | -28 | 021 55 32 | 51.009 | | | 1.707 | | 1215.450 | | 21.023 | 595.846 | 9810.640 | 19536.028 | |
| | 91 | | | | | | | | | | | | - 0.036 | - 0.029 | |
| | 160 08 16 | | | | | | | | | | | | 9810.604 | 19536.000 | CP13 |
| CP13 | 222 00 22 | -30 | 221 59 52 | 13.279 | | | | | | | | | -9804.233 | 19521.400 | |
| | 182 | | | | | | 2.109 | 604.459 | | | 12.459 | 07.621 | - 0.028 | - 0.029 | |
| | 122 24 58 | | | | | | | | | | | | 9806.331 | 19516.942 | CP12 |
| CP12 | 124 25 17 | -32 | 124 24 45 | 12.903 | | | | | | | | | -9789.321 | 19516.942 | |
| | 14 | | | | | | 17.122 | 1537.459 | | | 4.467 | 521.960 | - 0.030 | - 0.030 | |
| | 331 48 22 | | | | | | | | | | | | 9789.551 | 19516.912 | CP13 |
| CP13 | 266 33 30 | -35 | 266 33 15 | 120.401 | | | 46.191 | | 1581.911 | | 20.811 | 521.149 | 9789.521 | 19516.882 | |
| | | | | | | | | | | | | | - 0.031 | - 0.030 | |
| | | | | | | | | | | | | | 9789.490 | 19516.852 | |

$\Sigma = 1581.880$
$\Sigma = 1581.911$
$\Delta = 0.031$

$\Sigma = 521.149$
$\Sigma = 521.960$
$\Delta = 0.811$

$\Delta = (0.031^2 + 0.811^2)^{1/2} = 0.811$

$Z.F = \frac{0.811}{120.401} = \frac{1}{148.4813}$

$= 1:148.4813.249$

EDM TRAVERSE CHECK COMPUTATION.

EDT. 1009

## COMPUTATION OF TRAVERSE CO-ORDINATES

Page .....

Survey .....
Traverse of Check.
Field Book No. .....

Town Zomia
District A.E.A.
Province .....

Observed Azimuth from ..... to .....
Deducted Azimuth from ..... to .....
Closing Error for ..... Stations ..... per Station .....

Date 14/6/1986
Surveyor .....
Computer Matthew N. Onoh

| From Station A | Back Bearing Observed Angle Forward Bearing | Correction to Bearing | Corrected Bearing | EDM True Horizontal Length (m) | Cos Bearing | Sin Bearing | ΔN + | ΔN − | ΔN Arithmetic Sum | ΔE + | ΔE − | ΔE Arithmetic Sum | Origin ..... C. or T.N. Uncorrected Co-ords. Correction Final Co-ords. (in Red) N | E | To Station B |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | ° ' " | | | | | | | | | | | | |
| CP13 | | | | | | | | | | | | | 0324.015 | 17432.9[illegible] | CP12 |
| CP12 | | | 26 43 51 | 113.811 | | | 101.662 | | | 51.164 | | | 100.667 | 17530.847 | MD |
| MD | | | 40 32 12 | 60.124 | | | 45.950 | | | 39.160 | | | 101.01.672 | 17564.[illegible] | M1 |
| M1 | | | [illegible] 27 | 55.123 | | | | 21.693 | | 50.954 | | | 100.20.[illegible] | 17617.291 | M2 |
| M2 | | | 129 54 47 | 69.693 | | | | 43.032 | | 0.106 | | | 100.11.[illegible] | 17617.[illegible] | M3 |
| M3 | | | 53 48 10 | 62.612 | | | 36.932 | | | 50.524 | | | 100.68.[illegible] | 17667.[illegible] | M4 |
| M4 | | | 181 20 22 | 56.183 | | | | 32.110 | | 4.2.183 | | | 100.11.[illegible] | 17.911.[illegible] | M5 |
| M5 | | | 118 02 28 | 46.592 | | | | 21.620 | | 40.691 | | | 0.329.[illegible] | 17.[illegible] | M6 |
| M6 | | | 218 19 59 | 93.846 | | | | 57.915 | | | 45.880 | | 99.31.[illegible] | 17.[illegible] | M7 |
| M7 | | | 120 09 36 | 45.312 | | | | 45.113 | | | 37.858 | | 99.[illegible] | 17.[illegible] | M8 |
| M8 | | | 257 61 29 | 91.814 | | | | [illegible] 2 | | | 89.967 | | 99.42.[illegible] | 17.[illegible] | M9 |
| M9 | | | 149 52 31 | 58.990 | | | | 38.391 | | 6.908 | | | 99.08.[illegible] | 17.[illegible] | M10 |

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## COMPUTATION OF TRAVERSE CO-ORDINATES

Page

Survey
Traverse of
Field Book No. Check

Town Zavis
District Ar B-M
Province

Observed Azimuth from ... to ...
Deducted Azimuth from ... to ...
Closing Error for ... Stations ... per Station

Date 19/6/1990
Surveyor Matthews N. Bwalya
Computer

| From Station A | Back Bearing Observed Angle Forward Bearing | Correction to Bearing | Corrected Bearing | EDM True Horizontal Length (m) | Cos Bearing | Sin Bearing | ΔN + | ΔN − | ΔN Arithmetic Sum | ΔE + | ΔE − | ΔE Arithmetic Sum | Origin ... C. or T.N. Uncorrected Co-ords. Correction Final Co-ords. (in Red) N | Final Co-ords. (in Red) E | To Station B |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | ° ' " | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| X10 | | | 291 52 39 | 51.049 | | | 1.206 | | | | 51.029 | | 9810.620 | 13564.264 | M1 |
| | | | | | | | | | | | | | | | |
| M11 | | | 251 59 45 | 13.282 | | | | 4.102 | | | 12.662 | | 9806.518 | 13551.602 | M12 |
| | | | | | | | | | | | | | | | |
| M13 | | | 194 34 24 | 13.955 | | | | 13.182 | | | 4.462 | | 9793.336 | 13547.140 | CP13 |
| | | | | | | | | | | | | | | | |
| CP13 | | | 346 23 14 | 169.662 | | | 165.653 | | | | 33.891 | | 9958.989 | 13513.249 | CP12 |
| | | | | | | | | | | | | | | | |

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KST-1KP

## COMPUTATION OF TRAVERSE CO-ORDINATES

Page .....

Survey TRAVERSING — Town Zaria — Observed Azimuth from ..... to ..... — Date 13/6/19 86

Traverse of PRACTICAL WORK — District N.S.H — Deducted Azimuth from CP13 to CP12 — Surveyor Matthew N. Dwoh

Field Book No. ..... — Province ..... — Closing Error for 15 Stations 55" per Station 03" — Computer .....

| From Station A | Each Bearing Observed Angle Forward Bearing | Correction to Bearing | Corrected Bearing | STEEL TAPE True Horizontal Length (m) | Cos Bearing | Sin Bearing | ΔN + | ΔN − | ΔN Arithmetic Sum | ΔE + | ΔE − | ΔE Arithmetic Sum | Origin ..... C. or T.N. Uncorrected Co-ords. Correction Final Co-ords. (in Red) N | E | To Station B |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ° ' " | " | ° ' " | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| CP13 | 341 33 17 | | | | | | | | | | | | 9952.014 | 17977.054 | CP12 |
| | 114 | | | | | | | | | | | | 10065.472 | 19548.242 | |
| | 220 19 35 | | | | | | | | | | | | + 0.010 | + 0.016 | |
| CP12 | 76 42 30 | -02 | 76 42 28 | 113.268 | | | 101.663 | | 101.663 | 51.158 | | 51.158 | 10055.685 | 17537.251 | MD |
| | 206 | | | | | | | | | | | | 10101.552 | 17543.934 | |
| | 193 49 21 | | | | | | | | | | | | + 0.014 | + 0.017 | |
| MD | 40 32 11 | -05 | 40 32 06 | 60.149 | | | 45.519 | | 149.538 | 39.234 | | 90.392 | 10101.566 | 17583.968 | MA |
| | 220 | | | | | | | | | | | | 10080.052 | 17618.744 | |
| | 252 24 43 | | | | | | | | | | | | + 0.016 | + 0.027 | |
| MA | 112 47 37 | -05 | 112 47 32 | 55.133 | | | 121.496 | | 149.034 | 51.930 | | 141.322 | 10079.532 | 17618.362 | MB |
| | 244 52 52 | | | | | | | | | | | | + 0.022 | + 0.032 | |
| MB | 129 52 51 | -05 | 129 52 47 | 65.634 | | | | 65.674 | 234.708 | 0.126 | | 141.448 | 10041.874 | 17685.894 | MC |
| | 354 | | | | | | | | | | | | 10045.364 | 17665.884 | |
| | 56 53 20 | | | | | | | | | | | | + 0.026 | + 0.036 | |
| MC | 56 48 15 | -15 | 56 47 59 | 42.630 | | | 24.492 | | 300.450 | 62.356 | | 203.804 | 10069.832 | 17667.920 | MA |
| | 233 | | | | | | | | | | | | 10011.249 | 17711.074 | |
| | 359 52 17 | | | | | | | | | | | | + 0.030 | + 0.046 | |
| MA | 151 20 32 | -14 | 151 20 18 | 67.112 | | | | 52.115 | 311.705 | 42.122 | | 245.926 | 10011.219 | 17711.120 | MF |
| | 311 | | | | | | | | | | | | 9959.674 | 17751.672 | |
| | 166 42 15 | | | | | | | | | | | | + 0.032 | + 0.052 | |
| MF | 118 02 49 | -16 | 118 02 33 | 47.399 | | | 21.228 | | 332.933 | 40.596 | | 286.518 | 9990.902 | 17791.924 | MA |
| | 298 | | | | | | | | | | | | 9981.919 | 17805.892 | |
| | 240 19 42 | | | | | | | | | | | | + 0.038 | + 0.041 | |
| MA | 218 20 20 | -19 | 218 20 01 | 96.367 | | | | 59.435 | 391.367 | | 45.917 | 332.598 | 9931.357 | 17805.934 | MG |
| | 39 | | | | | | | | | | | | 9966.615 | 17668.047 | |
| | 121 49 40 | | | | | | | | | | | | + 0.044 | + 0.048 | |
| MG | 210 10 02 | -21 | 210 09 41 | 98.718 | | | | 85.106 | 476.473 | | 39.836 | 372.434 | 9946.659 | 17668.139 | MA |
| | 30 | | | | | | | | | | | | 9847.308 | 17678.300 | |
| | 226 4 44 | | | | | | | | | | | | + 0.048 | + 0.056 | |
| MA | 253 51 51 | -23 | 253 51 30 | 91.841 | | | | 19.328 | 495.801 | | 89.943 | 462.377 | 9828.028 | 17735.341 | MH |
| | 92 | | | | | | | | | | | | 9808.969 | 17735.104 | |
| | 92 05 06 | | | | | | | | | | | | + 0.049 | + 0.052 | |
| MH | 149 54 59 | -24 | 149 52 33 | 38.965 | | | | 32.346 | 514.115 | 6.824 | | 455.961 | 9788.574 | 17725.111 | MH0 |

KST-007

## COMPUTATION OF TRAVERSE CO-ORDINATES

Page

Survey TRAVERSING
Traverse of FRAMEWORK
Field Book No.

Town Zevis
Div A.G.V
Province

Observed Azimuth from ... to ...
Deducted Azimuth from CP13 to CP12
Closing Error for 35 Stations 36" per Station 03"

Date 13 | 6 | 1986
Surveyor
Computer Matthew N. Quaye

| From Station A | Back Bearing Observed Angle Forward Bearing | Correction to Bearing | Corrected Bearing | STEEL TAPE True Horizontal Length (m) | Cos Bearing | Sin Bearing | ΔN + | ΔN − | ΔN Arithmetic Sum | ΔE + | ΔE − | ΔE Arithmetic Sum | Origin ... C or T.N. Uncorrected Co-ords. Correction Final Co-ords (in Red) N | E | To Station B |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BM9 | | | | | | | | | | | | 9810.642 | 17539.028 | |
| | 281 58 09 | | | | | | | | | | | | 0.049 | 0.094 | |
| M10 | 291 55 06 | -28 | 291 58 21 | 51.054 | | | 19.903 | | 516.312 | | 51.066 | 526.450 | 9830.691 | 17514.150 | M11 |
| | 91 | | | | | | | | | | | | 9806.674 | 17521.868 | |
| | 180 05 16 | | | | | | | | | | | | 0.058 | 0.099 | |
| M11 | 252 00 22 | -30 | 251 59 52 | 13.333 | | | | 4.118 | 519.934 | | 12.650 | 538.100 | 9806.674 | 17521.467 | M12 |
| | 82 | | | | | | | | | | | | 9829.315 | 17514.866 | |
| | 122 34 56 | | | | | | | | | | | | 0.051 | 0.100 | |
| M12 | 194 45 18 | -23 | 194 34 46 | 19.915 | | | | 19.309 | 563.243 | | 4.892 | 543.042 | 9849.266 | 17514.966 | CP13 |
| | 14 | | | | | | | | | | | | 9955.9671 | 19496.926 | |
| | 321 48 32 | | | | | | | | | | | | 0.042 | 0.108 | |
| CP13 | 346 23 57 | -25 | 346 23 15 | 169.493 | | | 164.332 | | 991.939 | | 39.490 | 582.392 | 9978.010 | 17513.074 | CP12 |

$\Sigma+\Delta N = 350.935$ $\Sigma-\Delta E + 281.902$
$\Sigma-\Delta N = 351.022$ $\Sigma-\Delta E 281.990$
$e_N = .0.087$ $e_E = .0.088$

$L_m = \sqrt{(e_N^2 + e_E^2)} = 0.1230946$

$\frac{1}{2}f = \frac{994.426}{0.1230946} = 1:8324.904$

$= 1:7924.504$

STEEL TAPE TRAVERSE COMPUTATION.

KST. 1979

## COMPUTATION OF TRAVERSE CO-ORDINATES

Page .....

Survey .....
Traverse of .....
Field Book No. Cloth Computation

Town Davis
District A.S.M.
Province .....

Observed Azimuth from ..... to .....
Deducted Azimuth from ..... to .....
Closing Error for ..... Stations ..... per Station .....

Date 14/6/1976
Surveyor .....
Computer Matthew N. Quigley

| From Station A | Back Bearing Observed Angle Forward Bearing | Correction to Bearing | Corrected Bearing | Steel Tape True Horizontal Length (m) | Cos Bearing | Sin Bearing | ΔN + | ΔN − | ΔN Arithmetic Sum | ΔE + | ΔE − | ΔE Arithmetic Sum | Origin ..... C. or T.N. Uncorrected Co-ords. Correction Final Co-ords. (in feet) N | E | To Station B |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | ° ' " | | | | | | | | | | | | |
| CP12 | 346 26 42 | | | | | | | | | | | | 5962.046 | 19432.034 | CP12 |
| | 166 | | | | | | | | | | | | | | |
| CP12 | | | 76 47 55 | 13.514 | | | 101.468 | | | 50.149 | | | 10086.422 | 19532.783 | N10 |
| N10 | | | 40 52 14 | 40.332 | | | 45.994 | | | 34.261 | | | 10131.816 | 19567.045 | N1 |
| N1 | | | 142 09 29 | 68.427 | | | 54.454 | | | 43.342 | | | 10077.362 | 19610.387 | N2 |
| N2 | | | 109 52 45 | 69.453 | | | 68.478 | | | 11.106 | | | 10011.402 | 19621.493 | N3 |
| N3 | | | 63 48 11 | 67.670 | | | 34.936 | | | 60.181 | | | 10046.338 | 19681.674 | N4 |
| N4 | | | 151 19 48 | 61.115 | | | 53.111 | | | 43.198 | | | 10099.449 | 19724.872 | N5 |
| N5 | | | 119 02 01 | 46.004 | | | 21.623 | | | 40.626 | | | 10121.072 | 19765.498 | N6 |
| N6 | | | 214 19 59 | 53.812 | | | 50.600 | | | 18.210 | | | 10071.472 | 19783.708 | N7 |
| N7 | | | 210 09 29 | 95.219 | | | 65.059 | | | 69.850 | | | 10006.413 | 19853.558 | N8 |
| N8 | | | 253 61 24 | 91.342 | | | 19.809 | | | 89.232 | | | 9986.604 | 19942.790 | N9 |
| N9 | | | 109 52 24 | 28.042 | | | 53.242 | | | 6.805 | | | 9986.604 | 19935.985 | N10 |

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COMPUTATION OF TRAVERSE CO-ORDINATES

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Survey
Traverse of
Field Book No. Check Computation

Town Zavia
District A.B.U.
Province

Observed Azimuth from ... to ...
Deducted Azimuth from ... to ...
Closing Error for ... Stations ... per Station

Date 19/6/1986
Surveyor Matthew N. Owoh
Computer

| From Station A | Back Bearing Observed Angle Forward Bearing | Correction to Bearing | Corrected Bearing | True Horizontal Length (m) | Cos Bearing | Sin Bearing | ΔN + | ΔN − | ΔN Arithmetic Sum | ΔE + | ΔE − | ΔE Arithmetic Sum | Origin ... C. or T. N. Uncorrected Co-ords. Correction Final Co-ords. (in Red) N | E | To Station B |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | ° ' " | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| M.10 | | | 251 52 37 | 51.024 | | | 1.705 | | | | 51.003 | | 97.19 - 1.91 | 195.34 - 1.51 | M.11 |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| M.11 | | | 251 09 46 | 13.220 | | | | 4.112 | | | 12.568 | | 93.06 - 3.82 | 183.41 - 1.13 | M.12 |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| M.12 | | | 194 24 32 | 19.854 | | | | 17.302 | | | 6.980 | | 93.19 - 7.81 | 176.14 - 1.14 | C.P.13 |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| C.P.13 | | | 346 33 50 | 100.254 | | | 100.251 | | | | 50.355 | | 185.13 - 15.18 | 190.32 - 2.26 | C.P.14 |

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## COMPUTATION OF TRAVERSE CO-ORDINATES

EST. 1917

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Survey Tamworth No 9
Traverse of Plan 6466 & 16
Field Book No.

Town Tamworth
District A.B.N.
Province

Observed Azimuth from ... to ...
Deducted Azimuth from CP13 to CP12
Closing Error for 15 Stations 35" per Station 02"

Date 13/6/1896
Surveyor Matthew N. Quigley
Computer

| From Station A | Bark Bearing Observed Angle Forward Bearing | Correction to Bearing | Corrected Bearing | DDmm True Horizontal Length (ft.) | Cos Bearing | Sin Bearing | ΔN + | ΔN − | ΔN Arithmetic Sum | ΔE + | ΔE − | ΔE Arithmetic Sum | Origin ... C. or T.N. Uncorrected Co-ords. Correction Final Co-ords. (in Rec) N | E | To Station B |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ° ′ ″ | ″ | ° ′ ″ | | | | | | | | | | | | |
| CP12 | 341 23 15 | | | | | | | | | | | | | | |
| | 164 | | | | | | | | | | | | 9958.014 | 12432.084 | CP12 |
| | 220 19 35 | | | | | | | | | | | | 10055.445 | 17548.228 | |
| CP12 | 26 42 50 | -02 | 26 42 48 | 113.975 | | | 101.641 | | 101.631 | 51.149 | | 51.149 | - 0.026 | + 0.020 | |
| | 206 | | | | | | | | | | | | 10065.619 | 17523.248 | MD |
| | 193 49 21 | | | | | | | | | | | | 10101.592 | 17569.552 | |
| MD | 40 32 11 | -05 | 40 32 04 | 60.200 | | | 46.062 | | 101.583 | 39.134 | | 90.283 | - 0.038 | - 0.034 | |
| | 220 | | | | | | | | | | | | 10101.569 | 17569.586 | M1 |
| | 252 24 48 | | | | | | | | | | | | 10089.953 | 12617.999 | |
| M1 | 112 56 59 | -03 | 112 56 56 | 55.200 | | | | 21.444 | 147.904 | 50.462 | | 142.945 | - 0.043 | - 0.059 | |
| | 292 | | | | | | | | | | | | 10029.910 | 12618.052 | M2 |
| | 246 57 52 | | | | | | | | | | | | 10011.419 | 12618.105 | |
| M2 | 140 04 51 | -09 | 140 52 42 | 68.215 | | | | 62.674 | 232.581 | 0.106 | | 141.051 | - 0.060 | + 0.067 | |
| | 359 | | | | | | | | | | | | 10011.369 | 12618.159 | M3 |
| | 53 53 24 | | | | | | | | | | | | 10048.326 | 17668.520 | |
| M3 | 53 48 16 | -12 | 53 49 03 | 62.495 | | | 36.877 | | 304.781 | 50.215 | | 191.266 | - 0.030 | + 0.023 | |
| | 232 | | | | | | | | | | | | 10048.356 | 17669.543 | M4 |
| | 252 52 19 | | | | | | | | | | | | 10011.206 | 17710.916 | |
| M4 | 131 20 36 | -14 | 131 20 22 | 52.200 | | | | 32.120 | 311.343 | 42.196 | | 233.632 | - 0.080 | + 0.089 | |
| | 311 | | | | | | | | | | | | 10011.126 | 17710.805 | M5 |
| | 164 42 15 | | | | | | | | | | | | 9979.616 | 17751.249 | |
| M5 | 118 02 40 | -16 | 118 02 33 | 45.925 | | | | 24.590 | 332.953 | 40.633 | | 208.165 | - 0.084 | + 0.104 | |
| | 298 | | | | | | | | | | | | 9979.530 | 17751.353 | M6 |
| | 280 19 3. | | | | | | | | | | | | 9931.905 | 17705.458 | |
| M6 | 219 20 27 | -19 | 218 20 08 | 73.845 | | | | 57.928 | 390.866 | 46.091 | | 229.952 | - 0.1.. | + 0.122 | |
| | 39 | | | | | | | | | | | | 9961.609 | 17705.681 | M7 |
| | 191 49 40 | | | | | | | | | | | | 9886.936 | 17669.924 | |
| M7 | 210 10 41 | -28 | 210 09 46 | 95.100 | | | | 64.932 | 455.998 | 69.934 | | 359.696 | - 0.119 | + 0.134 | |
| | 30 | | | | | | | | | | | | 9886.659 | 17642.858 | M8 |
| | 222 41 46 | | | | | | | | | | | | 9842.462 | 17592.904 | |
| M8 | 257 51 51 | -23 | 257 51 30 | 91.895 | | | | 19.324 | 495.122 | | 89.920 | 449.510 | - 0.122 | - 0.101 | |
| | 97 | | | | | | | | | | | | 9842.320 | 17592.095 | M9 |
| | 92 08 06 | | | | | | | | | | | | 9809.720 | 17504.688 | |
| M9 | 169 56 59 | -26 | 169 56 33 | 28.850 | | | | 38.152 | 513.396 | 4.700 | | 458.294 | - 0.132 | + 0.124 | |
| | | | | | | | | | | | | | 9809.068 | 17504.862 | M10 |

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XSY-007

## COMPUTATION OF TRAVERSE CO-ORDINATES

Page

Survey TRAVERSING
Traverse of FEATHERWORK.
Field Book No.

Town Zeris
District A.B.Z.
Province

Observed Azimuth from to
Deducted Azimuth from CP13 to CP12
Closing Error for 15 Stations 35" per Star 0.2'

Date 13 | 6 | 1988
Surveyor
Computer Mathew N. Qwok

| From Station A | Back Bearing / Observed Angle / Forward Bearing | Correction to Bearing | Corrected Bearing | ODM True Horizontal Length (m) | Cos Bearing | Sin Bearing | ΔN + | ΔN − | ΔN Arithmetic Sum | ΔE + | ΔE − | ΔE Arithmetic Sum | Origin / Uncorrected Co-ords. / Correction / Final Co-ords. (in Red) N | Final Co-ords. (in Red) E | To Station B |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 349 | | | | | | | | | | | | 9810.898 | 17533.865 | |
| | 181 58 57 | | | | | | | | | | | | - 0.132 | + 0.193 | |
| M10 | 231 55 06 | -29 | 231 58 32 | 60.952 | | | 1.298 | | 612.092 | | 50.921 | 625.219 | 9810.766 | 17533.958 | M11 |
| | 91 | | | | | | | | | | | | 9806.704 | 17521.164 | |
| | 160 05 14 | | | | | | | | | | | | - 0.133 | + 0.198 | |
| M11 | 251 00 22 | -20 | 251 00 02 | 13.260 | | | | 4.096 | 519.166 | | 12.601 | 517.833 | 9806.671 | 17521.362 | M12 |
| | 92 | | | | | | | | | | | | 9789.644 | 17516.209 | |
| | 122 54 56 | | | | | | | 12.130 | 526.296 | | 4.455 | 522.245 | - 0.138 | - 0.200 | |
| M12 | 194 55 19 | -25 | 194 54 45 | 13.920 | | | | | | | | | 9789.506 | 17516.009 | CP13 |
| | 14 | | | | | | | | | | | | 9967.194 | 17476.869 | |
| | 331 48 32 | | | | | | 166.520 | | 000.916 | | 39.789 | 502.115 | - 0.180 | + 0.215 | |
| CP13 | 346 53 50 | -25 | 346 53 15 | 169.395 | | | | | | | | | 9967.014 | 17477.084 | CP12 |

$\Sigma$+ΔN = 350.938
$\Sigma$−ΔN = -500.715
$e_N$ = 0.180

$\Sigma$+ΔE = 281.949
$\Sigma$−ΔE = -281.164
$e_E$ = 0.215

$L_m = (e_N^2 + e_E^2)^{\frac{1}{2}}$ = 0.284015

P.E. = $\frac{\text{Perimeter}}{L_m}$ = $\frac{992.728}{}$ = 1:3541.083

= 1:3541.083

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ODM.

## COMPUTATION OF TRAVERSE CO-ORDINATES

Page .....

Survey .....
Traverse of .....
Field Book No. Check Computation

Town Zaria
District A.Z.U
Province .....

Observed Azimuth from ..... to .....
Deducted Azimuth from ..... to .....
Closing Error for ..... Stations ..... per Station .....

Date 14/2/1956
Surveyor Mathews N. Owolabi
Computer .....

| From Station A | Back Bearing Observed Angle Forward Bearing | Correction to Bearing | Corrected Bearing | ODM True Horizontal Length (m) | Cos Bearing | Sin Bearing | ΔN + | ΔN − | ΔN Arithmetic Sum | ΔE + | ΔE − | ΔE Arithmetic Sum | Origin ..... C. or T.N. Uncorrected Co-ords. Correction Final Co-ords. (in Red) N | E | To Station B |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | ° ' " | | | | | | | | | | | | |
| | 326 38 10 | | | | | | | | | | | | | | |
| | 146 | | | | | | | | | | | | | | |
| | | | 26 43 40 | 113.760 | | | 101.605 | | | 51.164 | | | | | |
| | | | | | | | | | | | | | | | |
| | | | 80 33 09 | 60.199 | | | 46.760 | | | 38.137 | | | | | |
| | | | | | | | | | | | | | | | |
| | | | 112 55 40 | 55.000 | | | | 21.649 | | 50.672 | | | | | |
| | | | | | | | | | | | | | | | |
| | | | 9 52 41 | 68.541 | | | | 68.541 | | 0.126 | | | | | |
| | | | | | | | | | | | | | | | |
| | | | 153 49 07 | 62.454 | | | 56.803 | | | 25.824 | | | | | |
| | | | | | | | | | | | | | | | |
| | | | 131 20 06 | 56.218 | | | | 37.152 | | 42.212 | | | | | |
| | | | | | | | | | | | | | | | |
| | | | 118 02 24 | 45.940 | | | | 21.506 | | 40.588 | | | | | |
| | | | | | | | | | | | | | | | |
| | | | 218 19 03 | 93.835 | | | | 82.922 | | | 43.936 | | | | |
| | | | | | | | | | | | | | | | |
| | | | 210 08 51 | 75.109 | | | | 64.949 | | | 37.928 | | | | |
| | | | | | | | | | | | | | | | |
| | | | 252 51 02 | 91.340 | | | | 19.329 | | | 89.283 | | | | |
| | | | | | | | | | | | | | | | |
| | | | 149 52 29 | 38.259 | | | | 32.262 | | 6.987 | | | | | |

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ODM

COMPUTATION OF TRAVERSE CO-ORDINATES

Page

Survey
Traverse of Check Computation
Field Book No.
Town Zomba
District
Province
Observed Azimuth from to
Deducted Azimuth from to
Closing Error for Stations per Station
Date 14/6/ 86
Surveyor
Computer Matthews N. Qwoh

| From Station A | Back Bearing Observed Angle Forward Bearing | Correction to Bearing | Corrected Bearing | True Horizontal Length (m) | Cos Bearing | Sin Bearing | ΔN + | ΔN − | ΔN Arithmetic Sum | ΔE + | ΔE − | ΔE Arithmetic Sum | Origin ..... C. or T. N. Uncorrected Co-ords. Correction Final Co-ords. (in Red) N | E | To Station B |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | ° ' " | | | | | | | | | | | | |
| N10 | | | 221 54 38 | 50.032 | | | 1.698 | | | | 50.006 | | | | N11 |
| N11 | | | 251 50 24 | 13.149 | | | | 4.095 | | | 12.506 | | | | N12 |
| N12 | | | 194 34 05 | 13.704 | | | | 13.135 | | | 4.053 | | | | CP13 |
| CP13 | | | 346 23 20 | 169.220 | | | 164.913 | | | | 39.855 | | | | CP14 |