COMPARATIVE ANALYSIS OF EARTHWORK QUANTITY DETERMINATION BY SIMPSON'S AND TRAPEZOIDAL RULES

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Abstract

The volume of earthwork is an essential factor in everyday road construction, and various methods are being employed at various stages of earthwork to determine accurate quantities of earthwork. This research work made comparison between Simpson's and Trapezoidal formulae for calculation of volumes of earthwork. The earthwork involved are excavation (cutting), embankment (fill). Values from the formation level, natural ground level, at centre-line of the route and configuration of the ground surface using both Total Station and Global Position System (GPS). Auto Desk Land Development (ALD) was used in plotting the cross section. The results were compared in terms of accuracy, speed, and precision. The results obtained shows that Simpson's rule gives more accuracy and precision; while application of prismoidal connection were applied to Trapezoidal rule to give approximate result. The research recommends the adoption of Simpson's rule in earthwork determination.

Keywords: Comparative Analysis; excavation, embankment, cross-sections.

INTRODUCTION

The excavation, removal and dumping of earth is a frequent work in road construction. In the implementation of any engineering project, such as construction of roads, railways, canals, reservoirs etc. The earth to be excavated at one point (cutting), hauled through a distance and embanked (filling) at another point. This whole process is referred to as earthwork quantity determination. A considerable portion of the project cost involves earthwork. This particular aspect is not given the desired attention by most state Ministries of Works. Except earthwork is determined judiciously, there remains the possibility of the expenditure on the earthwork being out of budget and hence the upward review of project cost. Therefore earthwork quantity determination required correct and careful assessment of the earthwork quantity excavated (cutting) and earthwork quantity deposited (filling).

Earthwork determination is an important aspect of engineering survey, the designs are needed in all aspect of highway construction for efficient operation of the traffic. The volume of earthwork is an essential factor in everyday road construction and various methods are being employed at various stages of earthwork to determine the accurate quantities of earthwork.

It is often necessary to compute the area of track of land which may be regular or irregular in shape. To compute volumes of earthwork to be cut or filled in planning a highway, it is necessary to compute the areas of the cross section Banister (1974). It is on this note, that this research study tends to compare analytically, Simpson's and Trapezoidal rules in earthwork quantity determination in terms of accuracy, efficiency, cost estimates, volume and computation.

In engineering projects, huge amount of materials have to be moved in order to form the necessary embankments, cuttings, foundations, basements etc. that have been specified in the design work. This particular aspect has been overlooked by both the contractors and the engineers, and lead to poor quality work and delay in the execution of most engineering projects. It is essential that engineers/surveyors should as a matter of fact make an accurate measurement as possible of areas and volumes involved in order that appropriate cost estimates, for earthwork quantities can be included in the tender documents. Base on this problem, the study seeks to analyse and compare Simpson's and Trapezoidal rules in terms of accuracy, cost estimate, speed of operation, volumes and computations using the data collected from Donga-Nyamusala link road, Jalingo, Taraba State.

The research work is aim at analytic comparison of earthwork quantity determination by Simpson's and Trapezoidal rules in terms of accuracy, efficiency, cost estimation, speed of operation, volume and computation. This will be achieved through the following objectives.

i) To employ Total Station Instrument to obtain the coordinates of Traverse stations.

ii) Calculate cross sectional area using level section formula.

iii) To determine the correct quantity of materials that can be ordered and placed using Simpson and Trapezoidal rules.

iv) To use Auto Desk Land Development to plot the cross section.

Previous study shows that earthwork quantity determination was predominantly done using the Analogue methods, and the accuracy attend were of substandard in terms of quality and precision and hence the constant review of contract work as a result of poor earthwork quantity determination. This study will seek to address this issue and to improve its data quality at various levels to match the present day surveying techniques.

Taraba State lies roughly between latitude 6^0 30′N and 9^0 36′N and longitude 9^0 10′E and 11^0 50′E, whereas the study area i.e. Donga-Nyamusala link roads Jalingo metropolis lies appropriately between latitude 06^0 27′N and 06^0 33′N and longitude 09^0 13′E, 09^0 46′E of the Greenwich meridian.

Simpson's rule assumes that instead of being made of a series of straight lines, the boundaries of cross section are series of parabolic areas. More accurate result is obtained since a better approximation of the true shape of the irregular boundary is achieved. While Trapezoidal rule gives an accurate rule of the boundaries are series of straight lines. Various methods can be used to calculate the volume of excavation or filling required as part of Surveying and Civil Engineering works. The method used is often largely determined by the type of work involved. Accuracy and speed of operation are the main factors to be considered when selecting the method of approach (Sho, 1973). The estimate of quantity and distribution of earthwork are essential prior to construction and these are locally computed in the design stage of the project (Ashok, 2000). It is often necessary to compute the area of a track of land which may be regular in shape. Land is ordinarily bought and sold on the basis of cost per unit area. To compute volumes of earthwork to be cut or filled in planning a highway, it is necessary to compute the areas of the cross sections.

Breed (1953) asserted that, with the increasing cost of land and materials, it is vital that the surveyor or engineer is able to make an assessment of relevant quantities involved in any particular project in accordance with the specific accuracy. Estimation of areas and volumes is fundamental to the majority of engineering project especially the implementation of highways. Also in identifying the importance of topographic map information in terms of determination of volume of earthwork in roads reservoirs etc. construction states that where volume of large scale earthwork have to be determined e.g. the formation of sports fields, reservoir, large factory building, the fieldwork consist of covering the area by a network of squares and obtaining the reduced levels. The volume is determined either from the grid level themselves or the contoured (topographic map) plotted from them (Irvine, 1988).

Agor (1984) identified measurement method of cross sectional areas in the construction of roads, the centre line of the road remain defined on the surface of the earth. The profile along the centre line and cross sections at interval can be plotted through appropriate surveying. Earthwork in such cases can be computed by computation of the cross-sectional area and application of the relevant rule.

Methodology

The research work, made comparison between Simpson's and Trapezoidal's formulae for calculation of volumes of earthwork. Cross sections and longitudinal sections were taken and the accuracy was determined by spacing of the cross sections.

Equipments/Materials Used

- Global Positioning System (GPS)
- Total Station (Leica TC 705)
- Reflector Prism
- Pegs, nails, beacon caps, hammers.
- One (100m) steel band tape.
- Pentium IV desktop computer with 256MB RAM and 40GB hard disk.
- DeskJet (printer)

Software Used

- Autodesk Land Development (ALD)

Virtually all the primary data were sourced from the State Bureau for Land and Surveying Jalingo and the Secondary Data was directly obtained from the field observation and part of the data was also obtained from PW (a construction firm). The data were acquired using Total Station Instrument and the GPS (Garmin. 12) giving the coordinates and height of the various stations. This include X;Y and Z (vertical and horizontal controls.

Survey control Establishment and the Design of Horizontal and Vertical Curve

The Global Position System (GPS) was used to obtain the coordinates of the various station points, that input into the instrument over the same station. The points number 1 – 135. (see table for data download from Total Station) Orientation station was set to serve as a reference control and measurements were taken to the orientation stations for linear and angular misclose.

The horizontal curve is one of the primary design control elements. It expresses the tangents and curves of a highway. A careful coordination of the horizontal alignment, vertical alignment, curvature, design speed, sight distance, super-elevation and the aesthetic principle are necessary at the initial design stage. In calculating the horizontal alignment the following formulae was used:

Data

$$TL = R \operatorname{Tan}\left(\frac{\phi}{4}\right)$$

$$CL = (2*\pi R)*\left(\frac{\phi}{360}\right) \quad \text{if } \phi \text{ is in degree}$$

$$CL = (2*\pi R)*\left(\frac{\phi}{400}\right) \quad \text{if } \phi \text{ is in grade}$$

$$EXT = TL * \operatorname{Tan}\left(\frac{\phi}{4}\right)$$

EXT = External Distance (m)

$$R = TL* \operatorname{Tan}\left(\frac{\phi}{2}\right)$$

TP_1 chainage = P_1 chainage – TL

TP_2 chainage = TP_1 chainage – CL

Where:

R = Radius of curve

ϕ = Deflection angle (deg or grad)

CL = Curve length (m)

TL = Tangent length (m)

PI = point of intersection

The vertical design of the road depends on a number of factors, such as passing/slopping site distance, drainage control, comfort of the travelens etc.

Vertical alignment is the longitudinal section of the road which shows the gradients and vertical curves mathematical representation is as follows:

L = KA---------------- (1)
Where;
L = length of the vertical curve
K = Constant which depends on the design speed
A = (G_1 – G_2) i.e. Algebraic difference of grades in percent

From Equation (1) $\left(K = \frac{L}{A}\right)$

The calculated value of K must be checked to ascertain whether it is greater than the minimum specified, then the assumed value of L is satisfactory, otherwise L should be changed and the calculation repeated.

Creating Cross Section/Profile

Calculation for the centreline slope is thus:

1) CHO + 000 to CHO + 200
   Final level at CHO + 000 = 232.38
   Final level at CHO + 200 = 235.18

Calc. (Final level at CHO + 200 – Final level at CHO + 000)/Dist*100

$$\frac{(235.18 - 232.38)}{200 * 100} = 1.4\%$$

2) CHO + 200 to CHO + 464.17
   Final level at CHO + 000 = 232.18
   Final level at CHO + 264.17 = 229.80

Calc.

$$\frac{(\text{Final level at CHO} + 264.17 \text{ - Final level at CHO} + 200)}{\text{Dist} * 100}$$

$$\frac{(232.38 - 235.18)}{264.17 * 100} = -2.01\%$$

Design Calculation for Horizontal Data
$\phi = 24^0\ 46'\ 56''$
R = 450m

The cross section and the profile were plotted using the data obtained from the total station; this was achieved by the use of ALD (Auto Desk Land Development). A software that was used in plotting the cross sections and the profile.

Presentation of Result and Analysis

Presentation of result

Horizontal Control

The horizontal control observed in the field as reference coordinate (RC) for easting and Northings was 762005.030, and 983957.890. The existing ground levels were obtained by survey, which acted as guide in the determination of the final level of the road.

$$TL = RTan\left(\frac{\phi}{4}\right)$$

TL = 450* Tan ($24^0\ 46'\ {}^{56''}\!/_{2}$) = 9886m

$$EXT = TL*Tan\left(\frac{\phi}{4}\right)$$

= 98*866*Tan($24^0\ 46'\ {}^{56''}\!/_{2}$) = 10.73

$$CL = Rtan\ Tan\left(\frac{\phi}{4}\right)$$

$$= \frac{(2 * 3.142 * 450) * 24^0 46'56''}{360} = 194.63$$

TP_1 = Chainage = P_1 chainage – TL
= 302.21 – 98.866 = 203.344m

TP_2 = Chainage = TP_1 chainage + CL
= 203.344 + 194.63 = 397.978m

Table 1: Tabulated Horizontal Curve Data

Curve Data	ϕ (deg)	Ext (m)	R(m)	CL(m)	TL (m)	IP (m)	TP_1	TP_2
1	24.782	10.73	450	194.63	98.866	302.21	203.344	399.9
2	7.143	0.681	350	43.632	21.844	584.39	562.54	606.18
3	68.59	31.37	150	179.58	102.31	1854.6	1752.32	1931.9
		4		9	9	4		1

Vertical Control

An assumed datum height Δ232 was used for the cross section.

Design calculation

Formula for k = L/A

Curve No. 1 L = 200

$G_1 = 1.4$

$G_2 = -2.01$

$A = (G_1 - G_2)$

$= 1.4 - (-2.01)$

$= 3.41$

$$k = \frac{200}{3.41} = 58.65$$

The positive sign only implies Hogging (crest) curve.

Since kmin< k(28<58.65) then L is satisfactory.

Curve No. 1 L = 264

$G_1 = -2.01$

$G_2 = -0.06$

$A = (G_1 - G_2)$

$= -2.01 - (-0.06)$

$= -1.95$

$$k = \frac{175}{-1.95} = -89.74$$

The minus implies sag curve Table 2: Tabulated vertical curve data

PV1	Station	Elevation	Grade out	Curve length	Type	K
	0.00	232.38	1.4		Crest	58.55
	200	235.18	–2.01	200	SAG	89.54
	464.17	229.86	–0.06	175		

Cross Section

The cross section was plotted using Auto Desk Land Development at horizontal and vertical scale of 1:100. The result of plotting show slight difference in the central height; this means that it is a level section (a relatively uniform slope) because of this the side slope used is 1.1 and 1.2 obtained by filling the approximate slope table on the Auto Desk Land Development software.

Table 3: Cut Area Computation for Cross section

Station	h	B	M	mh	b + mh	h(b + mh)
0 + 000	0.020	12.8	1	0.020	12.820	0.256
0 + 025	0.014	12.8	1	0.014	12.810	0.179
0 + 050	0.020	12.8	1	0.020	12.820	0.256
0 + 075	0.189	12.8	1	0.189	12.990	2.455
0 + 100	0.186	12.8	1	0.186	12.990	2.416
0 + 125	0.501	12.8	1	0.501	13.300	6.663
0 + 150	0.085	12.8	1	0.385	13.185	5.075
0 + 175	0.496	12.8	1	0.496	13.296	6.594
0 + 200	0.608	12.8	1	0.608	13.408	8.152
0 + 203	0.558	12.8	1	0.558	13.358	7.454
0 + 225	0.608	12.8	1	0.608	13.408	8.152
0 + 250	0.303	12.8	1	0.303	13.103	3.970
0 + 275	0.605	12.8	1	0.608	13.405	8.110

Table 4: Fill Area computation

Station	h	B	M	mh	b + mh	h(b + mh)
0 + 300	0.669	12.8	1	0.669	13.469	5.011
0 + 325	0.667	12.8	1	0.667	13.467	8.982
0 + 350	0.556	12.8	1	0.556	13.356	7.426
0 + 375	0.323	12.8	1	0.323	13.123	4.239
0 + 398	0.808	12.8	1	0.868	13.668	11.803
0 + 400	0.132	12.8	1	0.132	12.932	1.707
0 + 425	0.525	12.8	1	0.525	13.325	6.996
0 + 450	0.622	12.8	1	0.124	14.044	8.735
0 + 475	0.567	12.8	1	1.134	13.934	7.901
0 + 500	0.436	12.8	1	0.872	13.672	5.961
0 + 525	0.195	12.8	1	0.390	13.190	2.572
0 + 550	0.149	12.8	1	0.298	13.098	1.952
0 + 575	0.471	12.8	1	0.942	13.742	6.472
0 + 600	0.560	12.8	1	1.120	13.742	7.696
0 + 606	0.508	12.8	1	1.016	13.816	7.157
0 + 625	0.536	12.8	1	1.072	13.872	7.435

Volumes by Simpson's Rule

Volume of cut by Simpson's rule is given by:

$$\frac{D}{3}\left[A_1 + A_N + 4\left(A_2 + A_4 + ...A_{N\text{-}1}\right) + 2\left(A_3 + A_5 + ...A_{N\text{-}2}\right)\right]$$

And volume of fill by Simpson's rule is given by:

$$V_1 = \frac{D}{3}\left[A_1 + A_{N\text{-}1} + 4\left(A_2 + A_4 + ...A_{N\text{-}1}\right) + 2\left(A_3 + A_5 + ...A_{N\text{-}2}\right)\right]$$

The result computed for the volume by Simpson's rile are 1380.514m^3 (cutting) and 2431.683m^3 (filling).

Volume of cut by Trapezoidal Rule:

$$V = \frac{D}{2}\left[A_1 + A_{N\text{-}1} + 2\left(A_2 + A_3 + ...A_{N\text{-}1}\right)\right]$$

The result computed by this formulae after correction are: 1385.764m^3 and 2567.288m^3.

Application of Prismoidal correction to Trapezoidal Rule:

Prismoidal formulae for section is given by

$$CP_C = d/3\, S(h_1 + h_2)^2$$

CP_C = Prismoidal correction

$d = 25$ $S = 1$ $h_1 = 0.020(0+000)$ $h_2 = 0.014\ (0+025)$

(chainage 0 + 000 to 0 + 275)

$$CP_{C1} = \frac{25}{3}(0.020 - 0.014)^2 = 0.00029988$$

$$CP_{C2} = \frac{25}{3}(0.014 - 0.020)^2 = 0.00029988$$

$$CP_{C3} = \frac{25}{3}(0.020 - 0.189)^2 = 0.237998813$$

$$CP_{C4} = \frac{25}{3}(0.189 - 0.186)^2 = 0.000074997$$

$$CP_{C5} = \frac{25}{3}(0.186 - 0.501)^2 = 0.526841925$$

$$CP_{C6} = \frac{25}{3}(0.501 - 0.385)^2 = 0.112128848$$

$$CP_{C7} = \frac{25}{3}(0.385 - 0.496)^2 = 0.102670893$$

$$CP_{C8} = \frac{25}{3}(0.496 - 0.608)^2 = 0.104529152$$

$$CP_{C9} = \frac{25}{3}(0.608 - 0.558)^2 = 0.0208325$$

$$CP_{C10} = \frac{25}{3}(0.558 - 0.608)^2 = 0.0208325$$

$CP_{C11} = \frac{25}{3}(0.608-0.303)^2 = 0.775177325$

$CP_{C12} = \frac{25}{3}(0.303-0.605)^2 = 0.760002932$

Connect Trapezoidal's volume is given as

Trapezoidal volume – CP_{C1} + CP_{C2} + CP_{C3} + CP_{C4} + CP_{C5} + CP_{C6} + CP_{C7} + CP_{C8} + CP_{C9} + CP_{C10} + CP_{C11} + CP_{C12} = 2.9611389752

$\Rightarrow$ 1388.725–2.9611389752 = 1385.7636m^3

Volume of fill computation by Trapezoidal rule is given by;

$$\frac{D}{2}[A_1 + A_{N-1} + 2(A_2 + A_3 + ...A_{N-1})]m^3$$

Computed volume = 2579.450 Chainage (0 + 300 to 0 + 625)

$CP_{C1} = \frac{25}{3}(0.669-0.667)^2 = 0.000033332$

$CP_{C2} = \frac{25}{3}(0.667-0.556)^2 = 0.102670892$

$CP_{C3} = \frac{25}{3}(0.556-0.323)^2 = 0.452390237$

$CP_{C4} = \frac{25}{3}(0.323-0.868)^2 = 2.475109325$

$CP_{C5} = \frac{25}{3}(0.868-0.132)^2 = 4.513952768$

$CP_{C6} = \frac{25}{3}(0.132-0.525)^2 = 1.287023517$

$CP_{C7} = \frac{25}{3}(0.525-0.622)^2 = 0.078405197$

$CP_{C8} = \frac{25}{3}(0.622-0.567)^2 = 0.05041465$

$CP_{C9} = \frac{25}{3}(0.567-0.436)^2 = 0.286005226$

$CP_{C10} = \frac{25}{3}(0.436-0.195)^2 = 0.967977946$

$CP_{C11} = \frac{25}{3}(0.195-0.149)^2 = 0.035265256$

$CP_{C12} = \frac{25}{3}(0.149-0.471)^2 = 1.727997544$

$CP_{C13} = \frac{25}{3}(0.471-0.560)^2 = 0.132011386$

$CP_{C14} = \frac{25}{3}(0.560 - 0.508)^2 = 0.045664864$

$CP_{C15} = \frac{25}{3}(0.508 - 0.536)^2 = 0.613066144$

Corrected Trapezoidal Volume

Trapezoidal volume – CP_{C1} + CP_{C2} + CP_{C3} + CP_{C4} + CP_{C5} + CP_{C6} + CP_{C7} + CP_{C8} + CP_{C9} + CP_{C10} + CP_{C11} + CP_{C12} + CP_{C13} + CP_{C14} + CP_{C15}

= 2579.450 – 12.1618303

= 2567.288m^3

Table 5: Summary of volumes computation

Station	Volumes by Simpson's Rule (m^2)	Volumes by Trapezoidal Rule (m^3)	Difference (m^2)
0+00 to 0+275	1380.514	1385.764	05.25
0 + 300 to 0 + 625	2431.683	2567.288	135.605

Analysis of Results

Comparison of Simpson's and Trapezoidal Rules

The computed result in Simpson's rule for both fill and cut; 0+000 to 0+275 and 0+300 to 0+625, gave lesser volume, which by implication, Simpson's rule is more precise than Trapezoidal rule. (See Table 5).

From the results obtained at various levels of formular application, in terms of speed of operation, manually, Simple's rule is preferred; this is because for every Trapezoidal rule, prismoidal correction was applied to obtain an approximate result.

In terms of accuracy, since Simpson's rule assumed boundary between the various sections are arc of a parabola, hence the computed results are more accurate than Trapezoidal rule.

This contributes in ensuring that expenditure on earthwork is not out of budget and does not press on the total cost of the project invested.

Conclusion and Recommendation

This research study discussed earthwork determination in road design. Results of comparison between Simpson's and Trapezoidal rules shows that Simpson's rule give more accurate data in terms of precision, speed and accuracy in volume calculation, while Trapezoidal rule should only be applied where computation simplicity is required and for less accurate work where greater precision is not required. Hence, for success to be achieved in road construction, and for careful and judicious planning of earthwork determination the Simpson's rules should be employed.

The task of measuring areas and volumes in present day road construction, emphases should be made on correct areas and volumes determination, which are capable of good planning of works. The issue of correct quantity determination of earthwork should be addressed so that issues associated with swelling and shrinkage of soil materials used in earthwork quantities can be avoided.

Therefore Simpson's rule and Trapezoidal rules for earthwork calculations would give true volume if and of the following recommendations are employed:

- Programs calculations using various software packages, such as MATLAB, FORTRAN should be used to give better and precise results.
- The existing road, in cross section drawing faces the danger of being washed off in future by rain water, hence drainage facilities should be provided.
- Prismoidal correction can be applied to the trapezoidal rule for volume computation, while curvature correction should be applied to both Simpson's and Trapezoidal rule.

DATA DOWNLOADED FROM TOTAL STATION

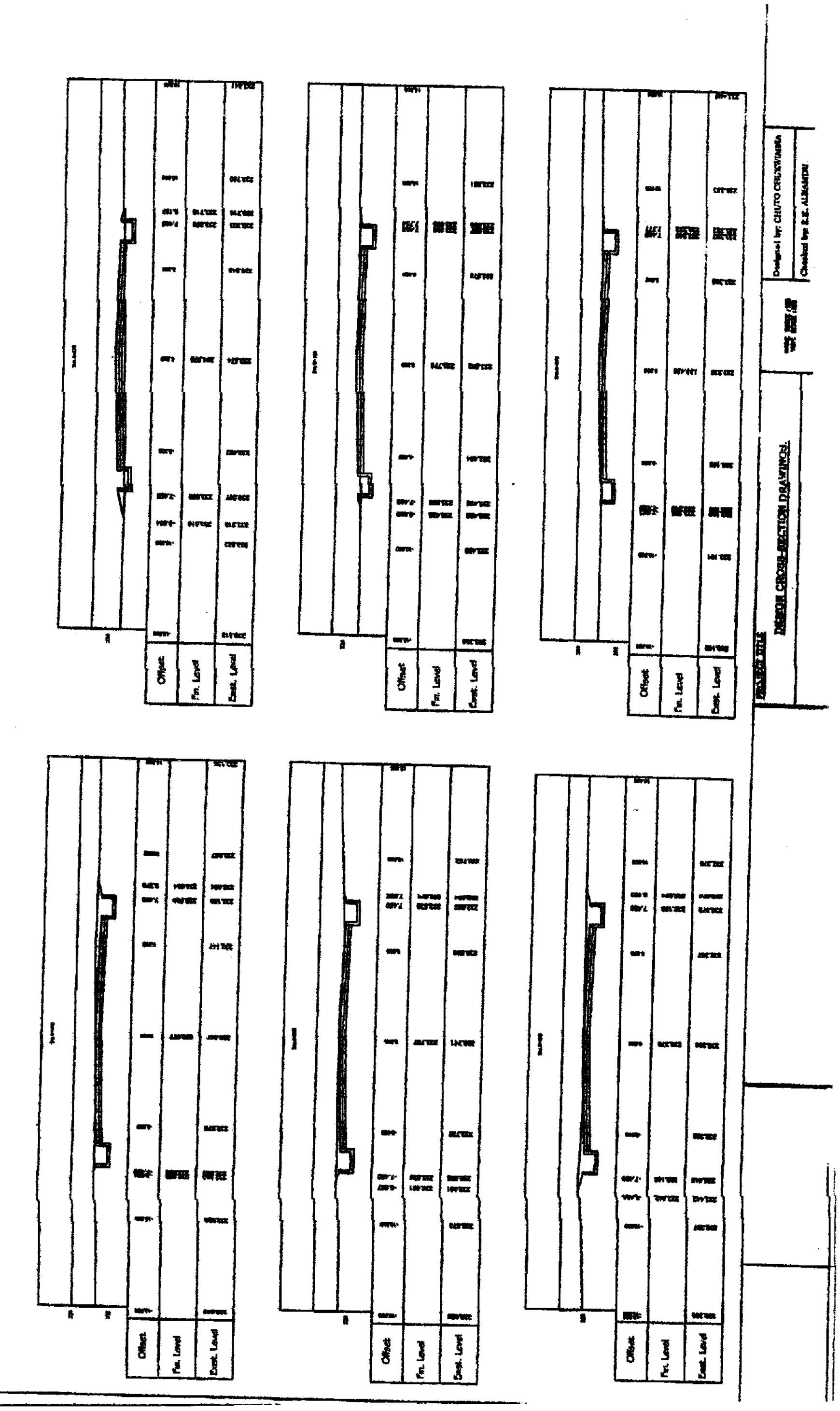
Station	X	Y	Z
RC	762005.3	983957.8	232.000
C000	762001.8	983956.6	232.276
L000	761997.1	983955.6	232.463
L001	761990.3	983954.6	232.265
R000	762006.5	983958.1	232.403
R001	762020.7	983961.1	232.674
C025	762000.2	983980.5	232.717
L025	761996.2	983979.9	232.716
L026	761985.6	983977.6	232.614
R025	762003.9	983980.8	232.517
R026	762014.9	983983.4	232.952
C050	761994.9	984005	233.044
C050	761994.9	984004.9	233.065
L050	761991.1	984004.1	232.971
L051	761979.6	984003.5	232.877
R050	761999.2	984005.9	233.149
R051	762006.6	984005.9	233.026
C075	761989.6	984029.3	233.235
L075	761985.5	984028.2	233.182
L076	761975	984024.6	233.13
R075	761992.7	984030.4	233.285
R076	761993.3	984031	233.304
C100	761984.3	984053.8	233.569
L100	761980.6	984052.6	233.458
L101	761970.3	984048.5	233.343
R100	761986.4	984054.5	233.648
C125	761979.3	984078.1	233.548
L125	761975.7	984075.5	233.431
L126	761965.1	984068	233.39
R125	761982.2	984079.8	233.583
R126	761989.1	984085	233.782
C150	761974.5	984108.6	233.905

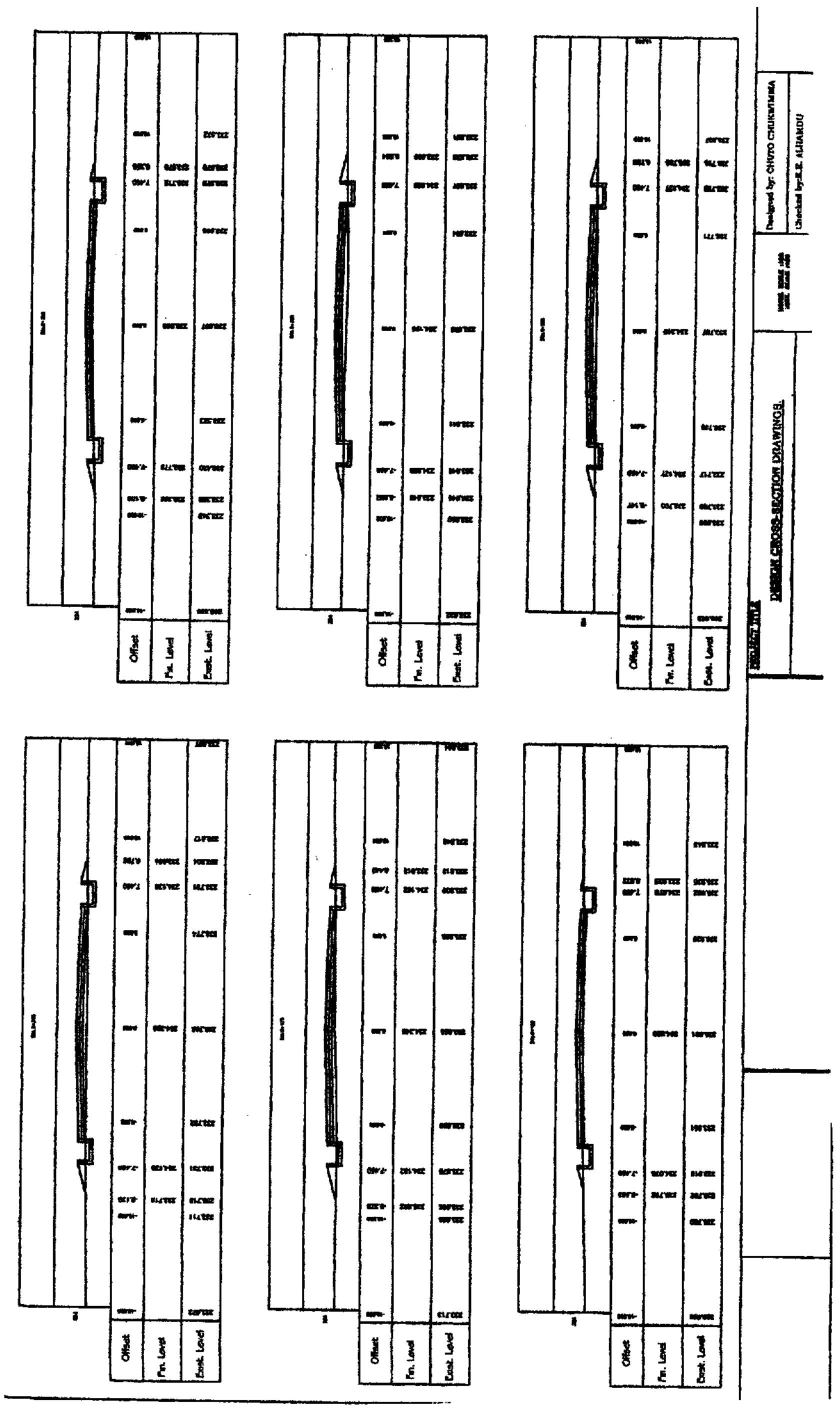
L150	761970.7	984107.2	233.875
L151	761961.9	984103.5	233.712
L152	761961.4	984102.8	233.699
R150	761977.1	984109.6	233.914
R151	761985.2	984111.7	233.99
C175	761968.6	984127.1	233.798
L175	761965	984125.7	233.643
L176	761955.3	984120.9	233.715
R175	761972.4	984129.1	233.842
R176	761983.2	984130.3	233.989
C200	761963.3	984151.5	233.787
L200	761960.3	984148.9	233.768
L201	761952.2	984147.3	233.701
R200	761967.1	984152.7	233.755
R201	761976	984157.2	233.822
C225	761958.1	984175.9	233.702
L225	761954.8	984174.8	233.657
L226	761946.3	984170.7	233.689
R225	761961.1	984178.8	233.518
R226	761972.6	984179.6	233.681
CP4	761965.1	984203.3	233.524
C250	761953.5	984208.4	233.626
L250	761949.2	984207.8	233.389
L251	761936.6	984207.8	233.219
R250	761957.6	984210	233.387
R251	761965.6	984212.9	233.432
C275	761943.4	984223.8	233.058
L275	761939.5	984221.7	233.036
L276	761932.6	984219.6	233.021
R275	761947.7	984225.8	232.999
R276	761956.5	984228.5	232.969
C300	761934.3	984247.2	232.53
L300	761930.6	984244.9	232.543
L301	761921.2	984239.9	232.601
R300	761939	984249.6	232.501
R301	761947.4	984254.4	232.376
C325	761924	984270	231.997
L325	761920.6	984268	232.042
L326	761912.3	984263.3	232.073

R325	761927.7	984272	232.022
R326	761938.1	984276.2	231.942
C350	761912.2	984292	231.898
L350	761908.9	984289.2	231.531
L351	761901.4	984281.8	231.659
R350	761914.3	984294.1	231.553
R351	761915.7	984295.7	231.54
CP6	761907.2	984302	231.381
CP7	761895.2	984313	231.024
C375	761899.3	984313.5	231.046
L375	761896.9	984311	231.041
L376	761889.3	984302.4	231.305
R375	761901.3	984315.9	230.941
R376	761906	984320.7	230.759
C400	761885.3	984334.1	230.255
L400	761882.4	984331.5	230.531
L401	761875.5	984324.3	230.687
R400	761887.8	984336.9	230.208
TBM3	761857	984327	230.826
C425	761870.8	984354.2	230.333
L425	761868.7	984350.1	230.5
L426	761860.4	984343.4	230.418
R425	761873.5	984359.1	229.972
R426	761879.5	984366.1	229.977
CP8	761863.9	984374	229.797
CP9	761854.8	984389.3	229.527
C450	761856.6	984373.8	229.91
L450	761853.8	984371.5	230.002
L451	761850.9	984369.1	229.96
R450	761858.5	984377.1	229.72
R451	761863.8	984381.6	229.628
C475	761841.3	984394.7	229.62
L475	761838.1	984392.1	229.72
L476	761829.4	984385.1	230.066
R475	761843.7	984397.8	229.497
R476	761852.2	984405	229.308
C500	761826.5	984415	229.578
L500	761823.2	984412.9	229.525
L501	761814.8	984406.1	230.006

R500	761829.2	984416.4	229.655
R501	761833.9	984420.7	229.349
CP10	761780.5	984437.1	230.023
CP11	761772.8	984446.7	230.003
C525	761804.1	984426.6	229.753
L525	761800.7	984423.3	229.838
L526	761795.4	984420.3	229.971
R525	761806.3	984428.3	230.518
R526	761810.5	984430.4	230.416
L550	761784.4	984442.9	229.682
L551	761779.7	984438.9	229.909
CP12	761737.7	984533.4	228.931
CP13	761723.8	984546	228.917
TBM4	761759.4	984467.9	230.154
C575	761782.5	984475.7	229.189
L575	761779.4	984473.3	229.365
L576	761770.3	984466.7	229.589
R575	761785	984478.4	229.039
R576	761794.6	984487	228.375
C600	761769	984492.1	229.163
L600	761766.2	984489.8	229.422
L601	761757.9	984484.8	229.566
R600	761771	984494.5	229.098
R601	761778.6	984500.5	229.094
C625	761751.8	984512.9	229.275
L625	761747.9	984510.6	229.275

CROSS-SECTIONAL AREA

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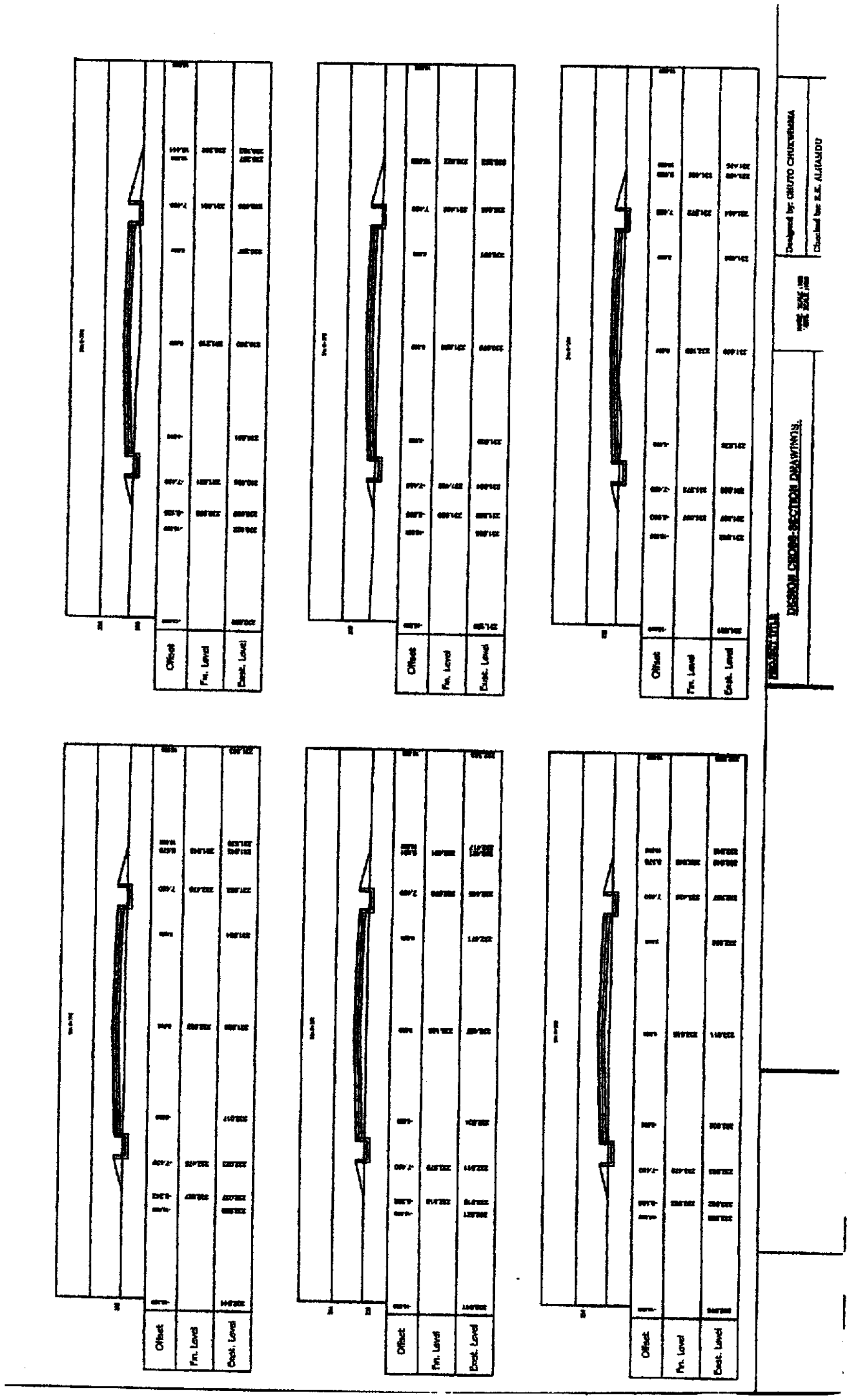

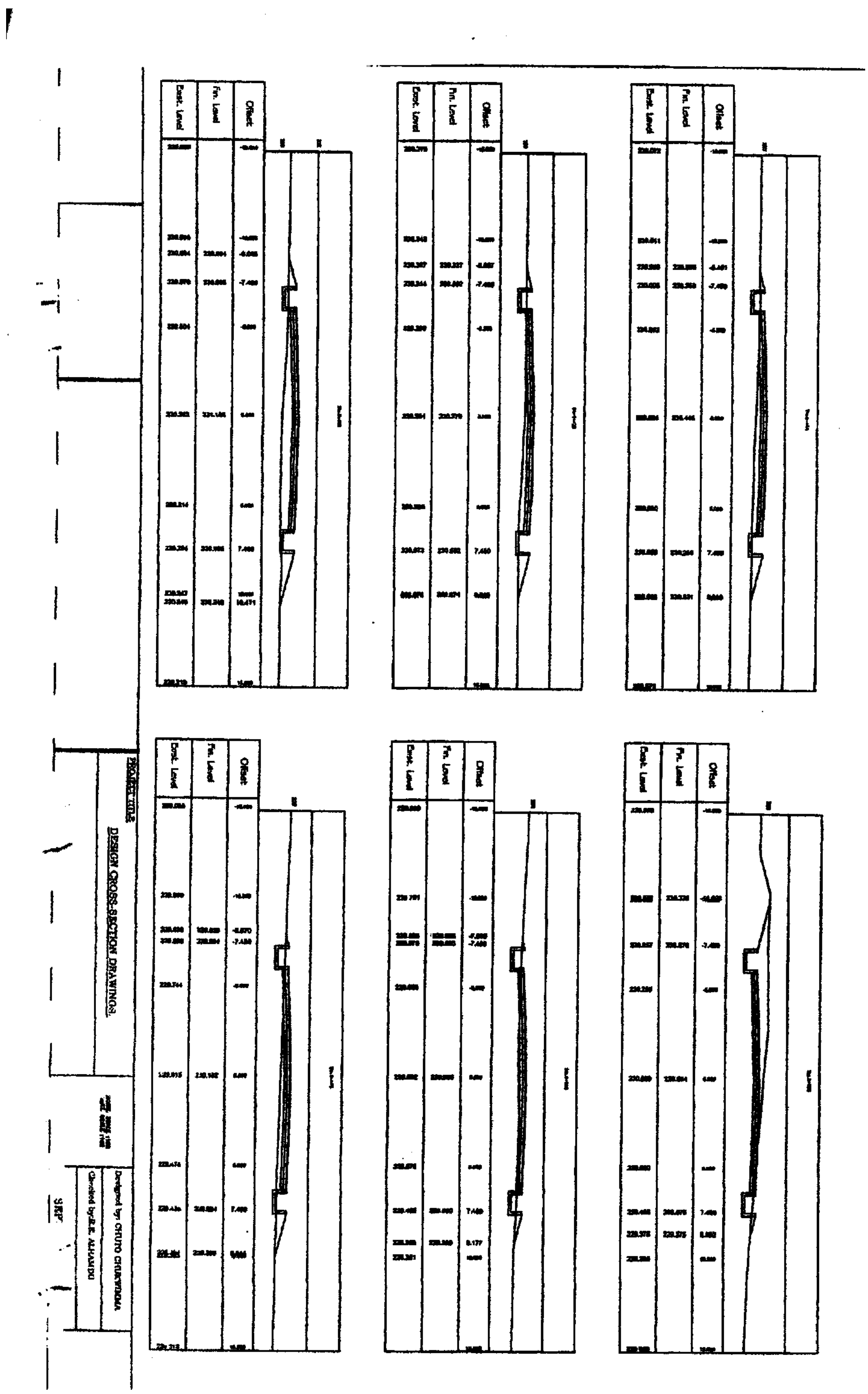
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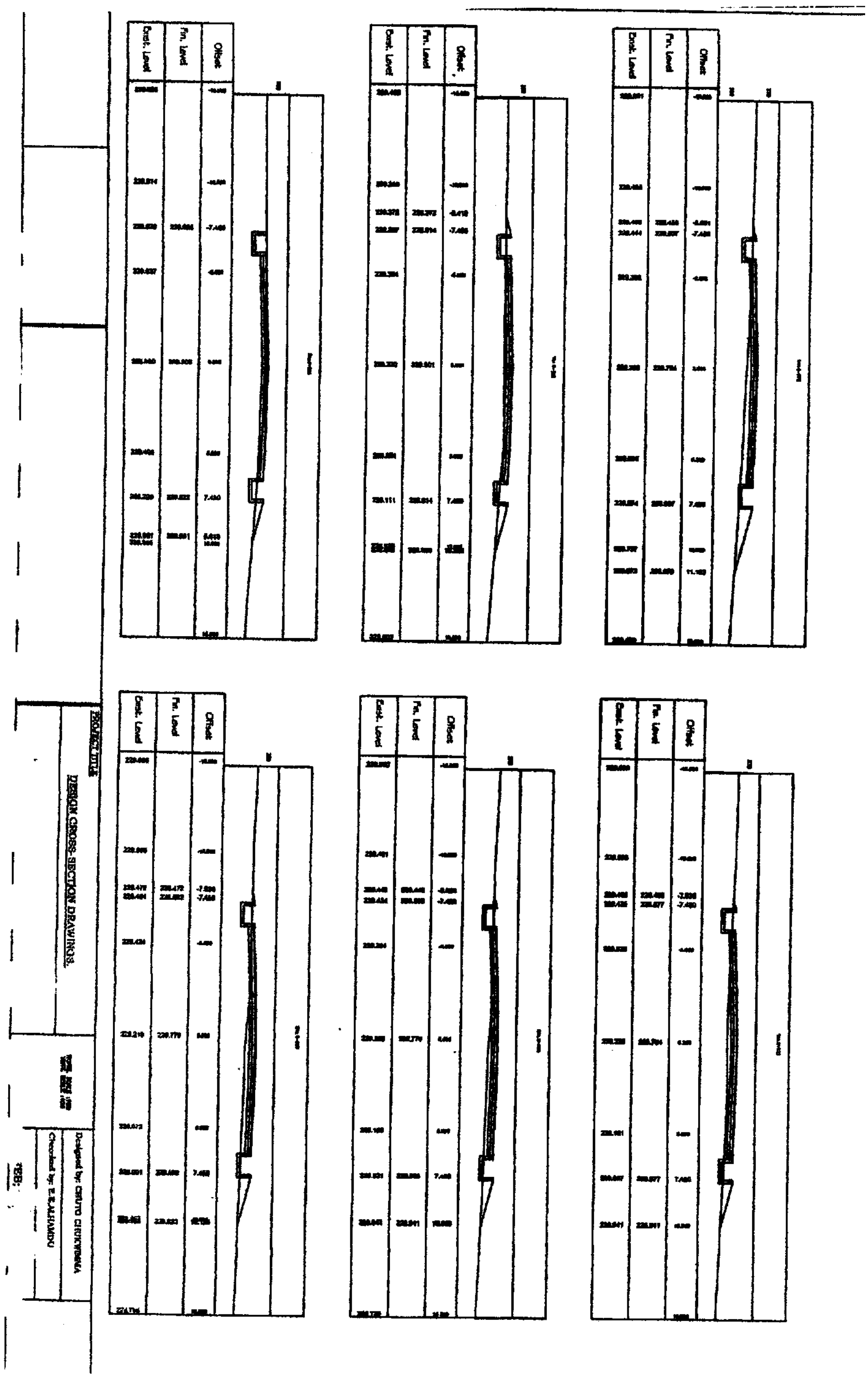
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