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The effect of a polygon route that is not stretched on the investigation of a rough incorrectly measured angle and edge

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Abstract

When a traverse net is in a tense position, the angles measured between the directions observed at the traverse points are close to 200^g. If the angles measured between the directions observed at the traverse points are around 100^g or 300^g, this indicates that the net is not in a tight manner. In both the Large-Scale Map and Map Information Production Regulation and the 1/2500 Large Scale Map Production Regulation, which was abolished, the traverse nets created must be stretched. In the event that the net is disturbed for compulsory reasons, there is no problem in the coordinate calculation of the traverse unless a rough error is made in the size of the edge and angle. However, if a rough error is made in the angle or edge dimension on a non-taut traverse net, is it possible to determine the point where the rough faulty edge or rough faulty angle is measured with the taught rules? Whether this is possible or not was investigated in this study. In this study, theoretical information on the subject has been given and practical studies have been done. Findings and opinions obtained as a result of the study are stated.

1. Introduction

When a traverse net is in a taut position, the angles measured between the directions observed at the traverse points are close to 200^g. If the angles measured between the directions observed at the traverse points are around 100^g or 300^g, this indicates that the net is not in a taut manner. A limitation has been imposed on the length of the net in order to ensure tautness in the traverse nets both in the Large-Scale Map and Map Information Production Regulation and in the abolished Large-Scale Map and Map Information Production Regulation.

For the total length of the traverse net, it must not exceed 1.5 times the length between the start and end points of the net. The formulas developed for the investigation of the coarse faulty edge and coarse faulty angle in the polygon [1-7] were developed for taut nets.

In practice, sometimes there are cases where the above requirement for taut nets cannot be fulfilled due to terrain conditions. A question may come to mind. What harm can it be to create a non-taut traverse net with a rough faulty edge or a faulty angle to the rough, in case of necessity. In such cases, if the angles and edges of the traverse are measured more carefully, there will be no abnormal situation in traverse coordinate calculations.

However, if a rough error is made in the edge size or angle measurement on a non-taut traverse net, how long are the rules for investigating the rough error in taut nets.

In a study conducted on this subject [3], information was obtained about the investigation of the rough defective edge on a non-taut traverse net, but a study on the investigation of the rough defective angle on a non-taut traverse net was not found in the literature [8-17].

This study was carried out in order to explain the situations that occurred during the investigation of a rough error in the edge size of a non-taut traverse net and to investigate the effects of a rough error in the angle size on this specified net. Theoretical information on the subject has been given and practical studies have been made, and the findings and opinions obtained as a result of the study have been stated.

2. The effect of a non-taut traverse net shape on the investigation of a roughly faulty edge

A coarse faulty edge on a taut traverse net may have been measured longer or shorter than its exact value. In the investigation of rough faulty edge on the traverse net; It is first investigated whether the rough faulty edge is measured longer or shorter than its exact value.

In Figure 1;

$$[\Delta Y] = \Delta Y_1 + \Delta Y_2 + \ldots\ldots\ldots + \Delta Y_n \tag{1}$$

$$[\Delta X] = \Delta X_1 + \Delta X_2 + \ldots\ldots\ldots + \Delta X_n \tag{2}$$

$$\overline{\Delta Y} = Y_C - Y_B \tag{3}$$

$$\overline{\Delta X} = X_C - X_B \tag{4}$$

$$\overline{BC}' = \sqrt{([\Delta Y]^2 + [\Delta X]^2)} \tag{5}$$

$$\overline{BC}'' = \sqrt{([\Delta Y]^2 + [\Delta X]^2)} \tag{6}$$

$$\overline{BC} = \sqrt{(\overline{\Delta Y}^2 + \overline{\Delta X}^2)} \tag{7}$$

$$fy = \overline{\Delta Y} - [\Delta Y] \tag{8}$$

$$fx = \overline{\Delta X} - [\Delta X] \tag{9}$$

$\overline{BC}' > \overline{BC}$ if the coarse faulty edge is measured longer than its absolute value,
$\overline{BC}'' < \overline{BC}$ if the rough edge is measured shorter than the absolute value.

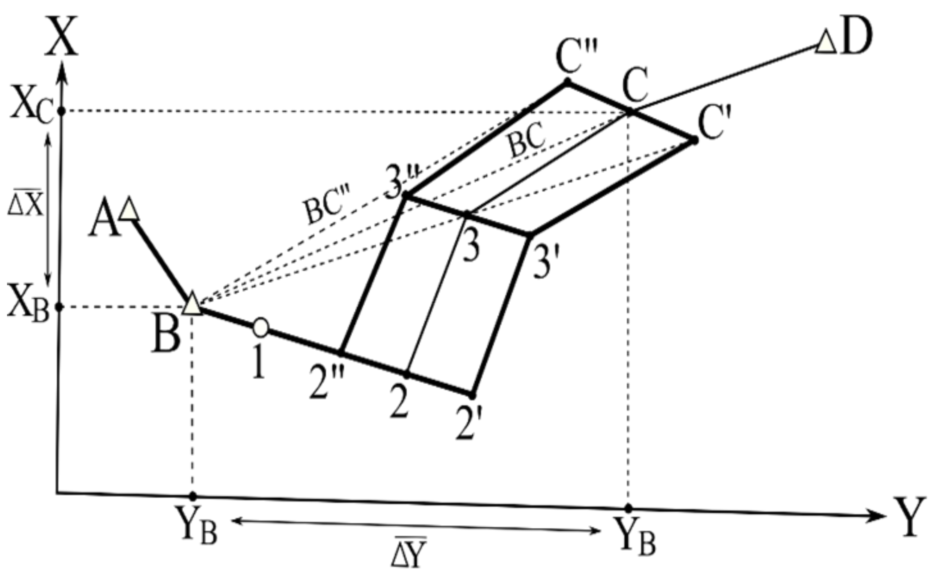

Figure 1. Schematic view of $\overline{BC}$, $\overline{BC}'$ and $\overline{BC}''$ in the form of a taut traverse net.

After determining the condition of the rough faulty edge, to find the approximate bearing angle of the rough faulty edge:

$$(CC') = \text{arc tan } \left(\frac{-fy}{-fx}\right) \tag{10}$$

If the coarse faulty edge is measured longer than its absolute value, the following equation is applied.

$$(CC') = \text{arc tan } \left(\frac{-fy}{-fx}\right), (C''C) = \text{arc tan } \left(\frac{fy}{fx}\right) \tag{11}$$

If the coarse faulty edge is measured shorter than its exact value (C''C) = arc tan (fy / fx) (11) relation applies [3].

If the bearing angle calculated from Equation (10) or (11) is approximately equal to the bearing angle of which edge in the polygon coordinate calculation chart, that edge is the rough faulty edge. If the shape of the traverse net is not taut and the rough error is made at the edge where the net tautness is distorted the most (Figure 2), the following situations are seen in the rough error edge investigation:

1-When the effect of an edge measured longer than its absolute value with coarse errors, on the (C) position of the end point of the net is examined, it should be $\overline{BC}$'>$\overline{BC}$, while $\overline{BC}$'<$\overline{BC}$ situation is encountered.
2-When the effect of an edge measured shorter than its absolute value with rough error on the position (C) of the end point of the net is examined, it should be $\overline{BC}$''<$\overline{BC}$, while $\overline{BC}$'>$\overline{BC}$ situation is encountered.

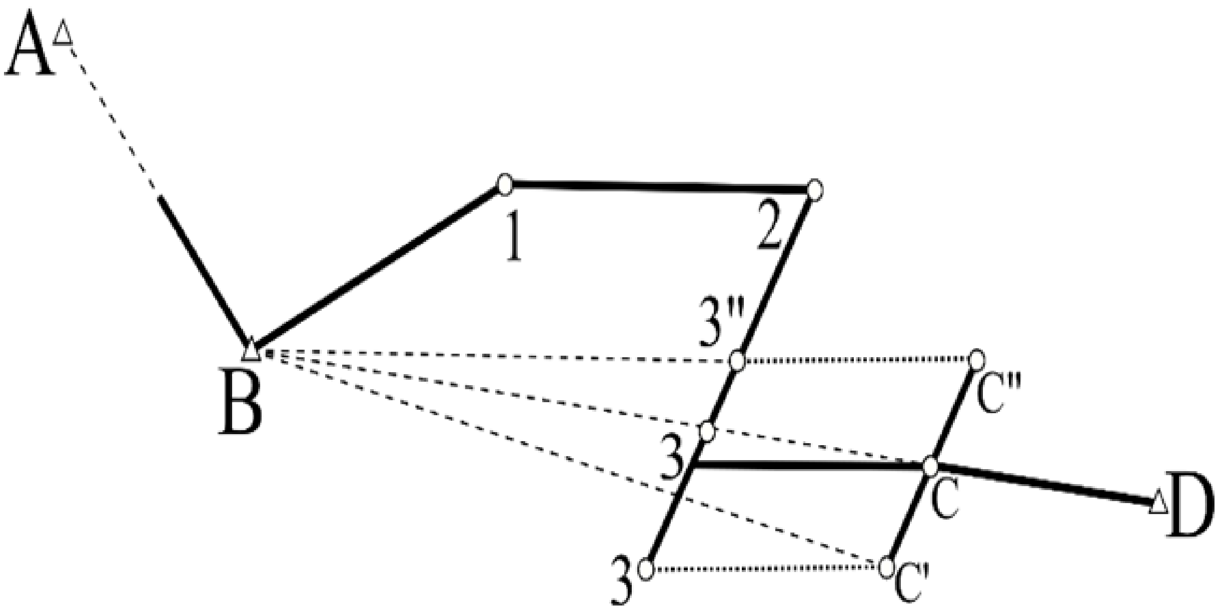

Figure 2. The effect of a rough error on an edge that deviates significantly according to the direction of the route on the position of the end point of the net (Schematic view of ($\overline{BC}$, $\overline{BC}'$ and $\overline{BC}''$)

If the shape of the traverse net is not taut and the rough error is made at an edge where the net tautness is not disturbed (Figure 3), the effect of this rough error on the position of the end point of the net is similar to that of the taut net.

In other words, if the coarse faulty edge is measured longer than its exact value, BC '> BC 'condition and if the coarse faulty edge is measured shorter than its absolute value, BC'' <BC condition is in question.

In Figure 3; The district obtained by Equations (10) or (11) because a misleading situation is encountered as $\overline{BC}$''>$\overline{BC}$ or $\overline{BC}$'>$\overline{BC}$ even though the rough error edge is measured longer or shorter than the absolute value angle will not reflect the actual situation.

In other words, it will not be possible to reach a definite conclusion from the provisions stated in the rough error edge search for taut traverse nets [3]. In this case, the measure of all sides on the traverse net will be repeated.

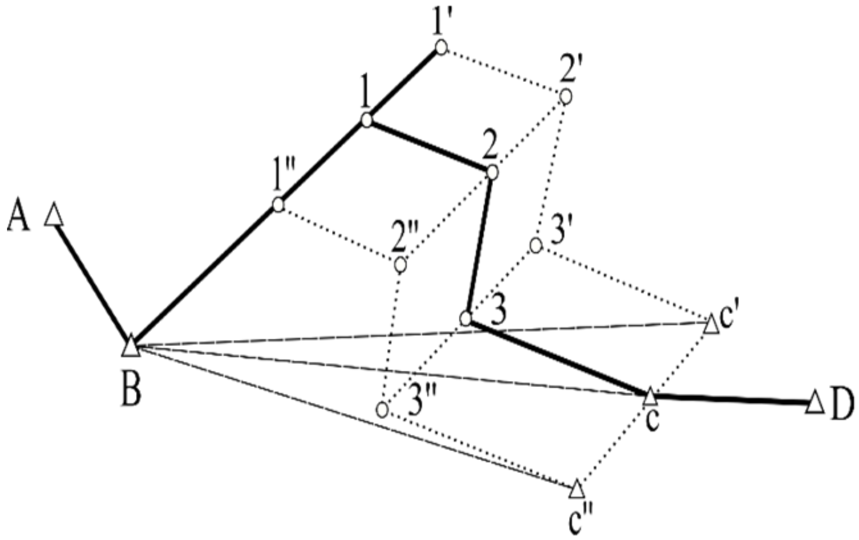

Figure 3. The effect of a rough error on an edge of the net that does not deviate significantly according to the direction of the net on the position of the end point of the net (Schematic view of $\overline{BC}$, $\overline{BC}'$ *and* $\overline{BC}''$)

3. The effect of a non -taut traverse net shape on the investigation of a roughly incorrect angle

In the graphical investigation of a rough error in angle measurement in a taut traverse net, the traverse points on the net are drawn on a plan according to their coordinates according to a determined scale. In the created plan, the middle perpendicular of the line, which combines the real position of the point where the traverse net is connected and its erroneous position, passes through the point where the wrong angle to the rough is measured [1], (Figure 4).

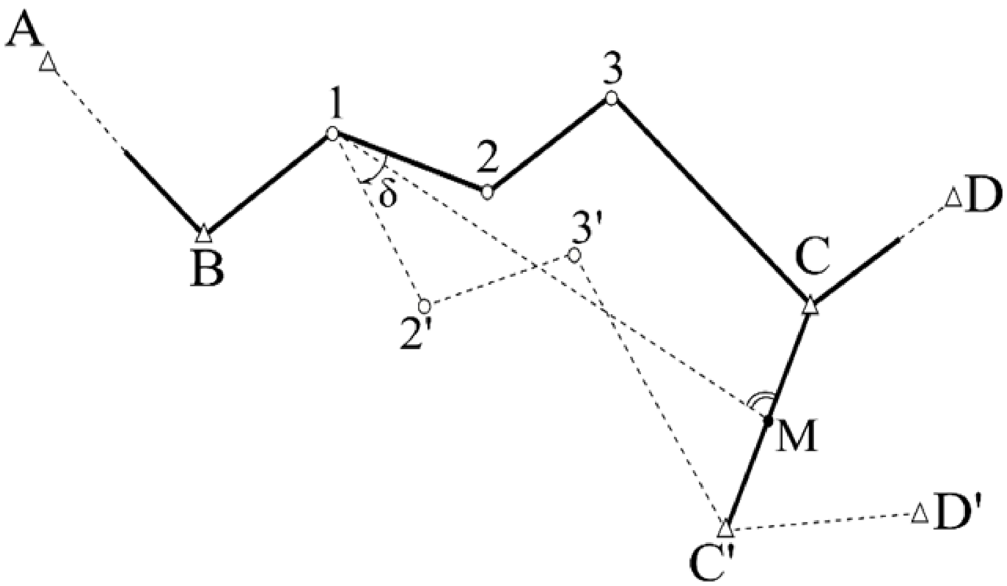

Figure 4. Graphically investigating the point where a rough erroneous angle is measured on the taut traverse net.

The following equations are applied in the investigation of the point where the rough angle is measured with the one-way calculation method.

$$Y_M = \frac{Y_C + Y'_C}{2}, \quad X_M = \frac{X_C + X'_C}{2} \tag{12}$$

δ = Angle-closing error exceeding the error limit to be

$$Y_P = Y_M - 0.5 * \frac{(X'_C - X_C)}{\tan\left(\frac{\delta}{2}\right)} \tag{13}$$

$$X_P = X_M + 0.5 * \frac{(Y'_C - Y_C)}{\tan\left(\frac{\delta}{2}\right)} \qquad (14)$$

The Y_P and X_P values calculated from the Equations (13) and (14) are compared with the coordinate values calculated in the polygon coordinate spreadsheet. The coordinate of which point in the polygon spreadsheet is approximately equal to the value of Y_P and X_P, the point where the rough angle is measured is that point. In the graphical detection of the rough error made in the angle measurement in a polygon on a non-taut traverse net, the following situation occurs in the above-mentioned plan. In this case, the middle perpendicular of the line that combines the real position of the point where the net is connected and its erroneous position does not pass through the point where the rough angle is measured (Figure 5). That is, in this case, it is not certain as in the taut net, the specified middle strut passes as shifted from the rough wrong point.

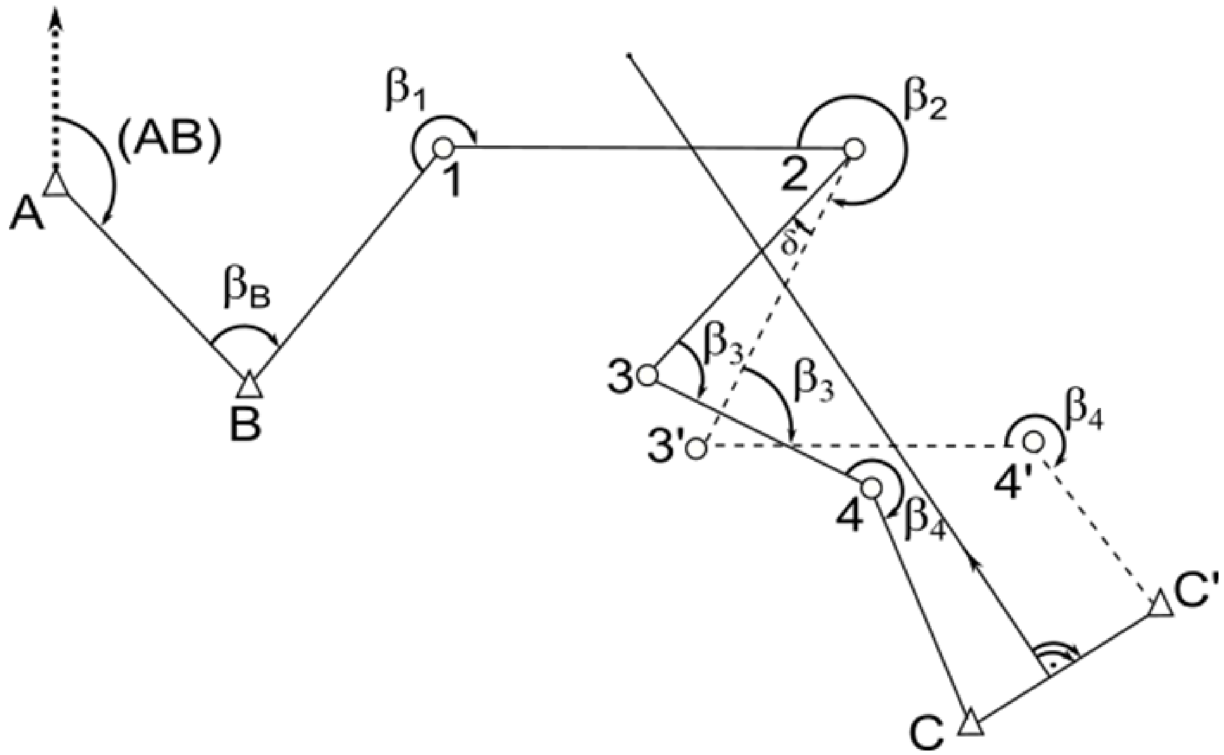

Figure 5. Graphically investigating the point where a rough erroneous angle is measured in the non-taut traverse net.

In this case, the Y_P, X_P coordinates obtained by the one-way calculation method are not very close to any of the coordinates calculated in the polygon coordinate spreadsheet. In this case, it will be necessary to use the only solution, two-way calculation method in investigating the gross error.

4. Numerical application

4.1. Applications related to coarse faulty edge investigation

In reality, a traverse net is taken into account, with angle measurements and edge dimensions without rough error and non-taut. It has been determined according to the formulas given below that the angle closure error, transverse closing error and longitudinal closing error do not exceed their error limits. In this given net (Figure 6), it was assumed that the two edges shown as an example were measured as longer and shorter than the exact value, and a rough faulty edge investigation was made.

Traverse angles;
β_B=152.1790 β_1=224.3075, β_2=375.7624, β_3=45.8265, β_C=242.3288,
Bearing angles:
(AB)= 125.3843 and (CD)= 165.7744
Traverse edges:
S_1 =320.50 m, S_2=350.36, S_3=180.65, S_4=345.86
Y_B= 29650.52m, XB=30584.92, YC=30454.48, XC=30498.66

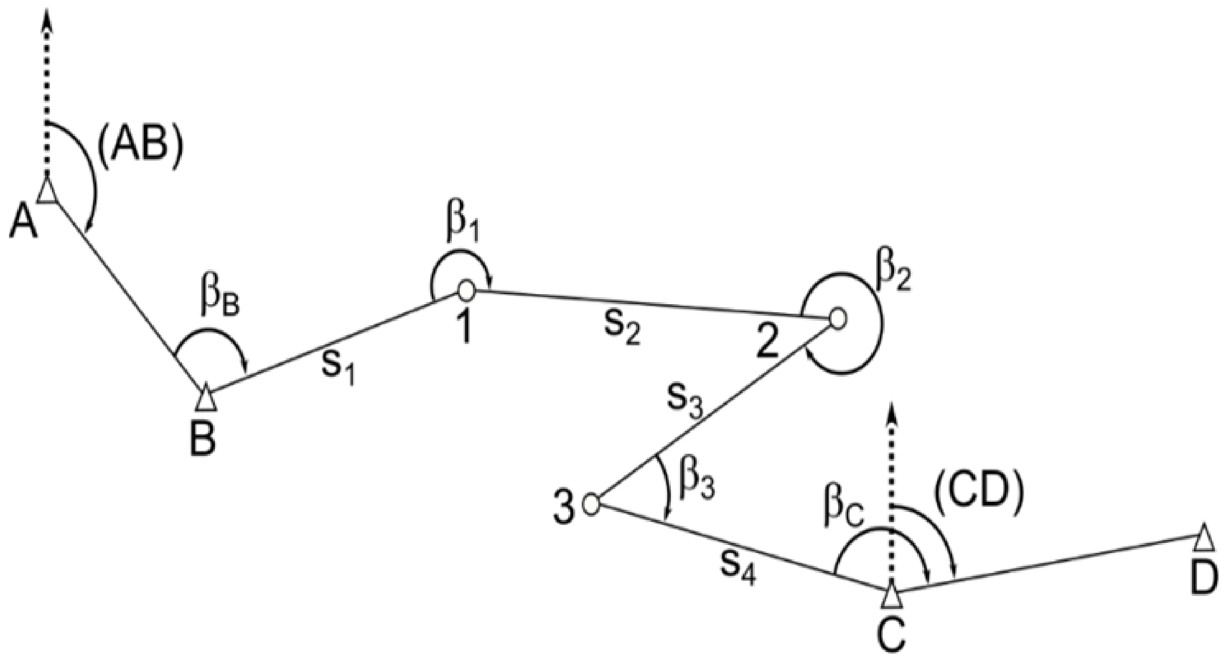

Figure 6. Graphically investigating the point where a rough erroneous angle is measured in the non-taut traverse net.

Table 1. Traverse coordinate spreadsheet with roughly accurate measurements.

Point Number	Traverse Angle (β)	Bearing Angle	Edge	Y ΔY	X ΔX
A B	-28^{cc} 152.1790	125.3843		29650.52	30584.92
P.1	-28^{cc} 224.3075	77.5605	320.50	-3 300.80	-2 110.64
P.2	-28^{cc} 375.7624	101.8652	350.36	-3 350.21	-2 10.26
P.3	-28^{cc} 45.8265	277.6248	180.65	-169.61	-2 -62.19
C	-29^{cc} 242.3288	123.4485	345.86	-3 322.66 30454.48	-2 -124.53 4382.63 30498.66
D		165.7744 -165.7885	[S]=687.15	$\overline{\Delta Y}$ = 803.96 [ΔY]=804.06	$\overline{\Delta X}$=-86.26 [ΔX]=-86.34
(AB)+[β]= 1165.7885 n*200= -1000.0000 (CD)'=165.7885	f_β=-0.0141		141/5=28 +1	f_y=-0.10	f_x=-0.08
Controls		$F_{\beta max}=1^c+\frac{150}{[S]}.(n-1).\sqrt{n}=2.12^c$		$S=\sqrt{[\Delta Y]^2+[\Delta X]^2}$=268.32 m	
$f_S=\sqrt{f_y^2+f_x^2}=\sqrt{f_L^2+f_Q^2}$=0.153m		$F_Q=0.06+0.00007.S+0.007.n.\sqrt{n}$=0.17m $F_L=0.06+0.00015.S+0.004.\sqrt{S}$=0.23m		$f_Q=\frac{1}{S}.(f_y.[\Delta X]-f_x.[\Delta Y])$ =0.15m $f_L=\frac{1}{S}.(f_y.[\Delta Y]-f_x.[\Delta X])$ =0.04	

Numerical Application 1: Suppose that in Figure 6, which is actually without rough error, 300.40m is measured as shorter than the exact value of 12 edges (350.36 m).

Solution 1:

ΔY_1=300.40*sin101.8652=300.27m,
ΔX_1=300.40*cos101.8652=-8.80m
[ΔY]=300.80+300.27-169.61+322.66=754.12m
[ΔX]=110.64-8.80-62.19-124.53=-84.88m
fy=803.96-754.12 =49.84m, fx=-86.26-(-84.88) = -1.38m

BC=$\sqrt{(803.96^2+86.26^2)}$=808.574m, BC'=$\sqrt{(754.12^2+84.88^2)}$=758.882 m

BC '<BC condition is in question.

(C''C) =200-arctan$\left(\frac{49.84}{1.38}\right)$=101.7623, C''C=$\sqrt{(49.84^2+1.38^2)}$=49.86m

For the test, the approximate bearing angle value of the edge, which was taken deliberately short from its exact value, was obtained. In this non-taut net, the difference of ± 200g of the calculated (C''C) bearing angle is not approximately equal to the bearing angle of the edge of the net (277g.6248 in Chart 1) that makes a significant deviation in the direction of the net. For this reason, the rough error should be investigated on the edge, which is approximately equal to the bearing angle (CC').

Numerical Application 2: Suppose in Figure 6, which is actually without rough error, 23 edges are measured 210.65 m longer than its exact value.

Solution 2:

ΔY_3 =210.65*sin277.6248=-197.77 m,
ΔX_3 =210.65*cos277.6248=-72.52 m
[ΔY]=300.80+350.21-197.77+322.66=775.90 m
[ΔX]=110.64-10.26-72.52-124.53=-96.67m
fy=803.96-775.90 =28.16m, fx=-86.26-(-96.67) = 10.33 m

BC=$\sqrt{(803.96^2+86.26^2)}$=808.574m, BC'=$\sqrt{(775.90^2+96.67^2)}$ = 781.899 m

BC '<BC condition is in question.

(C''C) =arctan$\left(\frac{28.16}{10.33}\right)$=77.6170, C''C=$\sqrt{(28.16^2+10.33^2)}$ = 29.995 m

Since (B1) is '(CC'), it is decided that the wrong edge is the B1 edge. However, if there was a taut net, it would have been BC '> BC and therefore (CC') = 277.6170. In this non-taut net, it is seen that the ± 200g difference of the (CC') bearing angle is approximately equal to the bearing angle (277g.6248) of the edge of the net, which deviates significantly according to the calculation direction in the study in Chart 1. In this case, it will be necessary to repeat the measurement of edge 23 as the rough faulty edge and edge B1 for checking.

4.2. Applications of coarse faulty angle survey

In reality, a traverse net is taken into account, with angle measurements and edge dimensions without rough error and non-taut. It has been determined according to the formulas given below that the angle closure error, transverse closing error and longitudinal closing error do not exceed their error limits. In this given net (Figure 7), it was assumed that the angle at the one point shown as an example was measured in error to the rough, and the investigation of the rough incorrect angle was carried out using the one-way calculation method.

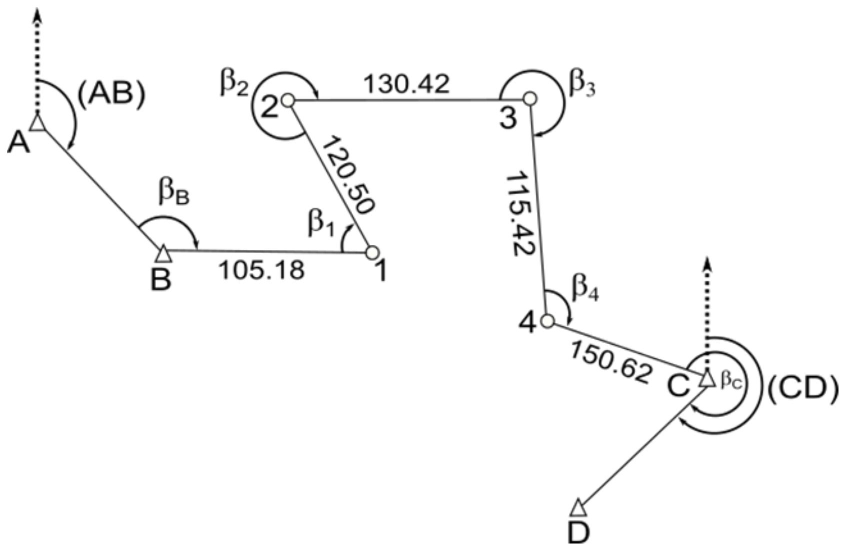

Figure 7. A non-taut traverse net

Traverse angles: β_B=165.2250, β_1=65.6672, β_2=353.2789, β_3=2861350, β_4=165.3614, β_C=301.4250
Traverse edges: S_1 =105.18 m, S_2=120.50, S_3=130.42, S_4=115.42, S_5=150.62 m
Y_B= 2000.00 m, XB=2000.00, YC=2221.60, XC=1809.76 m

Table 2. Polygon coordinate calculation chart.

Point Number	(β) Traverse Angle	Bearing Angle	Edge	Y ΔY	X ΔX
A B	-32 65.2250	136.3740		2000.00	2000.00
P.1	-32 5.6672	101.5958	105.18	105.15 2105.15	-1 -2.64 1997.35
P.2	353.2789	367.2598	120.50	+1 -59.28 2045.88	-1 104.91 2102.25
P.3	-33 286.1350	120.5365	130.42	+1 123.69 2169.58	-1 -41.35 2060.89
P.4	-33 65.3614	206.6682	115.42	+1 -12.07 2157.52	-1 -114.79 1946.09
C	-33 301.4250	172.0263	150.62	+1 64.07 2221.60	-2 -136.31 1809.76
D	1473.4665 1200.0000	273.4470 -273.4665 δ=-0.0195	[S]=687.15	$\overline{\Delta Y}$= 221.60 [ΔY]=221.56 fy=0.04	$\overline{\Delta X}$=-190.25 [ΔX]=-190.19 fx=-0.06

The net tautness condition specified in the New Large-Scale Map and Map Information Production Regulation is examined according to the following correlations.

BC=$\sqrt{(221.60^2 + 190.25^2)}$=292.06 m

[S]=687.15<1.5*BC=438.10

Since [S]>1.5 * BC at the end of the calculation, this traverse net is non taut since the required [S] <1.5 * BC condition is not met.

Numerical Application 3: Suppose that, from the data in Figure 6, the angle at the P3 point, which is actually without rough error, is measured as 286.6350.

Solution 3:

Table 3. Coordinate Spreadsheet of a traverse net that is not in a tight shape

Point Number	(β) Traverse Angle	Bearing Angle	Edge	Y ΔY	X ΔX
A					
B	165.2250	136.3740		2000.00	2000.00
		101.5990	105.18	105.15	-2.64
P.1	65.6672			2105.15	1997.36
		367.2662	120.50	-59.26	104.92
P.2	353.2789			2045.89	2102.28
		120.5451	130.42	123.69	-41.36
P.3	287.6350			2169.58	2060.92
P.4	165.3614	208.1801	115.42	-14.79	- 114.47
				2154.79	1946.45
		173.5415	150.62	60.81	-137.80
C	301.4250			2221.60	1809.76
	1473.4665 1200.0000	273.4470	[S]=687.15	2215.60	1808.65
D		-273.9665		$Y_M=(2221.60+2211.98)/2=2218.60$ $X_M=(1809.76+1807.35)/2=1809.205$	
		δ=-0.5195		$Y_P=Y_M-0.5*(X_{C'}-X_C)/\tan(\delta/2)=2172.\ 10$ m $X_P=X_M+0.5*(Y_{C'}-Y_C)/\tan(\delta/2)=2060.57$m	

The closest value to the calculated Y_P value is 2167.94 m in the traverse coordinate spreadsheet and the closest value to the X_P value is 2059.97 m. In this case, the point where the rough angle is measured is the P.3 point. Although there is little between the X value and the XP values of the coarse error point P.3, the difference between the Y value and the YP values is 2.52 m.

Numerical Application 4: Suppose that, from the data in Figure 6, the angle at the P3 point, which is actually without rough error, is measured as 287.1350.

Solution 4: The coordinates obtained as a result of the calculation are shown in Table 4.

Table 4. Coordinate Spreadsheet of a non-taut traverse net

Point Number	(β) Traverse Angle	Bearing Angle	Edge	Y ΔY	X ΔX
A					
B	165.2250	136.3740		2000.00	2000.00
		101.5990	105.18	105.15	-2.64
P.1	65.6672			2105.15	1997.36
		367.2662	120.50	-59.26	104.92
P.2	353.2789			2045.89	2102.28
		120.5451	130.42	123.69	-41.36
P.3	286.0350			2169.58	2060.92
P.4	165.3614	206.5801	115.42	-11.91	- 114.80
				2157.67	1946.12
		171.9415	150.62	64.26	-136.23
C	301.4250			2221.60	1809.76
	1473.4665 1200.0000	273.4470	[S]=687.15	2221.93	1809.89
D		-273.3665		$Y_M=(2221.60+2211.98)/2=2221.765$ $X_M=(1809.76+1807.35)/2=1809.825$	
		δ=1.0805		$Y_P=Y_M-0.5*(X_{C'}-X_C)/\tan(\delta/2)=2214.11$ m $X_P=X_M+0.5*(Y_{C'}-Y_C)/\tan(\delta/2)=1829.27$m.	

The closest value to the calculated YP value is 2167.94 m in the polygon coordinate spreadsheet and the closest value to the XP value is 2059.97 m. In this case, the point where the rough angle is measured is the P.3 point. The difference between the X value and the X_P values of the coarse faulty point P.3 is very large (231.65) and the difference between the Y value and the Y_P values is 44.53 m.

5. Discussion

For the research, the correct coordinates of a point, whose polygon angle was deliberately taken to the grid, and the coordinates obtained from the Equations (13) and (14) were examined. In the examination, a variation curve shown in Figure 7 for dy values according to δ rough error angle value and a change curve seen in Figure 8 for dx values were obtained. When the figures were examined carefully, it was seen that dy and dx errors occurring at small values of δ ‘were at the maximum value.

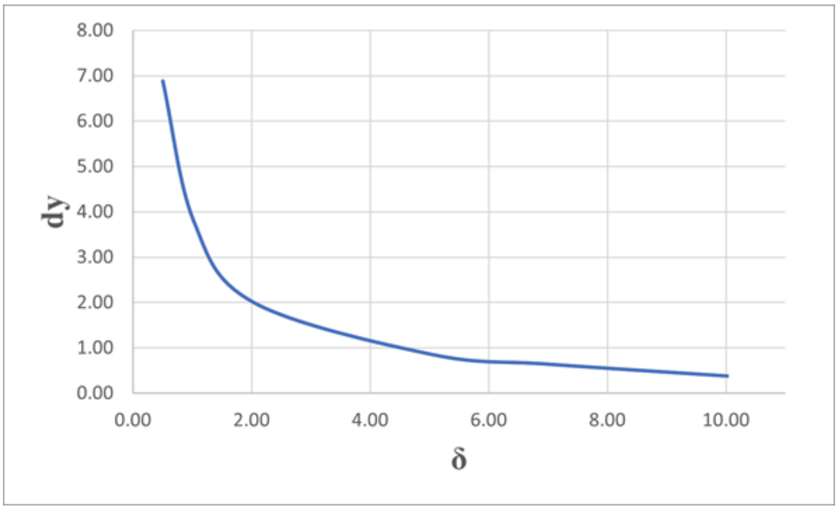

Figure 7. dy values according to δ rough error angle value

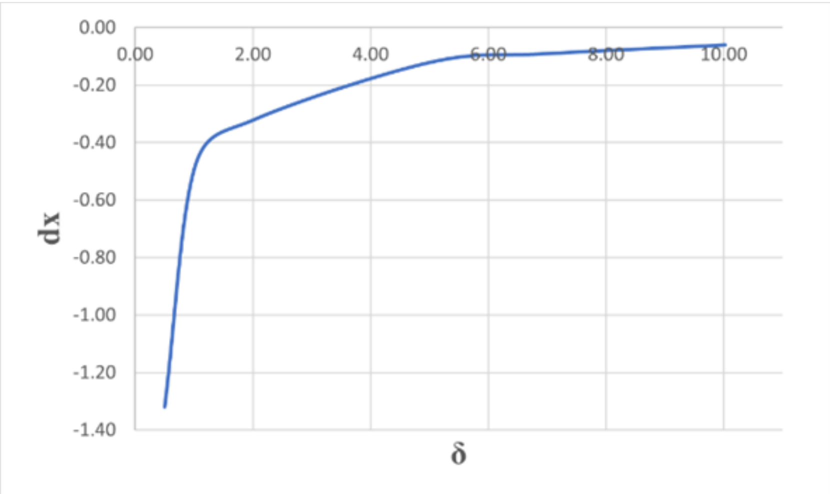

Figure 8. dx values according to δ rough error angle value

6. Results

- If a rough error is made on an edge that does not deviate significantly from the direction of the net on a non-taut traverse net, it is possible to detect the rough error by applying the rules specified in the investigation of the rough faulty edge in taut net.
- In a non-taut traverse net, if a rough error is made on an edge that deviates significantly from the direction of the net, it is not possible to detect the rough error by applying the rules specified in the investigation of the rough faulty edge in taut nets.
- This situation can be explained better by the following equations. On a net from B to C,
- BC=$\sqrt{(\Delta Y_{BC}^2 + \Delta X_{BC}^2)}$, BC'=$\sqrt{(⟦\Delta Y\ ⟧^2 + ⟦\Delta X⟧^2)}$ If the coarse is measured longer than the edge absolute value, BC'> BC should be the misleading BC' <BC condition.

- Similarly, if the coarse faulty edge is measured shorter than its precise value, BC'' <BC should be BC''> BC misleading situation is encountered.
- In this case, since it is not known on which edge the coarse faulty edge was measured, it will be necessary to investigate the faulty edge on many sides of the net.
- In a non-taut traverse net, if there is a rough error in the angle of an angle at a point that deviates or does not significantly deviate from the direction of the net, it is difficult to determine the rough defective point by applying the rules specified in the investigation of the rough defective angle on the taut nets.
- In the research, differences of up to ± 200 m were observed between the exact coordinates of the coarse error point and the coordinate values calculated by Equations (13) and (14). In this case, the bidirectional traverse coordinate calculation method should be applied to reveal the rough error point.
- If it is necessary to create a non-taut traverse net, great care should be taken when measuring the traverse angles and edges in order to avoid the above-mentioned situations.

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Author contributions

Yener Türen: Conceptualization, Methodology, Software **Hüseyin İnce:** Data curation, Writing-Original draft preparation, Software, Validation. **Nuri Erdem and Tuna Erol:** Visualization, Investigation, Writing-Reviewing and Editing.

Conflicts of interest

The authors declare no conflicts of interest.

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