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A METHOD FOR THE STAKE-OUT OF THE SEATS IN THE CONFERENCE ROOM

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Abstract. Before the application, the coordinates of the circle shaped seat places that will be applied in indoor space can be obtained by the help of common points determined in numerical project model formed in a local coordinate system. Practically, the coordinates of the points in the digital project model can be also obtained numerically by using the coordinates of the common points. However, converting to numerals manually, the factors such as the support quality of the project, exhaustion of the operator, hand tremble and screen resolution influence the sensitivity of the conversion to numerals. Errors made during the conversion negatively affect the coordinates of the points. The most suitable method not to make errors is the calculation of coordinates of the points in the project model by geodetic method. In this project, the calculation of the coordinates of the seat midpoints placed on the curves in a closed area, benefited from the corner point coordinates of the seats in the indoor space obtained from geodetic measurement in a local coordinate system before the application and benefited from the data of the other points of the indoor space are explained. Furthermore, the ground application of the midpoints of the seats on each curve row is explained. The accuracy of the stake-out of seats in the conference room is obtained between 1 and 2 cm.

Keywords: polar survey, digital terrain model of indoor space, digital project model of indoor space, programming the digital project model, polar application.

Introduction

In geomatics (surveying) engineering, the curve application is generally seen in road and canal projects. The ground application of curve intermediate points in an indoor space is generally been discussed in big places such as gymnasium and conservatories. Before the application, the coordinates of the circle shaped seat places that will be applied in indoor spaces can be obtained by the help of common points determined in numerical project model formed in a local coordinate system. Practically, the coordinates of the points in the digital project model can be also obtained numerically by using the coordinates of the common points. However, converting to numerals manually, the factors such as the support quality of the project, exhaustion of the operator, hand tremble and screen resolution influence the sensitivity of the conversion to numerals. Scanning should have the resolution between 150 and 300 dpi for the conversion done on the screen. For a good conversion, dot position sensitivity changes between ±0.08 mm and ±0.054 mm (Masry & Lee, 1988). Errors made during the conversion negatively affect the

coordinates of the points. The most suitable method not to make errors is calculation of coordinates of the points in the project model by geodetic method (Kavanagh & Bird, 2000). Necessary components for the stake-out is provided with the coordinates obtained from the curve intermediate points that will be applied in the digital project model. Research on the subject is handled since there has not been adequate information about the subject in the literature (Anderson & Mikhail, 1997; Wolf & Ghilani, 2002). In this study, the stake-out of the seats in the conference hall is performed and investigated the accuracy of this polar-method application.

1. Materials and methods

This study was carried out in the conference Hall of Trakya University in Edirne, Turkey. In an indoor space, a point that seeing the all corner points determined as station point and it is benchmarked according to the suitable corner points of a closed area. A total station is set up on this point. The height of reflector is adjusted to the height of the device. In the indoor space the device is directed

to a clear corner by modifying its horizontal angle equal to zero, the horizontal distance and the height difference values are read and recorded. Then, by holding the reflector to the other corner points of the indoor space are measured and recorded. The point that the total station set up and connection and measurement points are shown on a sketch which is prepared at an approximate scale (Figure 1).
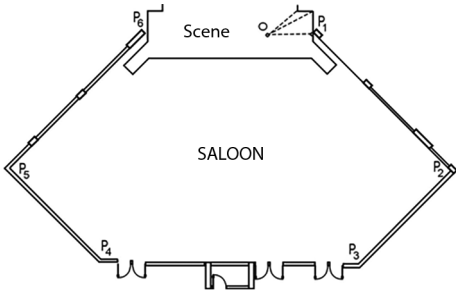

Figure 1. The indoor space station (*P*), connection (1) and survey points (2, 3, …, 8)

An arbitrary coordinate value is given for the point that the total station set up, the direction of which the horizontal angle is reset is considered as *X* axis given for the point that the device set up, the direction of which the horizontal angle is reset is considered as *X* axis, the axis upright to it is considered as *Y* axis. In this determined coordinate system, the measured horizontal angles (YA_i) gain bearing quality (P_i) = YA_i. The height of the point is accepted as zero ($H_P = 0$), by taking the height differences that belong to the measured corner points (Δh_i) into the consideration the heights of the corner points according to the determined reference points (H_i) and their coordinates are calculated with their relations (Kahmen & Faig, 1988). Figure 2 shows the flowchart of the stake-out of the seats in the conference room.
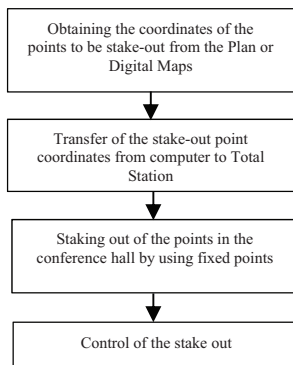

Figure 2. The flowchart of the stake-out of the seats in the conference room

$$Y_i = Y_0 + P_{0i} \times \sin(P_{0i});$$

$$X_i = X_0 + P_{0i} \times \cos(P_{0i}); \qquad (1)$$

$$H_i = \Delta h_i. \qquad (2)$$

The points of which the coordinates are calculated, load to a computer by means of CAD supported software programs (AutoCAD or NetCAD) and the shape of the

indoor space that's the model of the numerical terrain model is formed.

Using the polar method one determines distances and directions of points with known coordinates towards new points. Apart from the angular measurement and distance measurement a field book with the presentation of the new points with their numbers is made. For the polar method one needs at least two points with known coordinates in order to refer to an existing net and check the measurements from of one of the other points (http://vermessungsseiten.de/ortho/polarver-e.htm). Advantages:

– More accurate and faster procedure than locating objects by a baseline since no points on the baseline have to be lined in or marked out.
– Economic procedure.
– Data flow from the recording of data to mapping.

2. The stake-out of the seats in the conference room

The terrestrial measurements were performed using a Leica TC 605 (angle accuracy: 5″, distance measurement accuracy: 3 mm + 3ppm). Making of the numerical project model which will be located in an indoor space is done the following specified procedures, respectively:

– The calculation of the first row of curve (*A*), the intersection points with the side walls of the auditorium (A_O, A_N) and the curve centre (*O*):
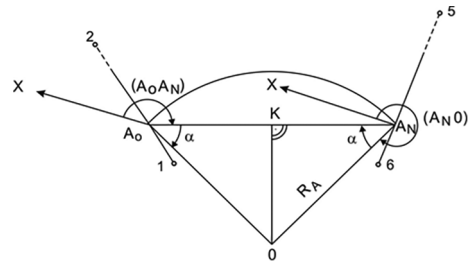

Figure 3. The intersection points (A_O, A_N) with auditorium side walls (P_1P_2, P_6P_5 lines) of the curve in the first row

In Figure 3, A_O point that passing through a row of which side P_1P_2 is cut by the first curve that has R_A radius and it's A_N point of which side P_6P_5 is cut by it are determined in indoor space project. The equivalent values of P_1A_O and P_6A_N from 1/50 scaled detail project that belongs to the closed area for terrain can be taken with ±1–2 cm sensitiveness. According to the geodesic basic relation (Bannister et al., 1992; Kahmen & Faig, 1988) by benefiting from (P_1P_2) and (P_6P_5) bearings the coordinates of A_O and A_N points are obtained.

$$(P_1P_2) = \arctan\left(\frac{Y_2 - Y_1}{X_2 - X_1}\right); \qquad (3)$$

$$(P_6P_5) = \arctan\left(\frac{Y_5 - Y_6}{X_5 - X_6}\right); \qquad (4)$$

$$Y_{A0} = Y_1 + P_1 A_0 \times \sin(P_1 P_2);$$

$$X_{A0} = X_1 + P_1 A_0 \times \cos(P_1 P_2); \qquad (5)$$

$$Y_{AN} = Y_6 + P_6 A_N \times \sin(P_6 P_5);$$

$$X_{AN} = X_6 + P_6 A_N \times \cos(P_6 P_5). \qquad (6)$$

The $(A_0 A_N)$ bearing and $A_0 A_N$ length is calculated by benefiting from the coordinates of the A_0 and A_N points and by benefiting R_A radius of the curve that passing through these points (Figure 3); α, $(A_0 O)$ and $(A_N O)$ benefiting from R_A radius in the row A with the coordinates of A_0 and A_N points (Figure 3).

$$A_0 K = \frac{A_0 A_N}{2}; \qquad (7)$$

$$\alpha = \arccos\left(\frac{A_0 K}{R_A}\right) \qquad (8)$$

and then

$$(A_0 O) = (A_0 A_N) + \alpha; \qquad (9)$$

$$(A_0 O) = (A_N A_0) - \alpha, \qquad (10)$$

the centre coordinates of O curve benefiting from their bearings

$$Y_0 = Y_{A0} + R_A \times \sin(A_0 O);$$

$$X_0 = X_{A0} + R_A \times \cos(A_0 O). \qquad (11)$$

– The calculation of coordinates of intersection points that the curve starting and ending points with the side walls of the auditorium from the second row to the finish row (i. row).

The centre of all curve generated in the indoor space are the same. The amount of distance between parallel curves (dr) can be same or different dr amount are changing at the cinema, theatre and conference *auditoriums* (Neufert, 2000). The values of dr amount can be taken from the project values as directly and from its detail plan with 1/50 scale.

If the seat row is equal distance to each other, the radius of the curve that occurs at the each letter row; $R_B = R_A + dr$ is at B row, $R_C = R_A + 2dr$ is at C row, $R_i = R_A + i \times dr$ is i. row.
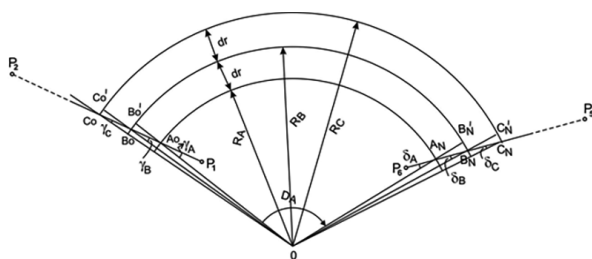

Figure 4. The intersection points (A_O, B_O, C_O, ..., K_O; A_N, B_N, C_N, ..., K_N) of the starting and finishing points with auditorium side walls ($P_1 P_2$, $P_6 P_5$) until from second row to the end row (i. row)

There are γ_A and δ_A deviations between radial directions which is passing from A_0 point and between radial directions which is passing from A_N point and $A_N P_5$ line, respectively (Figure 4). At this situation, as an example, $A_0 B_0$ distance on line $P_1 P_2$ with radius of $R_B = R_A + dr_{AB}$ and $A_N B_N$ distance on line $P_6 P_5$ will not be equal to $dr_{AB} \times \gamma_A$ and δ_A

$$\gamma_A = (OA_0) - (P_1 P_2); \qquad (12)$$

$$\delta_A = (P_6 P_5) - (OA_N) \qquad (13)$$

are obtained from these equations. $A_0 B_0 B_0'$ and $B_N A_N B_N'$ triangles in Figure 5 are considered approximately the right triangle. $A_0 B_0' = A_N B_N' = dr_{AB}$ is taken from project values in the specified triangles, $A_0 B_0$ and $A_N B_N$:

$$A_0 B_0 \cong \frac{dr_{AB}}{\cos\gamma_A}; \qquad (14)$$

$$A_N B_N \cong \frac{dr_{AB}}{\cos\delta_A}. \qquad (15)$$

The coordinates of B_0 and B_N are calculated by considering $A_0 B_0$ and $A_N B_N$ which are calculated from the coordinates of A_0 and A_N:

$$Y_{B0} = Y_{A0} + A_0 B_0 \times \sin(P_1 P_2);$$

$$X_{B0} = X_{A0} + A_0 B_0 \times \cos(P_1 P_2); \qquad (16)$$

$$Y_{BN} = Y_{AN} + A_N B_N \times \sin(P_6 P_5);$$
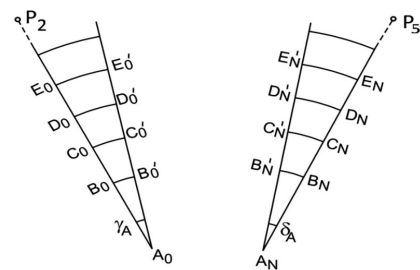
$$X_{BN} = X_{AN} + A_N B_N \times \cos(P_6 P_5). \qquad (17)$$

Figure 5. The intersection points (A_0, B_0, C_0, ... K_0; A_N, B_N, C_N, ... K_N) of the starting and finishing points with *auditorium* side walls ($P_1 P_2$, $P_6 P_5$) until from second row to the end row (i. row)

In the triangles (Figure 5) that will be formed by the expansion of AOBO and ANBN as going away from AO and AN – due to the deviations of right triangle acceptance – causes to obtain them wrong in calculating, by accepting. γA and δA as stable, the lengths of AOCO, AODO, …, AOKO and ANCN, ANDN,… ANKN which are necessary in calculating the coordinates of CO, DO, … KO and CN, DN,… KN points. In order to remove the effects of the error on the positions of the points, one after another calculating of the coordinates of CO, DO, …, KO and CN, DN,…, KN points is seen as a necessity.

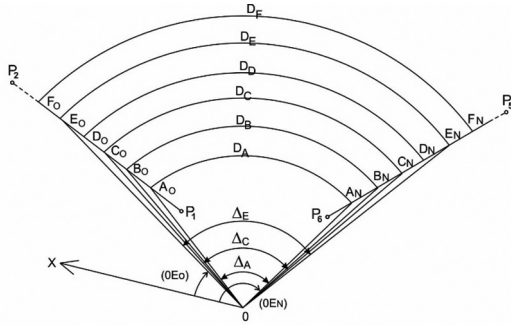– Calculation of the length of development and deviation angle for curve in each row.

Figure 6. The deviation angles (Δ_A, Δ_B, …, Δ_F) and development lengths (D_A, D_B, …, D_E) for the curves in each row

The deviation angle of curve in each row is equal to the difference of bearing angle from the curve centre between the bearing angle goes to the end point of related curve and the bearing angle point goes to the beginning point. (e.g. for the beginning and ending point of the curve in A row (OA_N), (OA_O) bearing angles) (see Figure 6). The co-ordinates of beginning and ending point of the curve are calculated. The beginning and ending point of the related curve (The beginning and ending point for A curve (like A_O, B_N; …)) and the bearing angles [(OA_O), (OA_N)] can be found according to the basic relation of geodesic using the coordinates of curve centre (O). The deviation angles (Δ_A) and length of development (D_A) according to the basic relation of geodetic by benefiting calculated bearing angles

$$\Delta_A = (OA_N) - (OA_0);$$ (18)

$$D_A = \frac{2 \times \pi \times R_A \times \Delta_A}{400^g}.$$ (19)

obtained by these equations (Allan et al., 1968; Kavanagh, 2003).

– Calculation of length of arc formed by the seats in the curves in each letter row.

The width of a seat is generally 55–60 cm in cinema, theatre and conference auditoriums (Ham, 1974; Neufert, 2000). As it will be stated in the numerical practice related to the subject, the radius of the curve in front of the stage is about 9.00–12.00 m. The difference (0.000046 m) of an arc piece of 60 cm in a circle having 15 m radius according to the length of joist is almost nothing. In this respect, the length of arc (S_i) formed by the seats can be calculated according to the numbers of the seats (N_i) and the width of one seat (k).

– Calculation of the way portion in the curves in each letter row.

There can be found a way length between the side walls existing in the indoor space and the beginning and ending seats in each letter row (Figure 7). The width of

this way can be design as in approximately equal distance. In addition, in the curves in a few rows can be leave a way portion together with the way portion from side walls (Figure 7).
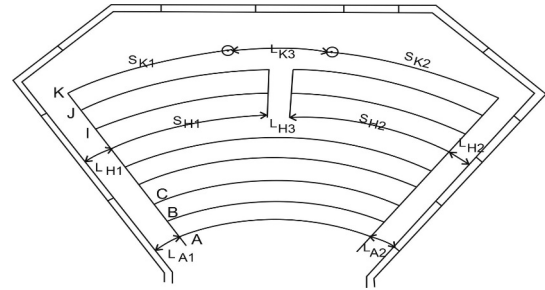

Figure 7. Presence of intermediate way portion at the curves in a few rows in auditorium together with side way portion

– Calculation of the side way portion at side walls in auditorium.

For the curve in each row, benefiting from the seat arc length (S_i) and the development lengths (D_i) obtained from Equation (19); if the side way portion on the left of the first seat (L_{i1}) in the curve and the side way portion on the right of the last seat (L_{i2}) can take as equal to each other (Figure 7).

$$L_{i1} \cong L_{i2} = \frac{[D_i - S_i]}{2}.$$ (21)

(L_{i1}) expression can be estimated from this relation.

An intermediate way *portion* (e.g. for the row of H curve, L_{H3}) can be left between curves together the side way portions at the curves in a few rows which placed behind the stages in auditorium (Figure 7). *At this condition the relating curves are divided into two parts.* The arc lengths which formed first and second parts (S_{H1}, S_{H2}) are calculated in a similar way in Equation (20) considering the width of the seat (k) and the seat number (like N_{H1}, N_{H2}) which will located in first and second parts at the curve in the same row. If the length of way portion (e.g. L_{H3}) is given in the project which are left in between at the curve in the same row, to the side way portion from the side walls (L_{H1}, L_{H2}) is approximately.

$$L_{H1} \cong L_{H2} = \frac{[D_H - (S_{H1} + S_{H2} + L_{H3})]}{2},$$ (22)

estimated from the equation.

At the curve in every row in auditorium, *the seats by placing beginning from side walls, if two* intermediate way *designed at the same curve, the related curve was divided to three parts* (like S_{A1}, S_{A2}, S_{A3}) (Figure 8) and the intermediate way portions located as two parts (like L_{A1}, L_{A2}). If known how many seats at the curve parts in the same row will take place, considering the arc length of the curve parts in the same row, the seat number and the width of one seat (for example for the row of A curve):

$$S_{A1} = k \times N_{A1}; \tag{23}$$

$$S_{A2} = k \times N_{A2}; \tag{24}$$

$$S_{A3} = k \times N_{A3}, \tag{25}$$

computed by these equations. If the intermediate way portions left in the same curve row is accepted as approximately in equal amount to each other (e.g. for the row of *A* curve):

$$L_{A1} \cong L_{A2} = \frac{\left[D_A - (S_{A1} + S_{A2} + S_{A3}) \right]}{2}. \tag{26}$$

  – Calculation of the bearing angles outgoing to the seat places in each letter rows form the curve centre.

If the intermediate points of the seats that will be located to curves in each row are assumed as existing on the concerned curve, for arc length from the side wall on the left of the first, second and i. seat intermediate point (for the seats in *A* curve row for instance K_{Ai}).
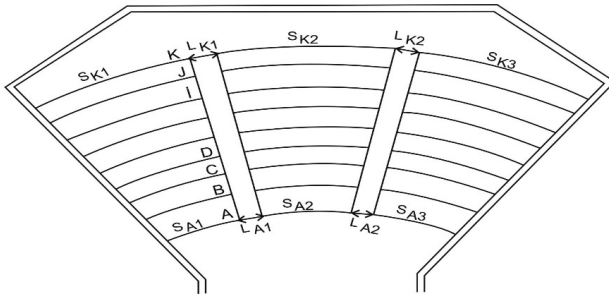
Figure 8. Locating of two intermediate way portions which are formed at the same curve in every row in Auditorium

$$K_{Ai} = L_{A1} + \frac{(2 \times i - 1) \times k}{2}. \tag{27}$$

By taking the radius lengths that belong to the concerned curve and arc lengths; the angles which see this arc from the concerned curve centre is obtained (β_{Ai}), ($\rho = 200^G/\pi$), (Figure 9):

$$\beta_{Ai} = \frac{K_{Ai} \cdot \rho}{R_A}. \tag{28}$$

The bearing angle at the curves in each row which is gone to the middle points of seats from that curve centre (e.g. for i. seat in a curve row):

$$\left[(OA_0) + \beta_{Ai} \right] > 400^g \rightarrow$$

$$(OA_i) = (OA_0) + \beta_{Ai} - 400^g; \tag{29}$$

$$\left[(OA_0) + \beta_{Ai} \right] < 400^g \rightarrow$$
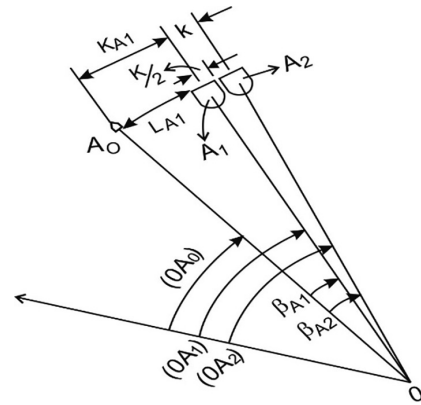
$$(OA_i) = (OA_0) + \beta_{Ai}. \tag{30}$$

Figure 9. The bearing angles which are gone to the middle point of seat at the row of one piece curve

The intermediate way portion (e.g. for the seats in *H* curve row L_{H3}) can be released together alleys on the curves of several rows placed behind of the *stage* in *auditorium* (Figure 7). At the first part of the curve in the same row; consider of the left intermediate way portion, the bearing angles go to intermediate points of first, second and other seats from curve centre are calculated as seen in Section 3.6.1. At the second part of the same curve; the seat numbers are ordered from right to left. The first, second and i. seat midpoint of specified curve, as arc length from *auditorium* right side wall ($L_{H2} = L_{H1} =$ to be side way portion), similar to Equation (27), for the placed seat midpoints at the first part of related curve:

$$K_{HNi} = L_{H1} + \frac{(2 \times i - 1)}{2} \times k. \tag{31}$$

The angles are seen these calculated arcs from centre (β_{HNi}) (Figure 10):

$$\beta_{HNi} = \frac{K_{HNi} \times \rho}{R_H}. \tag{32}$$

The bearing *angles (e.g. for bearing (OH_{Ni}))* went to the seat intermediate points in related curves from curve centre, considering the bearing value (OH_N) goes to the intersection point with the *auditorium* right side wall of related curve computed:

$$(OH_{Ni}) = (OH_N) - \beta_{HNi}. \tag{33}$$

On each curve in *auditorium* (Figure 8), if the seats are placed starting from side walls, three pieces curve (e.g. like S_{A1}, S_{A2}, S_{A3}) take place and two intermediate way in the same curve create (e.g. like L_{A1}, L_{A2}). The angle which is seeing the arc lengths from the side wall of the first, second and i. seat midpoints from curve centre at the first part in each letter row (e.g. β_{A1i}), considering the radius values of related curve, similar to the Equation (32):

$$\beta_{A1i} = (2 \times i - 1) \times k \times \rho / 2 \times R_A \tag{34}$$

with this relation; the angle which is seeing the arc lengths (e.g. like K_{A2i}) from the side walls of first, second and

other seat midpoints at second and third parts from the curve centre (like β_{A2i}), considering the arcs belong to curves and way portions and the radius values belong to related curve (e.g. arc length (K_{A3i}) and arc which is seeing this from the centre (β_{A3i}) from the side walls which belong to i. seat midpoint at the third curve part):

$$K_{A3i} = S_{A1} + L_{A1} + S_{A2} + L_{A2} + \left(2 \times i - 1\right) \times k/2; \quad (35)$$

$$\beta_{A3i} = K_{A3i} \times \rho/R_A, \quad (36)$$

can calculated by these Equations (35) and (36). From O curve centre, in curves at each row, at first, second and third part seats, the bearing angles go to the midpoints of i. seat (e.g. for the seat midpoint at the third row at curve A)

$$\left[\left(OA_0\right) + \beta_{A3i}\right] > 400^g \rightarrow$$

$$\left(OA_{3i}\right) = \left(OA_0\right) + \beta_{A3i} - 400^g; \quad (37)$$

$$\left[\left(OA_0\right) + \beta_{A3i}\right] < 400^g \rightarrow$$

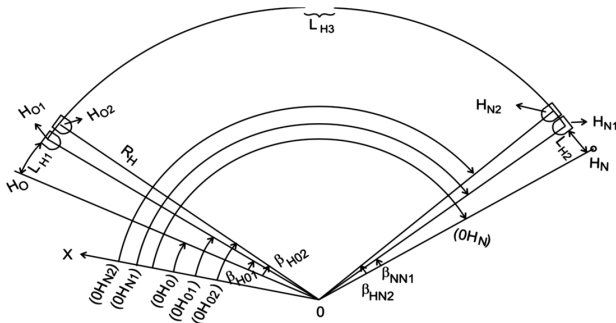$$\left(OA_{3i}\right) = \left(OA_0\right) + \beta_{A3i}. \quad (38)$$

Figure 10. The bearings from O curve centre to intermediate points of seat at first and second curve rows on two-pieces curve

 – Calculation of the coordinates of seat places at curves in each letter rows form curve centre

The coordinates of the seat midpoints according to basic correlation of geodesic which considering the determined radius values (R_i) and calculated bearings ($O\dot{I}_i$) for seat midpoints placed in each curve row.

$$Y_{ii} = Y_0 + R_i \times \sin(O\dot{I}_i);$$

$$X_{ii} = X_0 + R_i \times \cos(O\dot{I}_i) \quad (39)$$

obtained from equations.

 – Calculation of the heights of the curves in each letter rows and the slope between the curve row in front of stage and the curve row in the last row.

In *auditorium*, the slope between the curve in front of the *stage* and the curve at the end row is accepted as linear because of the ease in the application. In this case, difference of the horizontal distance ($A\dot{I}_Y$) and the height

difference (ΔH_{Ai}) between the curve in front of the *stage* and the curve row ($\dot{I}$) at the end of the *stage* can be taken from indoor spaces project (Figure 11). The determined horizontal distance ($A\dot{I}_Y$), as given directly benefiting from the values of their respective radius curves

$$A\dot{I}_Y = \Delta R_{Ai} = R_i - R_A \quad (40)$$

can be obtained from Equation (40). ΔH_{Ai} can be obtained from the difference of local height values of *auditorium* corner points in A and i curve rows in a closed area. Thus, the slope from A curve row to I curve row:

$$\tan \alpha_{Ai} = \Delta H_{Ai}/A\dot{I}_Y. \quad (41)$$

A curve row in front of the *stage*, at zero level and taken as the initial surface. The level differences from A row of curves at other letter row, the horizontal distances (dr) among curve rows are accepted as equal (e.g. row I at Figure 11 placed in row 8 from A):

$$\Delta H_{AB} = dr \times \tan \alpha_{Ai}; \quad (42)$$

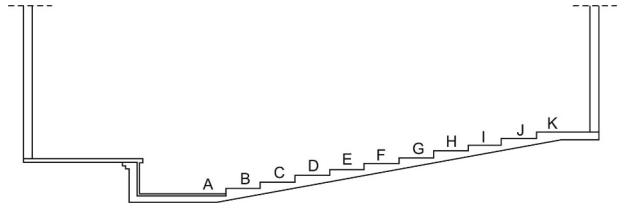$$\Delta H_{Ai} = 8 \times dr \times \tan \alpha_{Ai}. \quad (43)$$

Figure 11. The profile of inside of auditorium in indoor space

3. Results and discussions

P point which determined on the stage in the auditorium in section 1, also the station point for application of intermediate points of the curves in the numerical project model and one of determined corner points in the indoor area is the connection point ($\dot{I}_O$). The horizontal coordinates of P point is taken as a round value (like $Y_P = 100$ m, $X_P = 100$ m).

By benefiting from coordinates of the curve intermediate points, the station point, connection point (Y_{ij}, X_{ij}, i: the letter row belongs to the curve, j the seat row from the beginning in the curve that in i row) and their heights (by adjusting the reflector height to the device height) after the bearing angles of the curve intermediate points ($P\dot{I}_0$), ($P\dot{I}_j$) and the horizontal distance according to geodesic basic relation

$$\varphi_{ij} = \left(P\dot{I}_j\right) - \left(P\dot{I}_0\right) \quad (44)$$

by using equations; vertical application element (to be α_{ij}: slope angle, Z_{ij}: vertical angle) computed

$$\alpha_{ij} = \arctan\left(\Delta H_{ij} - \Delta H_P\right)/P\dot{I}_j; \quad (45)$$

Table 1. The application elements of curve intermediate elements to applicate from *P* station points in the digital project model by polar method

Station	Point	Bearing	Horizontal distance	Horizontal Angle	Vertical Angle Z_{ij}	The beam control between curve intermediate points
P	$\dot{I}_o$	$(P\dot{I}_o)$	$P\dot{I}_o$	0.000		
	A_1	(PA_1)	PA_1	$\varphi_{A1} = (PA_1) - (P\dot{I}_o)$	Z_{A1}	k
	.	.	.	.		
	A_N	(PA_N)	PA_N	$\varphi_{AN} = (PA_N) - (P\dot{I}_o)$	Z_{AN}	
	.	.	.	.		
	N_1	(PN_1)	PN_1	$\varphi_{N1} = (PN_1) - (P\dot{I}_o)$	Z_{N1}	

$$\left[\Delta H_{ij} - \Delta H_P \right] > 0 \rightarrow Z < 100^g \rightarrow Z_{ij} = 100^g - \alpha_i; \quad (46)$$

$$\left[\Delta H_{ij} - \Delta H_P \right] < 0 \rightarrow Z > 100^g \rightarrow Z_{ij} = 100^g + \alpha_i. \quad (47)$$

The obtained values and beam length between the intermediate points are shown in a table (Table 1).

The total station set up and by marked *P* point in the indoor space *stage* is installed again, the horizontal angle of tool as resetting is directed to $\dot{I}_o$ connection point selected indoor space. After made of forwarding to connection point, the application elements belong to curve intermediate points specified in Table 1. The stake-out points are made evident by nailing one each concrete nail and next to related point, point number are written to a small cardboard or metal piece and attached. The beam lengths are measured to control between the stake-out curve intermediate points, the correction process begins as soon as a paradoxical situation is seen.
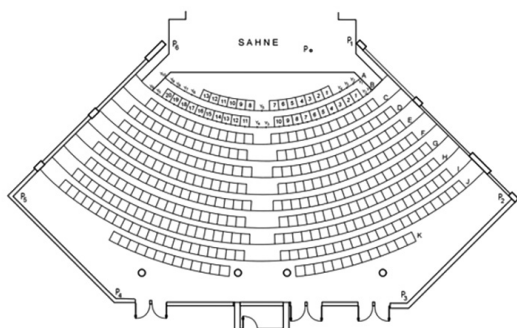

Figure 12. The station point was marked in closed area and other corner points being measured

The application with respect to the subject was encountered during the construction phase when was desired the application of the places of seat on the circular arc in Conservatory *auditorium*. In the appropriate way to the theoretical explanation made above, firstly, a station point on the stage in the state of rough construction in the indoor space has been marked, a small concrete nail has been driven to this point and by benchmarking from the near corners around a benchmark sketch has been arranged. The height of reflector has been adjusted in a way that will be equal to height of

the vehicle. As it will be seen in Figure 12, the P_1 numbered corner point has been chosen as the beginning point and the horizontal angle has been directed by being modified equal to zero, the horizontal distance and the height difference has been measured and then the measurements have been done by holding the reflector to the other corner points determined in the indoor area and they have been recorded to Table 2. The origin and coordinate of the station point have been taken as $Y_o = 100$ m, $X_o = 100$ m, the direction to the P_1 numbered point has been accepted as X axis, perpendicular axis to this axis is accepted as Y axis. The coordinates of corner points of indoor space which were formed to produce of the numerical ground model in this coordinate system have been calculated and recorded to the concerned columns in Table 2.

Table 2. The measurement and coordinate values of the corner points which was measured by polar method in an indoor space

Station	Point	Horizontal angle	Horizontal distance	Height differences	Y	X
P_o	P1	0.0000	6.214	0.05	100.00	106.21
	P2	11.3032	19.180	0.82	103.39	118.88
	P3	39.1542	20.180	0.91	111.64	116.48
	P4	96.1710	20.460	0.77	120.42	101.23
	P5	123.8024	19.470	0.82	118.12	92.89
	P6	135.1462	6.810	0.05	105.80	96.43

The seat places which are placed in indoor spaces like cinema, theatre and conference *auditorium* positioning on the same, concentric, circle arcs and when their application to the ground needed, created digital project model for seat places and intermediate ways and for the precise application of the points belongs to intermediate way, will provide a great simplicity for practitioners. Using this prepared digital project model, the digitization of architectural projects designed for indoor space in the classical meaning will have no need. *In addition, errors can be made during the digitization of the points will not be concerned.* The application elements of the relevant points obtains in a short time and to be precisely prepared by this digital project model.

The formula that gives the accuracy of the polar method used in the stake-out:

$$m_p^2 = m_s^2 + S^2 \frac{m_\varphi^2}{\rho^2},$$

m_p – point positioning error; S – distance; m_φ – horizontal angle measurement accuracy of the total station instrument; m_S – distance measurement accuracy of the total station instrument; $\rho = 180^o/\pi$.

The coordinates of the stake-out points given in the plan were transferred to the Total station instrument. Points were marked in the conference hall with the polar stake-out method. The coordinates of the stake-out points for the control were obtained by using the polar measurement method again. These obtained coordinates of points were compared with the coordinates of points on the plan. Standard deviation and mean values were calculated by using the dX and dY coordinate components obtained in this comparison. It has been observed that the standard deviation for application and application control is ±6 mm, considering that the differences up to ±3σ (18 mm) in the 99% confidence interval are acceptable in practice. The difference between the coordinates obtained from the stake-out control and the coordinates given in the plan is within the range of 1–2 cm, indicating that the operation performed with the desired precision. Bârliba et al. (2018), Ehrhart and Lienhart (2017), Neufert (2000) demonstrate that accuracy can be achieved for Total station survey in the indoor area only within 1–2 cm. The obtained results in this paper are consistent with this study.

Conclusions

The curve intermediate points – accepted as on the circles with the same centre that locate in closed areas such as cinema and lecture hall, and the necessary application elements for the ground application of these with polar method from a station point are obtained sensitively and in a short time. The errors that can be made during the drawing of the architectural project and the conversion to digitisation, negatively affect the coordinates of an architectural project, belonging to an indoor space obtained by conversion to digitisation with a computer supported CAD software. The conversion of all the points that composes the project to digitisation and connected with this, computing the application elements with the polar method, according to the digital project model, take much more time depending on the point number. During the formation of the digital project, while computing the coordinates of the start and finish points of the curves that intersect with the side walls, from the second letter row to the last, in order to obtain sensitive coordinates, the deviation angle at the point of intersection of side wall of the hall and the line that join sequentially the points of the former curve that intersect with the side wall of the hall to the curve centre in each row should be calculated and these angles should be taken into consideration in the

calculation of the coordinates. During the application of curve intermediate points with the polar method from a station point chosen in the closed area, the distance between the stake-out points should supply one seat width. Otherwise, related points should be applied again. These obtained coordinates of points were compared with the coordinates of points on the plan. Standard deviation and mean values were calculated by using the ΔX and ΔY coordinate components obtained in this comparison. It has been observed that the standard deviation for application and application control is ±6 mm, considering that the differences up to ±3σ (18 mm) in the 99% confidence interval are acceptable in practice. During the formation of the digital project model, in order to compute the coordinate of the point of the curve in the first letter row that intersect with the side wall of the hall sensitively, the distance from the intersection point to the corner point of the hall on the stage side should be taken with sensitivity of ±(1–2) cm with respect to architectural in-detail project.

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