Earthwork

Calculations of the Topsoil Area of the Auxiliary Spillway

This procedure makes use of the standard field stakeout notes, the formula for the curved surface area of the frustum of a right cone, and Forms KS-ENG-309a through 309d.

The surface area of the spillway slopes in curved sections is found by the summation of consecutive segments between each pair of adjacent staked out cross sections. The area of the inside and outside segments (see Figure KS4-2) is calculated on Form KS-ENG-309b.

The surface area of the spillway slopes in straight sections is found by the summation of consecutive segments between each pair of adjacent staked out cross sections. The area of the inside and outside segments is calculated on Form KS-ENG-309c.

The basic formula for the curved surface area is stated as follows:

$$A = \left[\frac{L\ P_B + P_T}{2} \right]$$

Where: A = Total lateral surface area
L = Slant height (See Figure KS4-1)
P_B = Perimeter of base
P_T = Perimeter of top

Figure KS4-1 Slant Height

This formula has been modified to compute the surface area in each segment of the inside or the outside slope as divided by the staked out cross sections. This adaptation makes use of survey stakeout notes and the side slope angles of the auxiliary spillway as staked in the field.

The formula is stated below and is derived as follows:

$$A = L \times \frac{P_B + P_T}{2} \times \frac{\varnothing}{360^\circ}$$

L = Average cut x slope factor

$\frac{P_B + P_T}{2}$ = Average perimeter or abbreviated as P_{B-T}

P_{B-T} = $2\pi R_{B-T}$

$\frac{\varnothing}{360^\circ}$ = The portion of the cone surface area subtended by the angle $\varnothing$

$\varnothing$ = The angle between two adjacent cross sections as shown on the field notes. The angle is expressed numerically in degrees with the minutes expressed as a decimal portion of a degree.

$\frac{\pi}{180^\circ}$ = 0.01745

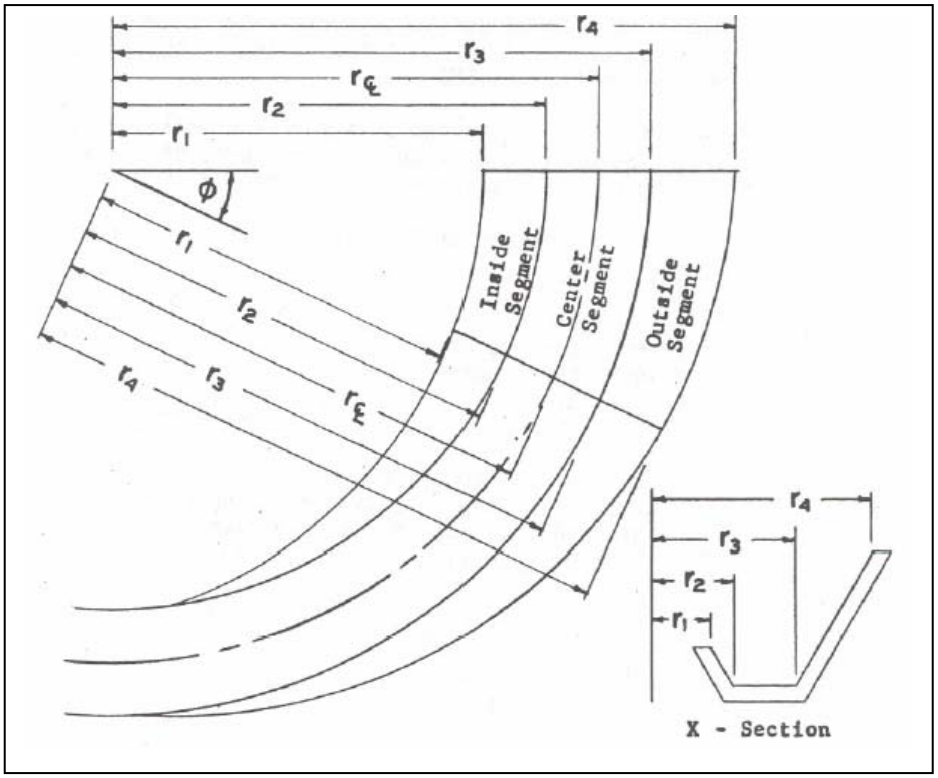
With terms substituted and rearranged, the working formula is as follows:

$$A = R_{B-T} \times \varnothing \times \text{Average Cut} \times \text{Slope Factor} \times .01745$$

This formula is used to compute the area of the individual curved sloping segments on Form KS-ENG-309b.

A sketch showing the location of the actual radii (r) with subscripts as used on the forms is shown on Figure KS4-2.

Figure KS4-2 Location of the Actual Radii (r) with Subscripts as Used on Forms KS-ENG-309a through 309d



The slope factor is read directly from Table KS-1 for the spillway side slopes as staked in the field.

Table KS-1 Slope Factor

Slope	Slope Angle (α)	$\frac{1}{\text{Sin } \alpha}$ or Slope Factor
1:1	45°	1.41
1½:1	33°41'	1.80
2:1	26°34'	2.24
2½:1	21°48'	2.69
3:1	18°26'	3.16
3½:1	15°57'	3.64
4:1	14°02'	4.12
4½:1	12°32'	4.61
5:1	11°19‘	5.10

α = Slope angle of spillway sides

$\frac{1}{\text{Sin } \alpha}$ = Slope factor

The topsoil area of the sloping sides between curved spillway sections will be computed in segments as divided by the stakeout cross sections with the following formula:

Area = Average Cut x Slope Factor x Distance

The areas of the curved and straight floor segments (spillway bottom) are calculated on Form KS-ENG-309d. This form also provides a Summary of Areas for all calculated areas from Forms KS-ENG 309b, 309c, and 309d. Partial floor areas at the approach and exit of the spillway or areas of fill must be calculated separately. A sketch showing the areas and calculations can be attached. The calculated area can be included in the Summary of Areas.

Forms KS-ENG-309a through 309d can be completed by hand and all calculations done by hand. The forms can also be completed on the computer and all calculations will be completed by the computer. Shaded areas on the form (on the screen) require input by the user.

Table KS4-2 Curved Excavation Earthwork Computations

1. Curved Sector ℄ Sta.	2. X Sec. Comp. Figures	3. X Sec. Comp. Shapes	4. X Sec. Comp. Base	5. X Sec. Comp. Alt.	6. Comp. Area Factor	7. X Sec. Comp. Areas	8. X Sec. Cent. X Dist.	9. Cent. Radius X Sec. Rc	10. Moment of Area A. Rc	11. Sector ℄ Arc Dist.	12. Deg. per Ft. of Arc A/L	13. Sector Δ Degrees	14. Sector Δ Radians	15. Sector Arc-Dist. Rad. Rc	16. X Sec. Area "A" sq. ft.	17. Volume Exc. cu. ft.	18. Volume Exc. cu. yd.
9+50	E		57	6.0	1.0	+342.00	28.50	+83.50	+28,552.00								
	a		25	1.0	1.0	-25.00	12.50	-67.50	-1,687.50								
	b		25	2.5	0.5	-31.25	8.33	-63.33	-1,979.00								
	c		5	2.5	0.5	- 6.25	1.67	-56.67	- 354.19								
	d		12	6.0	0.5	-36.00	4.00	-108.00	-3,888.00								
	e		32	1.0	0.5	-16.00	10.67	-90.67	-1,450.72								
9+50	X Sec.	See Plot	--	--	--	+227.50	--	+84.38	+19,197.53	50'	0.8186	40.930	0.71435	60.28	227.50	13,713.70	507.9
						Ans.		Ans.									Ans.

Δ = 86˚46’ or 86.7666˚
L = 106.0 feet
radians = 0.017453 x degrees

Procedure for Computinq the Volume of a Circular Curved Excavation

Step 1. Tabulate the curved sector cross section centerline (CL) station.

Step 2. Plot the curved reach cross section on Form SCS-ENG-315.

Step 3. Around the cross section plot the minimum external rectangle of enclosure "E," preferably having a common base with the cross section.

Step 4. Subdivide the areas located inside "E" and outside the cross section into component figure rectangles and triangles.

Step 5. By inspection, classify the shape of each component figure with "E" and show symbol in the shape column.

Step 6. Tabulate the base, the altitude, and area factors of each component figure.

Step 7. Compute, tabulate, and algebraically add the areas giving "E" a plus sign and the component figures outside "A" a minus sign. The sum is the net cross section area "A."

Step 8. Compute and tabulate centroid x distance for component figures.

Step 9. Compute and plot on the cross section the radii of the curve CL point and both ends of the external rectangle "E."

Step 10. Compute the radius moment arm about the center of curvature of the centroid of "E" and of each component figure outside "A" using the same algebraic signs as in Step 7.

Step 11. Take moments of area algebraically about the center of curvature.

Step 12. Divide the algebraic sum of the moments of area by the net area of "A" to get the moment arm or radius (Rc) of the centroid of "A."

Step 13. Compute the CL arc distance through which the cross section is to be rotated for volume computation.

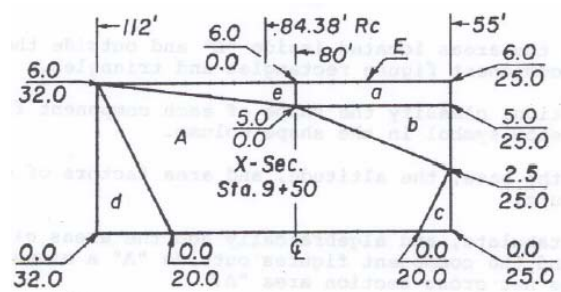
Step 14. Compute the central angle in degrees per foot of CL curve length Δ/L. Multiply Δ/L by the CL arc rotation distance from Step 13 to get the degrees of central angle Δ for each volume computation sector of the curved reach. Convert Δ from degrees to radians using the relation 0.017453 x degrees = radians.

Step 15. Multiply Δ :in radians by the radius of the centroid of "A" to get the centroid arc distance for each volume computation.

Step 16. Multiply the centroid arc distance from 15 by the cross section area "A" to get the sector volume in cubic feet.

Step 17. Add the sector volumes and divide by 27 to get the reach volume in cubic yards.

Figure KS4-3 Sample Plotting



The volume can also be computed using the Earthwork Volumes Spreadsheet. This spreadsheet can be used to calculate volumes of earthfill or excavation on a straight, curved, or angled baseline. Instructions for its use are contained in the spreadsheet. It contains macros that must be enabled at the start of the program. It is a worksheet template file to eliminate the possibility of accidentally overwriting the original file. Data entered into the spreadsheet can be exported to save file space and previously exported data can be imported as desired for editing. Questions concerning the spreadsheet should be forwarded to the developer or the construction engineer at the state office.

Actions Required Upon Completion of the Final Inspection of a Dam

Item	Reference
(a) Record permanent bench mark data on as-built drawings and seeding and fencing plan	National Engineering Manual (NEM) Section KS540.06
(b) Prepare survey field notes for the Division of Water Resources (DWR) of the following: • Final profile top of dam • Two surveyed cross sections of the constructed embankment section--One section near the deep flood plain area and the other section above the principal spillway elevation • Elevations for principal spillway inlets and pipe outlet • Centerline profile of auxiliary spillway and cross section at the control section Send a copy of the seeding and fencing plan and the survey field notes with a transmittal letter to DWR. In the letter, note the current condition of the seeded area and any obvious deviations from the approved plan. Send to the following address: Chief Engineer Division of Water Resources Kansas Department of Agriculture 109 Southwest 9th Street Topeka, Kansas 66612-1283 In addition, send a copy of this letter to the state conservation engineer (SCE).	Technical Release 62
(c) Take photographs of the completed dam	NEM Section KS513
(d) Complete Form SCS-ENG-547, Construction Completion Report, and forward to the SCE.	NEH Section 19, Page 4-34
(e) Complete Form KS-ENG-65, Dam Inventory Input and forward one copy through the assistant state conservationist for field operations to the SCE.	NEM Section KS520.21
(f) Prepare the as-built plan	NEM Sections 512.50 through 512.52
(g) Send the construction records and as-built plan to the state office within 90 days after construction is complete.	General Manual Title 120, Section 408.63, File Code 210-12