Ex 1

Several circular, concrete culverts that have a square-edged entrances with headwalls (n=0.013, ke=0.5) must be used to carry 54m3/s. The culverts are 20m long, on a 5.5 percent slope with upstream and downstream invert elevations of 261.0m and 259.9m respectively. The maximum allowable headwater elevation is 268m, and the elevation of the tailwater is 257.4m.

a. How many culverts should be used if the diameter of the culverts is 1950mm?
b. What is the headwater depth?
c. Is the system flowing under inlet or outlet control?
d. What is the velocity at the culvert exit?
e. Construct a performance curve showing the headwater elevation as a function of discharge. Consider both inlet and outlet control.

Solution

a. 3 culverts
b. 266.72 m
c. Inlet control (computed headwater : Inlet control)
d. 7.74 m/s
e. Output ➔ Plot Curves ➔ choose first three ➔ Before Q= 35m^3/s :Outlet Control

After Q= 35m^3/s: Inlet Control

Ex 2

A culvert is 11m long and has upstream and downstream inverts of 263.4 m and 263.1, respectively. The downstream tailwater elevation is below the downstream pipe invert.

For a Ke of 0.5 and a Manning's n value of 0.013, what minimum diameter concrete circular culvert (in mm) is required to pass 1.4m3/s under a roadway with a maximum allowable headwater elevation of 265.2m?

What is the headwater elevation for the selected culvert?

Solution

Diameter = 750 mm

Headwater Elevation = 265.18 m

Ex 3

An existing 9.73m long, 560x420mm steel and aluminum var CR arch (n=0.025) has a 90-degree headwall. The inverts are 33.11m and 33.09m. Assuming no tailwater effects, what is the maximum discharge that can pass through this culvert before the maximum allowable water surface elevation of 34.25 is exceeded?

Solution

Q = 0.4319 m^3/s

Ex 4

A 100-ft horizontal concrete ellipse pipe (n=0.013, Ke=0.5) on a 3.5% slope is required to carry 65cfs. Assume there is free outfall, and the maximum allowable headwater is 4.7 feet.

a. What minimum size pipe (in inches) is required?
b. What minimum size vertical concrete ellipse is required?

Solution

a. 4 culverts 92x143 inch
b. 7 culverts 181x116 inch

Ex 5

Twin culverts are proposed to discharge 6.5m3/s. The culverts will be 36.6m long and have inverts of 20.1m and 19.8m. The design engineer analyzed the three culverts systems described below. The tailwater elevation is free outfall. Which of the following proposed culverts will result in the highest headwater elevation? The lowest?

a. 1200-mm circular concrete pipes (n=0.013 and Ke=0.5)
b. 1220x910-mm concrete box culverts (n=0.013, 90º and 15º wingwall flares at entrance)
c. 1630x1120mm steel and aluminum var CR arches (n=0.025 and Ke=0.5)

Solution

a. HW = 21.92 m
b. HW = 21.94 m
c. HW=21.69 m

Ex 6

A 40-ft-long elliptical pipe (n=0.013 and Ke=0.5) will be constructed to carry 80cfs which inverts of 22.6ft and 22.1ft. The tailwater is constant at an elevation of 24.0ft. Which pipe will provide a lower headwater elevation: a 38x60-in. horizontal ellipse or a 60x38-in. vertical ellipse?

Solution

a. HW in horizontal = 26.41 m
b. HW in vertical = 27.75 m

Ex 7

A stream flows under a road through a 48-in concrete circular culvert that has a square-edge inlet with a headwall (n=0.013; ke=0.5). The culvert is on a 5% slope with a length of 31.2fr, a downstream invert elevation of 92.5ft, and a free tailwater outfall. The surface of the road is an elevation of 108.3 ft, and the stream has a base flow rate of 176.57 cfs.

a. If the runoff from a rainstorm adds another 176.57 cfs of flow to the stream, will the road be flooded?
b. What is the maximum flow rate that will not flood the rate?

Solution

a. HW = 128.07 > 108.3 ➔ Road Flooded

b. Q = 215.09 cfs

Ex 8

A detention pond drains through a circular concrete culvert that has a square-edge inlet with a headwall (n=0.013, ke=0.5). The peak discharge of the pond is 4m3/s, and the headwater elevation is 15.5m. The culvert is 10m long on a 5% slope. The depth of the headwater is 4m, and the tailwater elevation is below the elevation of the downstream invert. What is the elevation of the upstream invert? What size culvert is required?

Solution

a. Elevation of the upstream invert = 11.5 m
b. 1 050mm circular concrete .