BULE HORA UNIVERSITY

College of Engineering and Technology

Department of Hydraulic and Water Resources Engineering

Course Name: Bridge and Culvert

Course Code: HWRE 5233

Instructor: Nuresa Merga(MSC)

E-mail: nuresa44@gmail.com

- Learn to select appropriate site for bridges and culvert
- Plan, design and construction view of bridge and Culvert
- Be able to model bridge on natural river using HEC-RAS software

Course contents

Chapter one: Introduction

- General introduction to bridge and culvert

Chapter Two: Data Collections and site selection

- Types of bridge and culvert
- Selection of bridge type
- Site selection criteria for bridge
- Hydrological data collection and analysis

Chapter Three: Geometry of Bridge

- Span determination of bridge
- Bridge Loading and AASHTO Standard
- Design of Reinforced concrete and steel girder bridge

Chapter Four: Modeling Bridge and culvert Using HEC-RAS

Chapter One: General Introduction to B and C

Points to be covere

- General definition of bridg
- Major components of brid
- Types of bridge material
- Types of culvert
- The basic difference betw bridge and culvert
- Material of Culvert



History of bridge

- The first bridges were made by nature itself. ex- a fallen tree over a stream.
- Humans then began placing logs or planks across gaps they wanted to cross



…Cont’d

- The first complex bridges built were done by the ancient Greeks and Romans in the 13th century. Some of these are still



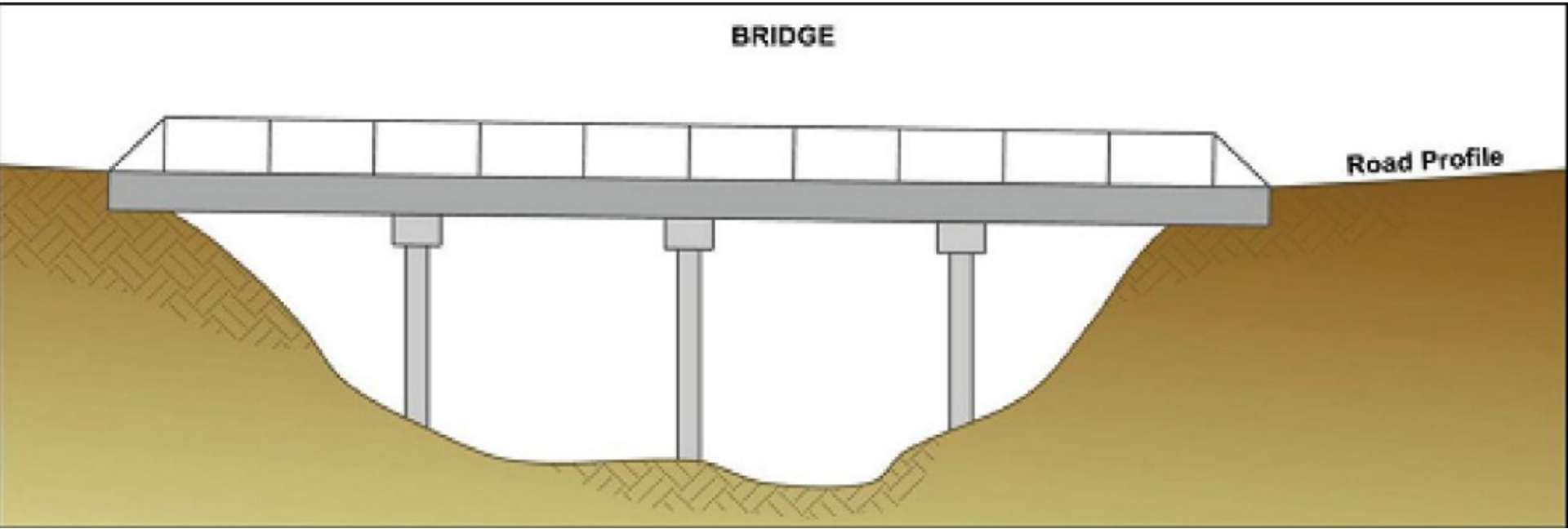
Bridge

- Bridge is defined in many prospective by different engineers in different ways, but in most general sense bridge is hydraulic structure constructed across the river to transports traffic over a



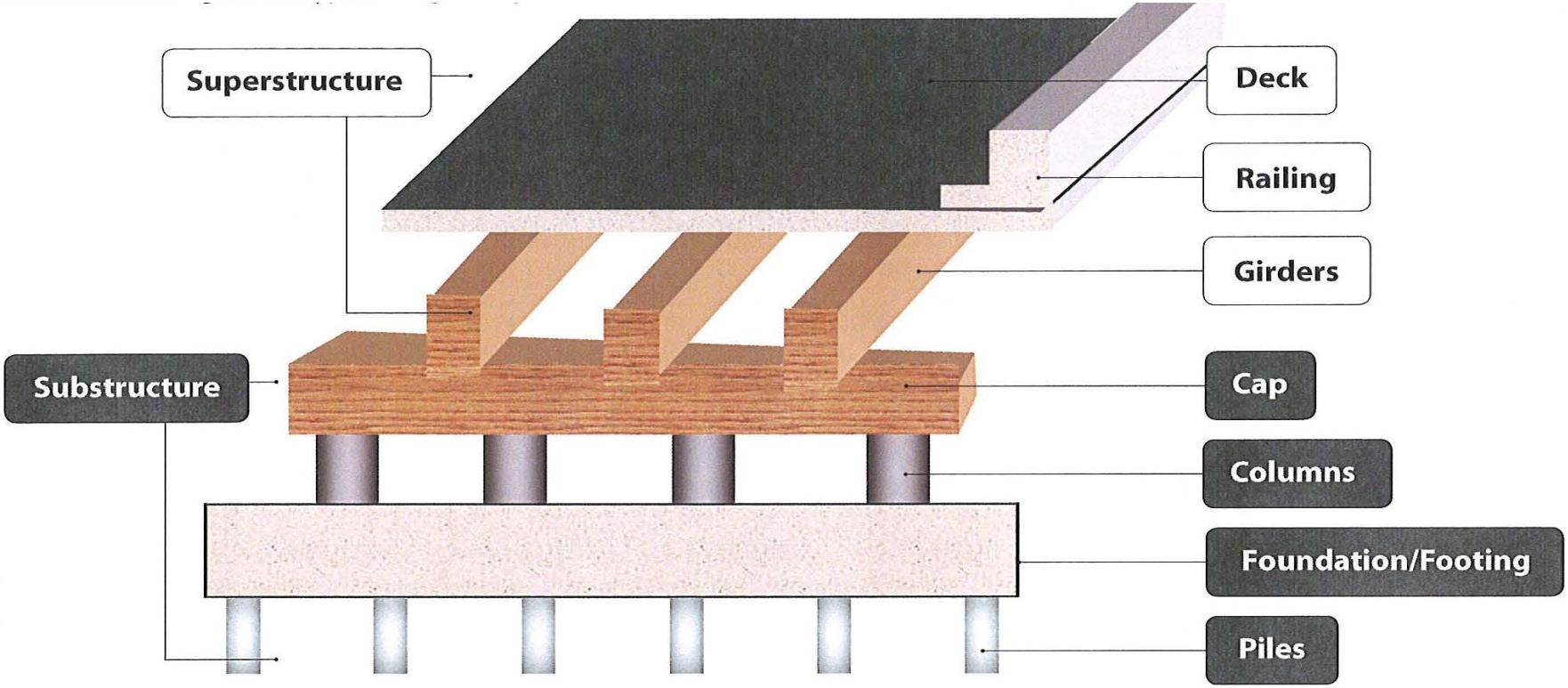
...Cont'd

- Bridge is part of a stream-crossing system that includes the approach roadway over the floodplain, relief openings
- Bridge is legally, a structure with a total



Major Component of Bridge

- Deck
- Superstructure
- Substructure



DECK

- Deck distributes loads to the Superstructure



Superstructure

- Superstructure distributes loads to the Substructure.



Substructure

Supports the Superstructure and distributes load into the ground



A stream-crossing system(Bridge or Culvert) should be designed and analyzed for the following important point prior to construction

- **Minimum cost subject to applicable criteria**
- **Desired level of hydraulic performance up to an acceptable risk level**
- **Mitigation of impacts on stream environment**
- **Accomplishment of social, economic, and environmental goals**

AASHTO general criteria related to the hydraulic analysis for the location and design of a bridge

- **Backwater will not significantly increase flood damage to property upstream of the crossing**
- **Velocity through the structure will not damage the highway facility nor increase damage to adjacent property**
- **Maintain the existing flow distribution as practical.**
- **Provide pier spacing and orientation and abutments designed to minimize flow disruption and potential scour**
- **Provide foundation design or scour countermeasures to avoid failure due to scour**

Cont'd

- **Design pier spacing and freeboard at the structure to pass anticipated debris and ice**
- **Consider acceptable risks of damage or viable measures to counter the vagaries of an alluvial stream.**
- **Consider minimal disruption of ecosystems and values unique to the floodplain and stream.**
- **Provide a level of traffic service compatible with that expected for the class of highway and compatible with the projected traffic volume.**
- **Design choices should support costs for construction, maintenance, and operation, including probable repair and reconstruction and potential liability that are affordable**

Culvert

- A culvert is a structure that is designed hydraulically to take advantage of submergence to increase hydraulic capacity

- It is also a structure used to convey surface runoff
through embankments.

- A culvert can be a structure that is usually covered with an embankment and is composed of structural material around the entire perimeter



…Cont’d

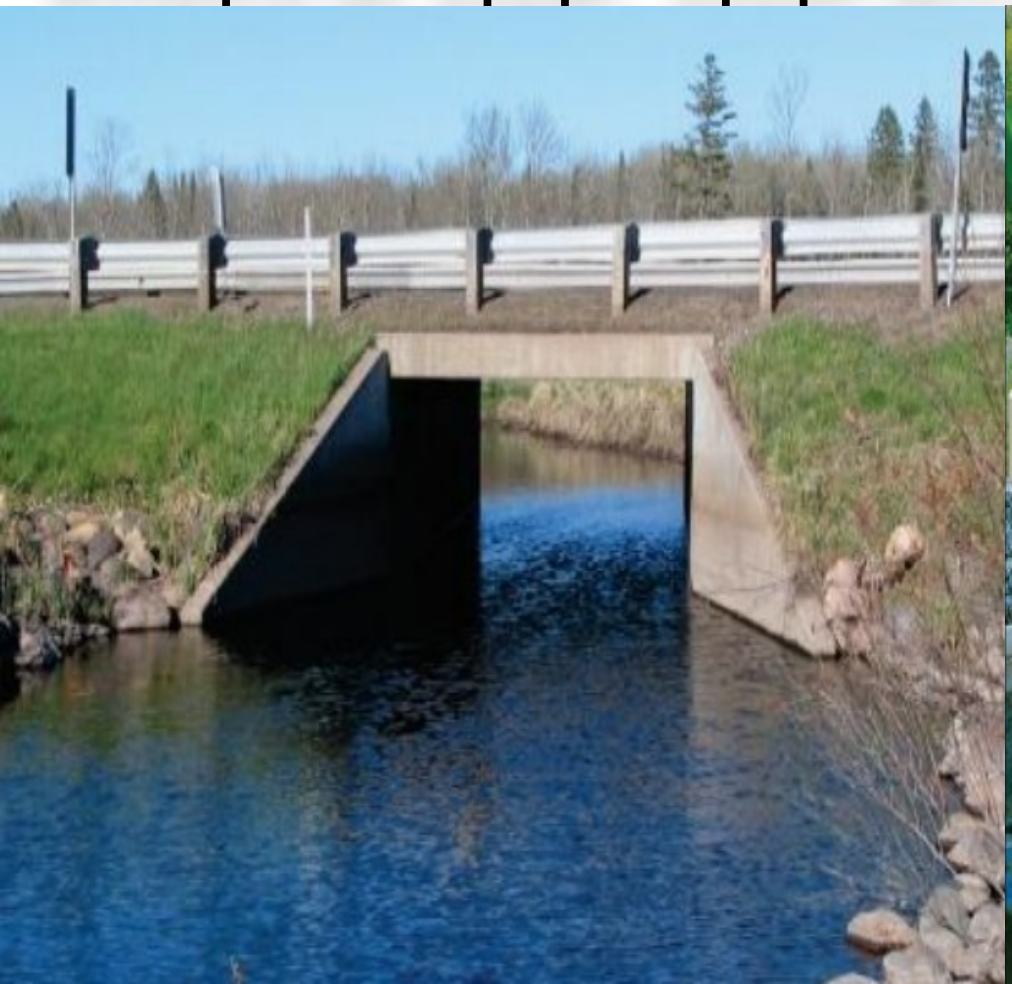
- A structure that supports a roadway or other access way over a water body by means of a fully enclosed conduit (complete pipe or box) that always has a constructed bottom and does not

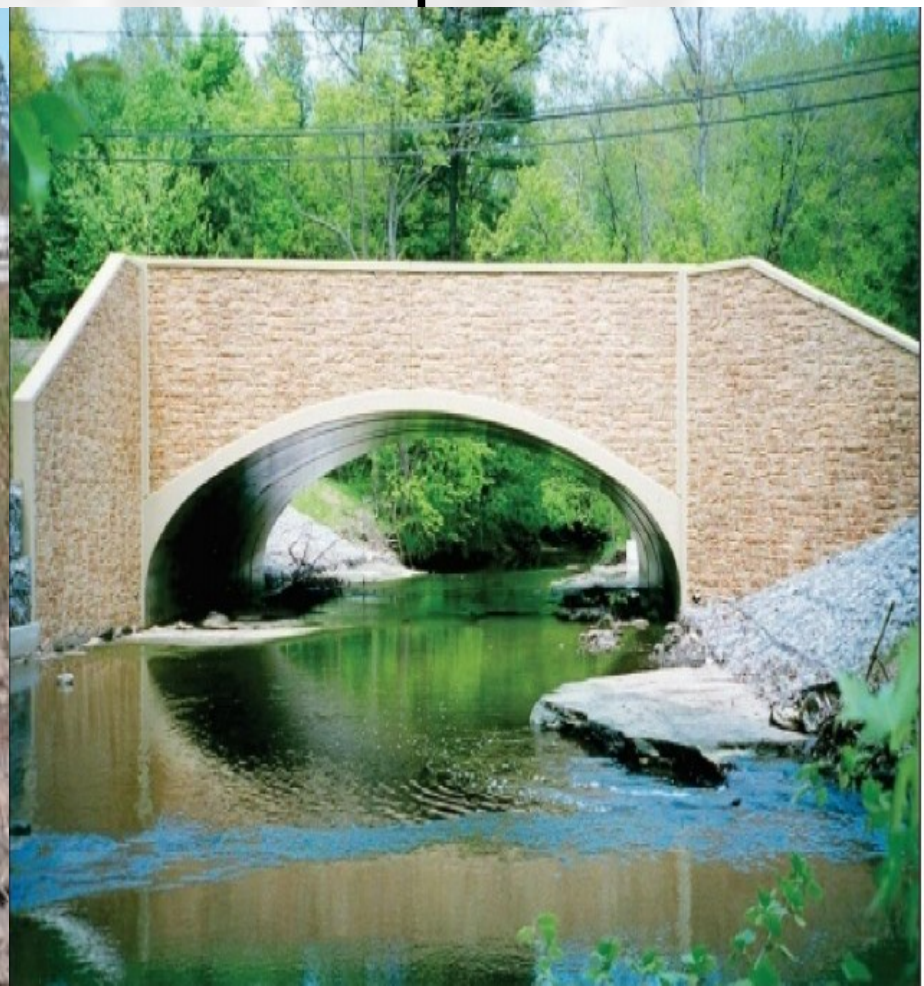




TYPES OF CULVERTS

- Common culvert types include circular (round) pipe,
  elliptical pipe, pipe-arch and square or





…Cont’d





Material Used for Culvert

- Concrete (reinforced and non-reinforced)
- Steel (smooth and corrugated)
- Corrugated aluminum
- Vitrified clay
- Plastic
- Bituminous fiber
- Cast iron
- Wood
- Stainless steel

Culverts are used;

- Where bridges are not hydraulically required
- Where debris and ice potential are tolerable
- Where more economical than a bridge (including guardrail

Bridges are used:

- Where culverts are impractical
- Where more economical than a culvert
- To satisfy land-use and access requirements
- To mitigate environmental concerns not satisfied by a culvert
- To accommodate ice and large debris.
- If you have heavy sediment loads or moving boulders

EXAMPLE 16.2.1

Analyze a 6 ft × 5 ft square-edged reinforced concrete box culvert for a roadway crossing to pass a 50-year discharge of 300 ft3/s with the following site conditions (adapted from Normann et al. (1985)):

Shoulder elevation = 113.5 ft

Stream bed elevation at culvert face = 100.0 ft

Natural stream slope = 2%

Tailwater depth = 4.0 ft

Approximate culvert length = 250 ft

Maximum allowable upstream water surface (head) elevation =110 ft (based on adjacent structures)

The inlet is not to be depressed (no fall). Refer to Figure 16.2.10 for further details.

SOLUTION

Consider an outlet control and determine the headwater elevation (*ELh*0) in steps 1–8.

Step 1 The tailwater depth is specified as 4.0 ft, which is obtained from backwater computations or from normal depth calculations.

Step 2 The critical depth is computed as $d_c = \sqrt[3]{\frac{(300/6)^2}{32.2}} = 4.27 \text{ ft}$.

Step 3 $\frac{d_c + D}{2} = \frac{4.27 + 5.0}{2} = 4.64 \text{ ft}$

Step 4 *h*0 = *TW* or (*dc* + *D*)/2, whichever is larger. For this problem *h*0= 4.64 ft.

Step 5 Use Table 16.2.3 to obtain the entrance loss coefficient. For the square-edged entrance, *Ke* = 0.5.

Step 6 Determine headlosses through the culvert barrel; use equation (16.2.4):

Step 6 Determine headlosses through the culvert barrel; use equation (16.2.4):

$$H = \left[1 + K_e + \left(\frac{29n^2L}{R^{1.33}}\right)\right]\frac{V^2}{2g}$$

where $A = 6 \times 5 = 30$ ft2, $V = 300/30 = 10$ ft/s, $R = A/P = 30/(6 + 6 + 5 + 5) = 1.36$ ft. For concrete box culvert, take $n =$ 0.012. So, $H = \left[1 + 0.5 + \left(\frac{29(0.012)^2(250)}{1.36^{1.33}}\right)\right]\frac{10^2}{2(32.2)} = 3.41$ ft

Because $TW < D$ there is only partly full flow at the exit. The headlosses would be more accurately computed from a backwater analysis.

Step 7 Determine the required outlet control head water elevation ($ELh0$), $ELh0 = EL0 + H0 + h0$, $EL0$ is the invert elevation at the outlet (see Figure 16.2.10):

$$EL_0 = EL_i - S_0L = 100 - 0.02(250) = 95 \text{ ft}$$

Then $ELh0 = 95 + 3.41 + 4.64 = 103$ ft. Also the approach velocity head $(V_u^2/2g)$ and the downstream velocity head can be considered in the calculation of $ELh0$ by adding $V_d^2/2g$ and subtracting $V_u^2/2g$ from the right-hand side of the above equation for $ELh0$.

Now consider inlet control and determine headwater elevation, $ELhi$.

Step 8 The design headwater elevation is now computed as $ELhi = HWi + ELi$, so HWi must be computed using equation (16.2.1), where

$$\frac{HW}{D} = C\left[\frac{Q}{AD^{0.5}}\right]^2 + Y + Z$$

and C and Y are obtained from Table 16.2.1 as $C = 0.0423$ and $Y = 0.82$ for a rectangular box culvert with 0° wingwall flares. $Z = -0.5S0 = -0.5(0.02) = -0.01$

$$\frac{HW}{D} = 0.0423\left[\frac{300}{30(5)^{0.5}}\right]^2 + 0.82 - 0.01 = 1.66$$

$$\frac{HW}{D} = 0.0423\left[\frac{300}{30(5)^{0.5}}\right]^2 + 0.82 - 0.01 = 1.66$$

To check,

$$\left[\frac{Q}{AD^{0.5}}\right] = 4.47 > 4$$

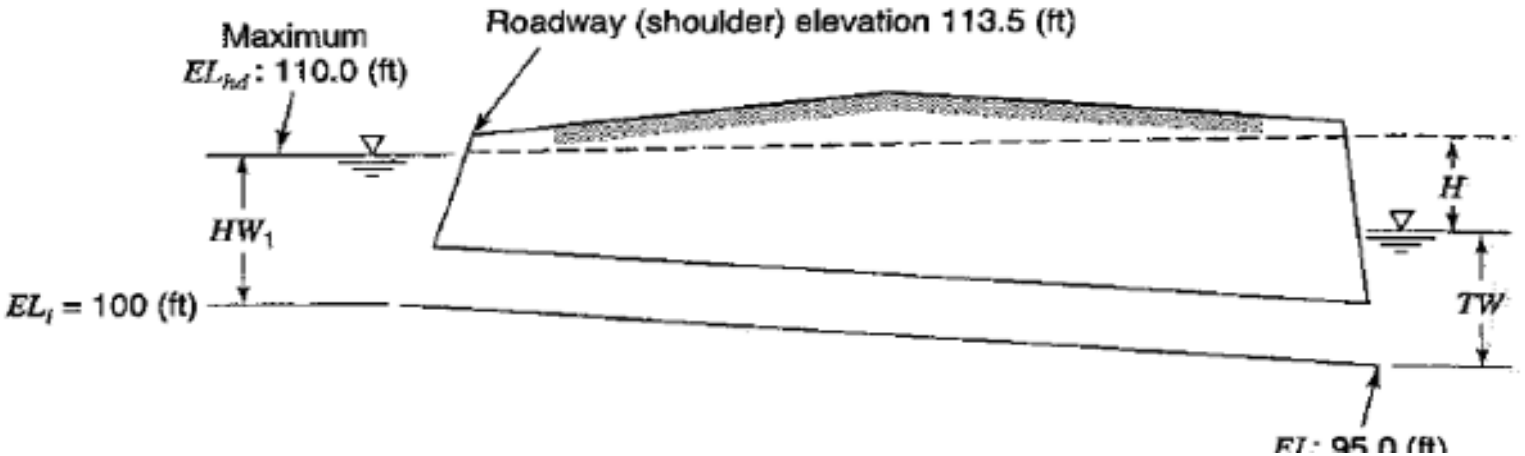
$$HW_i = D\left[\frac{HW}{D}\right] = 5(1.66) = 8.28 \text{ ft}$$

$$EL_{hi} = 8.28 + 100 = 108.28 \text{ ft}$$

The design headwater elevation of 108.28 ft exceeds the outlet-control headwater elevation of 103 ft. Also, the headwater elevation is less than the roadway shoulder elevation of 113.5 ft.

This design is OK; however, a smaller culvert could be considered. In fact, for this problem a 5 ft × 5 ft reinforced concrete culvert with either a square-edged entrance or a 45° beveled-edge entrance will work, as shown by Normann et al. (1985).

Figure 16.2.10 Details of culvert for Example 16.2.1.



- Dear all my students, follow the following Link for further information and examples

- https://www.chegg.com/homework-help/water-resources-engineering-2nd-edition-chapter-16.2-solutions-9780470460641

Assignment-

- **Bridge and Culvert Hydraulics**

1. What are the major factors you should consider while selecting appropriate site for bridge/culvert?

2. Write and discuss hydraulic causes of bridge/culvert failure and the remedial measure to over such failure

3. What is scour, how it affect bridge, and what assessment need to do in order to overcome scour problem in bridge

4. Write the fundamental steps which you should follow to model bridge using HEC-RAS software

5. Analyze 6ftx5ft square edge reinforced concrete box culvert for a road way crossing to pass a 50 year discharge of 300 ft^3/sec with the following site condition

- Shoulder elevation: 113.5ft
- Stream bed elevation at culvert face:100ft
- Natural stream slope: 2%
- Tail Water depth: 4ft
- Culvert length: 250ft
- Maximum allowable upstream water surface(head) elevation:110ft
- The inlet is not depressed

Cont’d

6. Design a culvert for the following Input Data for which 100 discharge is considered

- Discharge of 100-yr flood = 176 cfs
- Allowable HW = 4.5 ft.
- Allowable HW = 7.0 ft.
- Length of culvert = 100 ft.
- Natural channel invert elevations: Inlet = 15.50 ft, outlet = 15.35 ft.
- Culvert slope = 0.0015 ft. /ft.
- Tail water depth = 4.0 ft.
- Tail water depth is the normal depth in downstream channel
- Entrance type = Groove end with headwall

- **Send your Assignments via the email stated at first page of this materials**

Modeling Bridge and Culvert Using HEC-RAS Is to be hold in Computer Lab