LECTURE 07

CROSS DRAINAGE WORK

- In an irrigation project, when the network of main canals, branch canals, distributaries, etc. are provided, then these canals may have to cross the natural drainages like rivers, streams, etc at different points within the command area of the project.
- The crossing of the canals with such obstacle cannot be avoided. So, suitable structures must be constructed at the crossing point for the easy flow of water of the canal and drainage in the respective directions. These structures are known as cross-drainage works.

Necessity of Cross-drainage works:

- The water-shed canals do not cross natural drainages. But in actual orientation of the canal network, this ideal condition may not be available and the obstacles like natural drainages may be present across the canal. So, the cross drainage works must be provided for running the irrigation system.
- At the crossing point, the water of the canal and the drainage get intermixed. So, far the smooth running of the canal with its design discharge the cross drainage works are required.
- The site condition of the crossing point may be such that without any suitable structure, the water of the canal and drainage can not be diverted to their natural directions.

Types of Cross-Drainage Works:

- **Type I (Irrigation canal passes over the drainage)**
  - (a) Aqueduct
  - (b) Siphon aqueduct
- **Type II (Drainage passes over the irrigation canal)**
  - (a) Super passage
  - (b) Siphon super passage
- **Type III (Drainage and canal intersection each other of the same level)**
  - (a) Level Crossing
  - (b) Inlet and outlet

Selection of type of cross-drainage works

- Relative bed levels
- Availability of suitable foundation
- Economical consideration
- Discharge of the drainage
- Construction problems

Aqueduct : The aqueduct is just like a bridge where a canal is taken over the deck supported by piers instead of a road or railway. Generally, the canal is in the shape of a rectangular trough which is constructed with reinforced cement concrete. Sometimes, the trough may be of trapezoidal section.

- An inspection road is provided along the side of the trough.
- The bed and banks of the drainage below the trough is protected by boulder pitching with cement grouting.
- The section of the trough is designed according to the full supply discharge of the canal.

- A free board of about 0.50 m should be provided.
- The height and section of piers are designed according to the highest flood level and velocity of flow of the drainage.
- The piers may be of brick masonry, stone masonry or reinforced cement concrete. Deep foundation (like well foundation) is not necessary for the piers. The concrete foundation may be done by providing the depth of foundation according to the availability of hard soil.

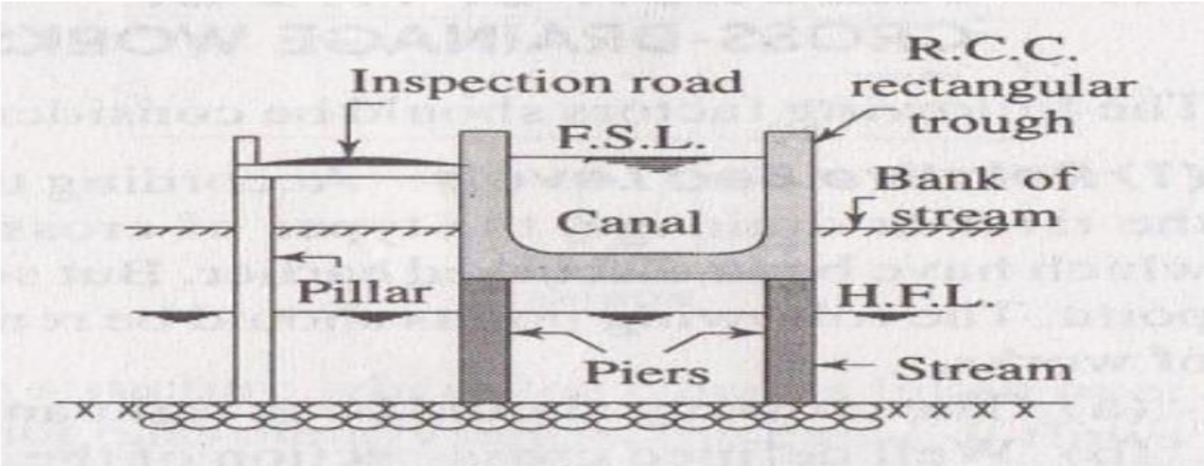


Fig: Aqueduct

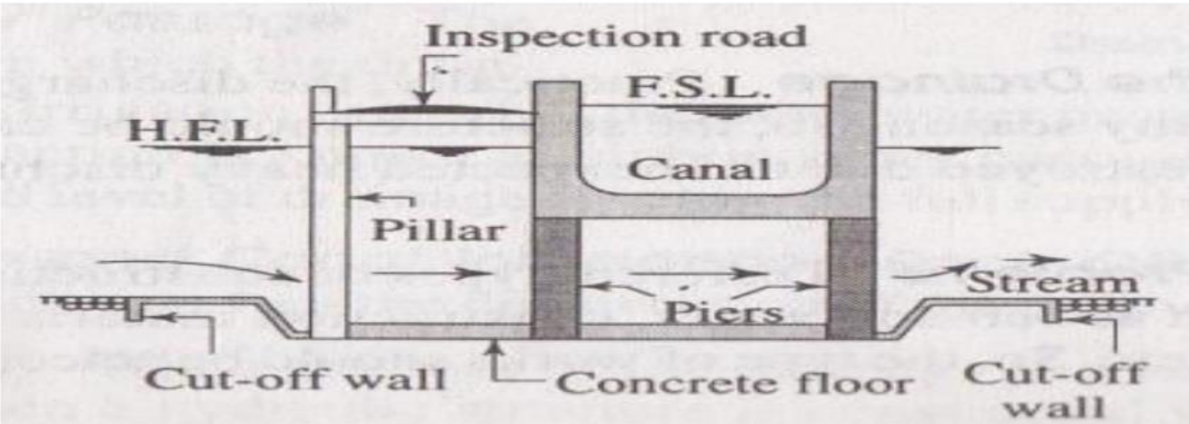


Fig: Siphon Aqueduct

- **Super Passage** The super passage is just opposite of the aqueduct. In this case, the bed level of the drainage is above the fully supply level of the canal. The drainage is taken through a rectangular or trapezoidal trough of channel which is constructed on the deck supported by piers. The section of the drainage trough depends on the high flood discharge. A free board of about 1.5 m should be provided for safety. The trough should be constructed of reinforced cement concrete. The bed and banks of the canal below the drainage trough should be protected by boulder pitching or lining with concrete slabs. The foundation of the piers will be same as in the case of aqueduct

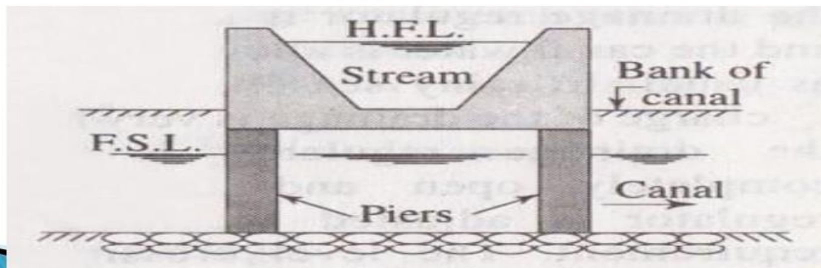


Fig: Super Passage

- **Siphon Super Passage:** It is just opposite siphon aqueduct. In this case, the canal passes below the drainage trough. The section of the trough is designed according to high flood discharge. The bed of the canal is depressed below the bottom level of the drainage trough by providing sloping apron on both sides of the crossing. The sloping apron may be constructed with stone pitching or concrete slabs. The section of the canal below the trough is constructed with cement concrete in the form of tunnel which acts as siphon. Cut-off walls are provided on upstream and downstream side of sloping apron. Other components are same as in the case of siphon aqueduct.

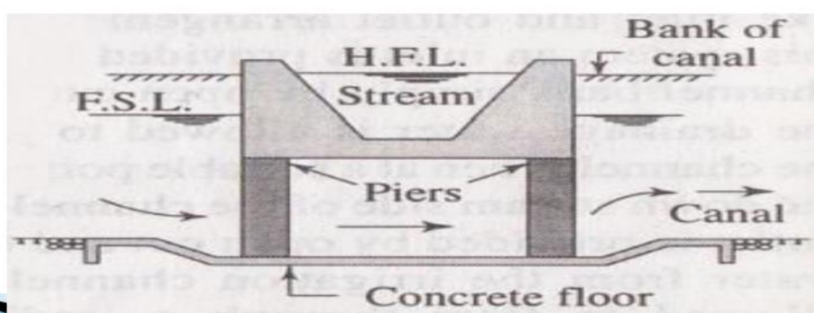


Fig: Siphon Super Passage

- **Level Crossing** The level crossing is an arrangement provided to regulate the flow of water through the drainage and the canal when they cross each other approximately at the same bed level. The level crossing consists of the following components:
  - Crest Wall: It is provided across the drainage just at the upstream side of the crossing point. The top level of the crest wall is kept at the full supply level of the canal.
  - Drainage Regulator: It is provided across the drainage just at the downstream side of the crossing point. The regulator consists of adjustable shutters at different tiers.
  - Canal Regulator: It is provided across the canal just at the downstream side of the crossing point. This regulator also consists of adjustable shutters at different tiers.

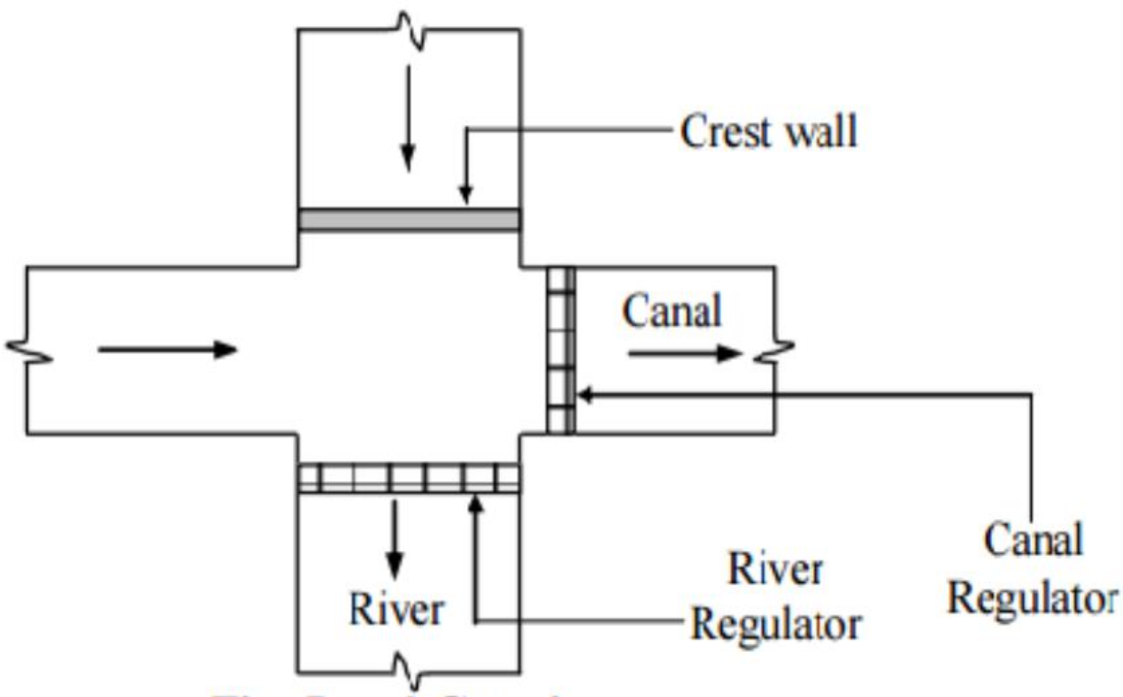


Fig: Level Crossing

- **Inlet and outlet:** In the crossing of small drainage with small channel no hydraulic structure is constructed. Simple openings are provided for the flow of water in their respective directions. This arrangement is known as inlet and outlet.
- In this system, an inlet is provided in the channel bank simply by open cut and the drainage water is allowed to join the channel. At the points of inlet and outlet, the bed and banks of the drainage are protected by stone pitching

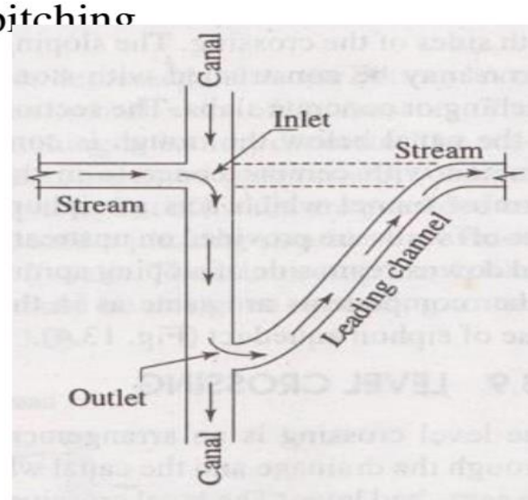


Fig: Inlet and outlet

Canal Escapes: It is a side channel constructed to remove surplus water from an irrigation channel (main canal, branch canal, or distributary etc.) into a natural drain.

The water in the irrigation channel may become surplus due to

Mistake

Difficulty in regulation at the head

Excessive rainfall in the upper reaches

Outlets being closed by cultivators as they find the demand of water is over.

Types of Canal Escapes:

(a) Weir type escape

(b) Regulator/sluice type escape

Weir type escape:

Crest level = FSL of the canal

Water escapes if W_L > FSL

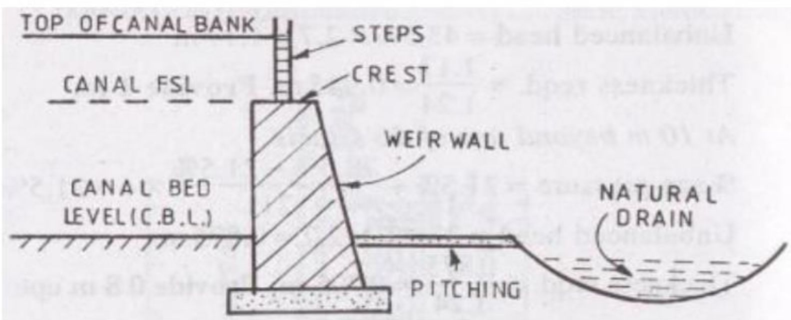
The crest of the weir wall is kept at R.L equal to canal FSL.

When the water level rises above FSL, it gets escaped.

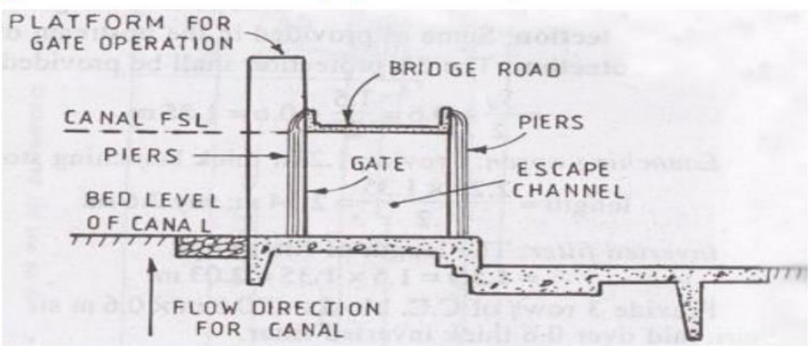
Regulator/sluice type escape:

- The silt of the escape is kept at canal bed level and the flow can be used for completely emptying the canal.
- They may be constructed for the purpose of scouring off excess bed silt deposited in the head reaches from time to time.

Weir type escape:



Regulator/sluice type escape:



Canal Outlets

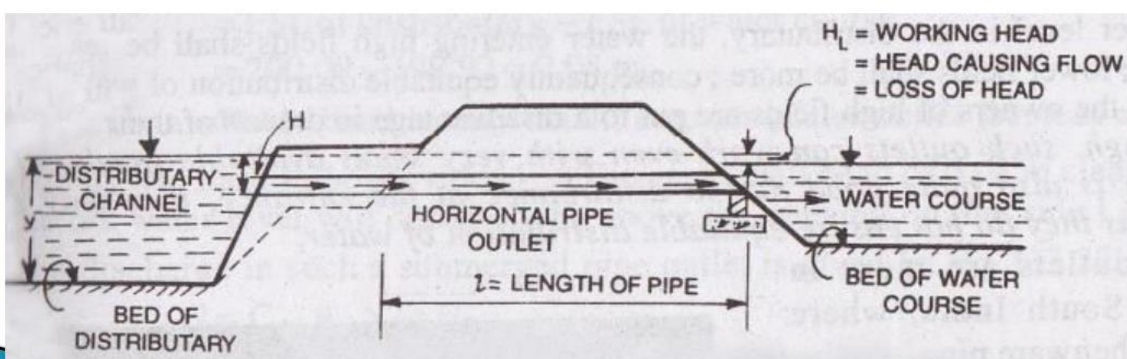
Canal Outlets: A canal outlet is a small structure built at the head of the water course so as to connect it with a minor or a distributory channel. It acts as a connecting link between the system manager and the farmers.

Requirements of a good module:

- It should fit well to the decided principles of water distribution.
- It should be simple to construct.
- It should work efficiently with a small working head.
- It should be cheaper.
- It should be sufficiently strong with no moving parts, thus avoiding periodic maintenance.
- It should e such as to avoid interference by cultivators.
- It should draw its fair share of silt.

- **Types of outlets/modules:**
- **(a) Non-modular module**: Non-modular modules are those through which the discharge depends upon the head difference between the distributary and the water course. Common examples are: (i) Open sluice (ii) Drowned pipe outlet

  Lowering of the bed of the water course will draw extra discharge. Thus equitable distribution of discharge may not be possible.



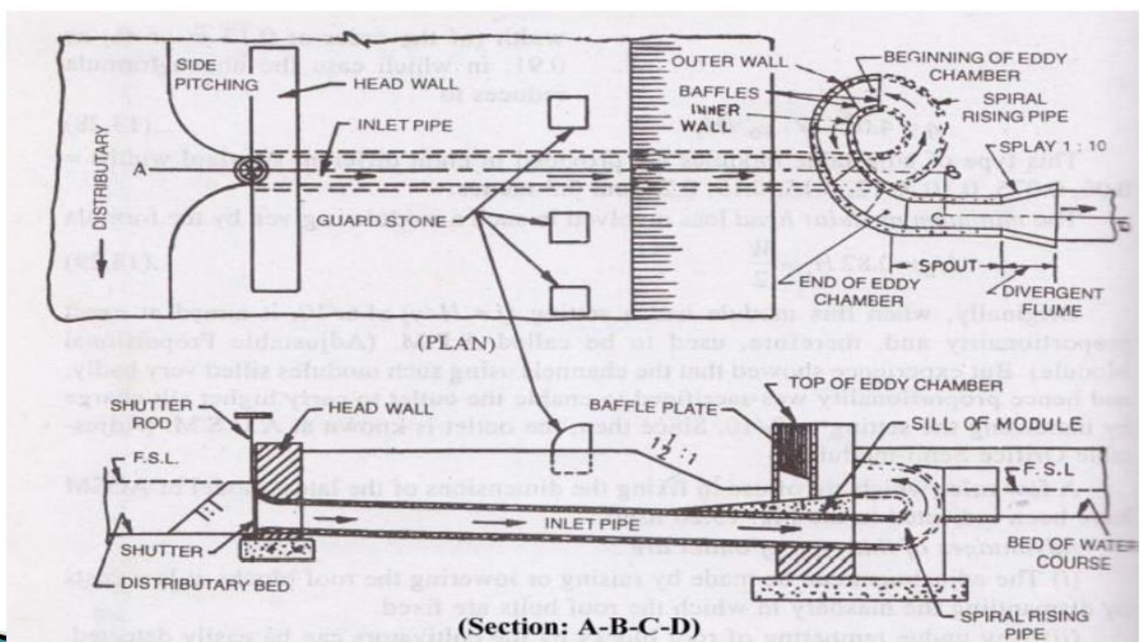
- **(b) Semi-modules or Flexible modules:** Due to construction, a super-critical velocity is ensured in the throat and thereby allowing the formation of a jump in the expanding flume. The formation of hydraulic jump makes the outlet discharge independent of the water level in water course, thus making it a semi module.

  Semi-modules or flexible modules are those through which the discharge is independent of the water level of the water course but depends only upon the water level of the distributory so long as a minimum working head is available.

  Examples are pipe outlet, open flume type etc

- **(c) Rigid modules or Modular Outlets:** Rigid modules or modular outlets are those through which discharge is constant and fixed within limits, irrespective of the fluctuations of the water levels of either the distributory or of the water course or both.

  An example is Gibb's module.



(PLAN)

(Section: A-B-C-D)

CANAL LINING

Based on lining:

i. Lined canals

ii. Unlined canals

Lined canals:

Provided with impervious bed and bank prevents seepage velocity of flow is on one.

Lining reduces the cross section area of canal.

Unlined canals:

Bed and banks are made of natural soil through which it is constructed velocity of flow is low.

CANAL LINING

Advantages:

- Reduces seepage loss- saves water
- Prevents water slogging
- High velocity of flow
- Does not allow sediments to deposit
- Prevents weed growth
- Less evaporation loss
- Saves land for canal construction
- Cost of canal structures is less as width is less
- High velocity, so flat hydraulic gradient more heat for power house.
- Area of C.S of lined channel is less
- Leaching of salts from sides prevented
- Maintenance cost is less.
- Stable channel is easy to operate.

Disadvantages:

- Lining require high initial cost
- Difficult to repair drainage
- Canal to lining outlets cannot be shifted
- Has no perms, hence ***shift*** on the banks is not easy

Types of lining :

a. Exposed and hard surface lining

1. Cement concrete (insite)
2. Precast concrete lining
3. Short Crete lining
4. Brick tile, stone blocks, Asphatic concreting

b. Buried membrane linings:

1. Spray- in plan asphalt membrane lining
2. Pre fabricated asphaltic membrane lining
3. PVC, synthetic rubber, Bentonite clay

c. Earth lining:

1. Thrust compact earthlings
2. Stabilized soil lining
3. Bentonite soil lining
4. Soil- cement lining

DESIGN OF UNLINED CANAL (ALLUVIAL CANAL)

KENNEDY'S THEORY

LACEY'S REGIME THEORY

DESIGN PROCEDURE (KENNEDY'S THEORY)

TYPE 1 **Q, N, m and s**

* Assume trial value of D in meters
* Calculate the velocity V using Kennedy's eqn

$$V=0.55\ D^{0.64}$$

* Get area of section

$$A = Q/V$$

* Knowing D and A, calculate the bed width B

The side slope of the canal in alluvial soil assumed to be ½:1 when the canal has run for some time.

$A = BD+(D^2/2)$ from which B can calculated

$$R = \frac{A}{P} = \frac{BD + \frac{D^2}{2}}{B + D\sqrt{5}}$$

* Calculate the perimeter and the hydraulic mean depth from the following relations

$P=B+D\sqrt{5}$

$R = A/P=(BD+D^2/2)/(B+D\sqrt{5})$

* Calculate the actual mean velocity of flow from Kutter's equation or Manning's or Chezy's formula. If this value of velocity is same as that found in step 2, the assumed depth is correct. If not, repeat the calculations with a changed value of D till the two velocities are the same.

$V=((23+(1/N)+(0.00155/S))/(1+(23+(0.00155/S))(N/\sqrt{R})))(\sqrt{[RS]})$

<u>Type 2:</u> **Q, N, m and B/D**

Calculate A in terms of D

$B/D = x$

$B = Dx$

$A = BD + (D^2/2) = xD^2+(D^2/2)$

$A = D^2(x+0.5)$

2) The value of velocity V is known in terms of D by Kennedy's equation

$V=0.55mD^{0.64}$

Substitute the values of V and An in the continuity equation and solve for D. thus

$Q = A X V = D^2(x+0.5) X 0.55mD^{0.64}$

$$\mathbf{Q = 0.55m(x+0.5)\ D^{2.64}}$$

Hence $D = (Q/(0.55m(x+0.5)))^{(1/2.64)}$

in the above relation Q, m and x are known. Hence D is determined

3) Knowing D, calculate B and R from the following relations

$$\mathbf{B = xD}$$

and $$\mathbf{R = (BD + D^2/2)/(B + D\sqrt{5})}$$

4) Calculate the velocity V from Kennedy's equation

$$\mathbf{V = 0.55\ m\ D^{0.64}}$$

5) Knowing V and R, determine the slope S from Kutter's flow equation. The equation can be solved trial and error

LACEY'S REGIME THEORY

Channel Design Procedure

Q, Mean dia of silt particles m_r or silt factor f should be known

*** Calculate the silt factor f $=1.76\sqrt{m_r}$**

*** Find out velocity V $=(Qf^2/140)^{1/6}$**

*** Find out area A $=Q/V$**

*** Find our perimeter P $=4.75\sqrt{Q}$**

*** Find out bed width B and depth D of the channel section since A and P are known. The slope of an irrigation channel is usually ½:1. Hence, Area $A = BD+(D^2/2)$**

$P = B+D\sqrt{5}$ [solve quadratic form]

$$D = (P - \sqrt{(P^2 - 6.944A)}\ /3.472$$

$$B = P - 2.236\ D$$

- Calculate $R = 5/2\ (V^2/f)$
- Also calculate $R = (BD+(D2/2))\ /\ (B+D\sqrt{5})$
- Find the slope $S = (f)^{5/3}/(3340\ .\ Q)^{1/6}$