CE-441-ENVIRONMENTAL ENGINEERING II

Lecture 7- Design of pumping station

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Objective

To elevate and transport wastewater when;

- Continuation of gravity flow is no longer feasible
- Basements are deep
- Any obstacle lies in the path of sewer
- Receiving stream is high than the sewer
- Sewage is to be delivered to an above ground treatment plant

Pumps for Sewage

- ❖Centrifugal,vertical,non clog type
- ❖Impeller having 2 or 3 vanes
- ❖Low head
- ❖RPM 200-1200

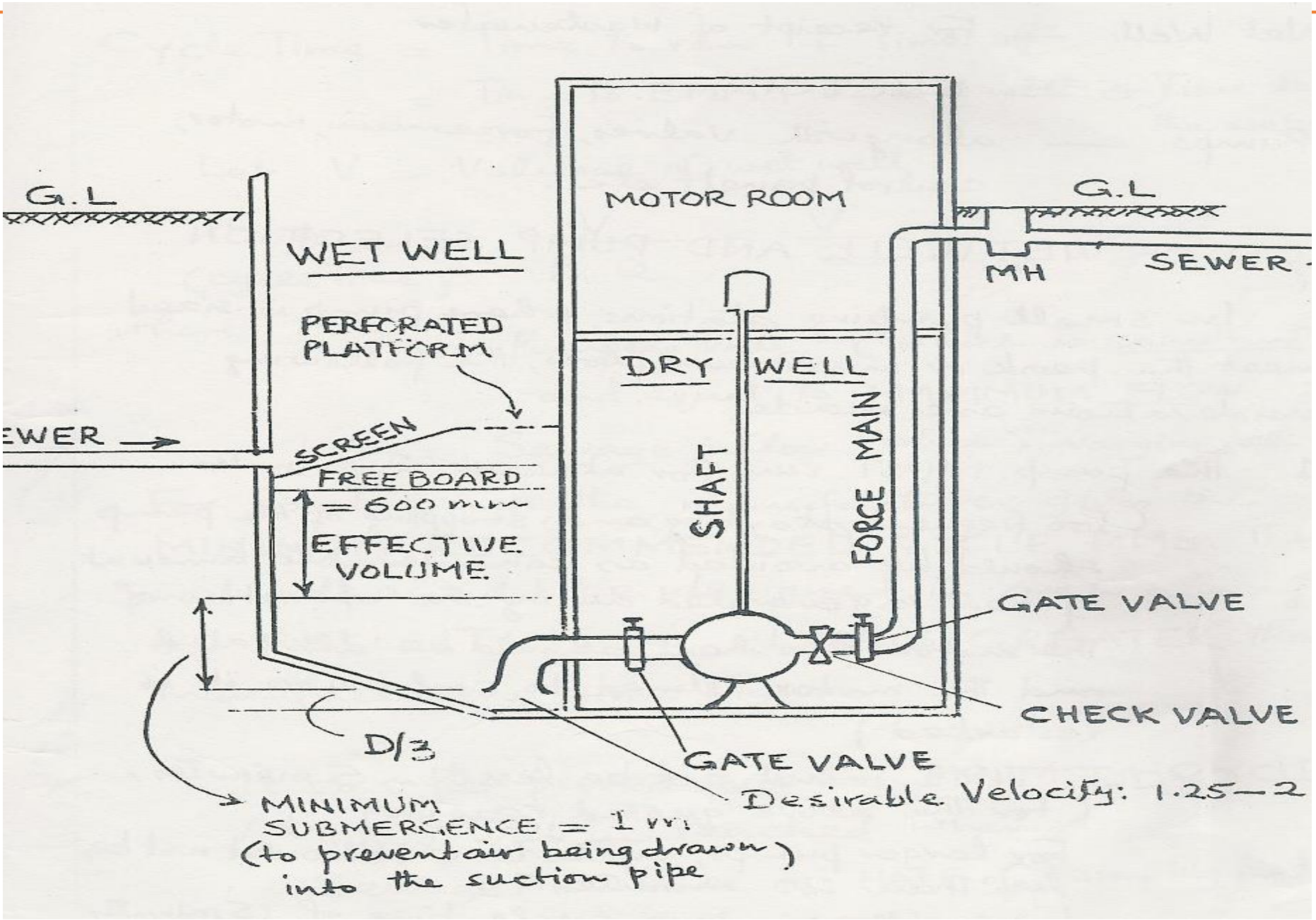
Other Aspects:

- Manufacturers specifies the sphere sizes which pump will pass
- Smallest discharge pipe is 80 mm
- Smallest suction pipe is 100 mm
- Pump suctions are usually larger than the discharge by about 25%
- Capacity of the pump=Maximum flow
- Number of Pumps=2 (minimum)

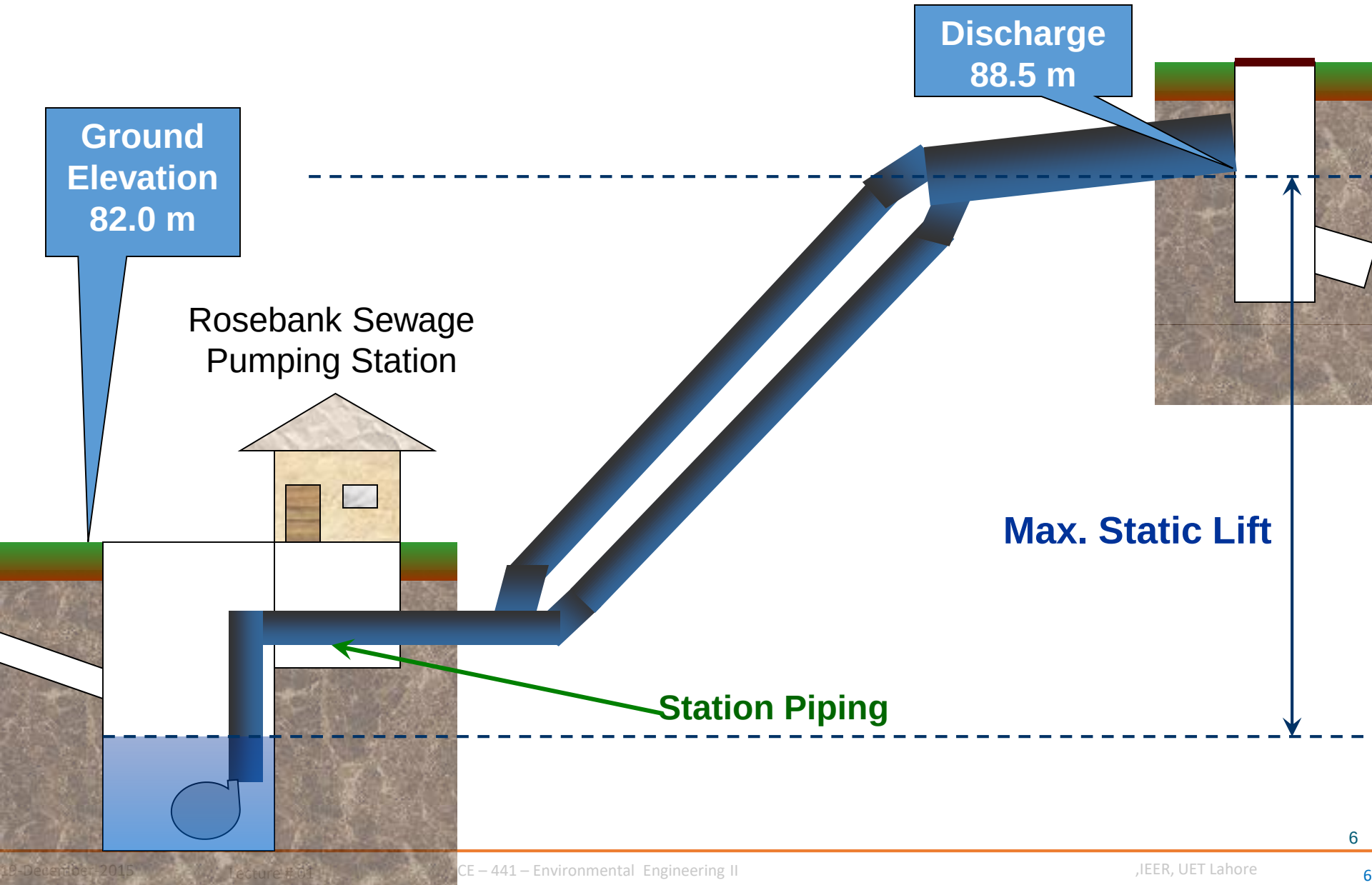
Components of sewage pump stations

1. Screens
2. Dry well (for installation of pumps)
3. Wet well (for receipt of wastewater)
4. Pumps

Sewage pumping station



Pumping Station Layout



Design of wet well and pump selection

Small pumping station where pump is sized to meet the peak flow, the following consideration are made:

1. Pump must be run for at least 2 minutes
2. Cycle time must not be less than 5 minutes so for smaller pumps 15 minutes and for larger pumps not less than 20 minutes
3. Detention time in the wet well at average flow should preferably be not more than 30 minutes to avoid sewage being septic

Cycle time

- It is the time between successive start ups of the motor pump

$$Cycle\ Time = Time\ to\ run + Time\ off$$

Cycle Time = Time to empty the wet well + Time to fill the wet well

Let

V= volume of wet well

$$Pump\ running\ time = \frac{volume\ of\ wet\ well}{Net\ discharge(P-Q)}$$

$$Filling\ time, pump\ off = \frac{volume\ of\ wet\ well}{inflow}$$

Therefore, cycle time equals to

$$t = \frac{V}{P-Q} + \frac{V}{Q}$$

Cycle time

Where,

P=pumping rate (constant and equal to max.flow)

Q=sewage inflow(vary with time)

•For each pump ,the manufacturer gives the **minimum recommended cycle time**. Wet well should be designed in such a way that the cycle time is always **greater** than manufacturer's given figure.

Proof:

$$t = \frac{V}{P - Q} + \frac{V}{Q}$$

Differentiating w.r.t Q (which is variable)

$$\frac{dt}{dQ} = \frac{V}{(P - Q)^2} - \frac{V}{Q^2}$$

For t_{min} , $\frac{dt}{dQ} = 0$

$$\frac{V}{(P - Q)^2} - \frac{V}{Q^2} = 0$$

$$P = 2Q$$

$$\boxed{Q = \frac{1}{2}P}$$

- It can be proved that the minimum cycle time will be reached when :

sewage flow rate=half of pumping rate

$$Q = \frac{1}{2}P$$

Thus

$$t_{min} = \frac{V}{P - \frac{1}{2}P} + \frac{V}{\frac{1}{2}P}$$

$$t_{min} = \frac{4V}{P}$$

So the volume of wet well is equal to

$$V = \frac{t_{\min} P}{4}$$

Pump Selection

- **Number**
  - ❖ 2 pumps for small stations (one as stand by),capacity at peak flow
  - ❖ At least 4 pumps for large pumping stations with following capacities

1. Minimum flow
2. Average flow
3. Maximum flow
4. Maximum flow(stand by)

- **Intake** – each pump should have separate intake

- **Velocity**- 0.6 m/s should maintained in the discharge line

- **Valves**-Place gate valves on both suction and discharge pipes .Also place check valves on discharge pipes

Problem 1

- A small subdivision produces an average wastewater flow of 120,000 L/day. The minimum flow is estimated to be 15,000 L/day and the maximum 420,000 L/day. Using a 2 min running time and a 5-min cycle time, determine the design capacity of each of two pumps and the required wet well volume.

Problem 2

A small sewage pump station is to have one pump operating at a time .It is expected that Q_{avg}=450m^3/day,Q_{min}=225m^3/day,Q_{max}=787.5 m^3/day will be the flow rates.

Determine the wet well capacity , and cycle time at min and average flows. The following operation are to be met with

1.Pump must run at least 2 min

2.Cycle time should not be less then 5 min

Also calculate the min cycle time.

Problem 3

- The min and peak sewage flows are 2500 m^3/day ,25000 m^3/day with an Q_{avg} of 7500m^3/day at the pumping station. Design the wet well if the pump has a min cycle time of 30 min. At what flow cycle time will be 2 times the min cycle time.

Problem 4

- Sewage pumping station is to be design to pump sewage with average and peak flows of 3000 m^3/day and 9000m^3/day. Pump has a min cycle time of 20 min. At what flow the cycle time will be twice the min cycle time.