Marks Scored:

KATHMANDU UNIVERSITY
End Semester Examination [C]
May/June, 2019

Level : B.E.
Year : IV
Course : CIEG 406
Semester : I
Exam Roll No. :
Time: 30 mins.
F. M. : 10
Registration No. :
Date 07 JUN 2019

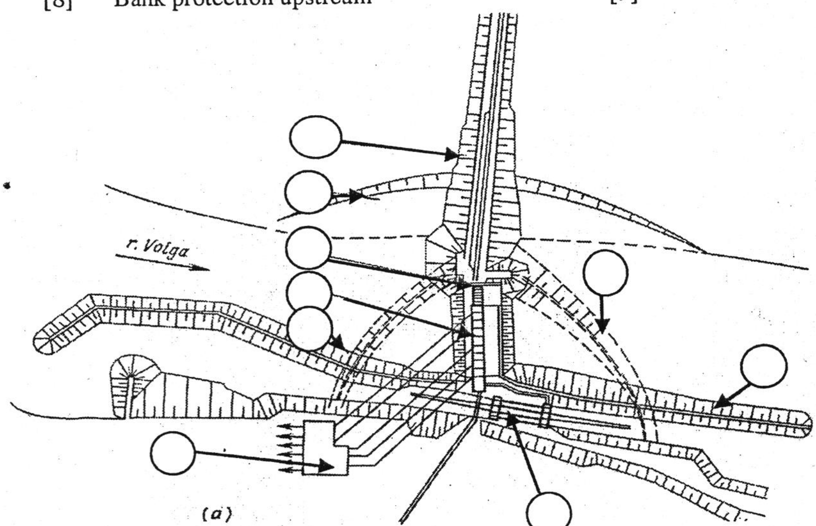
SECTION "A"
[20 × 0.5 = 10 marks]

Tick only the best answers. Calculation can be shown adjacent to the question.

1. What is the result of the product of the utilization factor and plant factor?
[ ] Diversity factor [ ] Load factor [ ] Demand factor [ ] Power factor

2. The mass-curve is a graphical representation of
[ ] Cumulative discharge and time
[ ] Discharge and percentage probability of flow being equaled or exceeded
[ ] Cumulative discharge, volume and time in chronological order
[ ] Discharge and time in chronological order

3. What type of power plant is this (see Sketch)? Name all the components in the blanks
[ ] Instream Hydropower Power Plant
[1] Earthen Dam on left bank
[2] Spill-way
[3] Powerhouse for ten aggregates
[4] Ships Lock
[5] Switch Yard
[6] Divide wall downstream
[7] Divide wall upstream
[8] Bank protection upstream
[9]



(a)

4. Find the power generated by a water mill, if it processes 100 l/s from a fall of 2.0 m. It has got an efficiency of 50%.
[ ] 0.655 kW [ ] 0.981 kW [ ] 0.456 kW [ ] 0.678 kW

5. There are several direct and indirect methods to obtain the velocity of the flow in a river. Which of the following formulas are used to calculate the discharge passed the given river cross-section if the slope-area method and staff are used respectively? Given that the wetted area (A), wetted perimeter (P) of the cross-section of the river, the energy slope of the river profile (Se) and rise of water head (H) above the surface of could be measured and the Strickler coefficient (K) and coefficient of discharge (C) water could be guessed based on the literature review and materials judgment of the given river morphology.
[ ] $Q= AKR^{2/3}S_e^{1/2}$; $Q=CA(2gH)^{1/2}$
[ ] $Q= AnR^{3/2} S_e^{1/2}$; $Q=A(2gH)^{1/2}$
[ ] $Q= An^{-1}KR^{2/3} S_e^{1/2}$; $Q=CA(2gH)^{1/2}$
[ ] $Q= An^{-1}KR^{2/3} S_e^{1/2}$; $Q=A(2gH)^{1/2}$

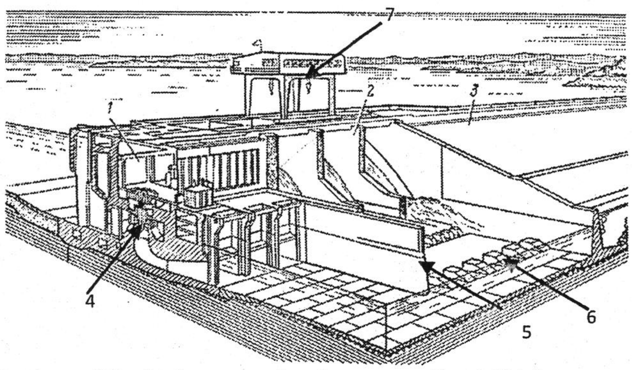
6. Based on the Froude number (F) of the supercritical flow, Steady Jump falls on:
[ ] $2.5<F<=4.5$ [ ] $1.7<F<2.5$ [ ] $4.5<F<=9$ [ ] $1<F<1.7$

7. In which of the following Acts of Government of Nepal, it is expedient to have the water supply precedes the hydropower development?

[ ] Water Resources Act 1992
[ ] Foreign investment and technology transfer Act
[ ] Electricity Act
[ ] Environmental Protection Act

8. What type of power plant is this (shown in Sketch)? Name all the components of it in the blanks below:

[ ]
[1]
[2]
[3]
[4]
[5]
[6]
[7]



9. One of the major objectives of the hydropower development policy 2001 is:

[ ] To minimize the potential risks in the Hydropower projects
[ ] Basin-wide planning
[ ] To tie-up electricity with a renewable source
[ ] To tie-up electricity with economic activities and rural development

10. Which of the following is not the component of electricity tariff

[ ] Electricity Transportation charges and related to management
[ ] Connection and metering charge
[ ] Management, Operation and maintenance charges
[ ] Capacity (kW) charge, related to system peak demand

11. Tick the incorrect statement

[ ] Both EIA and IEE are approved by Concerned Body
[ ] EIA is compulsory if Hydropower having installed capacity of 30 MW is within the national park
[ ] IEE is approved by the concerned ministry and EIA is sent to the Ministry of Forestry and Environment by concerned body
[ ] Monitoring is done after 2 years of implementation of the project

12. If we need to achieve the well-being of the society from development works then

[ ] Only tangible aspects must be considered
[ ] Tangible and intangible aspects must be given due consideration
[ ] Only intangible aspects must be considered
[ ] Only dollar evaluation may be adequate

13. Indicate numerically the proper sequence to following activities and indicate which activities belong to Political Representation, Planning and Engineering showing the flow process between them:

[1]	Social Needs	[4]	Basic Data and its Analysis
[3]	Engineering Objectives	[7]	Technical, Social and Economic Review
[2]	Social Objectives	[5]	Alternative Plans
[8]	Final Design	[9]	Construction Management
[10]	Operation and Maintenance	[6]	Selection of Plan
[1, 2]	Political Representation	[1, 2,3,4,5,6]	Planning
[3,4,5,6,7,8,9,10]	Engineering Design	[6,7,1]	Technical, Social and Economic Review

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14. Looking at the sequence of the longitudinal profile of a river, the river may be zoned as an upper course, middle course, lower course, and estuary. Show qualitatively, where will be the equilibrium state of sediment transport occur?

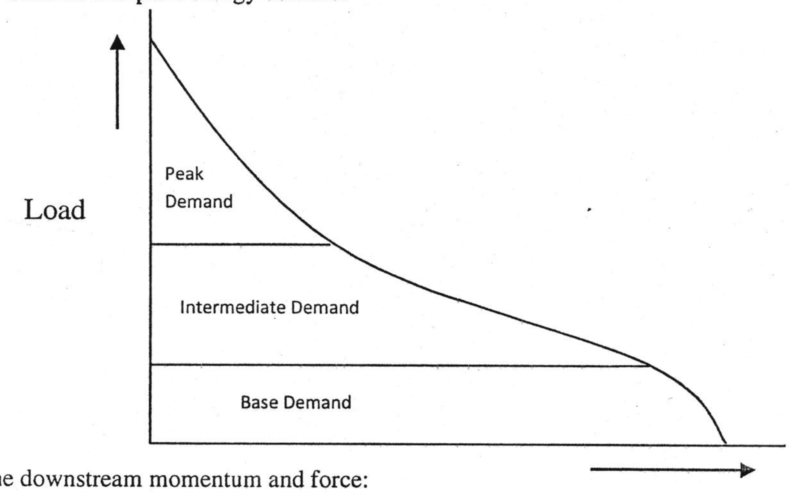
[ ] In between middle course and lower course
[ ] In between lower course and estuary
[ ] In between upper course and middle course
[ ] In the middle course

15. The net head is the head over the turbine under which its efficiency reaches

[ ] Medium at synchronous speed of the generator
[ ] Remain flat at the synchronous speed of the generator
[ ] Peak at the synchronous speed of the generator
[ ] Peak at the normal speed of the generator

16. Stack the position of different types of power plants in the load curve shown in Figure 1 below to satisfy the base energy demand, intermediate energy demand and peak energy demand.

a) Run-of-river Hydro Plant
b) Peaking Run-of-river Hydro Plant
c) Pump Storage Hydro Plant
d) Storage Hydro Plant
e) Thermal (Diesel Plant, Gas plant)
f) Thermal (Coal fired Plant)
g) Nuclear



17. In an unstable hydraulic jump situation the downstream momentum and force:

a) Have no influence
b) Are lesser to upstream momentum and force
c) Are equal to upstream momentum and force
d) Are slightly greater to upstream momentum and force

18. Moody chart is used to estimate

a) Reynolds number given friction factor and relative roughness
b) Relative roughness given Reynolds number and friction factor
c) Friction factor if given Reynolds number and relative roughness
d) Reynolds number given relative roughness and velocity

19. The generation planning for an isolated power project is done considering the combination of the following factors

i. Load center
ii. Regional balance
iii. Available infrastructure
iv. Cheaper project first

[ ] i, ii, iii and iv
[ ] iii, i and iv
[ ] i, iii, ii and iv
[ ] ii ,iii, and iv

20. The suitable type of power grid for rural electrification is:

[ ] Isolated Grid
[ ] Off-grid
[ ] Isolated mini-grid
[ ] Distribution line

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SECTION "B"
(Short answer questions)
[14 marks]

Attempt *ONLY TWO*. **The question no. 1 is compulsory.**

1. Answer the following questions in short:

   - What are the requirements to plan and design of an intake structure? Write four major principles of the arrangement of an intake structure on the river. [3]
   - Describe the necessary steps and formula for hydraulic design of an outflow from side weir with sketch. Differentiate between a diversion weir and a retaining weir showing the sketches. [4]

2. With a scheme or chart, give the basic approach for a systematic appraisal of Hydropower Project. What is an EOI in the hydropower development process and describe in brief the documents that must be submitted in the prescribed 3 types of forms? [3+4=7]

3. Describe the role of private sector for the development of hydropower in Nepal. Formulate the prospect and challenges and give your conclusive remark on the strategy on foreign direct investment and supporting Nepalese investors in hydropower with the example of Khimti Hydropower and Upper Tamakoshi Hydropower respectively. [3+4=7]

SECTION "C"
(Long answer questions)
[26 marks]

Attempt *ONLY TWO*. **The question no. 4 is compulsory**. Assume necessary data appropriately if missing.

4. Determine the electricity need of a typical village in Nepal for 500 household that has to be fulfilled by a micro/mini-hydropower plant that will be sited at nearby rivulet situated about 3 km away from the village. The village daily requirement for various activities are as follows:
   a. Drinking, washing and cooking water need @ 50 liter/day/HH with pumping from 25 m depth to a storage water tank above ground height of 5 m. Take a head loss of 2 m and 50% of pump efficiency. Give a sketch. Pumping is required for 2 hrs in the morning and 2 hrs in the evening. [2]
   b. Water for 150 cattle @40 liter/day/cattle with pumping from 25 m depth to a storage water tank above ground height of 5 m. Take a head loss of 2 m and 50% of pump efficiency. Give a sketch. Pumping is required for 4 hrs in the morning and 2 hrs in the evening. [2]
   c. Irrigation for 20 ha @50 m3/ha with pumping from 2 depth. Take a pipe efficiency of 95% and 50% of pump efficiency. Give a sketch. Irrigation is required for 5 hrs a day. [2]
   d. Each household uses electricity for lighting of 4 no of 50 Watt lamps for 3 hrs in the evening after 18:00 and a rice cooker of 700 Watt twice for 1 hr daily. [2]
   e. Villagers are also planning to have a saw mill of 20 kW and a rice mill of 20 kW to be operated for 4 hrs per day during off peak hours. [2]
   f. Put all these demand in a tabular format and calculate the total power need with respect to time of day. Plot the load curve and calculate energy analytically and graphically. [2]
   g. If a nearby rivulet has mean monthly average discharge of 300 liter/s then find out the gross vertical distance from intake to powerhouse (Head) needed to satisfy the total power demand calculated above of the village (Installed capacity). Assume turbine efficiency of 80%, generator efficiency of 95%, transformer efficiency of 97%, transmission and distribution efficiency of 90% and hydraulic efficiency of water ways of 95%. [4]

5. The two power stations X and Y supply to a system whose maximum load is 120 MW and minimum Load is 12 MW during the year. Assume reserve capacity of Plant Y as 22%. The estimated costs of these stations are as follows:

C_X = Rs (120/kW * kW + 0.028/kWh*kWh)

C_Y = Rs (115/kW * kW + 0.032/kWh*kWh)

If the load varies as a straight line, find for minimum cost of generation:

- Installed capacity of each station [2]
- The annual load factor, capacity factor and utilization factors of each machines [2]
- The average cost of production per kWh (self-unit cost) for the entire system [2]
- Explain the calculation process with a neat sketch [4]

6. It is perhaps wise to say "Bhaigayo ta Prakritik Hani: Banau Yeslai aba Sampada ko Khani" and use the dam created by a landslide as nature's gift instead of demolition it. The Jure landslides in Sindhupalchok created a natural reservoir on Sunkoshi river at Ramche is the story that fits well in this saying. To transform this devastation in to a flourishing business and to support the affected families, a multipurpose reservoir type project is proposed for irrigation, water-supply, water navigation, recreation and power production. To maintain the ecological regime of the river downstream, an environmental flow shall also be released through a fish ladder, which equals 10% of mean annual river flow. Ten percent of produced electricity will be used for pumping water for irrigation and 5 % - for water-supply through canal. The canal is located at a level of 970 m amsl from the reservoir water level at 960 m amsl. The rest of electricity will feed the grid.

- What should be the installed capacity power plant, irrigation pump, water-supply pump and the power to grid in kW? Take total efficiency of hydropower = 85%, efficiency of pump = 75%. Mean annual flow of river = 80 m^3/s. The power plant is located at the tow of 60 m high dam at 900 m amsl. All losses shall be ignored. Provide a neat sketch of the components of the multipurpose scheme. [4]
- How much of discharge for power plant, irrigation, water-supply and fish-ladder shall be released out of total river discharge? What should be the installed capacity of the power plant, irrigation and water-supply pumps? [3]
- If all the remaining power could be delivered to NEA grid each month throughout the year at the average rate of 8 Nrs/kWh at the rate of 85% Plant Factor, how much of money could the affected families get with a share of 10%? [3].

7.

a) Describe the functionality of a powerhouse. Show with neat sketch, the vertical and interior space with proper dimensions for accommodating various equipment. [4]

b). As an Area Service Center Engineer of AEPC, you may require to judge the impact of a micro/mini-hydropower plant implemented at an altitude of 1500 m in a village for the interconnection with the National Grid. The ambient temperature inside the powerhouse during midsummer afternoons can be up to 25° C. You will proceed with (a) the preliminary selection of an appropriate turbine by looking at the specific speed n_q in Fig 1 (b) the determine the generator rating in kVA with 50 Hz frequency and has 4 pair poles and (c) find the type of the hydropower project which operates under a discharge of 600 l/s and a gross-head of 8 m. Take the overall plant efficiency of 70 % and head loss 4%. To control the power output, an ELC with ballast load is suggested and the villagers also plan to use tube lights. Use the appropriate data from Table 1 below. Give your conclusive remarks on your result. [1+2+2+1=6]

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Table 1: Factors affecting Generator Rating

Ambient temperature in °C		20	25	30	35	40	45	50	55
A	Temp. factor	1.1	1.08	1.06	1.03	1	0.96	0.92	0.88
Altitude in m		1000	1500	2000	2500	3000	3500	4000	4500
B	Altitude factor	1	0.96	0.93	0.9	0.86	0.83	0.8	0.77
C	ELC correction factor	Without Electronic Load Controller							1
		With Electronic Load Controller							0.83
D	Power factor	When only light bulbs are used							1
		When tube lights and other appliances are used							0.8

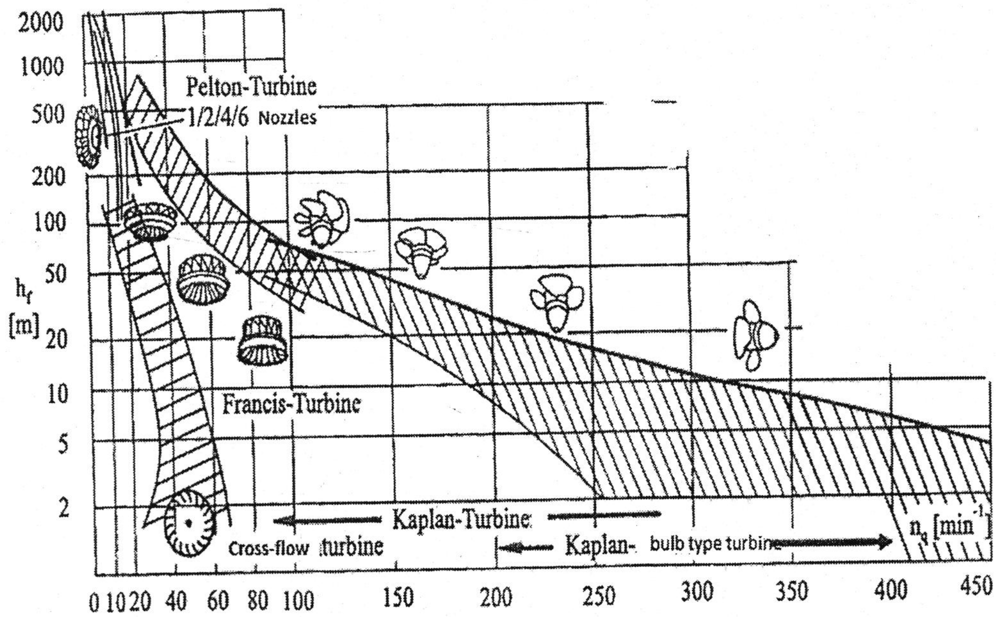


Fig. 2 Head vs specific speed curve for the preliminary determination of turbine type

Table 2: Formulae List: Hydropower (assume appropriately if any missing data found)

$v_{fall} = \sqrt{0.33(s-1)gd}$

$v_{permissible} = a\sqrt{d}$

$a = 36; d > 1mm$

$a = 44; 0.1 \le d \le 1mm$

$a = 51; d < 0.1mm$

$L = f\left(H \frac{v}{w - u_*}\right)$

$f = safety \quad factor = 1.2 \; to \; 1.5$

$u_* = \sqrt{gRS_e}$

$S_e = \left(\frac{Q}{nAR^{2/3}}\right)^{1/2}$

$\sigma_c = 0.625\left(\frac{n_s}{380.78}\right)^2$ for Francis Turbine

Setting of the turbine $H_s = (H_a - H_v) - \sigma_s H_n$

$n_q = n_{syn}\frac{\sqrt{Q}}{h_f^{0.75}} \; [min^{-1}]$

$n_{syn} = \frac{60 * f}{P} \; [min^{-1}]$

$n_s = \frac{2400}{\sqrt{H}} rpm$ for Francis Turbine

$D = \frac{84.6\phi H}{n_{syn}}$ m

$\boxed{\phi = 0.0197\, n_s^{2/3} + 0.025}$

$n_s = \frac{n_{syn}\sqrt{P\,[kW]}}{H_n^{5/4}}$

$$t = \frac{pR}{\sigma_{st}\eta_j - 0.6p} + 0.15(cm)$$

$$v_{opt} = 0.125\sqrt{2gH}$$

$$D = 0.52H^{-0.17}(P/H)^{0.43}$$

$$\sigma_{st} = 1200 \quad kg/cm^2$$

$$Generator\ rating = 1.3 * \frac{Turbine\ rating(kW)}{A * B * C * D} \quad [kVA]$$

$$C_P = \sqrt{\frac{\frac{K}{\rho}}{1 + \frac{D*K}{t*E}}} \ m/s$$

$$t = \frac{P_a D}{2\sigma} mm$$

$$h_f = \frac{fLv^2}{2gD} \ m$$

$T_c = 2\times(L/V_c)$

$$D_e = 0.62 \times \frac{P^{0.85}}{H^{0.65}} [m]$$

$$V_{eco} = 0.125\sqrt{2gH} [m/s]$$

$Z_{max} = v_o Sqrt(L_T A_T/(g A_{ST}))$[m]

$P_o = h_f/Z_{max}$ [-]

$hp = C_p * v_P/g$[-]

$Z_{max, US} = Z_{max}\ (1 - 2/3P_o + 1/9*P_o^2)$[m]

$Z_{max, DS} = Z_{max}\ (-1 + 2P_o$[m]

$T = 2pi * Sqrt(L_T A_{ST}/(g A_T))$[s]

$$Q = Av$$

$$v = \frac{1}{n} R^{2/3} S^{1/2}$$

$$A = By + zy^2$$

$$P = B + 2y\sqrt{1+z^2}$$

$$R = \frac{A}{P}$$

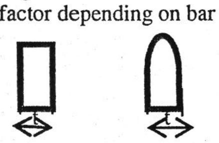
$$s = \frac{1}{k_1} \frac{t+a}{a} \frac{Q_i}{v_o} \frac{1}{\sin\alpha}$$

K_1-coefficient related to the partial clogging of the screen

- For no automatic raker = 0.20 to 0.30
- For automatic raker with hourly operation = 0.4 to 0.6
- For automatic raker with differential pressure sensor = 0.8 to 0.85

$$h_f = k\left(\frac{t}{a}\right)^{\frac{4}{3}} \frac{v^2}{2g} \sin\alpha$$

Where; h_f- loss of head through racks, m
t- the thickness of rack bars, mm
a-clear distance (spacing) between bars, mm
v- velocity of flow through the trashrack, m/s
α-angle of bar inclination to the horizontal
k-factor depending on bar shape



k=2.42 k=1.83

$$h_{fi} = \xi \frac{v_n^2}{2g}$$

v_n-normal velocity through the orifice

$\xi = \xi_s + \xi_\alpha$

Shape	ξ_s	Cone angle	ξ_α
Bell mouth	0.03 to 0.05	30°	0.002
Slightly rounded	0.12 to 0.25	45°	0.04
Sharp cornered	0.5	60°	0.07

$$Q_A = \frac{2}{3} c\mu b L\sqrt{2gh}$$

c-correction factor for submerged over-fall

$$c = 0.6\frac{a}{d}\cos^{1.5}\beta$$

Where a-internal width between bars
d-center to center distance between bars

$$h = \frac{2}{3}\chi h_E$$

β	χ	β	χ
0°	1.00	14°	0.899
2°	0.980	16°	0.865
4°	0.961	18°	0.851
6°	0.944	20°	0.837
8°	0.927	22°	0.825
10°	0.910	24°	0.812
12°	0.894	26°	0.800

$$h = \frac{b_P - b_b}{c_b - c_P} [hour]$$

Where h- duration of peak plant operation
b_P-cost of power for peak plant
b_b-cost of power for the base plant
c_P-cost of energy for peak plant
C_B-cost of energy for the base plant

Stored Energy in a reservoir
$E_{St} = 1/(3.6*10^6)*g*\rho_w*V*h_s$ [kWh]
Where, h_s is head over tailrace up to the center of gravity of the reservoir

Area below 3000 m is used for the estimation of flood of various return periods

$Q_{2\ daily} = 0.8154 \times (A\ below\ 3000\ m + 1)^{0.9527}$

$Q_{2\ inst} = 1.8767 \times (A\ below\ 3000\ m + 1)^{0.8783}$

$Q_{100\ daily} = 4.144 \times (A\ below\ 3000\ m + 1)^{0.8448}$

$Q_{100\ inst} = 14.630 \times (A\ below\ 3000\ m + 1)^{0.7343}$

Table: Standard normal variants S for floods for the chosen return period

Return period (T) (yrs)	Standard normal variant (S)
2	0
5	0.842

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Flood peak discharge, Q_F, for any other return periods can be calculated using:

$Q_F = e^{(\ln Q2 + S\sigma_{\ln QF})}$

Where:

$\sigma_{\ln QF} = \ln(Q_{100}/Q_2)/2.326$

10	1.282
20	1.645
50	2.054
100	2.326

Q=C x (Area of Basin)^{A1} x (Area below 5000m +1)^{A2} x (mean monsoon precipitation)^{A3}

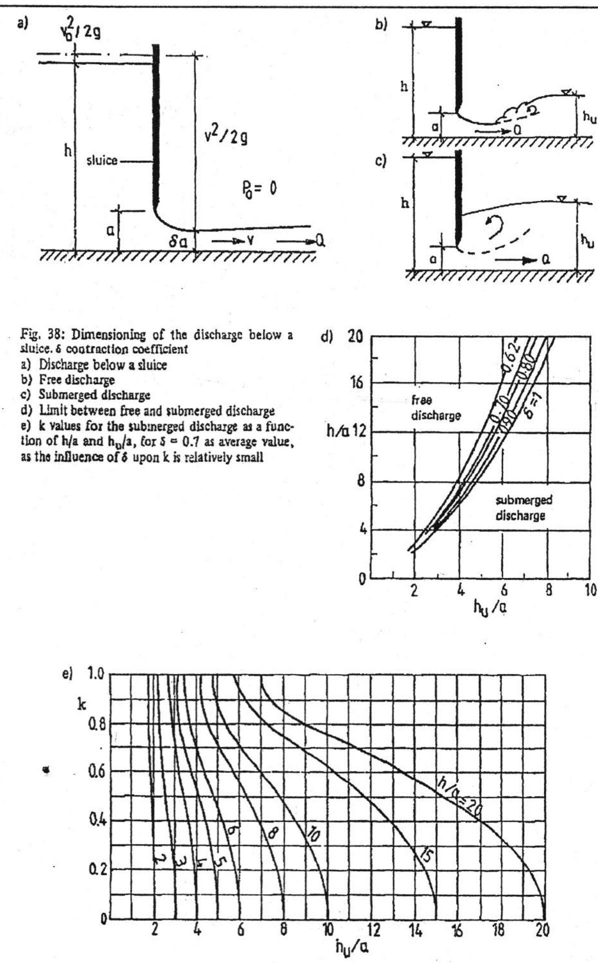
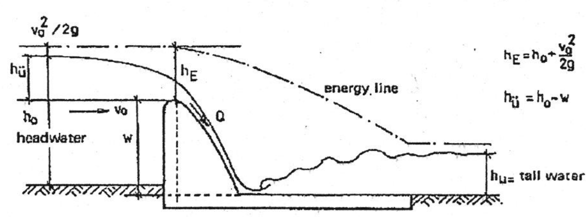
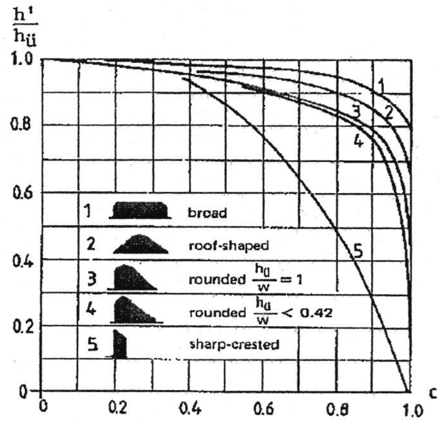


Fig. 38: Dimensioning of the discharge below a sluice. δ contraction coefficient
a) Discharge below a sluice
b) Free discharge
c) Submerged discharge
d) Limit between free and submerged discharge
e) k values for the submerged discharge as a function of h/a and h_u/a, for δ = 0.7 as average value, as the influence of δ upon k is relatively small



fixed weir: Position of water surface and energy line



Correction factor c for submerged overfall

crest form	μ
broad; sharp edges	0.49-0.51
broad; round edges	0.50-0.55
round overfall	0,70
sharp-edged	0.64
rounded	0.75
roof-shaped	0.79

weir coefficient μ for different weir forms (acc. to Press/Schröder [3])

Correction factor n for side weir calculation