COMPUTER AIDED HYDRAULIC DESIGN OF DIVERSION WEIRS WITH SIDEWISE INTAKES

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ABSTRACT

COMPUTER AIDED HYDRAULIC DESIGN OF DIVERSION WEIRS WITH SIDEWISE INTAKES

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A diversion weir is a headwork facility which raises and diverts clear water for various purposes such as irrigation and hydropower production etc. River discharge, irrigation water demand, hydraulic characteristics of river and sediment concentration in river flow affect the orientation and dimensions of the structure. Diversion weirs with sidewise intakes are widely used for irrigation purposes in plain rivers. In this thesis a user friendly, flexible computer program named as DWEIR was developed in Qbasic language for the preliminary design of a diversion weir with sidewise intake. It determines the dimensions and the total cost of the structure. It also enables a design engineer to have quick successive test runs to achieve an optimum solution. Computer program is tested on a case study in which smaller total cost of structure is obtained compared with that of the existing preliminary design.

Keywords: Computer Aided Design, Preliminary Design, Diversion Weir, Sidewise Intake

Science Code: 624.02.02

ÖZ

YANDAN ALIŞLI BAĞLAMALARIN BİLGİSAYAR DESTEKLİ TASARIMI

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Bağlama, sulama ve elektrik enerjisi üretimi amacı ile akarsu seviyesinin kabartılarak akarsudan temiz su alınmasını sağlayan bir çevirme yapısıdır. Akarsu debisi, sulama suyu gereksinimi, akarsu hidrolik özellikleri ve akarsu katı madde konsantrasyonu bağlama elemanlarının konumunu ve boyutlarını etkiler. Yandan alışlı bağlamalar ova akarsularında sıkca kullanılmaktadır. Bu çalışmada yandan alışlı bir bağlamalanın yapı boyutlarını ve yapı toplam maliyetini hesaplayan, Qbasic dilinde yazılmış, DWEIR adlı kullanımı kolay ve esnek bir bilgisayar programı geliştirilmiştir. Bu bilgisayar programı ayrıca hızlı ardışık denemelerle bir tasarım mühendisinin optimum tasarım elde etmesini kolaylaştırmaktadır. Örnek bir çalışmaya uygulanan bilgisayar programı sonucunda mevcut ön tasarımdan daha ekonomik toplam maliyet bulunmuştur.

Anahtar kelimeler: Bilgisayar Destekli Tasarım, Ön Tasarım, Bağlama, Yandan Alışlı Priz.

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A : Cross-sectional flow area

A' : Shear plane area

b : Thickness of piers

b_1 : Bottom width of main irrigation channel

B : Bottom width of settling basin

B' : Width of canal at the entrance of transition

B'' : Net width at the entrance of main channel

B''' : Width of the body in foundation stress analysis

B_1 : Net width at the enterance of intake

C : Spillway discharge coefficient

C' : Sluiceway discharge coefficient

C_D : Particle drag coefficient

C_e : Constant in dynamic force computation

C_i : Inlet loss coefficient

C_L : Relative permeability of soil

C_o : Spillway coefficient corresponding to design discharge

C_1 : Spillway coefficient due to inclination of the spillway face

C_2 : Coefficient corresponding to discharge other than design discharge

C_3 : Coefficient due to apron effect

C_4 : Coefficient due to submergence effect

d : Heigth of sluiceway opening

D : Mean diameter of bed material

e : Eccentricity

f : Friction coefficient between soil and concrete

f' : Freeboard in main canal

F : Difference between upstream and downstream energy levels

F_d : Earthquake force

F_h : Hydrostatic force

F_i : Ice load

Fr_{1sl} : Froude number before jump at downstream of sluiceway

Fr_{1sp} : Froude number before jump at downstream of spillway

F_s : Force due to sediment accumulation

FS_o : Factor of safety against overturning

FS_s : Factor of safety against sliding

FS_{ss} : Factor of safety against combined shear and sliding

FS_u : Factor of safety against uplift

F_u : Uplift force

F_w : Dynamic force in the resevoir due to earthquake

g : Gravitational acceleration

h : Water depth behind the weir

h' : Water depth in settling basin

h_a : Velocity head over the spillway

h_a' : Velocity head at riprap section in design of slotted bucket

h_{asl}' : Velocity head at riprap section after sluiceway

h_{asp}' : Velocity head at riprap section after spillway

h_s : Height of sediment accumulation in front of spillway

h_s' : Depth of foundation in front of spillway

h_w : Water depth behind the spillway

h_3 : Velocity head at riprap section

H : Total head over the spillway crest

H' : Effective hydrauilic head

H'' : Fall from the crest of the spillway

H_e : Total head over spillway crest other than design discharge

H_o : Upstream water depth

H_s : Height of backfill behind the side wall

H_w : Height of water column behind side wall

H_x : Elevation of point x about a datum

I : Moment of inertia

k : Earthquake coefficient

k_b : Coefficient of permeability of blanket

k_f : Coefficient of permeability of foundation

K : Dimensionless constant

K_a : Contraction coefficient of abutments

K_a' : Active earth pressure coefficient

K_i : Water surface elevation for any discharge i

K_p : Contraction coefficient of piers

K_r : Surface elevation of riprap section

K_s : Spillway crest elevation

K_t : Thalweg elevation of spillway axis

K_3 : Water surface elevation at riprap section

L : Length of stilling basin

L' : Length of settling basin

L'' : Net crest length

L_c : Effective crest length

Lcr : Total creep length

L_d : Length of base of main structure

L_e : Width of sluiceway opening

L_{sp} : Length of spillway

L_t : Length of transition

L_T : Total width of diversion weir

L_x : Creep length up to point x

L_1 : Length of rectangular blanket

M : Net moment

M_o : Overturning moments

M_r : Resisting moments

n : Manning's roughness coefficient

n' : Number of piers

P_a : Active earth force per unit width

R_e : Reynold's number

q_{sl} : Unit discharge of sluiceway

q_{sp} : Unit discharge of spillway

Q : Design discharge

Q_i : Discharge whit return period i

Q_{ir} : Irrigation discharge

Q_m : Maximum seepage rate

Q_o : Seepage rate per unit width

Q_s : Spillway discharge

Q_{sl} : Sluiceway discharge

Q_5 : 5 years flood discharge

Q_{10} : 10 years flood discharge

Q_{25} : 25 years flood discharge

Q_{50} : 50 years flood discharge

Q_{100} : 100 years flood discharge

r : Removal ratio of sediment

R : Hydraulic radius

R' : Radius of slotted bucket

R_h : Total horizontal force

R_{min} : Minimum radius of slotted bucket

R_v : Total vertical forces

R_4' : Hydraulic radius of flow just at the end of settling basin

R_5 : Hydraulic radius of flow at the entrance of settling basin

S_o : Bottom slope of main channel

S_o' : Bottom slope of settling basin

S_4' : Energy slope at the end of settling basin

S_5 : Energy slope at the entrance of settling basin

t : Thikness of upstream blanket

T : Thickness of overburden beneath the weir

T_{max} : Maximum tailwater depth

T_{min} : Minimum tailwater depth

U : Maximum mean flow velocity at riprap section

U' : Mean flow velocity in settling basin

U'' : Mean flow velocity through the gate

U_a : Approach flow velocity toward the weir

U_g : Entrance velocity of intake

U_o : Velocity at the exit of jump

U_s : Settling velocity of sediment particle

U_x : Uplift pressure head at point x

U_* : Shear velocity

U_{1sl} : Mean flow velocity before jump at the downstream of sluiceway

U_{1sp} : Mean flow velocity before jump at the downstream of spillway

U_1 : Average flow velocity in the main irrigation canal

U_2 : Average flow velocity at the entrance of transition

U_3 : Average flow velocity in front of the submerged curtain wall

U_{3sl} : Mean flow velocity of sluiceway at riprap section

U_{3sp} : Mean flow velocity of spillway at riprap section

U_4 : Average flow velocity just at the end sill of settling basin

U_4' : Average flow velocity at the end of settling basin

V : Volume of blanket material per unit width

w_i : Dimensions of side wall (i = 1, 5)

W : Weight of structure

x : Horizontal distance of trajectory in ski-jump bucket

x' : Point of application of moment at the base of body

y : Jet trajectory height in ski-jump buket

y_c : Critical water depth in main channel

y_{csl} : Critical water depth at the sluiceway

y_{csp} : Critical water depth at the spillway

y_1 : Initial depth of hydraulic jump

y_1' : Water depth in main channel

y_{1sl} : Water depth before jump at downstream of sluiceway

y_{1sp} : Water depth before jump at downstream of spillway

y_2 : Sequent depth of hydraulic jump

y_2' : Water depth at the entrance of transition

y_3 : Tailwater depth

y_3' : Water depth at the end of curvature

y_4 : Water depth just at the end sill of settling basin

y_4' : Water depth at the end of settling basin

y_5 : Water depth at the entrance of settling basin

y_6 : Water depth at the submerged curtain wall

y_6' : Water depth at the entrance sill of intake

z : Side slope of the trapezoidal cross-section

α : Angle between intake canal axis and a line connecting the canal sides between entrance and exit section

α' : Angle of side wall

β : Settling velocity parameter

β' : Angle of backfill behind the side wall

γ_s : Specific weight of soil

γ_{sub} : Submerged specific weight of soil

γ_w : Specific weight of water

Δ : Relative density

ΔH_R : Transition head loss

ΔH_a : Head loss at the entrance of main canal

ΔH_k : Head loss due to curvature

ΔH_e : Head loss at the end sill of settling basin

ΔH_c : Head loss through settling basin

ΔH_{ge} : Head loss at the entrance sill of settling basin

ΔH_g : Head loss at the submerged curtain wall at the intake

ΔH : Head loss above the entrance sill

δ : Wall friction between soil and concrete

ϕ : Exit angle of trajectory in ski-jump bucket

ϕ' : Angle of repose

λ : Mean rate at which particles settle out in suspension

σ_{all} : Allowable stress of soil

σ_{max} : Maximum base pressure

σ_{min} : Minimum base pressure

θ' : Angle between upstream face of weir and vertical line

τ : Allowable shear stress between concrete and soil

CHAPTER I

INTRODUCTION

A water supply, irrigation, or hydroelectric project require clear water which can be obtained from rivers. A diversion weir can be constructed across a river to raise the water elevation and to divert it for these demands. The people have attemped to divert water by means of a headwork facility throughout the centuries. An ideal intake should divert the desired water demand with almost negligible sediment concentration.

The orientation and dimensions of the structural elements of a diversion weir are dictated by the hydraulic and sedimentologic characteristics of rivers as well as the design irrigation discharge. The velocity and sediment concentration profile in vertical direction are inversely proportional to each other. Vertical distribution of sediment in a plain river is almost uniform which means that river water may be diverted from any elevation above a certain level relative to river thalweg. This level is determined such that the bed load is not allowed to enter intake. As the river bed slope increases the required elevation for water intake also increases relative to river thalweg to divert clearer water. Frontal or drop type intakes may be used in such cases. Majority of diversion weirs in Turkey are constructed in plain rivers to divert water for irrigation purposes through sidewise intakes.

The literature is limited in publications which give overall design criteria for diversion weirs. The aim of this study is to gather worldwide information about the analysis and design of various structural components of diversion weirs.

Elements of a water intake structure are described in Chapter II. Sediment handling facilities reported in literature are also dissusced briefly in this chapter .

Chapter III gives information concerning the diversion weirs with sidewise intakes.

Recommended hydraulic design procedure which can be followed for the design of a diversion weir with sidewise intake are given in detail in Chapter IV.

A user friendly flexible computer program is developed to minimize the time consuming efforts in the preliminary design of diversion weirs with sidewise intake. Prior to execution of the program it is assumed that the best constructional site is selected by the design engineer and there is no excavation, filling and foundation treatment works. The program gives the optimum bottom width of main irrigation channel, the length and width of settling basin, details of intake design, spillway crest elevation for one or two sided intakes. This is a general program which selects and design the type of energy dissipating facility at the toe of the spillway. The required stone size to be used in riprap section at downstream of the energy dissipating facility is determined. It also checks the stability analysis of the overall structure and the side walls against sliding, overturning, uplift and foundation stresses.

Qbasic is selected as the programming language as it allows easy interaction, accelerated execution and better presentation such as drawings. This program will enable a quick check of various dimensions of structure to achieve a safe and economic solution for the whole structure. The program can also be used to determine the dimensions of any structural element seperately and to check its stability analysis.

Consequently, a case study is performed to run the computer program. For this purpose, Başağaç diversion weir which is constructed to supply irrigation water for Sandıklı Örenler Project is considered. The total cost of the existing structure is compared with the cost obtained by running the computer program which recomputes the dimensions of overall structure. The total cost of structure obtained from the redesign by the computer program is found to be less than that of the existing preliminary design.

CHAPTER II

WATER INTAKES FROM RIVERS

2.1 Introduction

As water is of vital importance to human beings, it has been withdrawn from the fresh water sources such as rivers to meet several demands. A diversion weir needs to be constructed to raise water elevation in the river such that water can be received from any desired elevation at a smaller velocity. An intake is constructed to take the required amount of discharge from the river. An ideal intake should divert this discharge which is free from excessive sediment continuously under all conditions. In this chapter, general information about the types of intakes, diversion weirs and sediment control facilities are discussed. Some statistical information on the characteristics of the existing diversion weirs in Turkey are also given.

2.2 Sediment Transport

Water flowing in natural or artificial channels has the ability to scour sand, gravel or even larger particles from the bed or the banks, and sweep and accumulate them downstream. This phenomenon is known as sediment transport. Knowledge of sediment transport mechanism is very important for the design and the operation of hydraulic structures.

Sediment is transported by streams mainly in two broad categories; in suspension and as bed load. A typical sediment concentration profile throughout the depth is shown in Figure 2.1.

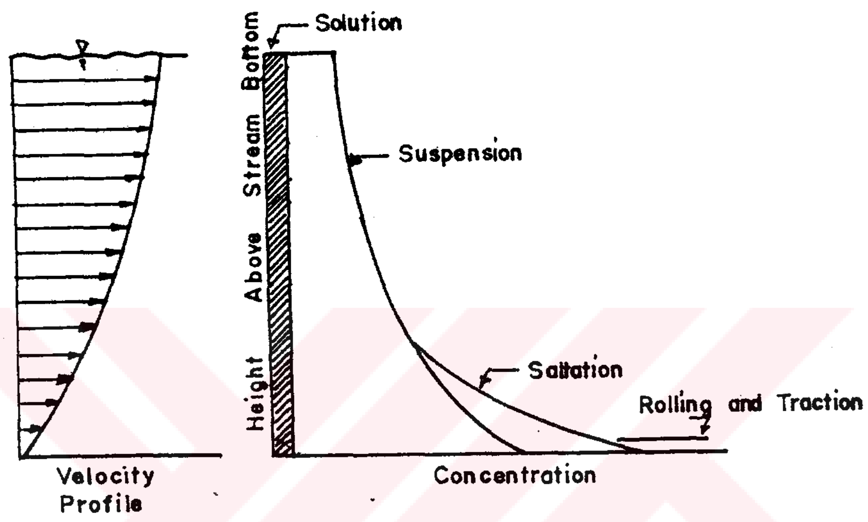


Figure 2.1 Sediment Concentration Profile (Mitchell, 1978)

As illustrated in Figure 2.1, sediment is transported in solution, suspension, saltation, rolling and traction. The suspension movement of all sediments carried by water is controlled by the particle settling velocity and the laws of fluid motion. Particles stay in suspension once they have been set in motion, as long as the turbulence of the river is greater than the settling velocity. The largest particles are carried by traction which consists of rolling and dragging along the water-soil interface. Particles intermediate in size between suspension and traction may be carried by saltation movements in contact with the river bed. Soluble materials like clays and colloids are carried in solution. The material transported by solution and suspension is called suspended load. Saltation, rolling and traction modes are generally known as bed load. The suspended load composed of fine material which enter the main channel from the side tributaries, or overland flow is called wash load. Rates of bed load and suspended load are the functions of hydraulic characteristics of the river. However, wash load depends on hydrologic properties of the basin. Practically, it is almost impossible to distinguish the wash load from the suspended load (Altınbilek and Yanmaz,1992).

In most of the plain rivers with loose boundaries the suspended load is much greater than bed load. However, in mountainous rivers the amount of bed load may be equal to or even more than the suspended load (Çeçen, 1993). Streams flowing in plains have more uniform sediment distribution. Figure 2.2 illustrates the sediment concentration profile in mountainous and plain rivers.

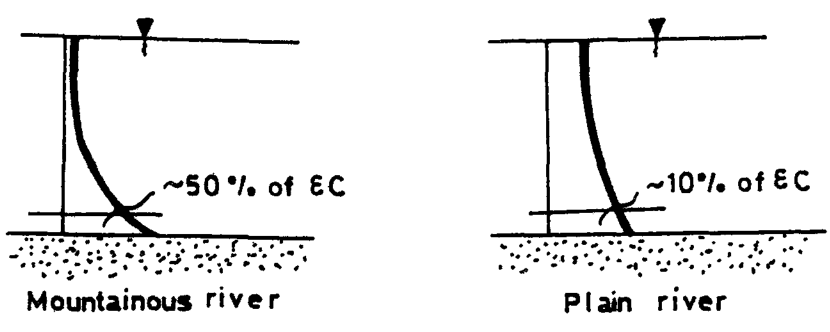


Figure 2.2 Sediment Concentration Profile in Mountainous and Plain Rivers

2.3 Water Intake Structures

A proper intake structure should prevent the entrainment of excessive grains into the system. Flow conditions, sediment concentration, size and distribution of the sediment are the important parameters affecting the design of an intake. If an intake is constructed in a mountainous stream, special attention should be paid to prevent the entrainment of sediment load into the intake, since the velocity of the incoming flow is considerably high. In this type of intakes water should be taken near the water surface, as the sediment concentration is relatively small close to the water surface. On the other hand, in plain rivers, the sediment concentration is almost uniform along the depth. So, it is possible to take water from any intermediary depth (Çeçen, 1993).

2.3.1 Types of Intake

Flow regime of the stream, concentration of sediment load, size and distribution of sediment grains are taken into consideration in the selection of intake type. There are three types of intake structures for the diversion weirs:

a) Sidewise (lateral) intakes

b) Frontal intakes

c) Drop (bottom) intakes

2.3.1.1 Sidewise (Lateral) Intakes

Sidewise intakes are suitable for plain rivers where the sediment concentration is almost uniform in vertical direction. These are the most common type that are used throughout the world. It is possible to construct this type of intake on both sides of the river, or on one side only depending on the location of the project area with respect to river. Selection of a suitable site for the construction of a sidewise intake is a very important issue. Straight and stable reaches of rivers are the ideal locations. If there is a natural river bend, where the secondary flow is fully developed, depending on the bend radius and the river width, the intake must preferably be located at the second half of the bend (Çeçen, 1993). Flow velocity near the water surface is higher than that of the river bed. So, centrifugal force near the water surface is higher which results in water particles move toward the outer bend of the river. To provide continuity, water near the river bed moves toward the inner bend. This phenomenon is called as spiral (helicoidal) flow. Figure 2.3 illustrates the secondary flows in a river section. As a result of secondary flows heavy bed load is swept towards the inside and relatively sediment free water flows near the outer bend.

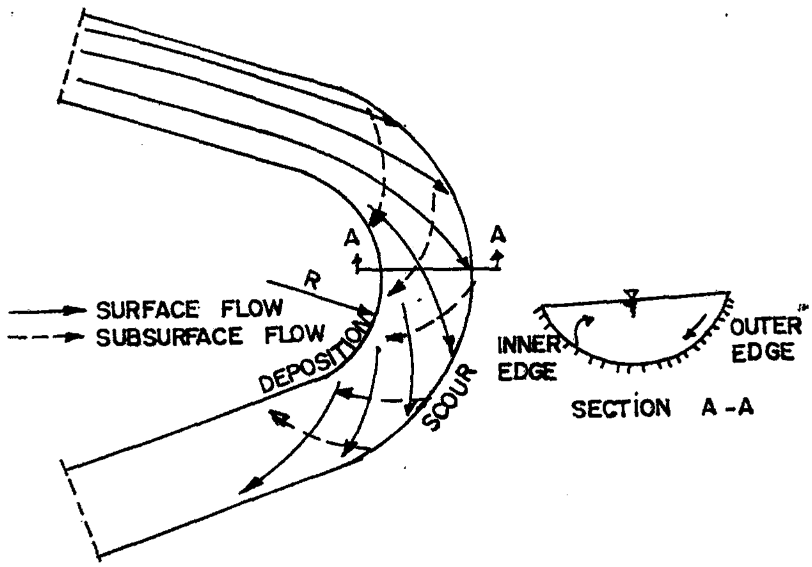


Figure 2.3 Secondary Flow Pattern

(Altınbilek and Yanmaz, 1992)

The amount of the sediment entering to intake highly depends on the ratio of intake discharge to the discharge of main channel as well as the location of the intake. In Figure 2.4 different orientations of intake and amount of sediment that enters to the system are given (Özbek, 1991). As it can be observed from Figure 2.4, the best orientation is achieved in case of items d and j. If there is no natural bend, construction of spur dikes, baffle walls and submerging walls etc, may facilitate secondary flows (See Figure 2.5).

Morphological characteristics of rivers should also be taken into consideration in the selection of location of an intake structure. Thus, firstly the river characteristics should be defined. According to the morphological features, rivers can be classified into four groups (Özbek, 1991).

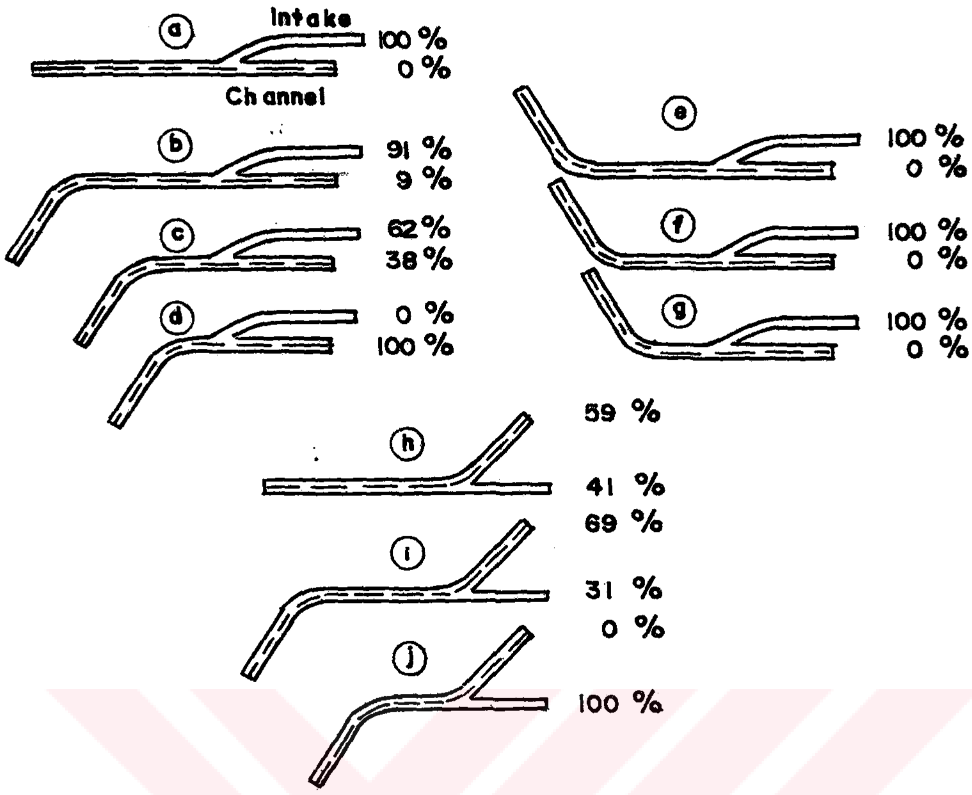


Figure 2.4 Several Orientations of Intake (Habermaas, 1935)

a) Rivers in regime (dynamic equilibrium): This is the case when, the amount of sediment entering to the control volume taken at the bed, equals to the amount of sediment leaving the control volume. Such an equilibrium is mainly achieved in long term.

b) Aggradation: There is a rise in the river bed due to deposition of excessive sediment.

c) Degradation: The river bed falls due to erosion of the bed.

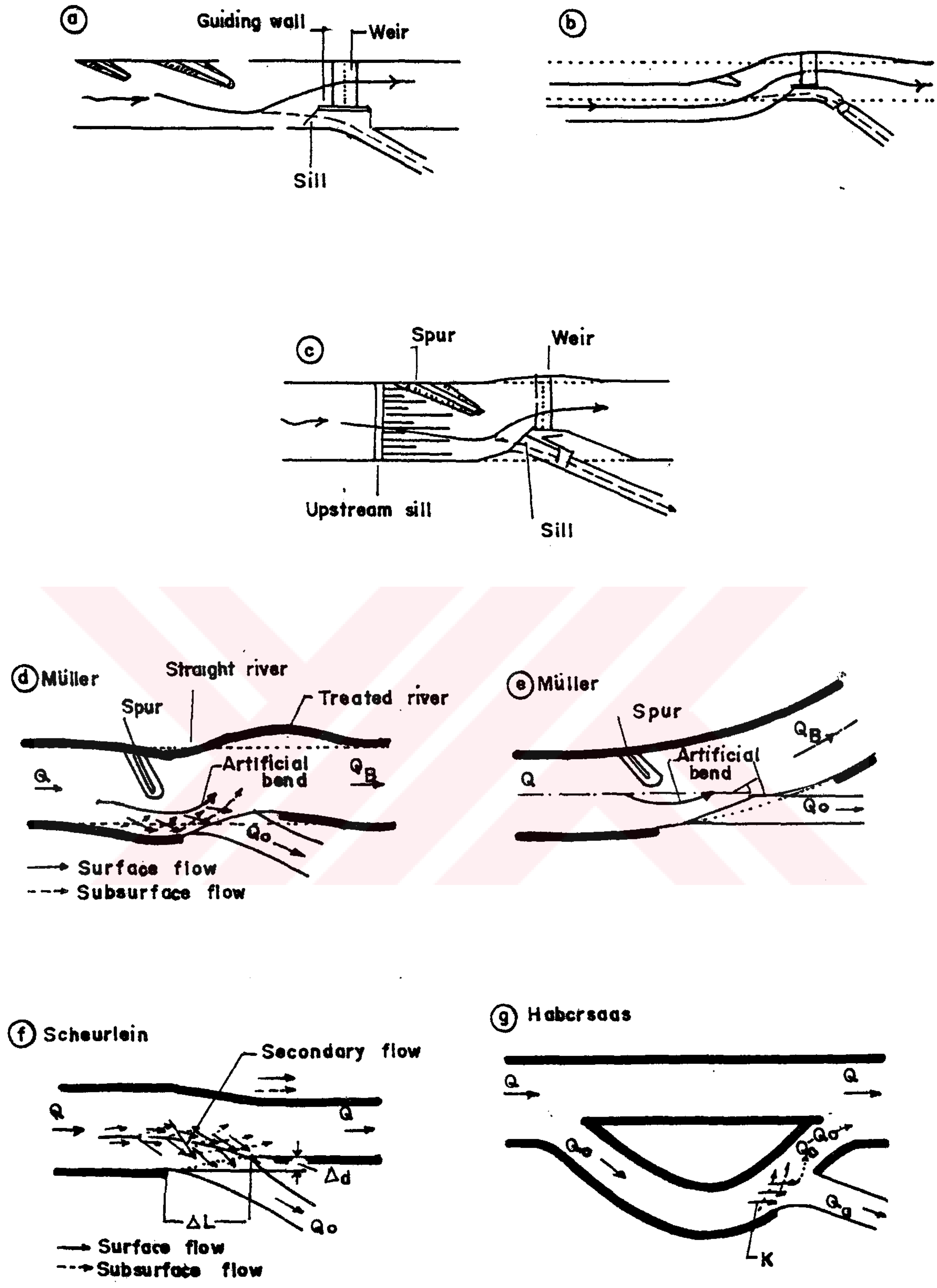


Figure 2.5 Artificial Measures for Secondary Flow (Özbek, 1991)

d) Latent erosion: Although the amount of incoming sediment is less than the one leaving the control volume, there will be no fall in the river bed, because the bed material may resists to the flow. Table 2.1 gives information about the location of an intake structure depending on the morphological characteristics of the river (Özbek, 1991). As it is seen from Table 2.1, the most suitable location for an intake structure with or without diversion weir is latent erosion reaches. On the other hand, if there is no diversion weir, reaches in dynamic equilibrium can be preferred also. However, reaches in dynamic equilibrium are the unsuitable locations for intakes with diversion weir.

There is no universal design criteria for sidewise (lateral) type of intakes. However, general guidelines can be outlined as follows (Çeçen, 1993):

a) Weirs are designed according to intake discharge, flood discharge, size of sediment and its amount, cross-section of the valley, state of the river bed.

b) At least one sluicegate has to be provided near the intake to flush the deposited sediment in the vicinity of the intake.

c) The dimensions of intake are determined under consideration of floating materials, river characteristics, intake discharge and rate of sediment transport.

Table 2.1 Selection of Water Intake Location (Özbek, 1991)

River	Upstream Section		Downstream Section	
Regime	Without Div. Weir	With Div. Weir	Excessive Sediment	Less Amount of Sediment
Dynamic Equilibrium	Suitable	Unsuitable	Unsuitable	Unsuitable
Aggradation	Unsuitable	Impossible	Impossible	Suitable
Degradation	Unsuitable	Suitable	Suitable	Impossible
Latent Erosion	Suitable	Suitable	Suitable	Suitable

d) Spurs and guide banks are often arranged to generate secondary flows which divert sediment away from the intake.

e) Form and height of guiding wall between the spillway and sluiceway is determined according to diverted discharge, the river characteristics, and the amount of sediment.

2.3.1.2 Frontal Type of Intake

Unlike the sidewise intake, frontal intake is suitable for steep sloped rivers. In this type of diversion weir, intake structure is placed on top of the sluiceway. Since the largest concentration of sediment will be at the lower section of the flow, diverted water will be free from excessive sediment. For frontal intakes it is vital to establish a parallel uniform flow inside the gravel sluice in front of the intake. Guiding walls, semi permeable curtains and other devices can successfully reduce the magnitude of secondary current (Çeçen, 1993). Figure 2.6 shows a frontal type of intake.

It is important to keep the sluice gates underneath the intake sufficiently raised, so as to return the sediment to main stream with only a small amount of flushing water. In this system flushing is continuous. The sluice gate is kept open to such extent that the largest particle entering the gravel sluice may pass safely. Dimensions of the sluiceway depend on the velocity of the incoming flow and hence the sediment concentration. A recommended bottom slope of the sluiceway is about 2.5%. In general, frontal water intake structure provide better sediment handling (Altınbilek and Yanmaz, 1992).

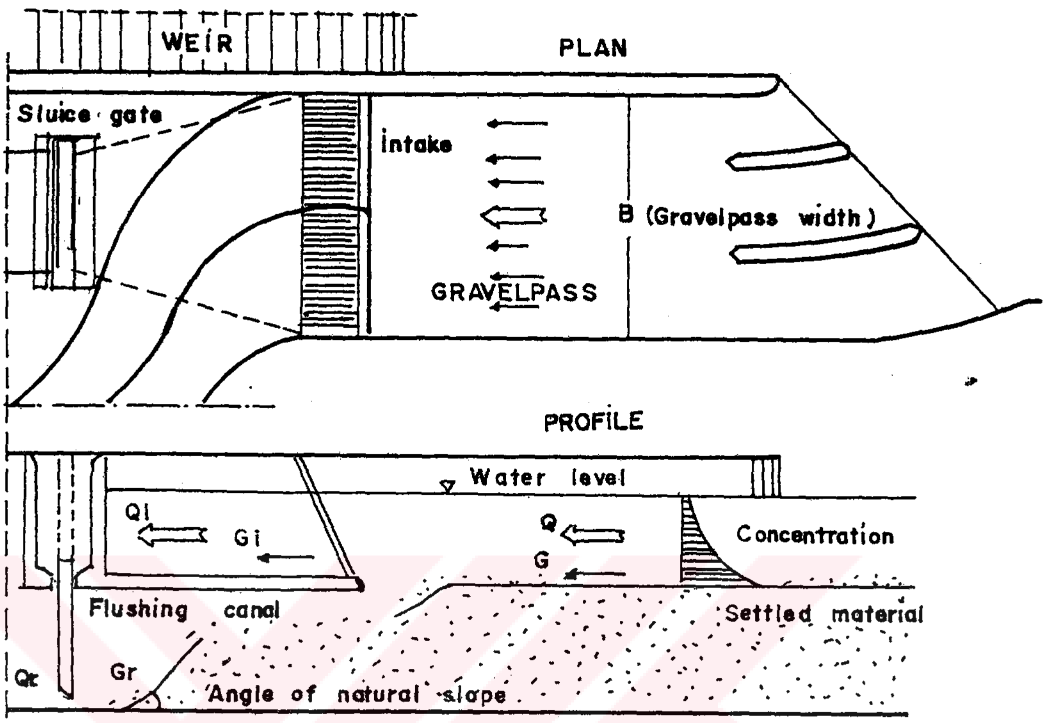


Figure 2.6 Frontal Type of Intake (Çeçen, 1993).

2.3.1.3 Drop (Bottom) Type of Intake

This type of intake is very suitable for very steep sloped mountainous rivers. If the bed slope of the river becomes greater than 5%, selection of drop type intake is strongly recommended. A spillway is built across the river whose crest is formed by a screen composed of steel bars with certain spacing. Only fine grains can pass through the screen while larger grains are held back by this rack (Altınbilek and Yanmaz, 1992). Figure 2.7 illustrates a bottom type of intake.

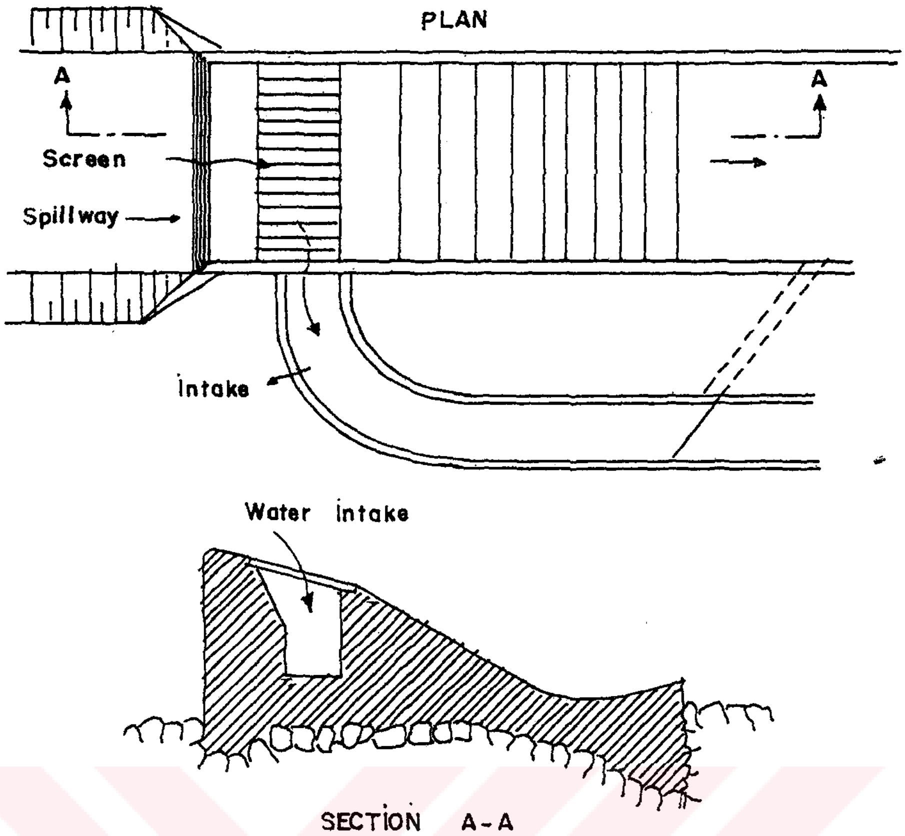


Figure 2.7 Drop (Bottom) Type of Intake

2.4 Diversion Weirs

A diversion weir is a hydraulic structure built across a river to raise water level and divert water for different purposes such as irrigation, electricity production etc.

2.4.1 Classification of Diversion Weirs

Diversion weirs can be classified according to design discharge, orientation of water intake, structural design and water holding capacity (Erkek and Ağıralioğlu, 1986).

2.4.1.1 Classification According to Design Discharges

Diversion weirs are designed for a peak discharge having a return period of T_r = 100 years(Q_{100})

i) Small diversion weirs: $Q_{100} < 100\ m^3/sec$

ii) Intermediary diversion weirs:
$100 < Q_{100} < 500\ m^3/sec$

iii) Large diversion weirs: $Q_{100} > 500\ m^3/sec$

If there is no big difference between long term minimum and maximum discharges of the river, small diversion weirs are suitable. Otherwise crest elevation of the spillway should be determined such that irrigation requirement is satisfied during minimum discharge.

2.4.1.2 Classification According to Orientation of Water Intake

a) Sidewise (lateral) intake

b) Frontal intake

c) Drop (bottom) type intake

2.4.1.3 Classification According to Structural Design

a) Conventional type with spillway

b) Gated Diversion Weir

c) Rubber (inflatable) type diversion weir (Anwar, 1967; Conner, 1969; Harrison, 1970; Binnie, 1973; Anwar, 1975; Hitch, 1983)

2.4.1.4 Classification According to Water Holding Capacity

a) Impermeable diversion weir (such as masonry, concrete, reinforced concrete, steel)

b) Permeable diversion weir (rock, stone, wood etc)

c) Semi-permeable

Selection of suitable type depends on economy and hydraulic safety. Initial cost of conventional type is higher than that of the gated type, whereas operational and maintenance expenses of gated weirs are higher than that of the conventional one. Topography, purpose of construction, foundation conditions, sediment concentration etc, should be considered in the selection of a suitable construction site. Rock is the most suitable foundation type for diversion weirs, since it does not need any considerable improvement. So constructing of a weir on rock foundation will be economical solution. On the other hand, clay-mud foundation is difficult to treat which requires an expensive investment. Gated diversion weirs are suitable for deep and stiff foundations. Sand and gravel foundation may also considered to be suitable for conventional type.

2.5 Diversion Weirs in Turkey

There are 138 diversion weirs under operation in Turkey. Information related to these structures are obtained from the General Directorate of Turkish State Hydraulic Works. As it is observed from Table 2.2 the majority of the diversion weirs in Turkey are of sidewise intake type (90%) for irrigation purposes (94.2%).

Table 2.2 Characteristics of Diversion Weirs in Turkey

Classification		Number of Weirs	%
According To Purpose	Irrigation	130	94.2
	Flood Control	4	2.9
	Municipal Water	2	1.4
	Navigation	1	0.7
	Power	1	0.7
According To Orientation of Intake	Sidewise	130	94.2
	Frontal	7	5.1
	Drop	1	0.7
According To Structural Type	Conventional	92	66.7
	Gated	46	33.3
According To Design Discharge	Large	27	19.6
	Intermediary	43	31.2
	Small	26	18.8
	Unknown	42	30.4

2.6 Sediment Handling Facilities Around Intakes

Additional measures taken against sediment handling in the vicinity of intakes are training walls, guiding banks with or without central island, pocket and guiding wall, sand screens, guide vanes (bottom or surface), stream inlets and tunnel type sediment diverters (Ranga Raju, 1978). However, details of sediment diverters are out of the scope of this study.

CHAPTER III

ELEMENTS OF DIVERSION WEIRS WITH SIDEWISE INTAKES

3.1 Introduction

In this thesis, diversion weirs with spillway and sidewise intakes are studied only. Figure 3.1 illustrates the general plan view of a typical diversion weir with sidewise intake. Such a structure is mainly composed of two components:

a) Ogee type overflow spillway or gated weir

b) Sidewise intake structure

Figures 3.2, 3.3, and 3.4 show the longitudinal profiles of ogee type spillway, sluiceway, and intake structure, respectively.

3.2 Elements of Main Body

The main structural element (spillway or gates) collects and raises water at the upstream. Various structural elements of a body are as follows:

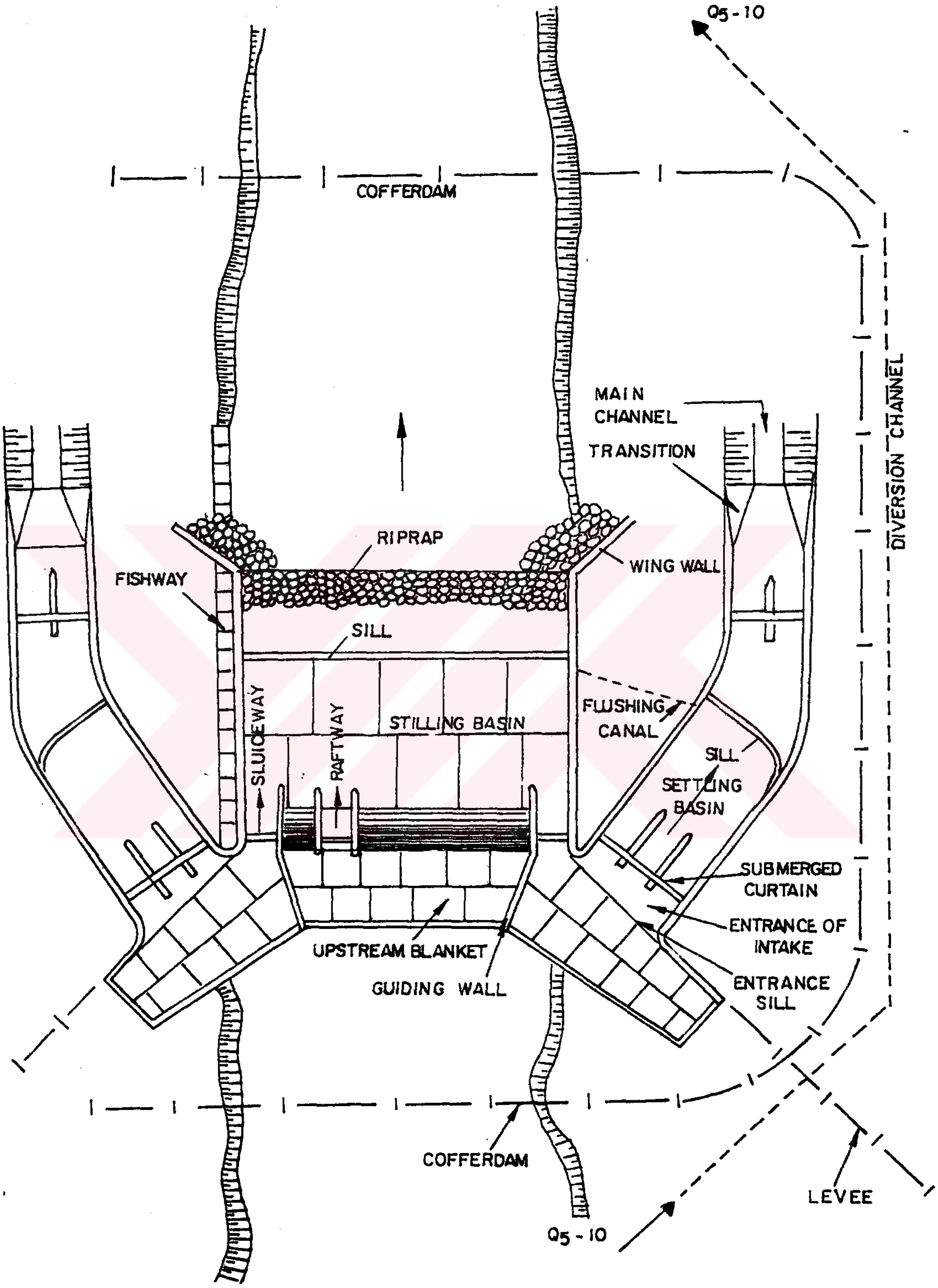


Figure 3.1 Plan View of a Diversion Weir With Sidewise Intake (Altınbilek and Yanmaz, 1992)

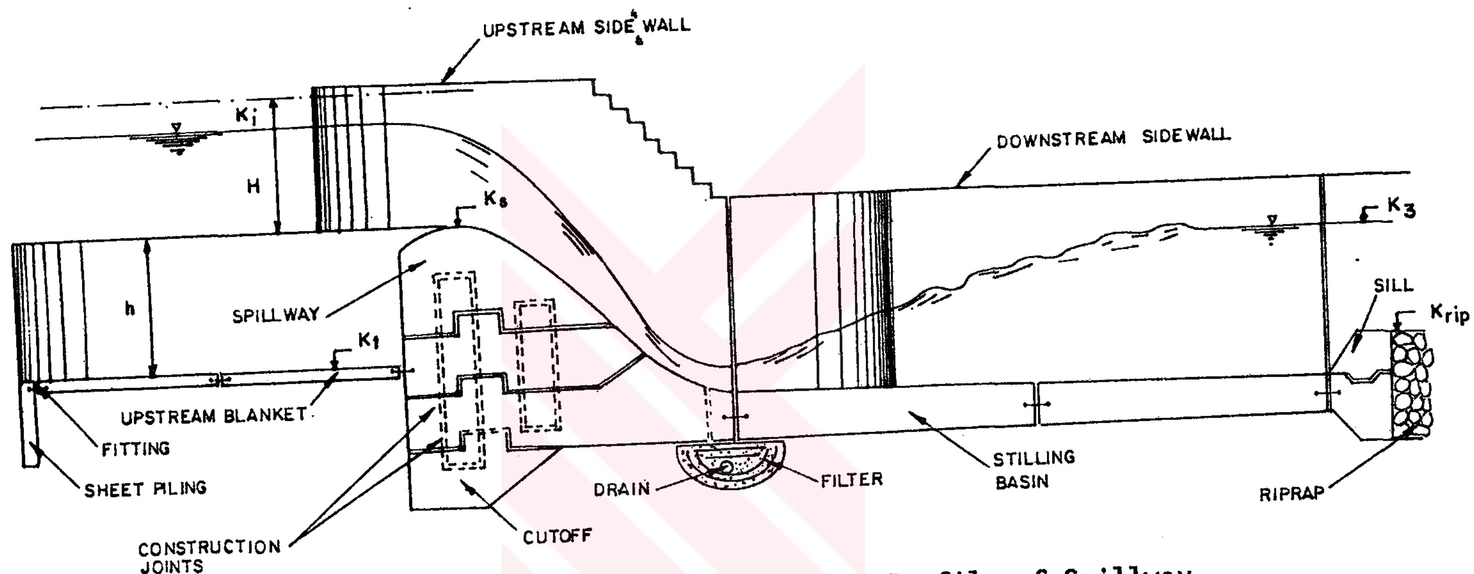


Figure 3.2 Longitudinal Profile of Spillway

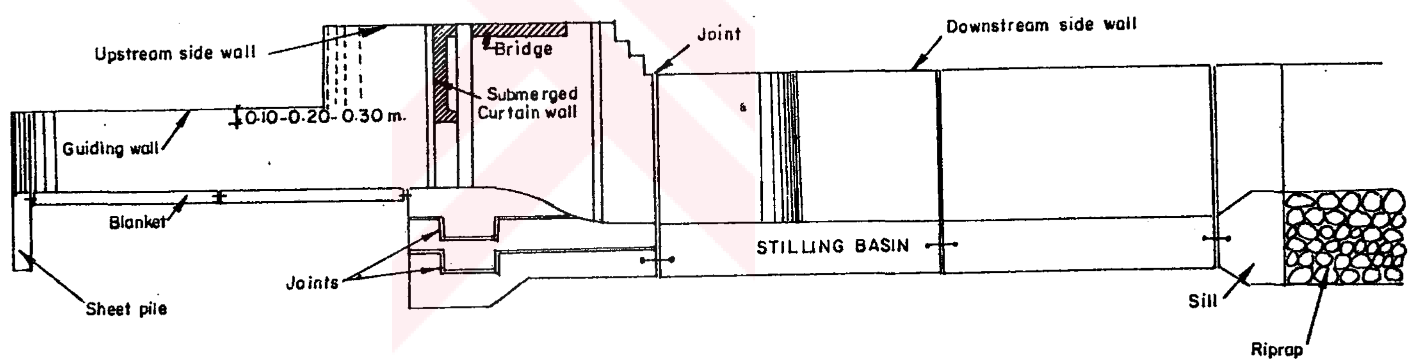


Figure 3.3 Longitudinal Profile of Sluiceway

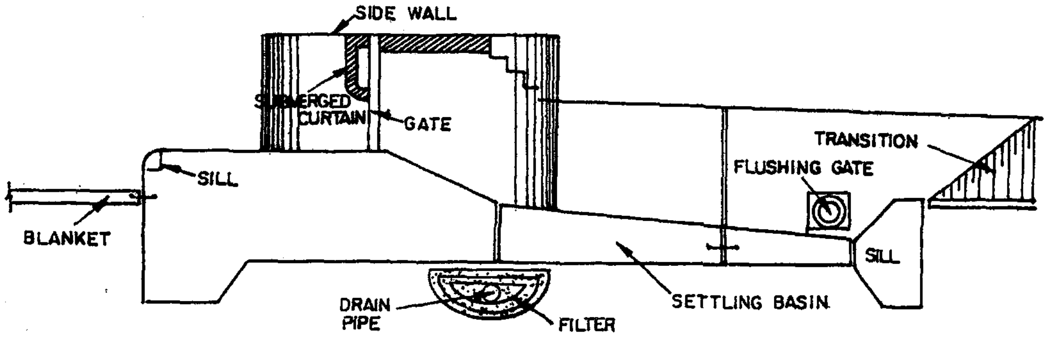


Figure 3.4 Longitudinal Profile of an Intake (Altınbilek and Yanmaz, 1992)

3.2.1 Side Walls

They confine the river flow as the boundaries of the structure. Side walls can be constructed as concrete or reinforced concrete retaining walls (See Figure 3.2).

3.2.2 Spillway or Gates

They collect the required amount of water, raise and give it to the intake structure at the desired elevation. Besides, they discharge flood flow to the downstream section.

There is usually a service bridge over the spillway crest. When the weir is gated, piers are constructed to support these gates. For diversion weirs, mostly ogee type overflow spillways are utilized. The ogee shape considers profile of aerated lower nappe falling over a sharp crested weir. The upper curve at the crest may be made either broader or sharper than the actual nappe (Varshney and Gupta, 1977). The crest profile of ogee type overflow spillway is given in Figure A.1 (USBR, 1987).

3.2.3 Sluiceway and Guiding Wall

Sluiceway with the bottom elevation same as thalweg prevents deposition of sediment (such as sand, gravel etc) in front of the intake . A sluiceway is located at the same side as intake canal. If there are two intakes on each side of the river, sluiceways should then be located on both sides. A submerged curtain wall and a gate is constructed with sluiceway. When the sediment deposition reaches to a certain level, opening of this gate facilitates the transportation of sediment particles to the downstream.

Guiding wall directs the bed load towards the sluiceway. It modifies stream lines and smooths out the turbulence. Guiding wall is a concrete or masonry structure with a thickness of 50-75 cm. It should be constructed such that it makes 15°-20° angle with the flow direction. Its height should be higher than the maximum water surface in the upstream and its length should be extended in the upstream direction beyond the level of entrance of intake (Özbek, 1991). Generally, guiding wall is constructed with 300 dosage concrete if it is reinforced, 250 dosage can be used otherwise (Sungur, 1988).

3.2.4 Energy Dissipating Facilities

Flow of water over the spillway face or through the gates is highly turbulent with supercritical regime. This excessive energy should be dissipated at the toe of the spillway in order to avoid erosion at the river bed.

The design of energy dissipator depends on many factors such as (Varshney and Gupta, 1977);

a) Nature of foundation
b) Magnitude of floods and their recurrence frequency
c) Flow velocity
d) Rating curve relationships of the water course at the site of structure.

A hydraulic jump is very effective in dissipating this energy. By virtue of its highly turbulent mixing, considerable mechanical energy will be dissipated over a relatively short reach. Two important points in the design are that the hydraulic jump should occur for all possible operations and its position should remain fixed (Hager and Sinniger, 1985). Compared to usual hydraulic jump on horizontal bed, a step may stabilize the jump location. Besides, chute and baffle blocks are also used for the same purpose in the stilling basin depending on the magnitude of the kinetic energy at the toe. Figure 3.5 illustrates the effect of tail water depth on the character and location of a hydraulic jump (Henderson, 1966).

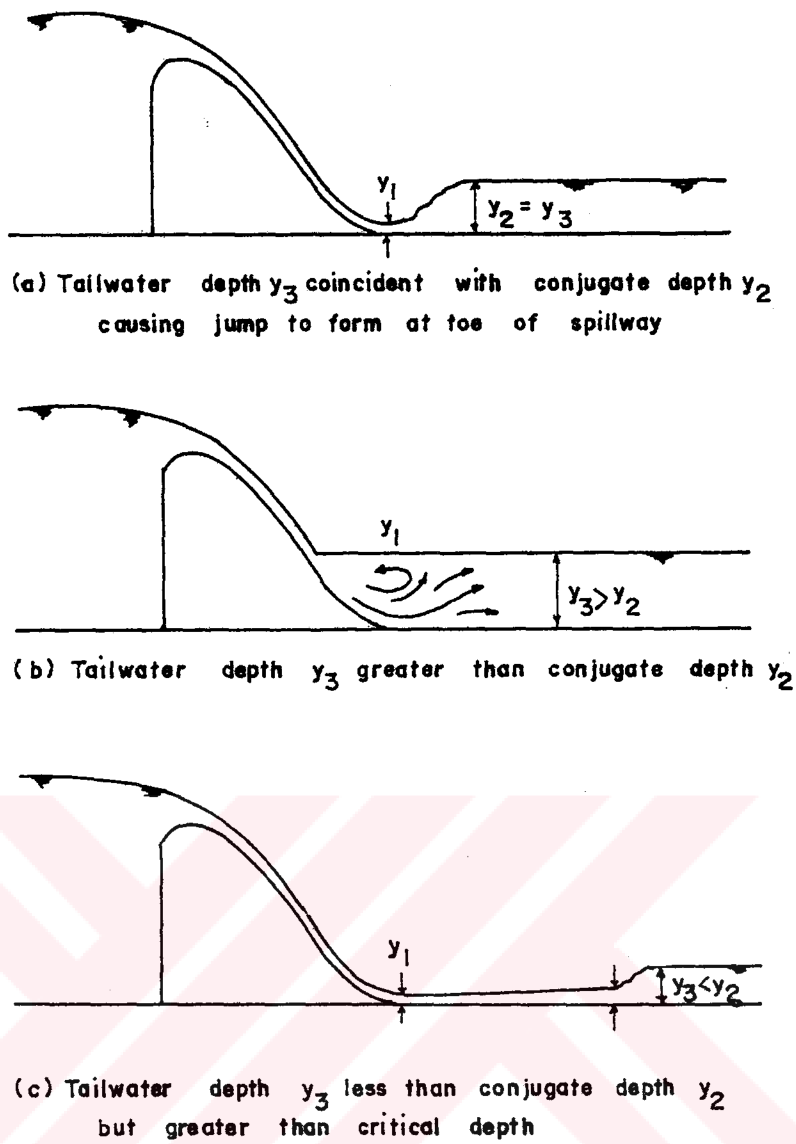


Figure 3.5 Effect of Tailwater Depth on the Character and Location of a Hydraulic Jump (Henderson, 1966)

The chute blocks are used to furrow the incoming jet and lift a portion of it from the floor, producing a shorter length of jump. These blocks also tend to stabilize the jump and improve its performance.

On the other hand baffle blocks are placed in intermediate position across the stilling basin floor. Their function is to dissipate energy mostly by impact action. They are useful in small structures with low incoming velocities. They are sometimes unsuitable, however, since very high velocities may make cavitation possible.

Energy dissipating facilities at the toe of the spillway can be selected on the basis of the interaction of conjugate depth of hydraulic jump and tailwater depth as follows:

a) Hydraulic jump type stilling basin: If the tailwater depth y_3 is less than the conjugate depth y_2, hydraulic jump will move towards downstream which may result in scour problem in the river bed. A stilling basin must then be constructed at the toe with a bottom elevation below the thalweg.

b) Bucket type energy dissipators: This type of dissipators are constructed when the tailwater depth y_3 is greater than the conjugate depth y_2. In this situation hydraulic jump will be drawn out by the tailwater, towards the spillway face and little energy will be dissipated. Best solution may be construction of a bucket type deflector.

c) When $y_2 = y_3$, a mat foundation with a bottom elevation at the thalweg is enough.

3.2.4.1 Hydraulic Jump Type Stilling Basins

In Turkey, hydraulic jump type stilling basins are widely used in diversion weirs. This type of stilling basin can be classified into four categories;

i) Stilling basins in which the value of Froude number at the spillway toe is less than 2.5. In this case a mat foundation is constructed with a length,

$$L = 6(y_2-y_1) \tag{3.1}$$

in which L is the stilling basin length

y_2 is the sequent depth and

y_1 is the initial depth of jump

ii) Stilling basins with the Froude number at the toe is between 2.5 and 4.5 which is called U.S.B.R Type I Basin (Figure 3.6) .

iii) Stilling basins with Froude number at the toe is greater than 4.5 and the velocity at the toe is less than 15 m/sec which is called U.S.B.R Type II Basin (Figure 3.6). This basin dissipates the energy by the impact blocks. The desirable dimensions of the length of the basin, height of the baffle blocks, and end sill as recommended by U.S.B.R are shown in Figure 3.6.

iv) Stilling basin with the Froude number at the toe is greater than 4.5 and the velocity at the toe is greater than 15 m/sec, which is called U.S.B.R Type III Basin (Figure 3.6).

The height of end sill which is found from Figure 3.6 is checked with the value obtained by subtracting sequent water depth from the tailwater depth.

3.2.4.2 Bucket Type Energy Dissipators

Bucket type energy dissipators allow the use of relatively short structure with marked economy over the sloping apron or the conventional hydraulic jump type stilling basin. The bucket design i.e. solid roller bucket, slotted roller bucket or ski-jump bucket changes with the tailwater level and the conditions of the bed rock (Varshney and Gupta, 1977).

i) Solid Roller Bucket: This type of bucket is shown in Figure 3.7. It consists of a bucket type apron with a concave profile of considerable radius and lip which deflects the high velocity flow away from the stream bed. The dissipation of surplus energy in the water is accomplished by the diffusion of the water jet in a large mass of water and by overcoming the boundary resistance of the loose soft bed.

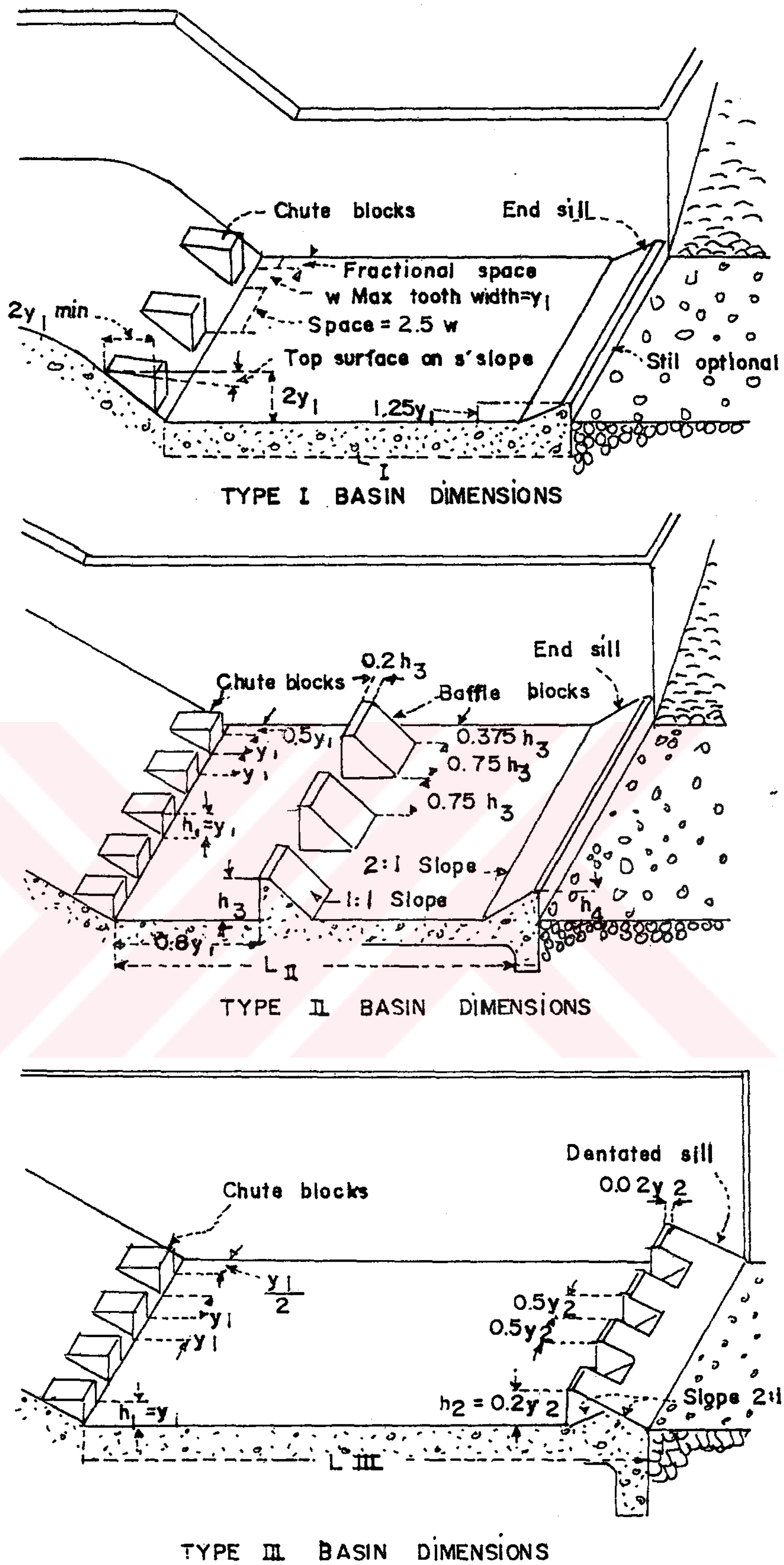
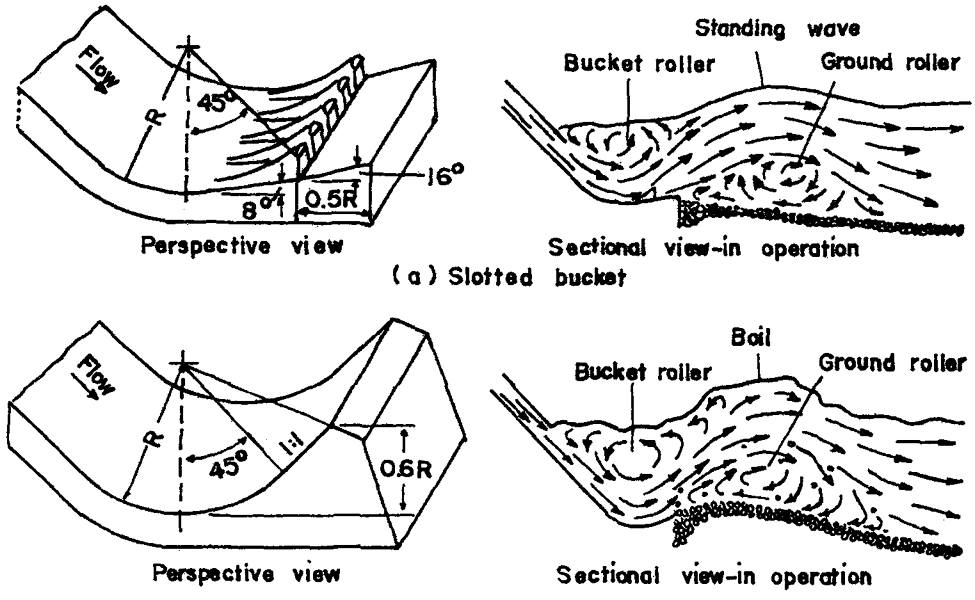


Figure 3.6 Types of Stilling Basin (USBR, 1987)



(b) Solid bucket

Figure 3.7 Solid and Slotted Roller Bucket Type Energy Dissipators (Varshney and Gupta, 1977).

The following relation has been found to give a satisfactory value for the radius of the bucket, R' (Varshney and Gupta, 1977)

$$R' = 0.6(H''H)^{\frac{1}{2}} \tag{3.2}$$

in which H'' is fall from the crest of the spillway to bucket invert, H is head over the spillway crest

In case of roller buckets, a 45° bucket exit angle is most effective.

Positioning of the bucket invert needs a major decision and is mainly governed by the tail water levels, rock strata and cost of excavation and concreting. The desirable tailwater depths range from 1.3 to 1.4 times the sequent depth y_2.

ii) Slotted or Dentated Bucket: Various designs are available for slotted roller bucket. The U.S.B.R design (Figure 3.7) may be adopted for design.

iii) Ski-jump Bucket: This type of energy dissipator is suitable where the stream bed is composed of firm rock and tail water depth is less than required for the formation of hydraulic jump. Figure 3.8 illustrates the definition sketch of a ski-jump bucket.

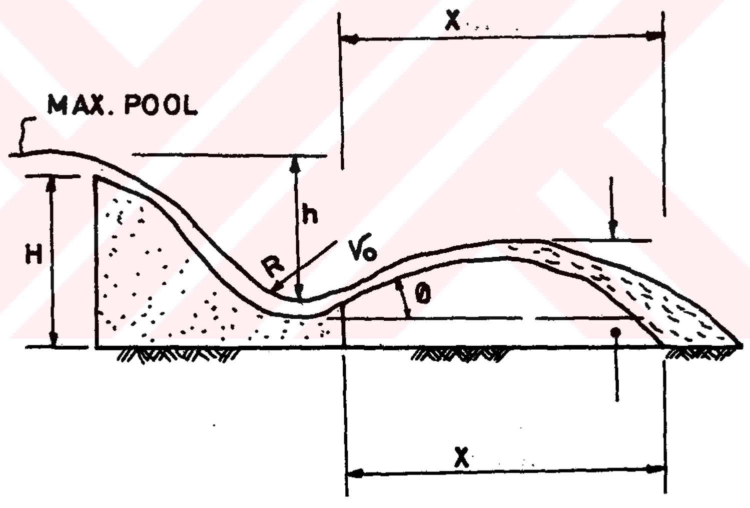


Figure 3.8 Ski-jump Bucket Energy Dissipator (Varshney and Gupta, 1977).

All the relations given for the solid roller bucket are applicable in this case also.

For entrance slope the steepest spillway slope should be used as 4 vertical to 1 horizontal (Varshney and Gupta, 1977). The exit angle, is an important factor in determining the length of the trajectory. Theoretically, if friction, air retardation etc. are neglected, the following formula can be used to evaluate the horizontal distance x, of the trajectory,

$$x = \frac{U_o^2 \sin 2\phi}{g} \tag{3.3}$$

The jet trajectory height, y, is given by the relation,

$$y = h \sin^2\phi \tag{3.4}$$

where ϕ is the exit angle for which 30° to 35° will make a good choice (Varsheny and Gupta, 1977). In this study ski-jump bucket design is ignored, since the solid and slotted bucket type are used widely rather than ski-jump type bucket. The value of minimum R can be obtained from Figure A.9 which is recommended by U.S.B.R. (1987)

3.2.5 Riprap

At the end of stilling basin there is riprap a section which prevents erosion of the river bed. Its length and thickness should be at least 10 m and 75 cm, respectively (Sungur, 1988). For a specific design, its effectiveness may be tested through model studies.

Diameter of the rock to be used in riprap section can be found from the following formula (Jansen et al., 1979):

$$D \geq \frac{KU^2}{2g\Delta} \tag{3.5}$$

in which Δ is the relative density and it can be taken approximately as 1.65 for sound rock, U is the maximum mean flow velocity at riprap section, K is a dimensionless constant as a function of state of flow which varies between 0.4 and 1.4 for laminar and turbulent river flows, respectively. To be on the safe side 1.4 is taken in this study.

3.2.6 Upstream Blankets And Cut-Offs

These two elements prevent piping and reduce uplift pressure under the base of main structure built on pervious foundation by increasing length of seepage. Well designed filters and pressure reducing drains prevent piping. Blankets are effective on the upstream side, drainage holes or relief wells, on the other hand, are provided on the downstream side. Upstream blankets are generally rectangular concrete blocks (See Figure 3.1, 3.2, 3.3, 3.4) fitted each other firmly by fitting. Their lengths are about 4-5 m with a thickness of 30 cm. Each separate concrete block is placed in a staggered manner (Sungur, 1988).

Besides rectangular blocks, there is also trapezoidal blanket i.e upstream blanket with uniformly decreasing thickness in the upstream direction. Length of rectangular upstream blanket and its thickness can be calculated from the following formula (Gill, 1980),

$$L_1 = 1.263\left(\frac{V}{\alpha}\right)^{1/3} \tag{3.6}$$

or,

$$L_1 = 1.596L_d\left(\frac{Q_o}{Q_m}-1\right) \tag{3.7}$$

$$V = tL_1 \tag{3.8}$$

$$\alpha = \frac{k_b}{k_f T} \tag{3.9}$$

in which L_1 is length of blanket, V is volume of blanket material per unit width, L_d is length of base of the main structure, Q_o is seepage rate per unit width under the weir in case of no blanket, Q_m is maximum seepage rate, t is the blanket thikness, T is thickness of the overburden beneath the weir, k_b and k_f are coefficients of permeability of blanket and foundation material respectively. Figure 3.9 illustrates the dimensions used in formulas.

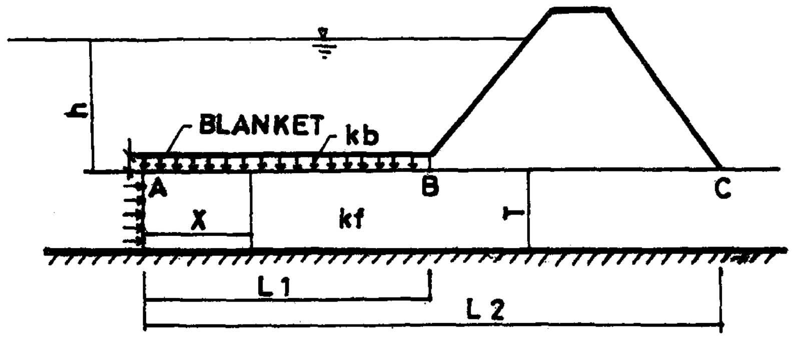


Figure 3.9 Schematic of A Rectangular Blanket of Dam on Pervious Foundation (Garde and Raju ,1980).

On pervious foundation values of Q_o and Q_m are expressed as:

$$Q_o = \frac{k_f\ h\ T}{L_d} \tag{3.10}$$

$$Q_m = k_f\ b\ h\ T\ \{b(L_2-L_1)+\tanh(b\ L_1)\}^{-1} \tag{3.11}$$

where $b = \dfrac{k_b}{k_f\ T\ t}$

Concrete cut-offs placed at the bottom of upstream face of spillway and at downstream side of stilling basin are also effective in retarding the seepage path.

3.3 Elements of Sidewise Intake Structure

3.3.1 Side Walls

They form the boundary of intake structure as retaining walls. As it is seen from Figure 3.4 retaining walls along the intake are constructed in two different levels. The first one which is the height of retaining wall up to settling basin is found by adding a proper freeboard to the maximum water stage at the upstream. The second level which extends up to the main channel is computed by adding a proper freeboard to water depth in settling basin.

3.3.2 Intake Entrance Structures

One of the entrance structures is a submerged curtain wall (Figure 3.4). This wall, especially during floods, prevents entrainment of floating subjects to the intake structure. Bottom elevation of the submerged curtain wall should be at least 0.1 meter below the crest. However, 0.2 meter is preferable for this elevation (Sungur, 1988). At the very beginning of entrance, there is an upward entrance sill (Figure 3.4) whose upstream face is rounded. Its top elevation should be at least 60 cm above the thalweg (Sungur, 1988). If the amount of sediment is very high, a screen with closely spaced bars may be constructed in front of the gate. However, it increases the minor losses.

3.3.3 Settling Basin

3.3.3.1 General

Settling basin is one of the most important elements of intake structure as it facilitates the accumulation of sediment which passes through the intake. This can be achieved by a properly designed settling basin. In the design of such a basin, sediment transport rate in the stream, allowable sediment size to be settled, fraction of water taken from the stream and purpose of the intake should be taken into consideration. However, whatever the degree of perfection, it is not possible to prevent the entrainment of sediment completely (Çeçen, 1993).

In settling basins large particles like sand and gravel are kept, otherwise they enter to main channel, and cause irregular settlement along the channel and in front of the gates etc. Therefore, these particles should be removed as soon as possible from the system. On the other hand, smaller particles like silt, clay and colloids should preferably be conveyed by the canal to the fields where they have a fertilizing function (Kop, 1991).

A proper settling basin should have the following characteristics (Kop, 1991);

a) The velocity in settling basin should be small enough for sand particles to settle out.

b) Storage capacity of settling basin should be large enough to retain the sediment that has settled during the working period.

c) The accumulated sediment in the settling basin, should be flushed back into the stream by means of a flushing canal or gate located at the end of settling basin (See Figure 3.4). For a proper flushing operation, the following criteria should be satisfied;

i) Sufficient supply of water

ii) Sufficient head between settling basin and recipient water course

iii) Sufficient steep bed slope in settling basin for the generation of required flushing velocities and tractive force.

iv) A device (sliding or radial gate) preventing return flow from the cross-section downstream of the settling basin.

Settling basins always consist of a curved end sill to direct the sediment accumulated at the end of the basin towards the flushing canal (Figure 3.4)

3.3.3.2 Classification of Settling Basin

Settling basins can be classified according to various criteria. In this study settling basins that are constructed for irrigation purposes are considered only. There are three criteria to classify settling basins (Çeçen, 1993):

i) Shape
ii) Type of flushing system
iii) Flushing direction

According to shape, settling basins are divided into two groups;

a) Rectangular settling basins
b) Circular settling basins

According to flushing system they are provided with

a) Intermittent flushing
b) Continuous flushing

c) Combination of intermittent and continuous flushing

d) Mechanically cleaned settling basins

According to flushing direction,

a) Flushing system in the flow direction

b) Flushing system against the flow direction (with reverse slope) (See Figure 3.10).

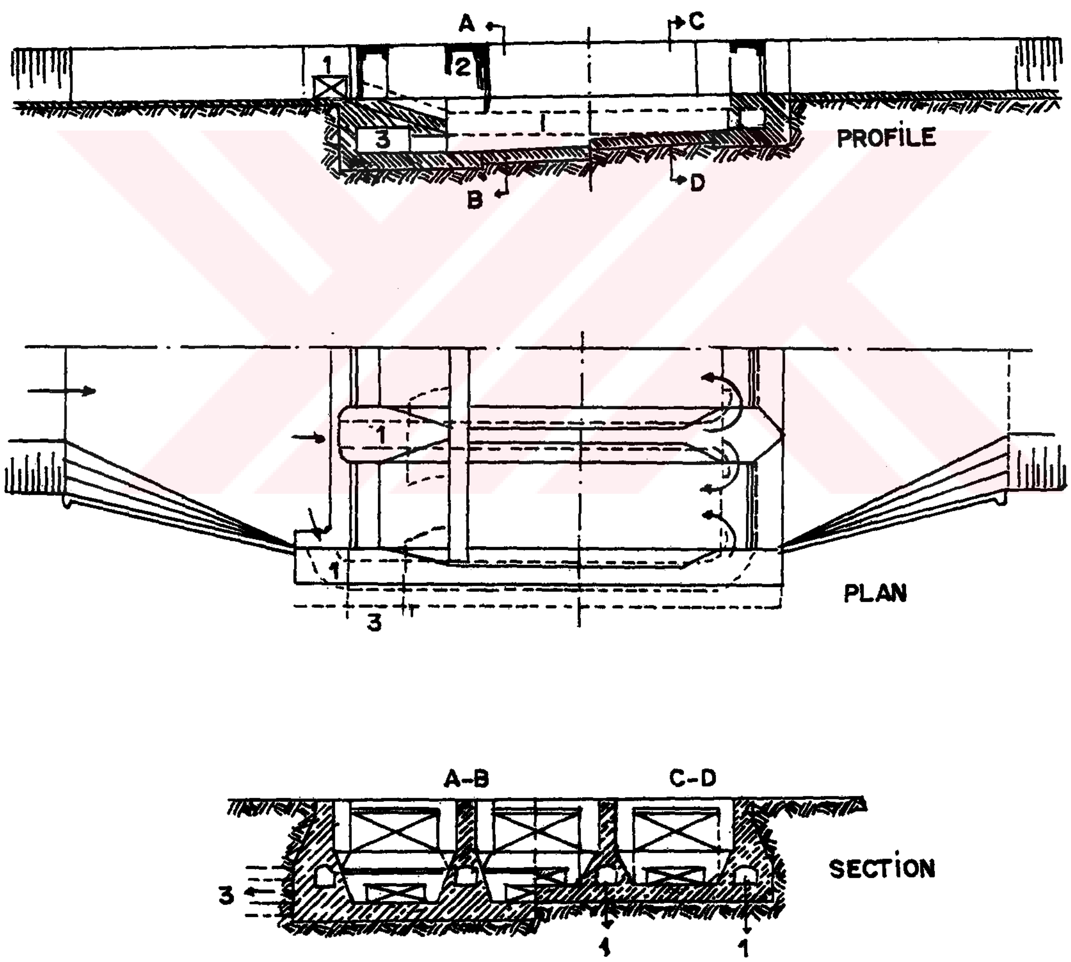


Figure 3.10 Flushing System Against the Flow Direction (Çeçen, 1992)

3.3.3.3 Design of Settling Basin

Minimum length and depth of settling basin should be designed such that, when the storage section of settling basin has been filled and irrigation canal continues to give water to the field, sand and gravel should still be settled in it.

Bed slope of settling basin is determined such that, when the water level is uniform at the end of flushing period, generated tractive force should still be large enough to remove the settled particles. Based on experience, 1% bed slope is usually maintained in settling basin in Turkey (Sungur, 1988).

Various formulas recommended for the determination of length of a settling basin are as follows;

Kop(1991), proposed the formula:

$$L' = \frac{Q_{ir}}{U_s(B+zh')} \tag{3.12}$$

in which L' is the length of settling basin, Q_{ir} is irrigation discharge, U_s is fall velocity of sediment particle to be settled, B is bottom width of settling basin, z is side slope if the cross section of the basin is trapezoidal and h' is water depth in the settling basin.

In case of a rectangular cross section Equation 3.12 reduces to

$$L = \frac{Q_{ir}}{U_s B} \qquad 3.13)$$

From Stokes law, settling velocity of sediment particles in spherical shape can be determined from (Graf, 1971)

$$U_s = \left(\frac{4\ g\ D\ \blacktriangle}{3\ C_D}\right)^{\frac{1}{2}} \qquad (3.14)$$

in which D is mean diameter of sediment to be settled, $\blacktriangle$ is the relative density of sediment, g is gravitational acceleration, C_D is particle drag coefficient which is approximately 0.4 for turbulent flow ($R_e = U_s D / \nu > 2.1$) around the falling particle, R_e is Reynolds number. The value of C_D is given by $24/R_e$ for laminar flow with $R_e \leq 0.1$ and for transition regime between $0.1 \leq R_e \leq 2.1$ it is obtained from;

$$C_D = \frac{24}{R_e} + \frac{3}{\sqrt{R_e}} + 0.34 \qquad (3.15)$$

Turkish State Hydraulic Works consider the following approach in the determination of sediment size, D, to be settled, in the settling basin

$$D = 10RS_o \qquad (3.16)$$

where R is hydraulic radius of main trapezoidal channel for half irrigation discharge, and S_o is the bed slope of main channel. Equation 3.16 can be obtained from Shields diagram (Bayazıt, 1971).

If the size of particle computed from the Equation 3.16 is greater than 0.5 mm, it is preferably to be settled in the basin.

The length of settling basin can then be computed from Equations 3.12 or 3.13 proposed by Kop (1991).

Sümer (1977) has suggested another approach to find the length of settling basin on the basis of removal ratio of sediment:

$$L = - \frac{6\left(\frac{U'}{U_*}\right) h'}{K\lambda} \ln(1-r) \qquad (3.17)$$

where U' is mean flow velocity in the settling basin, U_* is shear velocity which is equal to $(g\ R\ S_0)^{\frac{1}{2}}$, h' is water depth in settling basin, K=0.42 (constant), λ, mean rate at which particles settle out in suspension, which is found from Figure 3.11 as a function of ß:

$$\beta = \frac{U_s}{KU_*} \qquad (3.18)$$

in which ß is settling velocity parameter, r is removal ratio of sediment. As the value of r increases the length of settling basin also increases. The design engineer should take a reasonable value for r with the assumption that the settling basin is to be cleaned against sediment accumulation during off irrigation season.

Li and Shen (1975) have found the length of settling basin by the help of random walk model which assumes the solid particle settlement in turbulent flow as a random phenomenon. Motion of particle is assumed to consists of number of small discrete steps. Following simplifying assumptions have been made as;

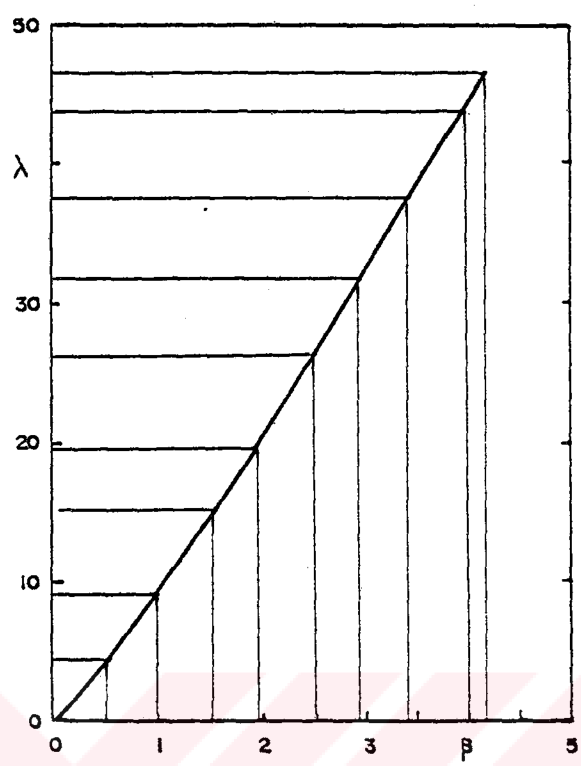


Figure 3.11 Mean Rate as a Function of ß (Sümer, 1977)

a) Solid particle has the same velocity component as those of surrounding fluid plus a constant vertical fall velocity of the particle.

b) A number of single solid particle settlements do not interfere with each other.

c) The flow is steady and uniform in the ordinary sense i.e. over a time.

d) Secondary current can be ignored and the velocity fluctuation in the transverse direction has no influence on solid particle settlement.

According to these assumptions outlined above, the turbulent fluctuating velocity should not have much influence on the mean settling length and average time for a particle to settle from the water surface to the channel bottom. Therefore, the mean settling length can be approximated by:

$$L = \frac{U'h'}{U_s} \tag{3.19}$$

Height of the end sill of settling basin can be determined from the volume of sediment accumulation in settling basin between two successive flushing operation. Volume of settling basin is determined according to the amount of incoming sediment and flushing period. For instance, if the basin is flushed daily then there may be no need to construct a high sill, but if it is flushed weekly or monthly, end sill with a considerable height should be built.

Specifications accepted by Turkish State Hydraulic Works require construction of an end sill in the range of 0.6 to 1 meter in height depending upon the sediment concentration of the river and discharge passing through settling basin.

Moreover, if continuous flow of water is needed during some periods, then settling basin should be constructed in the form of compartments (Avcı, 1993). Otherwise, it is not possible to give water continuously without flushing. To get rid of this problem, dividing walls are constructed in settling basin. This type of settling basin brings another advantage in case of highly variable intake rates. For example for very low discharges all gates need not to be operated.

3.3.4 Flushing Canal

It provides the flushing of settling basin. It can be formed as a circular pipe with a minimum diameter of 80 cm or a rectangular box culvert. There is always a gate in front of the flushing canal. By opening this gate and closing the gates at the entrance of main canal, turbulence is created and deposited sediment is discharged to the river at the downstream. For continuous flushing, it should has the minimum self cleansing slope. Various flushing devices can be constructed at the bottom of settling basin such as (Çeçen, 1993):

a) Flushing in the flow direction
b) Transversal flushing
c) Flushing by funnels located at the bottom of settling basin

3.3.5 Main Channel Entrance Structure

It is composed of submerged curtain wall, pier, gate and a service bridge. It is similar to intake entrance structure. It provides the measurement for discharge. Gates of this structure are closed during flushing period to prevent entrainment of sediment into main irrigation canal.

3.3.6 Transition and Curvatures

Transition connects the rectangular settling basin to the trapezoidal main channel. Proper transition should conform the following criteria (French, 1989):

a) Avoids excessive losses of energy
b) Provides hydraulic safety both for transition structure and water way
c) Eliminates cross-waves, standing waves and other turbulence.

It is possible to construct many types of transition in diversion weirs (See Figure 3.12). Although it increases the head loss compared to the other types, it is a common practice to construct straight line type transition, since it is easy to construct. Formwork of other types are very difficult and expensive. In Turkey, straight line type transition is widely used in diversion weirs.

Length of transition can be calculated from the following formula (French, 1989):

$$L_t = 2.35(B' - b_1) + 1.65zy_2' \qquad (3.20)$$

where L_t is length of the transition, B' is width of intake at the transition, b_1 is bottom width of the main irrigation channel, z is side slope of the intake if it is trapezoidal in shape, and y_2' is water depth at the entrance of transition.

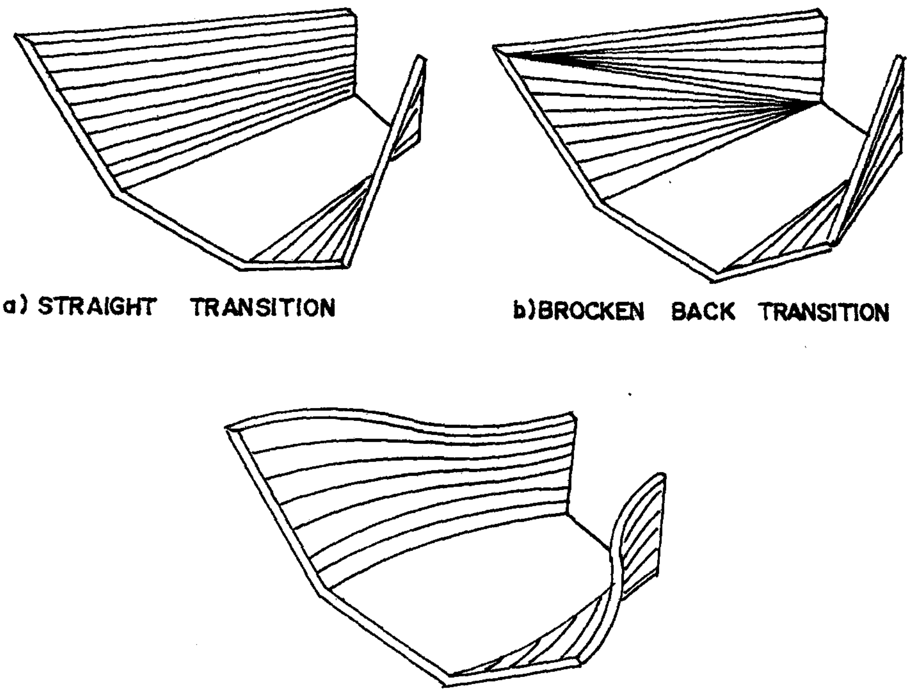


Figure 3.12 Types of Transition (Sungur, 1988)

Besides, Sungur (1988) presents the following formula that is accepted by Turkish State Hydraulic Works in the projects of diversion weirs:

$$L_t = \frac{b_1 + 2z(y_1'+f') - B'}{2 \tan \alpha} \qquad (3.21)$$

where f' is freeboard, $f' = 0.2(1+y_1')$ (Altınbilek and Yanmaz, 1992), y_1' is water depth in the irrigation channel, α is the angle between channel axis and a line connecting the canal sides between entrance and exit section.

In the intake structures change in direction is provided by curvatures with a proper radius. Projected horizontal length of curvatures is approximately taken as 15 times the water depth in the channel in preliminary design of diversion weirs in Turkey.

3.4 Auxiliary Elements of a Diversion Weir

3.4.1 Levees

They are constructed on both sides of the river at the upstream to prevent the flooding of side plains due to backwatering. In order to achieve an economic solution it is possible to construct them in decreasing height towards the upstream direction till the flow reaches uniform flow condition.

3.4.2 Cofferdams

Cofferdams are very small earth structures to provide dry area during the construction of a diversion weir. They are designed for 5 or 10 years flood discharge (U.S.B.R., 1987).

3.4.3 Diversion Canal

It transmits water from upstream to downstream during construction. It is designed for 5 or 10 years flood discharge (Sungur, 1988).

3.4.4 Fish Passage

This element is constructed on the rivers in which fishing is important. It is placed near the side wall. It can be constructed from 250 dosage concrete or stone. There should be 1.5-2 m water depth at the entrance to provide passage for fish. Details in specifications of a fish passage can be obtained from Sungur (1988).

3.4.5 Raft Passage

This is a structural element which provides the passage of logs to the downstream. There is an opening at the upstream face of the spillway with a bottom elevation lower than spillway crest. Raft passage may be constructed if log transportation is important in the river (Altınbilek and Yanmaz, 1992).

CHAPTER IV

OPTIMUM HYDRAULIC DESIGN

4.1 Introduction

In this chapter, dimensions of a diversion weir with a sidewise intake will be investigated for an optimum solution. A computer program developed for the quick preliminary analysis, design, and cost computations of the structure is given in Chapter 5.

4.2 Determination of Spillway Crest Elevation

Crest elevation of a spillway is determined by adding head losses through intake structure and proper freeboard to the water surface elevation at the entrance of main irrigation channel. Flow is subcritical in the main channel which makes it a downstream control section. Since the required bottom elevation of the main channel at the end of intake is commonly dictated by irrigation requirements, the water surface elevation at this section can be easily computed. Intake head losses are then calculated from downstream towards upstream starting from the beginning of main channel.

4.2.1 Optimum Bottom Width Determination of Main Irrigation Canal

From the hydraulic point of view, an open channel should be designed such that it should convey maximum discharge having least wetted perimeter which is called best hydraulic section. However, this section may not always be practical. For instance, it brings difficulties in construction or type of foundation does not allow such a section. In general, a channel section may be designed for the best hydraulic section but should be modified for practicability. A best hydraulic section gives the minimum area for a given discharge but not necessarily the minimum excavation (Chow, 1959).

Trout (1982) presents charts which are utilized for the minimization of lining cost. Actually, the total cost of construction should be minimized (Altınbilek and Yanmaz, 1992).

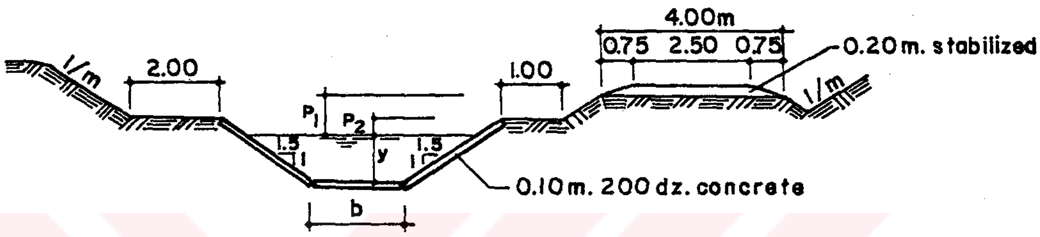
Classical irrigation channels are generally constructed in trapezoidal cross-section in Turkey, as well as U.S.A and many countries of the world (See Figure 4.1). Flow in the channel is assumed to be uniform during continuous operation. Therefore, Manning's equation can be used in the determination of bottom width of the channel and the corresponding water depth;

$$Q_{ir} = \frac{A}{n} R^{2/3} S_0^{\frac{1}{2}} \qquad (4.1)$$

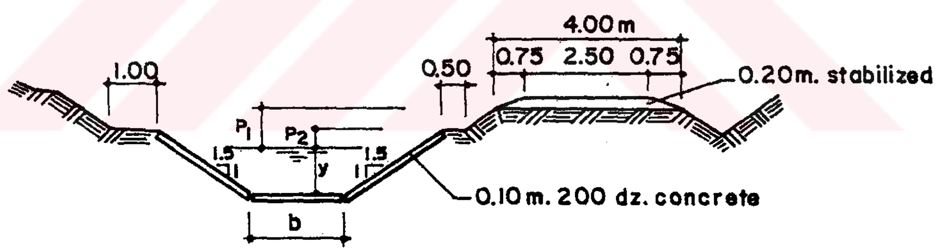
where Q_{ir} is the irrigation discharge, A is the cross-sectional area of flow (i.e $A=b_1y_1'+zy_1'^2$), b_1 is the bottom width of channel, y_1' is the water depth in the main channel, z is side slope of channel, n is the Manning's roughness coefficient, and R is the hydraulic radius which is computed from

$$R = \frac{A}{b_1 + 2y_1'(1+z^2)^{\frac{1}{2}}} \tag{4.2}$$

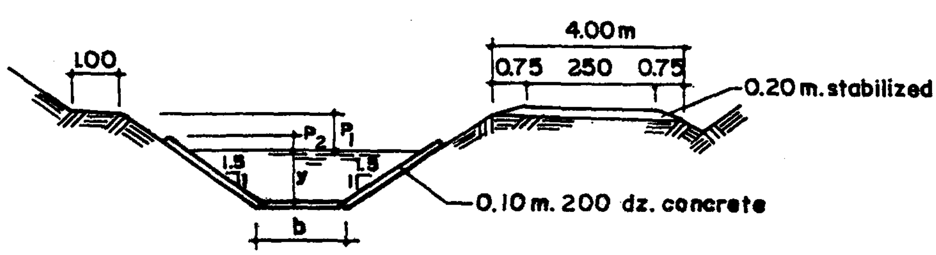
and S_0 is the bottom slope of main irrigation channel.



Cross-section for Q>5 m³/ sec. in cut.



Cross-section for 1<Q<5 m³/sec. in cut.



Cross-section for Q<1 m³/sec. in cut.

Figure 4.1 Recommended Channel Cross-Section

Irrigation discharge is determined according to amount of water needed by the crops in the project field that has to be irrigated. Commonly, the weighted consumptive use requirement corrected by the losses in conveyance, application and storage is considered for this purpose (Hansen et al., 1980).

Turkish State Hydraulic Works and U.S.B.R recommend the side slope of lined irrigation channel with 1 vertical on 1.5 horizontal side slope (Altınbilek and Yanmaz,1992). All the irrigation channels are constructed with lining to prevent erosion of the channel perimeter and to decrease seepage. Mostly concrete is used as lining material in Turkey (Kızılkaya, 1988).

Bottom slope of the main channel depends on topography and the head required to carry the design discharge.

There are two unknowns namely b_1 and y_1' with only one equation. Any bottom width is assumed and the corresponding water depth is obtained from Manning's equation. Experience curves are recommended by U.S.B.R. for the preliminary selection of bottom width or water depth of a lined trapezoidal channel (See Figure 4.2). As it can be seen from Figure 4.2 the bottom width curve envelopes the water depth curve for the given discharge range. This may be considered as a reasonable limitation since greater water depths in a narrow channel may create seepage problems.

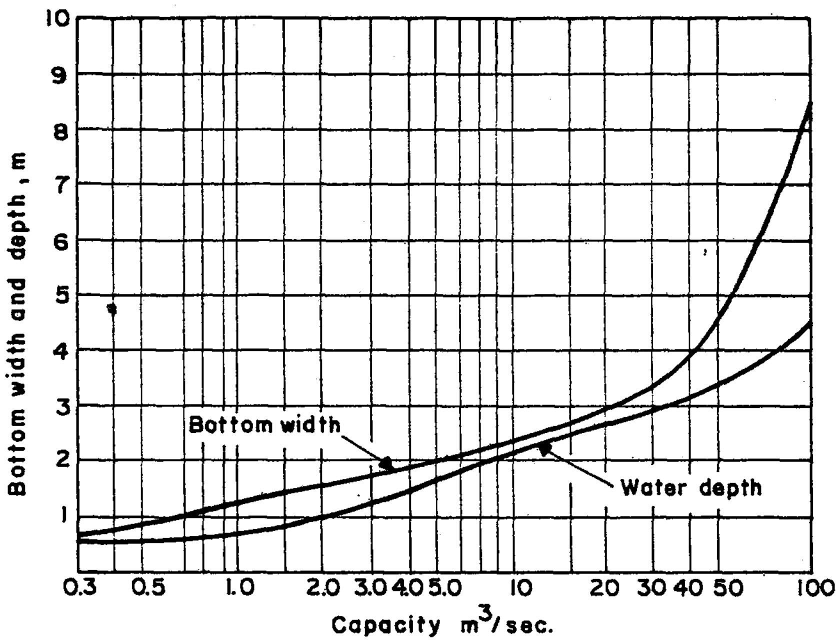


Figure 4.2 Experience Curves Showing Bottom Width and Water Depth of Lined Channels (U.S.B.R., 1987)

The total cost which is the summation of the costs of excavation, lining and purchasing the land is then determined. If this manipulation is performed for a wide range of b_1 values, one can plot the relationship between b_1 and total cost from which the optimum value of b_1 can be identified. Manning's equation can be rewritten as;

$$AR^{2/3} = \frac{(b_1 y_1' + z y_1'^2)^{5/3}}{(b_1 + 2y_1' (1+z^2)^{\frac{1}{2}})^{2/3}} = \frac{nQ_{ir}}{\sqrt{S_0}} \tag{4.3}$$

After finding optimum bottom width, water depth in the channel can be found from Equation 4.3 and should be checked with the critical depth, y_c, to satisfy the following criteria.

$$\frac{y_1'}{y_c} \geq 1.1 \qquad (4.4)$$

Critical water depth can be found from Figure A.2 given in Appendix A.

The relations between b_1 and the total cost for various $nQ/\sqrt{S_0}$ values which have been obtained using 15000 TL/m^3, 3800 TL/m^2, 9000 TL/m^2 for the unit costs of excavation, lining and purchasing the land, respectively, are shown in Figure 4.3. As it can be observed from Figure 4.3, as $nQ/\sqrt{S_0}$ increases, the optimum bottom width also increases. In Turkey, new year unit prices are obtained from previous year unit prices multiplied by a constant factor reflecting the inflation rate. Such a yearly increase in unit cost will only affect the total cost as the optimum bottom width remains unchanged (See Figure 4.4). Therefore, one can generalize the relation between optimum bottom width and the corresponding optimum water depth which is obtained from Equation 4.3 to obtain sets of charts for various $nQ/\sqrt{S_0}$ values (See Figure 4.5). The inspection to Figure 4.5 indicates that the optimum water depth is less than the optimum bottom width which is in good agreement with the criteria of U.S.B.R. (See Figure 4.2). Charts in Figure 4.5 can be utilize for $0.1 \leq Qn/\sqrt{S_0} \leq 100$ with the computed value of $Qn/\sqrt{S_0}$ the optimum b_1 curve intersected and the optimum value of b_1 is read from left ordinate whereas optimum y_1' is obtained by intersecting the optimum y_1' curve and reading from the corresponding value from the right ordinate.

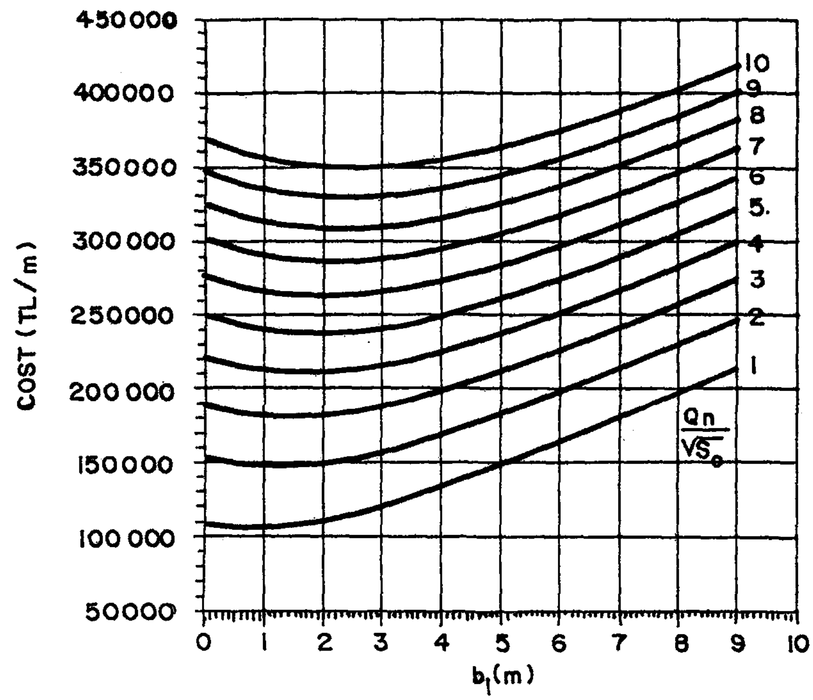


Figure 4.3 Optimum Bottom Width for Various $Qn/\sqrt{S_0}$

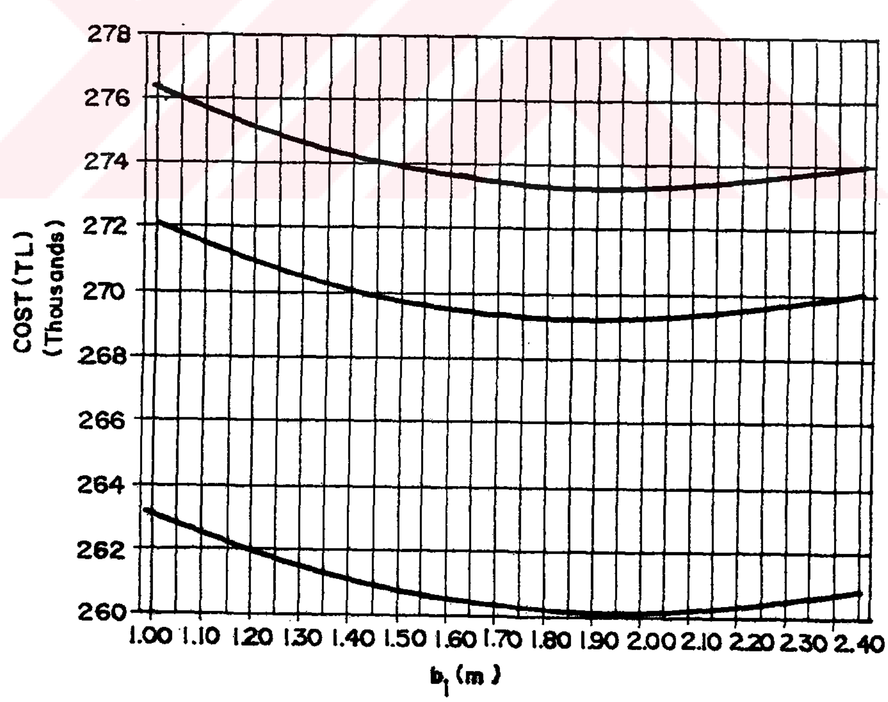


Figure 4.4 Relation Between Total Cost and Bottom Width for Various Rates of Prices

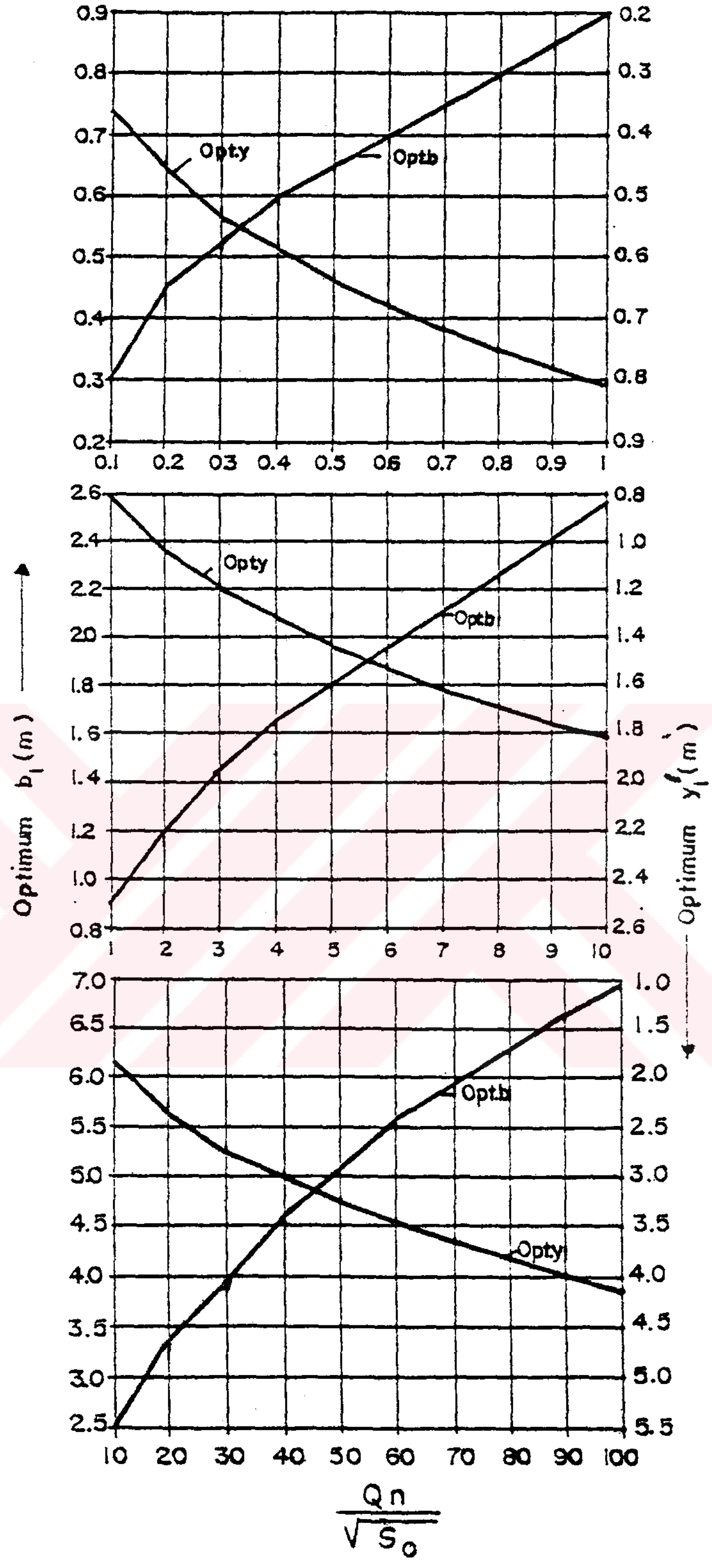


Figure 4.5 Optimum Bottom Width and Water Depth for Various Values of $Qn/\sqrt{S_0}$

Figure 4.6 illustrates the general plan and longitudinal profile of an intake structure. The possible head losses from downstream to upstream are as follows:

a) Head loss duo to transition (ΔH_R)

b) Head loss at the entrance of main channel (ΔH_a)

c) Head loss due to curvatures (ΔH_k)

d) Head loss at the end sill of settling basin (ΔH_e)

e) Head loss through settling basin (ΔH_c)

f) Head loss at the entrance sill of settling basin (ΔH_{ge})

g) Head loss at the submerged curtain wall at the intake (ΔH_g)

h) Head loss above the entrance sill (ΔH)

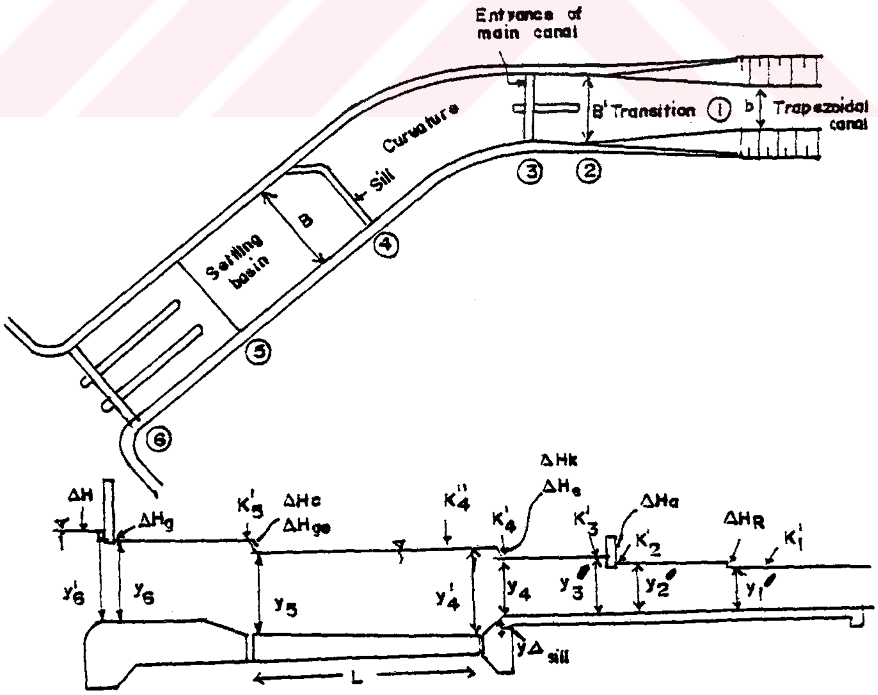


Figure 4.6 General Plan and Longitudinal Profile of an Intake

4.2.2 Head Loss Due To Transition

In case of inlet transition, i.e. transition from wider to narrower width, the velocity entering the transition is less than the velocity leaving it. Transition head loss, ΔH_R, can be calculated from the formula given below (Chow, 1959; Vittal and Chiranjeevi, 1983; French, 1989)

$$\Delta H_R = C_i \frac{U_1^2 - U_2^2}{2g} \tag{4.5}$$

in which C_i is inlet loss coefficient, U_1 is the average flow velocity in the main irrigation channel, U_2 is the average flow velocity just at the entrance of transition. Inlet loss coefficient is given in Table 4.1 for different types of transition.

Table 4.1 Inlet Loss Coefficients (French, 1989)

Transition Type	Ci
Warped	0.10
Cylinder Quadrant	0.15
Simplified Straight Line	0.20
Straight Line	0.30

As it is proposed by Vittal and Chiranjeevi (1983) and Sungur (1988) C_i=0.3 is used for straight line transition in

Equation 4.5 to find the flow velocity at the entrance of transition, Bernoulli's equation is written between the beginning and end section of the transition;

$$y_1' + \frac{U_1^2}{2g} + \Delta H_R = y_2' + \frac{U_2^2}{2g} \qquad (4.6)$$

where y_2' is Q_{ir} /(B'U_2) and B' is the width of canal at the entrance (See Figure 4.6). From the design of main channel optimum water depth y_1' and corresponding flow velocity U_1 are known. Value of B' must be greater than b1, which can be taken approximately 2.5 times of b_1 which is the most economical choice, that is found by computer program analysis, since although as the B' gets wider spillway height gets smaller this is not provide economy. The type and dimension of gates used at the entrance of main channel should also be considered in the selection of the value of B'. By inserting value of y_2' into Equation 4.6 only unknown becomes U_2 and it is found by trial and error. After that transition loss is computed from Equation 4.5.

4.2.3 Head Loss at the Entrance of Main Channel

At the entrance of main channel gates are used to regulate the flow and to prevent entrainment of water to the canal during flushing period. The number and size of gates and width of the canal depends on each other and flow conditions. Therefore, the decision about them should be given at the same time. If the channel is very wide, it is recommended to construct few gates depending on the required discharge. To support gates, piers and curtain walls are constructed between them. As a common practice, thickness of piers is taken at least 0.5 meter according to the specifications of Turkish State Hydraulic Works. However, if there is a service bridge on the piers then it should be constructed wider to support all appurtenances safely. Due to these piers, gates and curtain wall, some head loss occurs at the entrance which is known as the entrance loss.

Sungur (1988), proposed the following formulas to calculate this headloss (See Figure 4.7)

$$U'' = 0.65\ (2\ g\ \Delta H_a)^{\frac{1}{2}} \tag{4.7}$$

$$U'' = \frac{Q_{ir}}{B''\ y_2} \tag{4.8}$$

in which U'' is the mean flow velocity through the gate, B'' is net width of entrance which equals the width of entrance minus (number of piers) * thickness of piers.

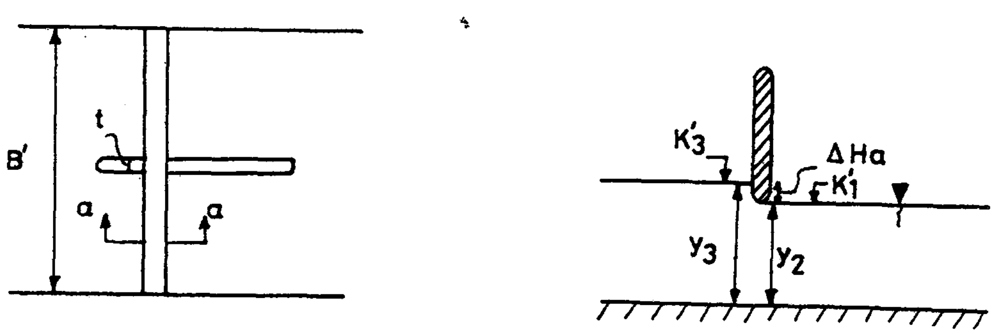


Figure 4.7 Plan and Profile of Main Canal Entrance

4.2.4 Head Loss Through Curvature

Transition from settling basin to entrance of main canal is provided by a curvature. If the centers of curvatures are the same or widths of the basin and entrance of main canal are the same then there is no head loss due to curvature (Sungur, 1988). After determining the width of the entrance to main channel and keeping the height of the end sill constant, minimum required width of settling basin is determined according to the criteria that the mean flow velocity has to be at most 0.3 m/sec at the end of settling basin to prevent entrainment of large particles to the canal (Sungur, 1988; Kop, 1991). With this criteria, the width of settling basin is assumed, and head loss through the curvature is given by Sungur (1988) as follows;

$$\Delta H_K = 0.2 \frac{U_3^2 - U_4^2}{2g} \tag{4.9}$$

in which U_3 is average flow velocity in front of the submerged curtain wall, and U_4 is average flow velocity at the end of settling basin. To find U_4, Bernoulli's equation is written between sections 3 and 4 shown in Figure 4.6.

$$y3' + \frac{U_3^2}{2g} + \Delta H_K = y_4 + \frac{U_4^2}{2g} \tag{4.10}$$

in which y_3' can be determined from:

$$y_3' + \frac{U_3^2}{2g} = y_2' + \frac{U_2^2}{2g} + \Delta H_a \tag{4.11}$$

$$y_4 = \frac{Qir}{BU_4} \quad (4.12)$$

where B is settling basin width which is greater than B'.

4.2.5 Head Loss at the End Sill of Settling Basin

Sungur (1988), proposed the following relation to calculate the head loss at the end sill of settling basin,

$$Q_{ir} = 2.88\ B(\frac{2}{3} \Delta H_e^{3/2} + y_4\ \Delta H_e^{1/2}) \quad (4.13)$$

in which, y_4 is the flow depth just at the end sill of settling basin, To ensure on properly designed settling basin, velocity in the basin should be checked at this stage. Therefore, firstly water depth just in front of the end sill is found from energy equation

$$y_4' + \frac{U4'^2}{2g} = y_4 + \frac{U_4^2}{2g} + \Delta H_e + \Delta sill \quad (4.14)$$

in which Δsill is height of the end sill.

$$U_4' = \frac{Q_{ir}}{By_4'} \quad (4.15)$$

U_4' should be less than 0.3 m/sec as mentioned before.

4.2.6 Head Loss Through Settling Basin

This is a very minor head loss. Therefore, it can be estimated as 0.01 or 0.02 meters but if the sensitive calculation is required, then length of settling basin should be found first by using the Equations described in Section 3.3.3.3 The largest length among them is preferred. Head loss through settling basin is then found by:

$$\Delta H_c = L'\left(\frac{S_4' + S_5}{2}\right) \qquad (4.16)$$

in which L' is length of settling basin, S_4' and $S_5'$are the energy slopes at section 4', and 5, respectively (Figure 4.6) which can be expressed from Manning's equation as;

$$S_4' = \frac{n^2\, U_4'^2}{R_4'^{4/3}}\ , \qquad S_5' = \frac{n^2\, U_5^2}{R_5^{4/3}} \qquad (4.17)$$

By writing Bernoulli's equation between sections 4' and 5, U_5 is found from;

$$y_4' + \frac{U_4'^2}{2g} + \Delta H_c = S_o'L + y_5 + \frac{U_5^2}{2g} \qquad (4.18)$$

in which S_o' is the bottom slope of settling basin which is about 0.01 (Sungur, 1988) and

$$y_5 = \frac{Q_{ir}}{BU_5} \qquad (4.19)$$

Value of ΔH_c is then computed from Equation 4.16.

4.2.7 Head Loss at the Entrance Sill of Settling Basin

This head loss is approximately taken as 0.02 meter (Sungur, 1988).

4.2.8 Head Loss at the Submerged Curtain Wall at the Intake

The entrance velocity is recommended to be in between 0.6 and 1 m/sec (Sungur, 1988). The net width at the entrance of intake;

$$B_1 = B - n'b \qquad (4.20)$$

where n' is the number of piers and b the is thickness of each pier. Entrance velocity, U_g, is given as,

$$U_g = 0.65(2g \Delta H_g)^{\frac{1}{2}} \qquad (4.21)$$

$$U_g = \frac{Q_{ir}}{B_1 y_6} \qquad (4.22)$$

Values of ΔH_g and y_6 are determined, using Equations 4.21 and 4.22.

4.2.9 Head Loss Above the Entrance Sill

Head loss above entrance sill is calculated from

$$Q_{ir} = 2.88\, B\left(\frac{2}{3}\, \Delta H^{3/2} + y_6'\, \Delta H^{1/2}\right) \qquad (4.23)$$

in which ΔH is head loss due to entrance sill, y_6' is water depth at the sill. Assuming the same velocity at just upstream of the gate and through the gate the water depth at the upstream of gate can be computed from;

$$y_6' = y_6 + \Delta H_g \qquad (4.24)$$

Spillway crest elevation is then computed by adding almost 10 cm freeboard to the water surface elevation at the upstream of the intake gate.

4.3 Determination of Spillway Crest Length

Length of spillway crest is generally taken as the length of valley at the crest elevation (Figure 4.8). Although this length may be suitable for narrow valleys, it will not be economic for wide valleys. In such a case a shorter length is tried and the corresponding raising effect of water in the upstream is computed. In fact an optimum crest length which minimizes the costs of structure and upstream levees should be searched. For very narrow crest length the possibility of high degree of water raising and hence the increased uplift should be considered.

Length of spillway crest should also be checked such that the flow velocity in stilling basin is not excessive, that is normally less than 15 m/ sec.

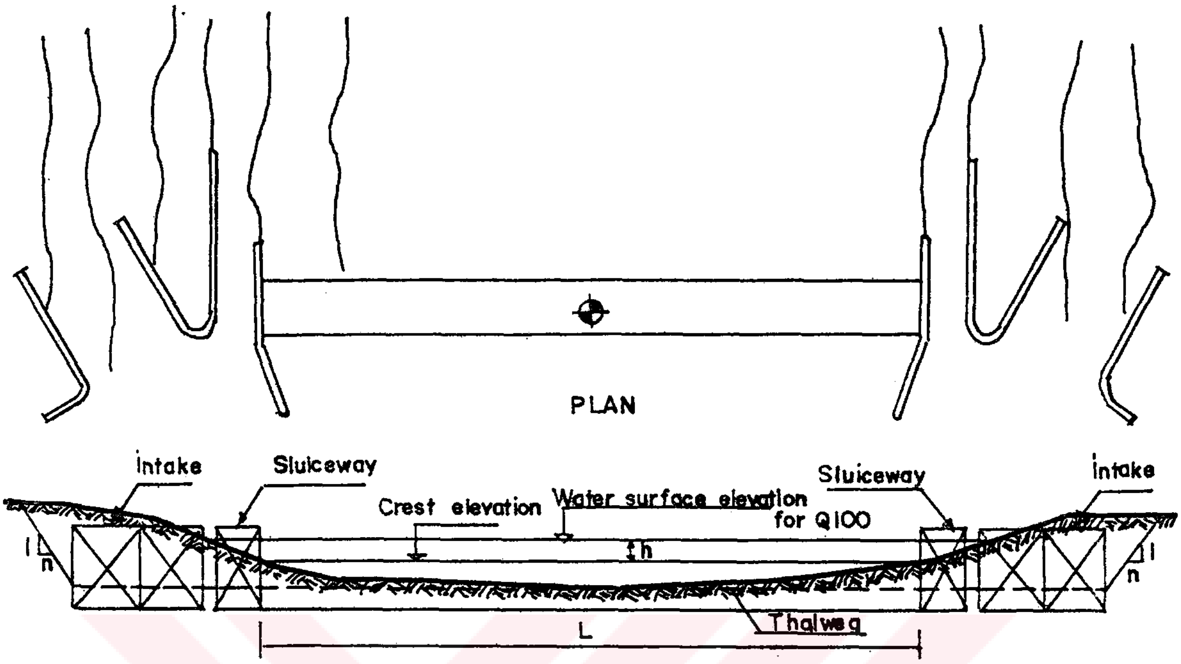


Figure 4.8 Schematic in Determination of Crest Length

4.4 Determination of Spillway and Sluiceway Discharges

Spillway and sluiceway discharges can be computed in the following order. Figure 3.2 illustrates some symbols used in the computations.

a) Any water surface elevation is assumed for design discharge (K_i)

b) Water depth, h, is computed as $h = K_i - K_t$

c) Approach flow velocity U_a is computed

$$U_a = \frac{Q_i}{hL_T} \tag{4.25}$$

in which L_T is total width of the diversion weir (i.e. width of spillway + width of sluiceways + thickness of guiding walls)

d) Total head, H, over the spillway crest is computed

$$H = K_i - K_s + \frac{U_a^2}{2g} \tag{4.26}$$

e) Spillway discharge coefficient C is found from Figures A.3 through A.7

$$C = C_0 C_1 C_2 C_3 C_4 \tag{4.27}$$

in which C_0 is the coefficient corresponding to design discharge, C_1 is the coefficient due to inclination of the spillway face, C_2 is the coefficient corresponding to discharges other than design discharge. It is a function of H_e/H, H_e is total operating head for any discharge, C_3 is coefficient due to apron effect and, C_4 is coefficient due to submergence effect.

f) Spillway discharge is computed from:

$$Q_s = C L_c H^{3/2} \tag{4.28}$$

in which Qs: spillway discharge

C : spillway discharge coefficient

L_c: effective crest length,

H : total head over the spillway crest

Effective crest length can be computed from

$$L_c = L'' - 2(n'K_p + K_a)H \qquad (4.29)$$

where L'' is net crest length which is equal to the total crest length minus the total thickness of piers on the crest, n' is number of piers, K_a and K_p are abutment and pier contraction coefficients, respectively. Values of K_a and K_p can be obtained from Altınbilek and Yanmaz (1992)

g) Sluiceway discharge Q_{sl} is computed from (Sungur, 1988).

$$Q_{sl} = C'dL_e(2gh)^{\frac{1}{2}} \qquad (4.30)$$

in which d and L_e are height and width of the sluiceway opening, respectively. C' is found from Figure A.8

h) If summation of spillway and sluiceway discharges equal to design discharge, assumption for the upstream water depth is correct. Otherwise, a new value for K_i is assumed and all those steps are performed until the total discharge value is obtained.

Above procedure is repeated for Q_5, Q_{10}, Q_{25}, and Q_{50} discharges also.

4.5 Design of Stilling Basin

Following steps should be performed to design a hydraulic jump type the stilling basin:

a) The whole stilling basin is assumed to consist of two parts, along the sluiceway and along the spillway.

b) Water surface elevation at the riprap section is read from downstream rating curve for design discharge.

c) Water depth, y_3, and mean flow velocity leaving the spillway, U_{3sp}, and sluiceway, U_{3sl}, are computed at the riprap section,

$$y_3 = K_3 - K_r \qquad (4.31)$$

$$U_{3sp} = \frac{Q_s}{L_{sp} y_3}, \quad U_{3sl} = \frac{Q_{sl}}{L_e y_3} \qquad (4.32)$$

d) Respective velocity heads are computed as

$$h_{asp}' = \frac{U_{3sp}^2}{2g}, \quad h_{asl}' = \frac{U_{3sl}^2}{2g} \qquad (4.33)$$

Difference between upstream and downstream water levels, F, can be computed as

$$F = K_i + h_a - (K_3 + h_a') \qquad (4.34)$$

e) Critical water depths at the respective parts of stilling basin are computed from,

$$y_{csp} = \left(\frac{q_{sp}^2}{g}\right)^{1/3}, \quad y_{csl} = \left(\frac{q_{sl}^2}{g}\right)^{1/3} \qquad (4.35)$$

in which $q_{sp} = Q_{sp}/L_c$ and $q_{sl} = Q_{sl}/L_e$

f) The difference in energy levels at the upstream and riprap section is evaluated. This value is assumed to be the head loss due to hydraulic jump. The initial and conjugate depth of hydraulic jump can be computed from the specific force and enrgy loss equation through the jump.

g) Mean flow velocities before the jump at the downstream of spillway and sluiceway are computed as;

$$U_{1sp} = \frac{q_{sp}}{y_{1sp}}, \quad U_{1sl} = \frac{q_{sp}}{y_{1sl}} \qquad (4.36)$$

h) Finally, Froude number is computed as;

$$Fr_{1sp} = \frac{U_{1sp}}{(gy_{1sp})^{\frac{1}{2}}}, \quad Fr_{1sl} = \frac{U_{1sl}}{(gy_{1sl})^{\frac{1}{2}}} \qquad (4.37)$$

At the end of computations;

If $y_2 < y_3$, deflector bucket is suitable whereas for $y_2 > y_3$, base of stilling basin is lowered by an amount to confine the jump in the basin.

The radius and the minimum elevation of inner face of slotted bucket should be computed from Equation 4.38. Figure 4.9 shows the symbols used in computations.

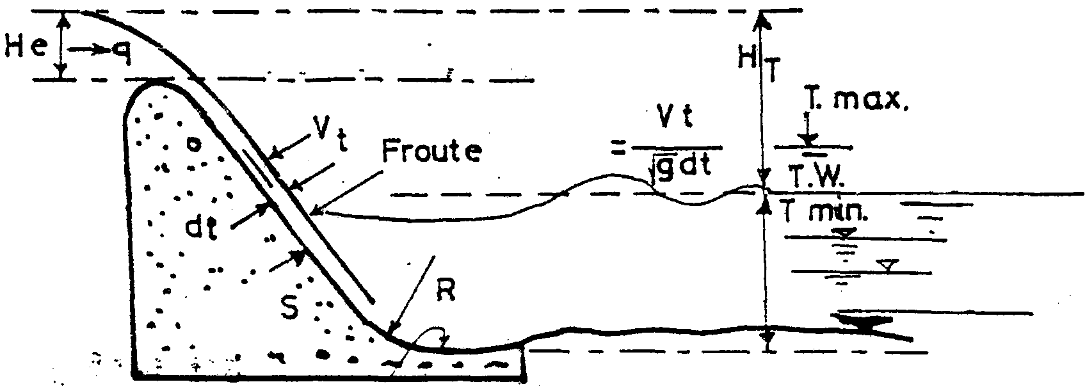


Figure 4.9 Symbols Used in Slotted Bucket Design

$$R' = R_{min}(y_1 + h_a') \qquad (4.38)$$

in which R' is radius of the slotted bucket, R_{min} is a minimum radius as a function of Froude number before hydraulic jump. Figure A.9 shows the relations between R_{min}, maximum and minimum tailwater depth at riprap section and Froude number. In this figure, h_a' is velocity head at tail water.

In the second step maximum and minimum tail water depths are found from Figure A.9 Then average depth is calculated as;

$$\text{Average depth} = (T_{max} + T_{min})/2 \qquad (4.39)$$

Minimum elevation of bucket inner face is calculated as:

$$\text{Minimum elevation} = y_3 - \text{Average depth} \quad (4.40)$$

This procedure is repeated for all design discharges and the minimum is taken as design value.

4.6 Design of a Side Wall

Side walls forming the boundaries of structure are designed as concrete retaining walls.

Figure 4.10 illustrates a schematic diagram of a typical side wall and forces acting on it.

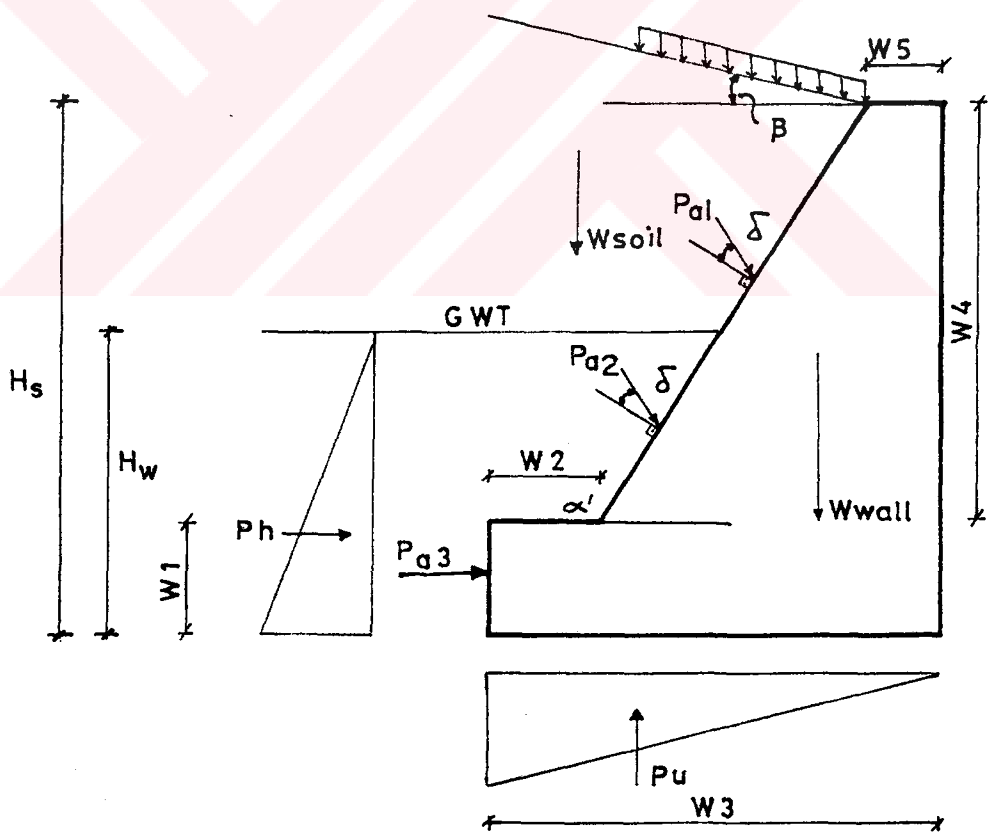


Figure 4.10 Schematic Diagram of the Side Wall

As shown in Figure 4.10 the dimensions of side wall are characterized by 6 variables: namely; W1, W2, W3, W4, W5 and ,α'.

The forces acting on the wall are as follows:

i) Weight of the wall itself and weight of soil prism on it
ii) Active earth force
iii) Hydrostatic force
iv) Uplift force

In this study , active earth force is found by using Coulomb's, theory (Bowels, 1988).

$$P_a = \frac{1}{2} \gamma_s H_s^2 K_a' \qquad (4.41)$$

in which P_a is active earth force, γ_s is specific weight of soil, H_s is height of backfill, and K_a' is active earth pressure coefficient. Bowels (1988), proposed the value of K_a' as follows;

$$K_a' = \frac{\sin^2(\alpha'-\phi')}{\sin^2\alpha'\sin(\alpha'+\delta)\left[1+\left[\frac{\sin(\phi'+\delta)\sin(\phi'-\beta')}{\sin(\alpha'-\delta)\sin(\alpha'+\beta')}\right]^{\frac{1}{2}}\right]^2} \qquad (4.42)$$

where α' is the angle of the wall, ϕ' is angle of repose, β' is the angle of backfill, δ is wall friction between soil and concrete which is estimated by Bowels (1988), as 2/3 ϕ'.

Hydrostatic force can be computed as;

$$F_h = \frac{1}{2} \gamma_w H_w^2 \qquad (4.43)$$

in which F_h is hydrostatic force per unit length, γ_w is specific weight of water and H_w is the height of water column.

A retaining wall should be checked against sliding, overturning and foundation stresses.

4.7 Structural Computations

Structural computations require seepage analysis, stability analysis against uplift force, overturning and sliding.

4.7.1 Seepage Analysis

The methods available for seepage determination through the foundation of a diversion weir are as follows:

i) Finite Difference Method
ii) Finite Element Method
iii) Electrical Analog Models
iv) Flow Net Analysis
v) Lane's Creep Analysis

In this study, only Lane's Creep Analysis is explained. It is simple in use. In the seepage analysis of diversion weirs Lane's approach is used in Turkey. After investigating more than 300 diversion weirs in U.S.A. Lane proposed a method which is based on the determination of a minimum creep length adjacent to the structure long enough to prevent piping problem (Altınbilek and Yanmaz, 1992). The creep length is related to effective hydraulic head, H', and relative permeability of soil, C_L. Table 4.2 illustrates the values of C_L for different types of foundation.

Table 4.2 Relative Permeabilities Used in Creep Analysis (Altınbilek and Yanmaz, 1991)

Foundation Material	C_L values
Very fine clay & silt	8-8.5
Fine to medium sand	5-6.5
Medium sand	4-5
Sand & fine gravel	3.5-5.5
Rock (fractured)	3.0
Rock (stratified)	2.5
Plastic clay	4.0
Clay, gravel & sand	2.0
Hard clay	2.5
Marn & very hard clay	2.0

Field measurements of Lane indicated that the permeability of alluvial bed in horizontal direction is about three times that of in vertical direction. Therefore, in computations the vertical distances adjacent to the structure are considered as they are, while horizontal distances are taken as one third of their values. The inclined distances are considered as vertical if the inclination is equal or greater than 45°, horizontal otherwise. To prevent piping problem, which is the erosion of finer particles in the soil, following inequality should be satisfied.

$$L_{cr} \geq C_L H' \tag{4.44}$$

in which L_{cr} is the total creep length of the structure, H' is the elevation difference between upstream and downstream water levels. In the analysis, both full upstream and empty downstream and overflowing cases should be considered separately for spillway. On the other hand, for sluiceway and intake maximum water surface elevation at upstream and closed gate should be taken into consideration. If $L_{cr} = C_L H'$, uplift at any point x of the structure adjacent to the foundation, can be determined from;

$$U_x = H_o - (H_x + \frac{L_x}{C_L}) \tag{4.45}$$

in which U_x is the uplift pressure head, H_o is the upstream water depth, H_x is the elevation at point x relative to datum which is generally the river thalweg at the upstream and L_x is the total creep length up to point x.

In order to reduce the uplift pressure following measures can be taken (Erkek, Ağıralioğlu, 1986)

1) Permeability of soil is reduced by mixing different soils
2) Seepage path is increased by cut-off walls, sheet piles and upstream blankets
3) Filters and drains are provided.

Seepage analysis should be performed under the spillway, sluiceway and intake structure separately.

4.7.2 Stability Analysis

4.7.2.1 Stability Analysis Against Uplift

Apron is assumed to be critical against uplift. Sluiceway and intake structure should also be checked against uplift. For stability analysis against uplift, weight of the critical section and uplift forces beneath this section should be taken into consideration. Figure 4.11 illustrates a schematic drawing of the forces acting on the intake structure for the stability analysis against uplift. Factor of safety against uplift, FS_u, is computed from;

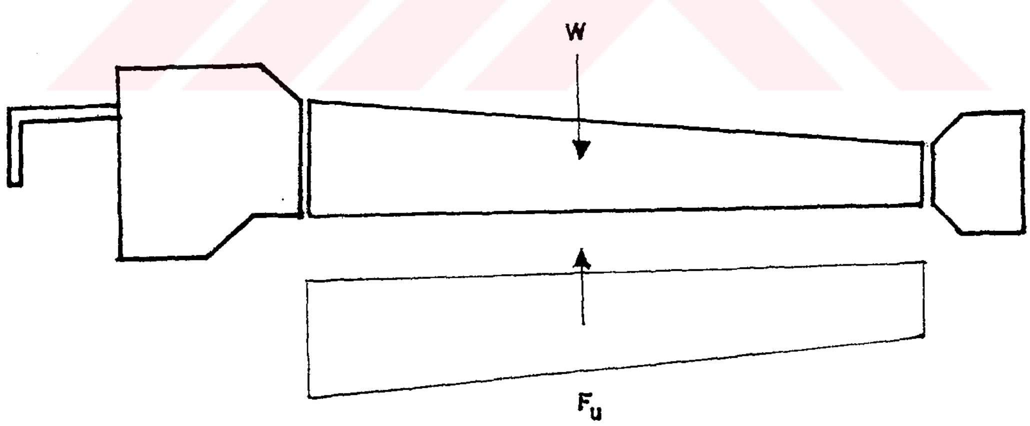


Figure 4.11 Forces in Uplift Analysis of an intake

$$FS_u = \frac{\Sigma W}{\Sigma F_u} \geq 1.2 \qquad (4.46)$$

where ΣW is the total weight of apron, and ΣF_u is the total uplift force acting between the apron.

4.7.2.2 Stability Analysis Against Overturning

The diversion weir must be safe against overturning for all loading conditions. Overturning analysis is done only for body of the spillway. Intake and sluiceway are not checked against overturning since the moment arms of the disturbing forces are very small. The most critical case, which is the full upstream and no tail water is considered in the overturning analysis. Figure 4.12 illustrates the forces acting on the spillway. Forces, should be taken into consideration in this analysis and their values are given below.

a) Weight of the spillway (W). This force acts at the centroid of the body.

b) Hydrostatic forces produced by water in the reservoir and the tailwater.

$$F_h = \frac{1}{2} \gamma_w h_w^2 \qquad (4.47)$$

in which F_h is the hydrostatic force per unit width, γ_w is the specific weight of water, h_w is the water depth behind the spillway.

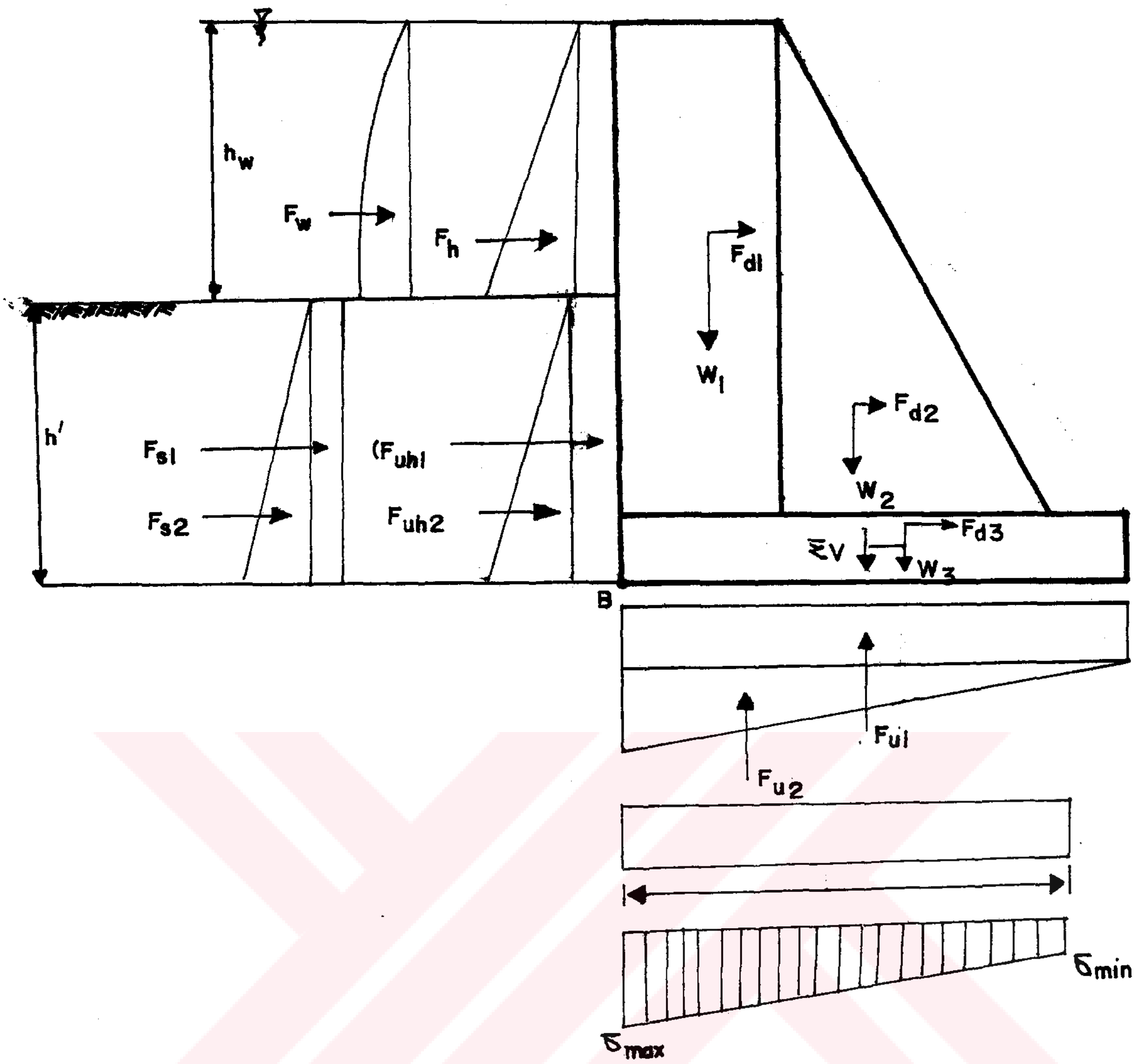


Figure 4.12 Forces Acting on the Spillway Body

c) Uplift force acting under the base of the diversion weir. The uplift pressure is assumed to vary linearly from that created by the full reservoir at the upstream face to the pressure created by tailwater depth at the downstream toe.

d) Forces due to sediment accumulation in the reservoir and in contact with the diversion weir. It may be determined from lateral earth pressure expression..

$$F_s = \frac{1}{2} \gamma_{sub} h_s^2 K_a' \qquad (4.48)$$

in which F_s is force due to sediment accumulation per unit width, γ_{sub} is the submerged specific weight of soil, h_s is the depth of sediment accumulation relative to reservoir bottom elevation, K_a' is the active earth pressure coefficient given by Coulomb's theory (Bowels, 1988)

$$K_a' = \frac{1-\sin\phi'}{1+\sin\phi'} \qquad (4.49)$$

where ϕ' is the angle of repose. This force acts at $h_s/3$ above the reservoir bottom. However, this force generally ignored since sluiceways provide continues flushing.

e) Ice loads F_i, should be considered in cold climates only. Melting of ice sheet may exert dynamic temperature stresses on the body. Ice force per unit width of the diversion weir can be determined from Table 4.3. For the diversion weirs whose height is less than 5 meters, ice load can be ignored.

Table 4.3 Ice Force (Altınbilek and Yanmaz, 1991)

Thickness of Ice Sheet (cm)	Change of Temperature (C/hr)		
	2.5	5	7
25	30	60	95
50	58	90	130
75	75	115	160
100	100	140	180

f) Earthquake force on the diversion weir, F_d, which must be assumed to act both horizontally and vertically through the center of gravity of the structure. Their direction should be assumed so as to produce critical condition for overall safety. It can be determined from the formula given by,

$$F_d = kW \tag{4.50}$$

where k is the earthquake coefficient which is the ratio of earthquake acceleration to gravitational acceleration. In this study, only horizontal direction is considered.

g) Dynamic force in the reservoir induced by earthquake. It can be computed from following formula (Jansen, 1988),

$$F_w = 0.726 C_e k \gamma_w h_w^2 \tag{4.51}$$

where F_w is the force per unit width of dam and C_e is a constant given by,

$$C_e = 0.7\left(1 - \frac{\theta'}{90}\right) \tag{4.52}$$

in which θ' is the angle between the upstream face of the dam and a vertical line (in degrees). The force F_w acts at a distance $0.412h_w$ above the bottom of reservoir.

h) Active earth force. It can be calculated as follows

$$P_a = \frac{1}{2} \gamma_{sub} h'^2 K_a \qquad (4.53)$$

in which h' is the height of soil shown in Figure 4.12.

The factor of safety against overturning is found from;

$$FS_o = \frac{\Sigma M_r}{\Sigma M_o} \qquad (4.54)$$

where ΣMr is total resisting moments and ΣMo is total overturning moments about the toe. Stability analysis against overturning should be performed for three cases:

i) Analysis with earthquake load

ii) Analysis without earthquake load

iii) Analysis with empty reservoir

Factor of safety against overturning without earthquake load must be greater than or equal to 1.5. On the other hand, factor of safety against overturning must be greater than or equal to 1.2 if earthquake is taken into consideration (Sungur, 1988). When the factor of safety against overturning is analyzed for empty case, point B is taken into consideration. For moments direction of earthquake forces also change to act towards the upstream.

4.7.2.3 Stability Analysis Against Sliding

Both body and apron are considered in sliding analysis. Factor of safety against sliding, FS_s should be computed for both cases.

$$FS_s = \frac{fR_v}{R_h} \geq 1.50 \text{ (without earthquake)} \qquad (4.55)$$

$$FS_s = \frac{fR_v}{R_h} \geq 1.20 \text{ (with earthquake)} \qquad (4.56)$$

where R_v is vectorial summation of total vertical forces, R_h is vectorial summation of total horizontal forces and f is friction coefficient between soil and concrete. Table 4.4 shows values of f for different materials.

Table 4.4 Values of Friction Coefficient

(Altınbilek and Yanmaz, 1991)

Material	Sound rock,clean and irregular surface	Rock, some jointing	Gravel and coarse san	Sand	Shale
f	0.8	0.7	0.4	0.3	0.3

4.7.2.4. Stability Analysis Against Combined Shear and Sliding

The diversion weir must also be checked for shear and sliding together. Factor of safety against combined shear and sliding is defined as

$$FS_{ss} = \frac{fR_v + 0.5A'\tau}{R_h} \qquad (4.57)$$

where A' is the area of shear plane and τ is the allowable shear stress in concrete. FS_{ss} may be taken as 5.0 for usual loading with no earthquake and 3.0 for the case with earthquake.

4.7.2.5 Stability Analysis Against Foundation Stresses

The diversion weir must also be checked for foundation stresses. Maximum stress acting under the base must be less than the allowable compressive stress in soil, and minimum stress must be greater than zero. Foundation stresses are checked for the body of the spillway and side walls. Maximum and minimum stresses are calculated using

$$\sigma_{max} = \frac{R_v}{A'} + \frac{Mc}{I} \tag{4.58}$$

$$\sigma_{min} = \frac{R_v}{A'} - \frac{Mc}{I} \tag{4.59}$$

in which A' is the area of shear plane per unit width, M is the net moment about center line of the base, $M = R_v e$, e is the eccentricity,

$$e = \frac{B'''}{2} - x' \tag{4.60}$$

and x' is the point of application of R_v from the toe:

$$x' = \frac{\Sigma M_r - \Sigma M_o}{R_v} \qquad (4.61)$$

I is the moment of inertia, $I = \frac{B'''^3}{12}$

$c = B'''/2$.

Figure 4.12 shows the foundation stresses under the base. Table 4.5 gives the allowable compressive stresses for foundation materials.

Table 4.5 Allowable Compressive Stress For Foundation Materials (Altınbilek and Yanmaz, 1991)

Material	Allowable stress, a(kN/m)
Granite	4000-6000
Limestone	2500-5000
Sandstone	2500-4000
Gravel	250-500
Sand	150-400
Firm clay	250-300
Soft clay	50-100

CHAPTER V

COMPUTER PROGRAM

A computer program is developed for the preliminary design of a diversion weir with a sidewise intake. In the following, information about the capabilities of this program is given.

5.1 Scope of the Program

This computer program computes the optimum dimensions and total cost of a conventional diversion weir with sidewise intake. The word optimum does not always comprise the minimum cost but it also corresponds the case in which all the stability criteria such as sliding, overturning, foundation stresses are satisfied provided that at least one of them have the minimum allowable value. At the beginning of this program it is assumed that the best construction site is selected and this site is ready for construction without any excavation, filling and foundation treatment works etc.

5.2 Programming Language

The program is written in Quickbasic programming langugage. It is purposely chosen as it has many advatages over Fortran language. It is easier to prepare a user friendly program in Qbasic than Fortran. Editor of Qbasic is also very effective in the development stage of the program. This gains importance especially when the program is very long.For instance, it is possible to see errors immediately without execution of the program on the same line such as syntax errors, duplication of labels or definitions etc. Moreover, if a Qbasic statement is written wrong then it does not accept it and not arrange the line in Qbasic form. In addition to these, it is possible to draw any figure with Qbasic programming when it is defined. As a conclusion it can be said that Qbasic can be used effectively in such long programs .

5.3 Flowchart of the Program

Executional order of the program is given in the form of a flowchart in Figure 5.1.

5.4 Description of the Program

The program is composed of two main parts, namely design computations of the structure and the stability analysis. If the information about the diversion weir (such as dimensions of intake, spillway and sluiceway discharges, type of stilling basin etc.) is known and only stability analysis of the structure is required then it is enough to select the corresponding alternative in the menu.

The flowchart of the program shows that in addition to the main division there are subdivisions in the design and stability analysis.

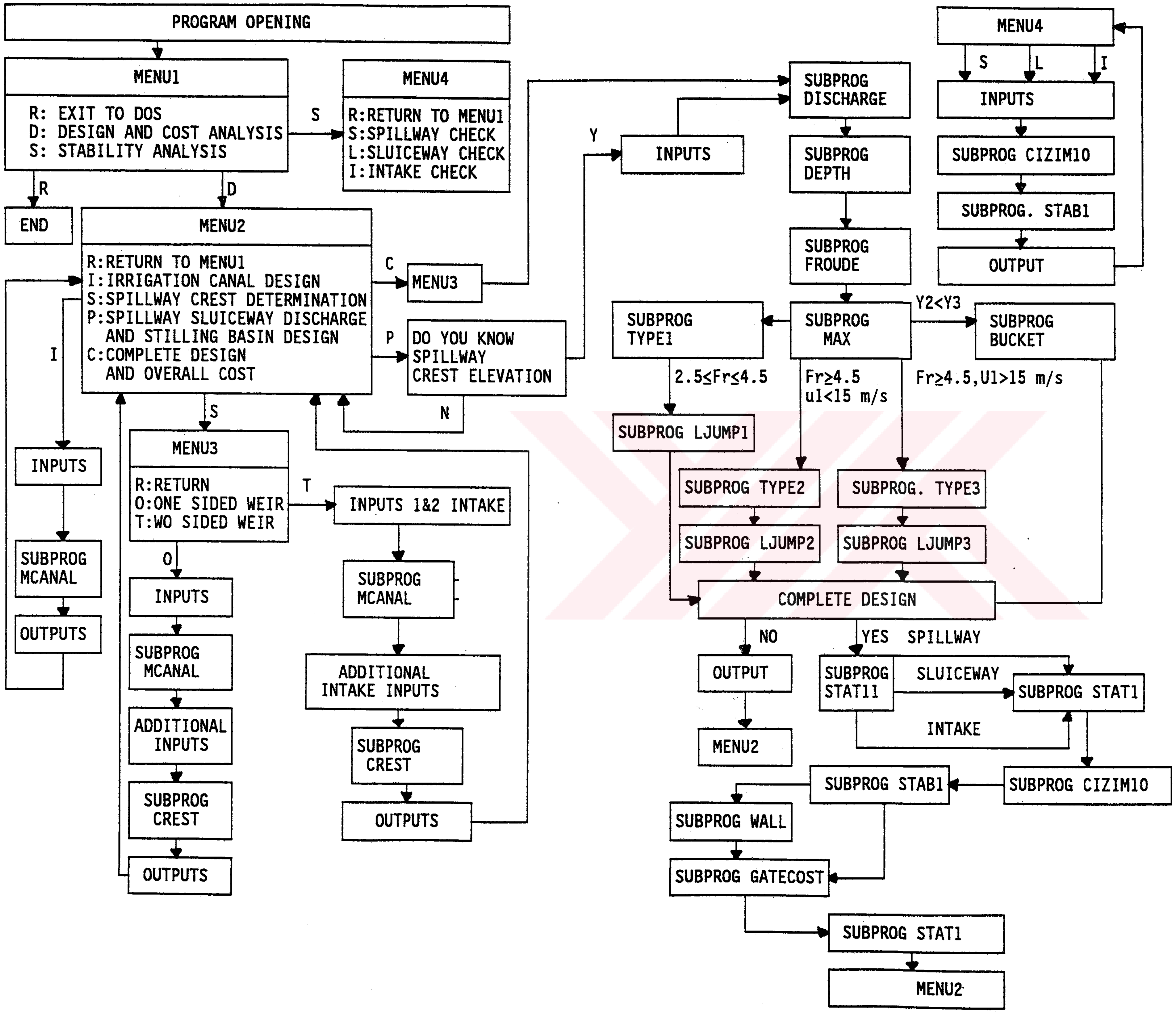


Figure 5.1 Program Flow Chart

The program follows certain steps in all subdivisions during the execution. Firstly the required choice is selected. Secondly program reads the inputs and call corresponding subprograms depending on the choice. Sometimes it asks user for more information in between subprograms if it is necessary. After the execution of the subprograms it sends outputs to a file which is specified previously, and it returns the previous menu and starts to wait for a new choice .

There are seventeen subprograms used in the main program. The functions of these subprograms are as follows:

a) Subprogram MCANAL: It designs the main irrigation channel by cost optimization.

b) Subprogram CREST: After the design of main irrigation channel subprogram CREST designs the whole intake structure starting from downstream towards the upstream. Namely, it computes length of transition, width and length of settling basin, all water depths and head losses through the intake and finally the spillway crest elevation .

c) Subprogram DISCHARGE: It computes spillway and sluiceway discharges separately. As a result of the computations, it also finds water surface elevations on the spillway for any operation.

d) Subprogram DEPTH: This program computes water depths before and after the hydraulic jump.

e) Subprogram FROUDE: It computes the Froude numbers in the stilling basin just before the hydraulic jump for each spillway and sluiceway discharge.

f) Subprogram MAX: It finds the maximum Froude number and corresponding conjugate and tail water depths among all Froude numbers of spillway and sluiceway discharges .

g) Subprogram TYPE1: If the Froude number is in between 2.5 and 4.5 then this subprogram computes related dimensions of U.S.B.R. Type I stilling basin.

h) Subprogram LJUMP1: It determines the length of U.S.B.R. Type I stilling basin.

i) Subprogram TYPE2: When the Froude number is greater than 4.5 and flow velocity at the toe before the hydraulic jump is less than 15 m/sec, TYPE2 subprogram computes the dimensions of U.S.B.R. Type II stilling basin.

j) Subprogram LJUMP2: It finds the length of U.S.B.R. Type II stilling basin.

k) Subprogram TYPE3: When the Froude number and flow velocity just before the hydraulic jump are greater than 4.5 and 15 m/sec, respectively, this program finds the dimensions of U.S.B.R. Type III stilling basin.

l) Subprogram LJUMP3: It computes the length of U.S.B.R. Type III stilling basin.

m) Subprogram BUCKET: If bucket type energy dissipator is suitable then this subprogram computes the dimensions of solid or slotted (dentated) bucket according to choice of the user which depends on type of foundation.

n) Subprogram ÇİZİM: After the joints and block definitions are performed this subprogram draws the model of weir and critical sections for stability anaysis.

o) Subprogram STAB: This program checks the structure against sliding, overturning, combined shear and sliding, uplift and base pressures. The structure is checked against stability for the following three cases;

i) With earthquake consideration

ii) Without earthquake consideration

iii) When the reservoir is empty

Prior to these checks, program firstly performes the following computations

1) Cross-sectional area of the structure

2) Center of gravity of the structural element

3) Seepage analysis by Lane's method and uplift pressure

After the stability analysis is completed, subprogram STAB computes the cost of spillway, sluiceway, intake and blanket if the stability analysis on the second menu is chosen.

p) Subprogram WALL: It designs a retaining wall by checking it against sliding, overturning and base pressure.

r) Subprogram GATECOST: It computes the cost of gates for various types.

The list of the program is given in Appendix B.

5.5 Notes On Inputs

Inputs of this program can be categorized into four groups;

1) Inputs that are assumed to be determined; this type of inputs are determined or directly given to the user previously. These are;

a) Irrigation discharge: it can be computed by considering the evapotranspiration rate of the project area (Hansen et al., 1988).

b) Design Discharges: Design discharges can be determined from the frequency analysis of a nearby stream gaging station (Q_{100} , Q_{50} , Q_{25}, Q_{10}, Q_5).

c) Downstream rating curve: it can actually be obtained by studying the water surface profiles of the river under various discharges. HEC-2 program can be utilized for this purpose (Hoggan, 1988).

2) Inputs determined through topographic analysis:

a) Bottom slope of the main irrigation channel

b) Bottom elevation at the entrance of the main irrigation channel which is dictated by the levels of irigation fields.

c) Thalweg elevation in front of the spillway axis

d) Length of the spillway crest corresponding to spillway crest elevation

3) Inputs based on the material characteritics:

a) Manning's roughness coefficient for concrete and river, n

b) Specific weights of conrete, water, saturated soil, dry soil etc

c) Angle of repose, ϕ

d) Friction coefficient between soil and concrete,f

e) Relative permeability of the soil, C_L

f) Allowable stress of soil, σ_{all}

4) Inputs determined by the user: This type of inputs depends on the user's experience and judgement. These are as follows;

a) Number and thickness of the piers at the entrance of main canal and intake. In fact, number of piers depend on width of the channel and the number of gates that will be used. Information about the type of gates and their dimensions are given in Tables 5.1, 5.2, 5.3 and 5.4 for standart C, D, E and rapier gates respectively. One can choose one of them in the design or the designer can select any gate with dimensions out of the range of the values given in these tables. Thickness of the pier depends on the magnitude of forces acting on it. For a prelimenary design, the

Table 5.1 Characteristics of Standart Straight C Type Gate (DSI Gates, 1982)

Number	Width (m)	Height (m)	Minimum Weight (kg)
1	0.60	2.17	357.00
2	0.75	1.92	448.00
3	1.00	1.67	378.00
4	1.15	1.62	417.50
5	1.15	1.77	453.20
6	1.30	1.87	505.00
7	1.75	1.37	472.60

Table 5.2 Characteristics of Standart Straight D Type Gate (DSI Gates, 1982)

Number	Width (m)	Height (m)	Minimum Weight (kg)
1	1.4	2.02	680.00
2	1.7	1.92	730.00
3	1.8	1.52	672.00
4	1.8	1.72	716.00
5	1.9	1.37	660.00
6	2.2	1.62	875.00
7	2.5	1.62	950.00

Table 5.3 Characteristics of Standart Straight E Type Gate (DSI Gates, 1982)

Number	Width (m)	Height (m)	Minimum Weight (kg)
1	1.76	2.20	1 190.00
2	2.00	2.50	1 310.00
3	2.20	1.85	1 235.00
4	2.50	1.55	1 265.00
5	2.80	1.75	1 485.00
7	4.00	1.65	1 975.00

Table 5.4 Characteristics of Rapier Type Gate

(DSI Gates, 1982)

Type	Width (m)	Height (m)	Minimum Weight (kg)
1	0.47	0.40	58.00
2	0.57	0.55	72.50
3	0.67	0.65	87.50
4	0.77	0.70	97.00
5	0.97	0.95	131.00

thickness of a pier can be taken as 0.5 m if there is no service bridge on it. At least 0.8 m can be selected otherwise.

b) Sill height at the end of settling basin can be selected in between 0.6 and 1 m (Sungur, 1988).

c) Bottom slope of settling basin can be selected as 0.01 (Sungur, 1988).

d) Desired removal ratio of sediment should be entered in percentage.

e) Freeboard for spillway can be selected as 10 cm (Sungur, 1988).

f) Number of sluiceways depend on deposited sediment in front of the spillway and the number of intakes. If there are intakes on both sides, sluiceway should be constructed on each side of the spillway.

g) Width and height of the sluiceway can be taken between 2 to 3 meters depending on the amount of deposited sediment.

h) Number and thickness of the piers on spillway crest. If there is a service bridge, piers are required to support it. Explanations in item (a) are valid here also.

i) Contraction coefficient of piers and abutments. These depend on the shape of the pier and the abutments (Altınbilek and Yanmaz, 1992).

j) Inputs for stability analysis. As it is seen from the flowchart of the program, stability analysis of the structure is done for three sections seperately. These are spillway, sluiceway and intake structures. The program can analyze any type of structure in any form. However, to achieve this, the user should prepare a sketch before execution as explained in the following paragraphs.

Firstly, the shape of structure is drawn and x and y coordinates are placed such that y axis coincides with the spillway face and x axis coincides with the river thalweg. After that numbers are given to each joint that specify the form of the structure. Upstream blankets and cut-offs should also be taken into consideration at this stage. Figure 5.2 illustrates a schematic diagram of a spillway model.

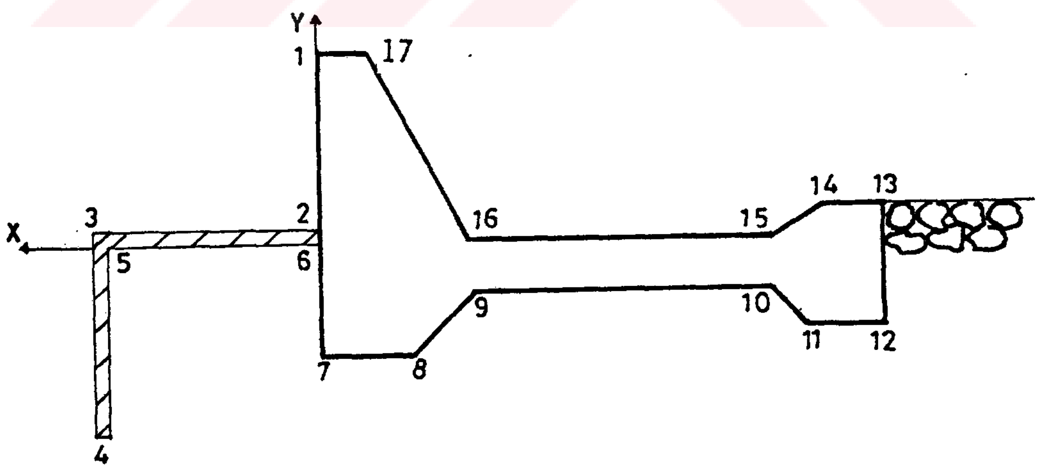


Figure 5.2 Schematic Diagram of a Spillway Model

It is possible to start giving joint numbers at any joint, in counterclockwise direction

In the second stage, the structure should be divided into triangular blocks and they are numbered. Two models are seen in Figure 5.3 which illustrate two different divisions for the same structure.

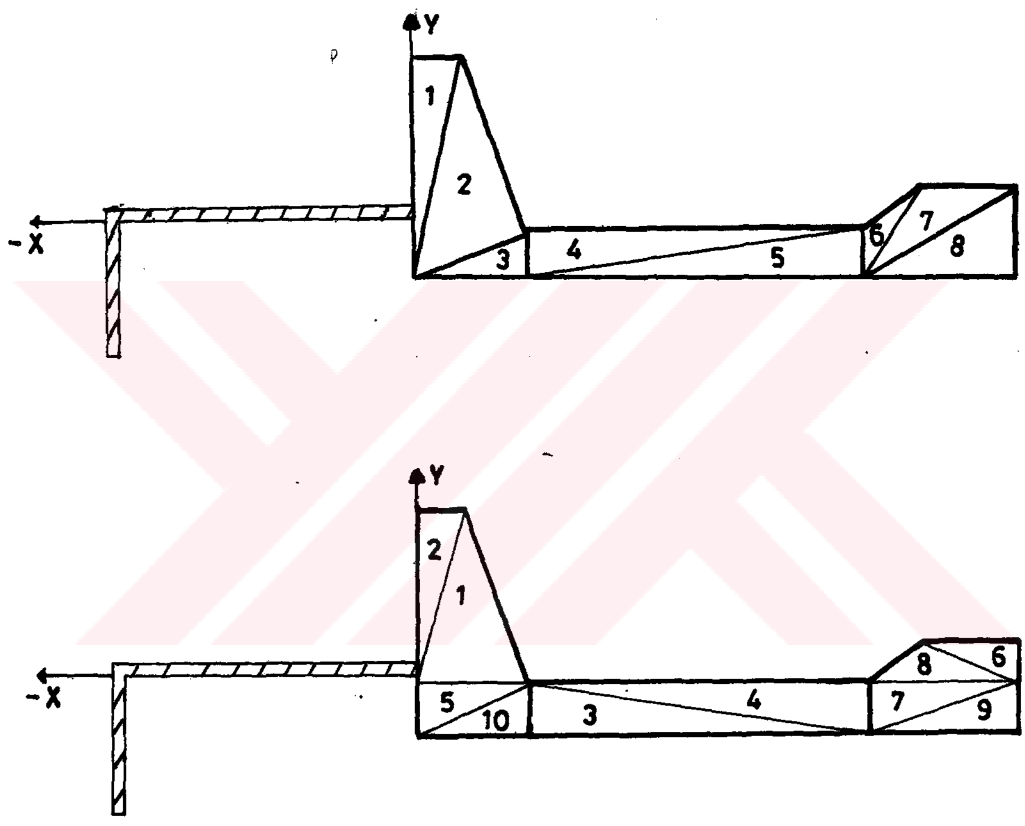


Figure 5.3 Division of a Structure into Triangular Blocks

However, the user should be carefull in determining triangular blocks, because critical sections (against uplift,overturning etc.) should be defined by one or more triangles. Figure 5.4 illustrates two situations with allowable and not allowable conditions. For instance in Figure 5.4 (a) critical section against uplift can be specified by the triangles 4 and 5, but in Figure 5.4 (b) this is not possible.

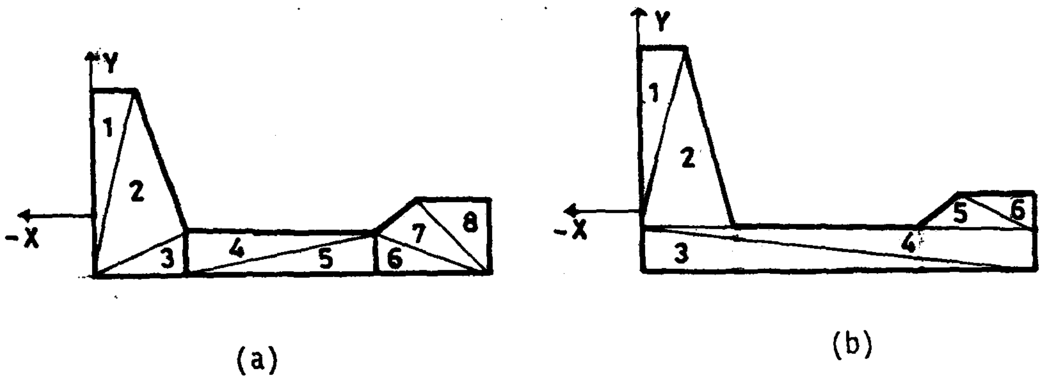


Figure 5.4 Division of Triangular Blocks

CHAPTER VI

CASE STUDY

For the case study, Başağaç diversion weir with two sided intakes which is constructed to supply irrigation water requirements of Sandıklı Örenler project is studied. The dimensions obtained from the computer program and from the existing project are compared. Tables 6.1, 6.2 and 6.3 and 6.4 tabulate the inputs. The cost analysis is performed with 1992 unit prices. Figures 6.1, 6.2 and 6.3 illustrate the existing spillway, sluiceway and intake structure models, respsectively. Figures 6.4, 6.5 and 6.6 illustrate the proposed spillway, sluiceway and intake structure models, respsectively.

The dimensions, stability checks and the overall cost of Başağaç diversion weir is compared with those of the existing project in Table 6.5. As it can be seen from the results the proposed computer programming gives smaller overall cost.

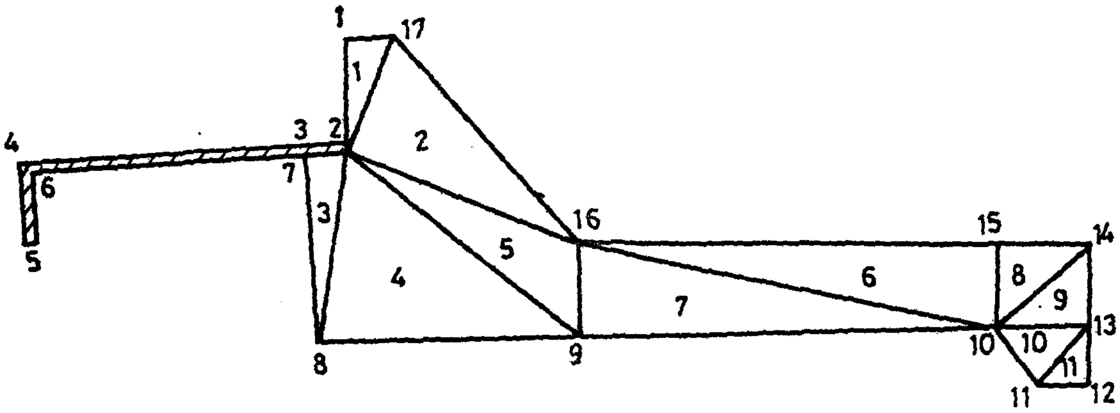


Figure 6.1 Model of Existing Spillway

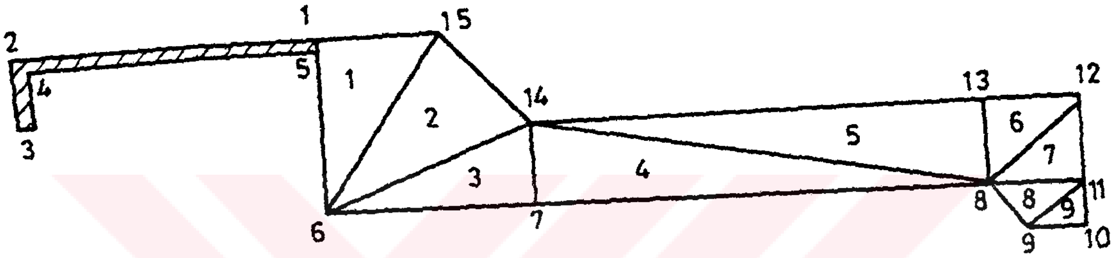


Figure 6.2 Model of Existing Sluiceway

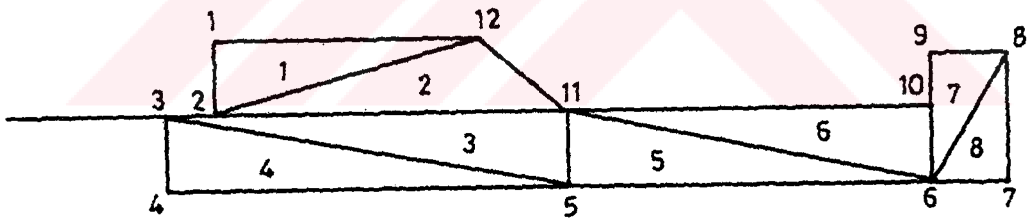


Figure 6.3 Model of Existing Intake

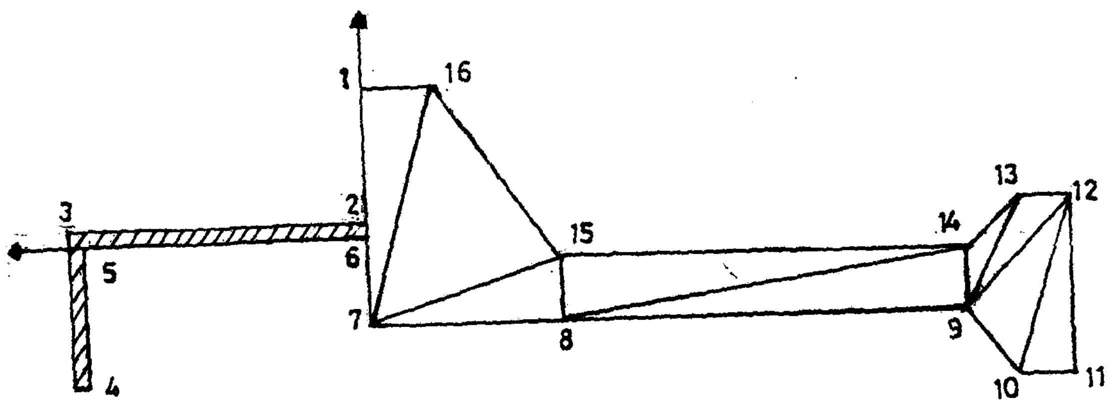


Figure 6.4 Model of Proposed Spillway

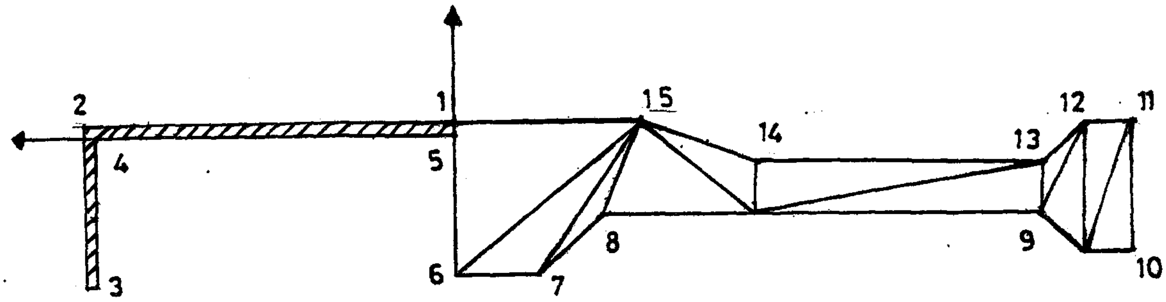


Figure 6.5 Model of Proposed Sluiceway

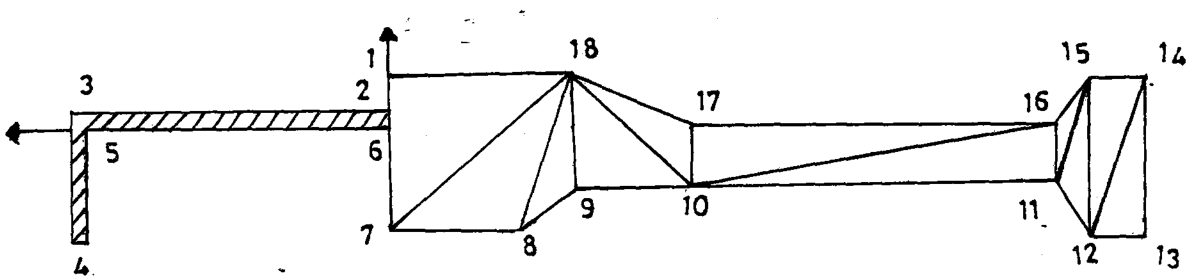


Figure 6.6 Model of Proposed Intake

Table 6.1 Required Inputs to Design Intake Structures

Inputs	First Intake	Second Intake
Irrigation discharge (m3/s)	1.385	0.85
Manning roughness	0.016	0.016
Bottom slope of main canal	0.00035	0.0003
Bottom elevation of main canal	1027.65	1027.75
Unit cost of excavation(TL/m)	15000	15000
Unit cost of lining (TL/m)	3800	3800
Unit cost of land (TL/m)	9000	9000
No.of piers at entrance of main canal	0	0
Thickness of piers (m)	0	0
End sill height	1	1
Bottom slope of settling basin	0.0003	0.00097
Desired removal ratio of sediment	-	-
No. of piers at intake entrance	0	0
Thickness of piers (m)	0	0
Thalweg elevation	1027.3	1027.3
Freeboard (m)	0.15	0.15
Desired entrance velocity (m/s)	0.6	0.6

Table 6.2 Required Inputs to Determine Spillway and Sluiceway Discharges and Stilling Basin Design

Inputs	Values
Length of spillway (m)	24.5
No. of Sluiceways	2
Width of sluiceway opening	2.5
Heigth of sluice of sluiceway	1
Thickness of the divider wall	0.6
100 years design discharge (m3/s)	227.48
50 years design discharge (m3/s)	218.6
25 years design discharge (m3/s)	172.2
10 years flood design discharge (m3/s)	114.7
5 years design discharge (m3/s)	73.4
Water surface elevation at riprap section for Q100	10.2815
Water surface elevation at riprap section for Q50	10.281
Water surface elevation at riprap section for Q25	10.2785
Water surface elevation at riprap section for Q10	10.275
Water surface elevation at riprap section for Q5	10.2725
Surface elevation of riprap section	1026.45
Unit weight of water (kN/m3)	9.81
Unit weight of concrete (kN/m3)	24
Unit weight of dry soil (kN/m3)	19.5
Unit weight of saturated soil (kN/m3)	21
Relatyive permeability	5
Number of pier on spillway crest	3
Thickness of piers on spillway crest (m)	0.3
Abutment contraction coefficient	0.2
Pier contraction coefficient	0.01
Allowable compressive stress of soil (kgf/cm2)	1.5
Ground water table depth (m)	1.5

Table 6.3 Coordinates of the Joints in Stability Analysis of Existing Structure

Joint Numbers		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Spillway	X	0	0	-17	-17	-17	-0.5	-0.5	6.2	29.7	30.7	31.2	31.2	30.7	6.2	1.4
	Y	1.7	0	0	-12	0	0	-2.3	-2.3	-2.3	-2.9	-2.9	-0.9	-0.9	-0.9	1.7
Sluiceway	X	0	-15	-15	-15	0	0	7.5	31	32	32.5	32.5	31	7.5	2.8	
	Y	0	0	-1.2	0	0	-2	-2	-2	-2.6	-2.6	-0.6	-0.6	-0.4	0	
First Intake	X	0	0	-0.2	-0.2	13	34.5	35.2	35.2	34.5	34.5	13	9.5			
	Y	0.56	0	0	-1.8	-2	-1.8	-1.8	0.53	0.53	-0.5	-0.5	0.54			
Second Intake	X	0	0	-0.2	-0.2	13	35.4	36.1	36.1	35.4	35.4	13	10.5			
	Y	0.51	0	0	-1.8	-2	-1.8	-1.8	0.44	0.44	-0.5	-0.5	0.5			

Table 6.4 Coordinates of the Joints in Stability Analysis of Proposed Structure

Joint Numbers		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Spillway	X	0	0	-10	-10	-10	0	0	3.5	3.5	14.5	15	15.5	14.5	14	3.5	1.4		
	Y	1.5	0	0	-3	0	0	-3	-3	-3	-3.5	-3.5	-0.9	-0.9	-2	-2	1.53		
Sluiceway	X	0	-15	-15	-15	0	0	2	4	6	16	17	17.6	17.6	17	16	6	4	
	Y	0	0	-3	0	0	-3	-3	-2.5	-2.5	-2.5	-3.3	-0.3	-0.3	-0	-1	-1.3	0	
Intake	X	0	0	-15	-15	-15	0	0	3	5	7	26	27	27.6	28	27	26	7	3
	Y	0.6	0	0	-0.4	0	0	-3.0	-3.0	-1.7	-1.7	-1.7	-2.2	-2.2	0.4	0.4	-0.3	-0.3	0.6

Table 6.5 Comparison of Dimensions and Cost of Proposed and Existing Projects for Başağaç Diversion Weir

STRUCTURAL COMPONENTS		PARAMETERS														
		b1 (m)	y1 (m)	Ltran (m)	B' (m)	B (m)	L' (m)	Gates								Crest Elevation (m)
								Main Channel Entrance				Intake Entrance				
								Type	Width (m)	Height (m)	Weight (kg)	Type	Width (m)	Height (m)	Weight (kg)	
First Intake	Existing	1.20	0.81	3.00	2.50	3.00	22.00	Rapier 5	1.00	0.90	131.00	Rapier 5	1.00	0.80	131.00	1.70
	Proposed	0.95		3.61	2.40	2.90	19.00	Rapier 5	1.00	0.90	131.00	Rapier 5	1.00	0.80	131.00	1.50
Second Intake	Existing	1.00	0.70	2.50	2.00	3.00	22.00	Rapier 4	0.70	0.75	97.00	Rapier 4	0.70	0.75	97.00	1.60
	Proposed	0.80		3.32	2.00	2.50	19.00	Rapier 4	0.70	0.75	97.00	Rapier 4	0.70	0.75	97.00	1.42
Spillway	Existing															1.70
	Proposed															1.50
				Chute Blocks				Baffle Blocks					Sluiceway Gate			
		Type	L (m)	Width (m)	Height (m)	Spacing (m)	Number	Width (m)	Height (m)	Spacing (m)	Number	Location (m)	Type	Width (m)	Height (m)	
Stilling Basin	Existing	Mat F.	23.50	-	-	-	-	-	-	-	-	-	E	2.50	1.00	
	Proposed	Type II	4.27	0.20	0.20	0.20	60.00	0.60	0.35	0.60	20.00	1.35	E	2.50	1.00	
		FSu	FS. Against Overturning			FS. Against Sliding			FS. Against Shear and Sliding			Base Pressure (kN/m)				
			With E.	Without E.	Empty	With E.	Without E.	Empty	With E.	Without E.	Empty	Minimum	Maximum			
Spillway	Existing	1.61	2.41	2.72	15.21	2.87	10.57	4.43	9.65	35.47	-	34.58	48.39			
	Proposed	1.37	1.76	2.21	6.27	1.81	3.70	3.68	6.43	13.15	-	9.76	110.50			
Sluiceway	Existing	1.36	-	-	-	2.60	7.06	4.42	5.84	15.85	-	-	-			
	Proposed	1.35	-	-	-	1.21	1.74	3.18	4.23	6.07	-	-	-			
First Intake	Existing	1.00	-	-	-	1.09	1.98	4.16	6.16	11.19	-	-	-			
	Proposed	1.42	-	-	-	1.15	1.89	3.66	4.85	7.98	-	-	-			
Second Intake	Existing	0.86	-	-	-	1.22	2.45	4.28	6.89	13.89	-	-	-			
	Proposed	1.42	-	-	-	1.15	1.89	3.66	4.85	7.98	-	-	-			

E = Earthquake

FS = Factor of Safety

FSu = Factor of Safety Against Uplift

Total Cost of Existing Structure = 337 500 000 TL.

Total Cost of Proposed Structure = 183 006 600 TL.

CHAPTER VII

DISCUSSIONS

In this thesis, the design criteria for diversion weirs with sidewise intakes are studied in detail. Specifications used in Turkey are reviewed and related literature is studied to reinforce the points which are not clear in design. In the development of the computer program the folllowings are considered:

1) Bottom width of main irrigation channel is found by cost optimization. By selecting optimum bottom width considerable economoy is provided. Especially for very long irrigation channel projects this fact becomes more important since, bottom width other than the optimum one which is even very close to it brings additional total cost. Therefore bottom width of the main channel should be found by cost optimization. But this value should also satisfy the hydraulic requirements at the same time that is water depth should not be greater than critical water depth to prevent supercritical flow in the channel.

2) Transition from rectangular to the trapezoidal cross-section is provided with a straight line transition. There are many other types of transition structure but the straight transition is the most widely used in practice, although it produces higher head

loss than the other types. The construction of straight transition is easier than the other types, which results in an economical solution.

3) Bottom width just at the entrance of transition should be taken such that it should satisfy hydraulic conditions and economy at the same time. If width is chosen small, then the flow area of rectangular canal becomes less than the trapezoidal canal, so the water surface elevation raises from upstream to downstream which is the case not wanted. Therefore, an anlysis is done for bottom width, which satisfies both hydraulic conditions and economy, and it is found that the width taken approximately 2.5 times the optimum bottom width of main canal gives reasonable results.

4) End sill of the settling basin should be determined depending on the amount of sediment entering to intake canal. However, mostly the sediment measurements are not effectively performed for this purpose. So, in this study the end sill of settling basin is taken between 0.6 and 1m.

5) One of the most important structural components of an intake is the settling basin. This structure is constructed to facilitate the accumulation of the sediment entering to the intake system. If the sediment can not be kept efficiently, it causes irregular accumulations in the main channel. So, its design should be performed very carefully. There are different approaches to find the length of sediment particle settlement in the literature. In this thesis, three approaches are studied. In one of them diameter

of sediment and corresponding settling velocity are taken into consideration (Kop, 1991). In the second approach random walk model is used to find the length of settling basin (Li and Shen, 1975). The third approach considers the desired removal ratio (Sümer, 1977).

Special measures against sediment handling facilities gains importance in Turkey since 500 million tons of sediment is transported by the rivers in a year. Most of the settling basins do not operate effectively due to poor design (Bekişoğlu, 1991). Therefore, the followings should be specified for more effective settling basin design:

i) Sediment characteristics such as, amount, size and size distribution of sediment particles should be determined carefully.

ii) Diameter of sediment particle which is desired to be settled out in the basin should be well specified.

iii) By appliying different methods, length of settling basin should be found and the maximum one among them should be preferred for final design to be on the safe side.

The minimum diameter of sediment to be settled is assumed as 0.5 mm in this thesis.

6) If the diversion weir has two intakes on each side of the river then hydraulic computations through the intakes are repeated separately. At the end spillway crest elevation is taken such that the requirements of both intakes are satisfied under all

operation conditions. This means that the greater spillway crest elevation is chosen as design value.

7) There are no certain criteria about the design of guiding walls which direct the bed load towards the sluiceway. Mostly, engineers use their judgements and experiences when they design this element. The best way of determining the dimensions and orientation of a guiding wall is the model study. In this study, 0.6 m thickness is assumed for preliminary design.

8) Flow conditions at the toe of the spillway and sluiceway may be different from each other. If the required lowering of the energy dissipating basin relative to the river thalweg are different for spillway and sluiceway, a dividing wall between sluiceway and spilllway may be constructed until the riprap section.

9) A formula is given to determine the riprap diameter in Chapter III (Equation 3.5). The effectiveness of the riprap section depends on the size of the rock, numbers of layer of the rock and length of the section. The most effective section is obtained through model studies. In the computer program the minimum length and the thickness of the layer as specified by Turkish State of Hydraulic Works are considered for the preliminary design.

10) In seepage analysis Lane's creep method is used since it is easy and practical. In this study homogenous soil conditions are considered only. However, it is possible to apply this method if the soil is nonhomogenous. Moreover, if there are two

different layers beneath the foundation, soil properties adjacent to the structure should be taken into account in the computations.

11) In the comparison of the costs of the existing project and this study, only initial costs are considered. Annual operation and maintanence costs are ignored since both alternatives may have almost the same cost for these purposes.

12) If the structure is not safe against any disturbing tendency, the seepage through the foundation of the structure should be reduced. Based on the successive executions of the program, the most effective and economic way in reducing the uplift is observed to be the installation of drains compared to the others.

CHAPTER VIII

CONCLUSIONS

A computer program is developed for the preliminary design and cost computations of a diversion weir with sidewise intakes. In the development of the computer program, the related specifications are reviewed by studying the literature in detail. It is aimed to develope a user friendly interactive program. The capabilities of this program are as follows:

1) The program is executed with the assumption that the site is ready to construction after, filling and foundation treatment works. The soil beneath the foundation is homogenous.

2) The program computes preliminary dimensions of a diversion weir by hydraulic and structural computations. For final design, the results should be modified by taking local site conditions into account. The results may be reinforced with model studies.

3) It computes only initial cost of construction. Actually, the present worth of alternatives should be compared in an economic analysis. However, similar alternatives of diversion weir design yields almost the same maintanance and operation cost.

4) The program is developed for only diversion weirs with conventional type spillway. But it is possible to modify it into gated diversion weirs also. The only difference between these two cases is the operation of them and the crest elevation values of the structures. In case of gated diversion weir crest elevation

values of the structures. In case of gated diversion weir crest elevation should be chosen greater than spillway crest such that overflowing of water is not allowed.

5) Best construction site, considering overall land cost, foundation conditions, closeness to the project area and availability of material is selected before. Design of cofferdams, upstream levees and diversion channel are not considered in this program. All these details are investigated currently in a different study.

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APPENDICES

APPENDIX A

FIGURES

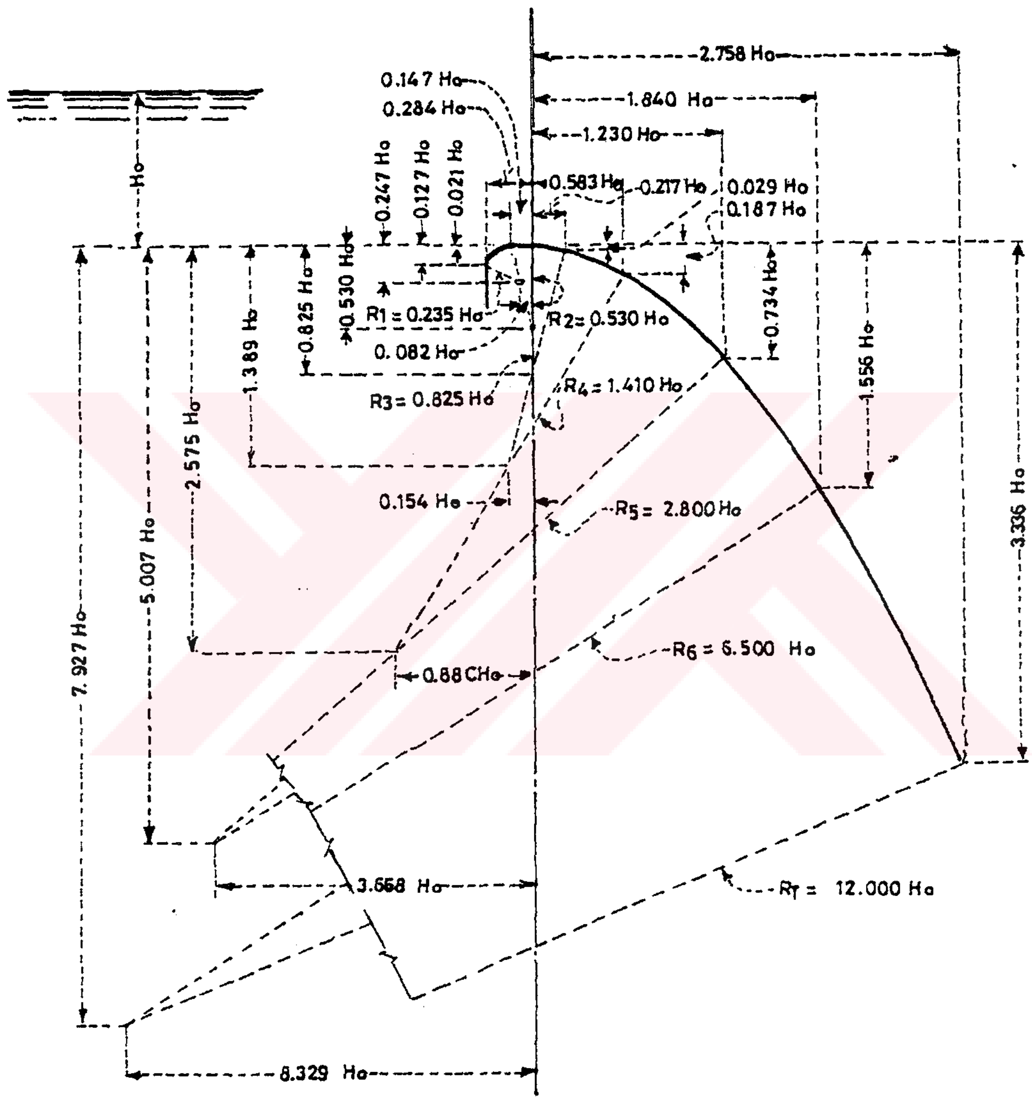

Figure A.1 Profile of Ogee Type Overflow Spillway

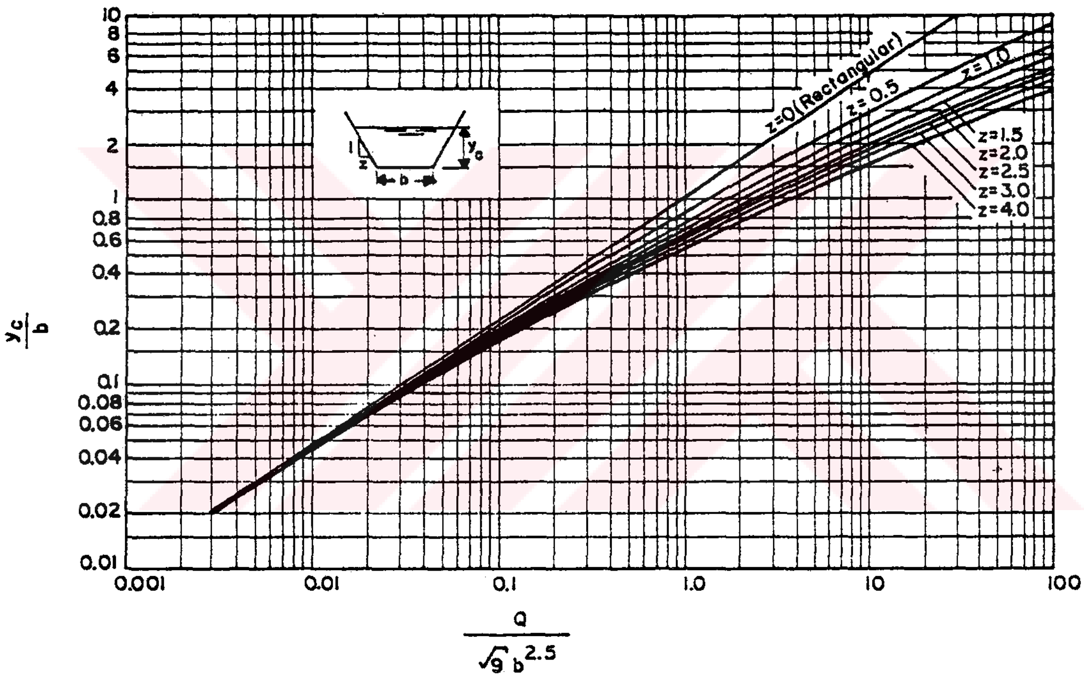

Figure A.2 Determination of Critical Water Depth in a Trapezoidal Channel

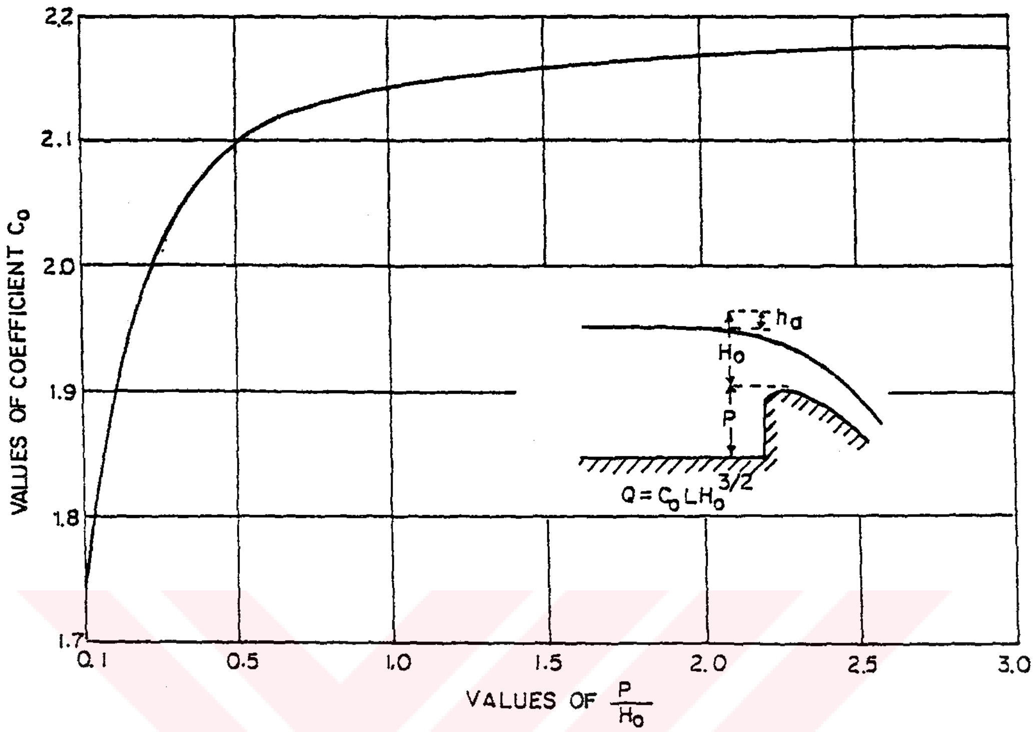

Figure A.3 Coefficient of Design Discharge

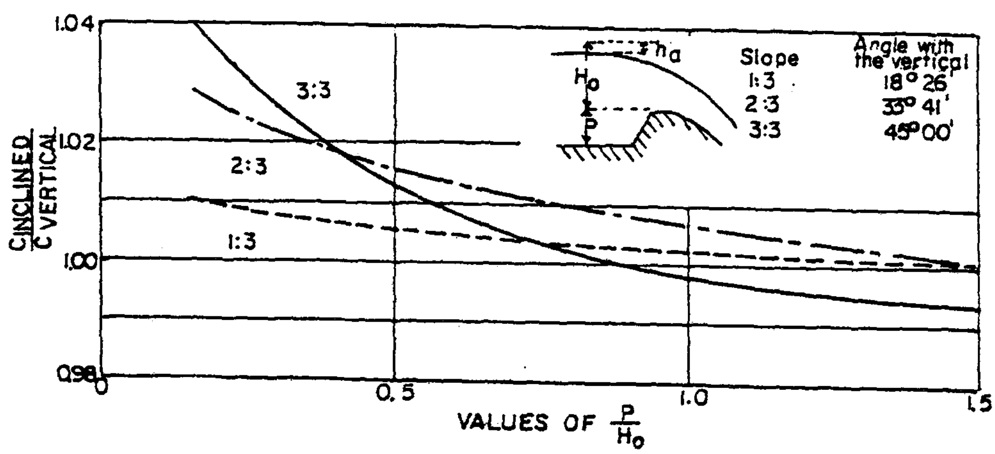

Figure A.4 Coefficient of Discharge for Ogee Shaped

with Sloping Upstrem Face

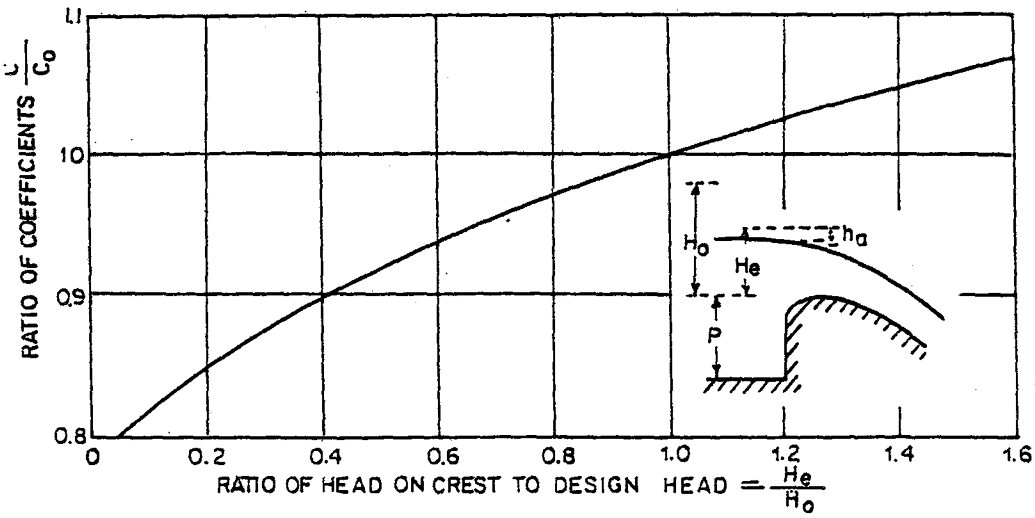

Figure A.5 Coefficient of Discharge for Heads Other Than Design Head

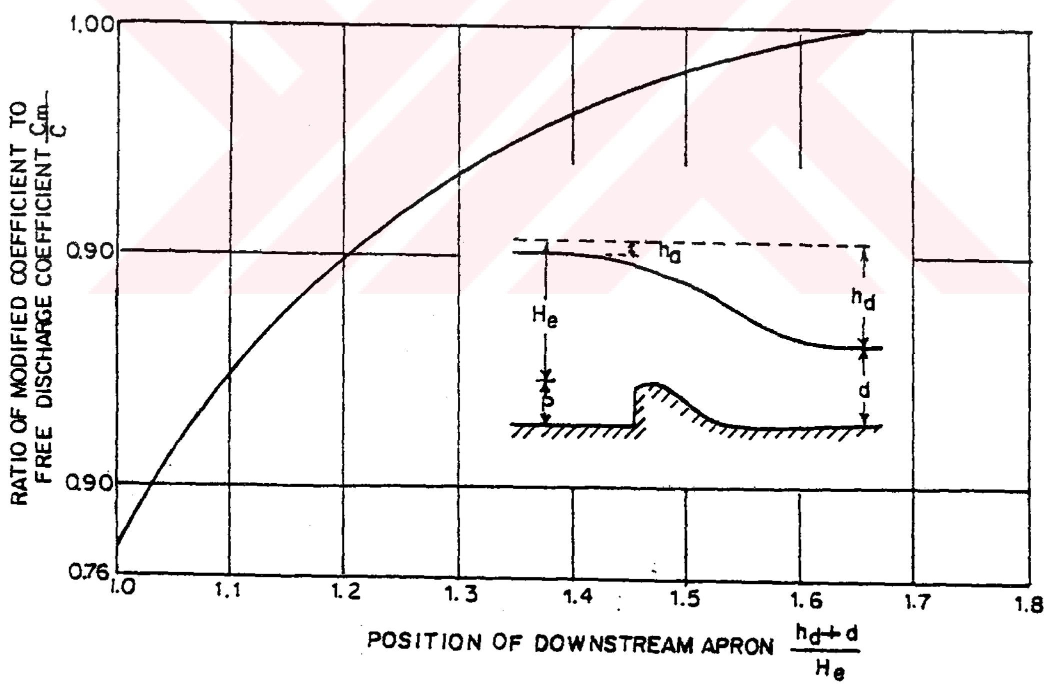

Figure A.6 Coefficient of Discharge Due to Apron Effect

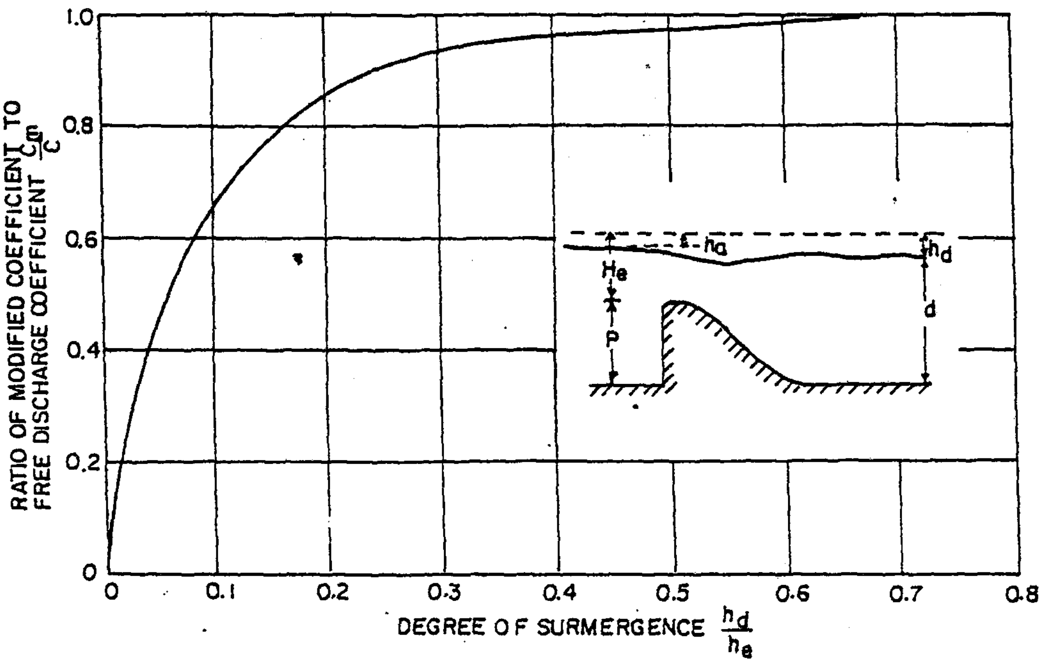

Figure A.7 Coefficient of Discharge Due to Tailwater Effect

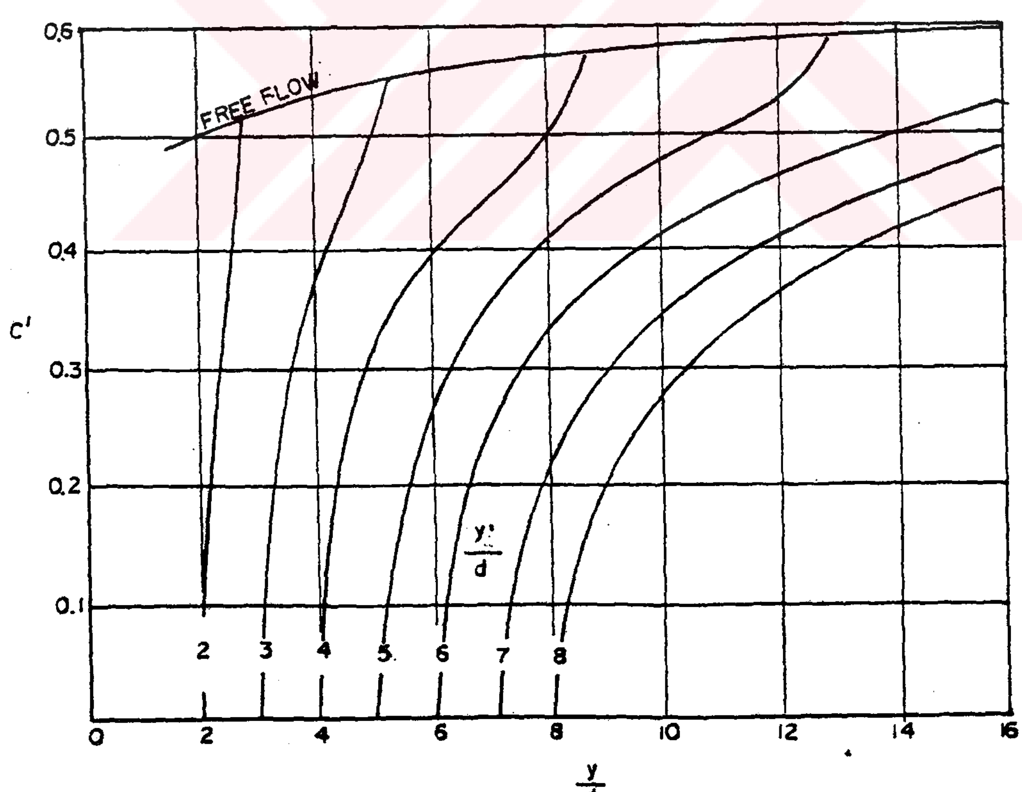

Figure A.8 Determination of C' Coefficient

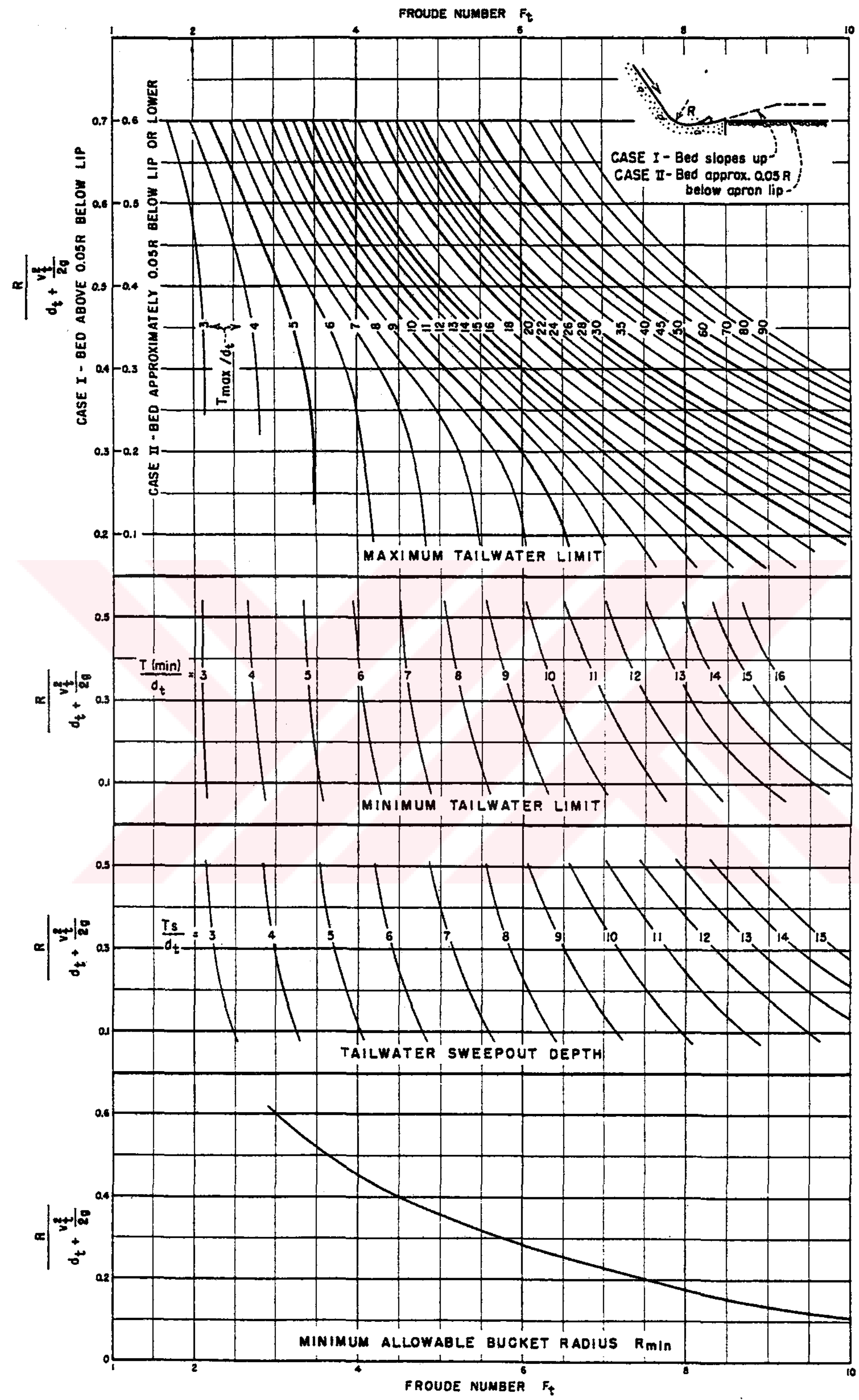

Figure A.9 Limiting Criteria for Slotted Bucket Design

APPENDIX B

LIST OF COMPUTER PROGRAM

```
DECLARE SUB crest (q!, n!, sbed!, bele!, B2!, n1, T1!, DSILL!, sbasin!,
ratio!, NUM, T2!, uent!, BOTELE!, freebr!, LTRAN!, hr!, HA!, hc!, He!,
hcc!, hge!, hg!, h!, HEIGHT!, surele!, B4!, D!, L!, y6p!, B1!, opty!,
f!, Y5!)
DECLARE SUB mcanal (q!, n!, sbed!, cex!, clin!, cland!, B1!, opty!, f!)
DECLARE SUB WALL (WALL1!, gw!, GC!, gs!, GSD!, siga!, BET!, FI!, fric!,
w4!, w1!, w2!, w3!, w5!, pmin!, pmax!, fss!, fsov!)
DECLARE SUB bucket (QDES!(), kinit!(), ks!, k3!(), ho!(), YDES1!(),
USTIL!(), FR1!(), NO3!, FILOUT$)
DECLARE SUB gatecost (GATE$, b3p!, unitpr!, n1!, cost4!)
DECLARE SUB STAB1 (jo!(), ho!(), k1!(), k2!(), k3!(), NJ!, nb!, sj1!,
sj2!, jou1!, jou2!, jom!, JOME!, JOHAC1!, JOHAC2!, jnuo1!, jnuo2!,
jnus1!, jnus2!, gw!, GC!, gs!, GSD!, C!, hi!, EQA!, FI!, siga!, f!,
us!(), sno!(), nbu!, nbo!, can!, FILOUT$, NO3!, kinit!(), k3!())
DECLARE SUB MAX (FRIM!, USTILI!, YDES1I!, YDES2I!, frmax!, K3I!, krip!,
FRSIM!, USILSI!, YDESFI!, YDESSI!, YDES11!, ydes22!, ydes33!, U3!, U3S!,
U33DES!)
DECLARE SUB type3 (LSPILL!, YDES11!, ydes22!, ydes33!, frmax!, FILOUT$,
NO3!, U33DES!)
DECLARE SUB type2 (LSPILL!, YDES11!, ydes22!, ydes33!, frmax!, FILOUT$,
NO3!, U33DES!)
DECLARE SUB type1 (LSPILL!, YDES11!, ydes22!, ydes33!, frmax!, FILOUT$,
NO3!, U33DES!)
DECLARE SUB froude (qgec!, k3gec!, krip!, LT!, ks!, kinit!, FR1!, U1!,
y1!, y2!, ua!, U3!)
DECLARE SUB discharge (qim!, BOTELE!, LT!, ks!, HEIGHT!, k3!, krip!,
INC$, qspill!, qslui!, kinit!, LSPILL!, SD1!, SD2!, numslc!, q100!, ho!,
hgec!, co!, NPI%, TPI!, KAA!, KP!, ua!)
DECLARE SUB FRAME1 () : DECLARE SUB FRAME2 () : DECLARE SUB FRAME3 ()
DECLARE SUB FRAME6 () : DECLARE SUB YAPI () : DECLARE SUB Ljump3 (frmax,
Ljump, ydes22)
DECLARE SUB Ljump1 (frmax, ydes22, Ljump) : DECLARE SUB Ljump2 (frmax,
Ljump, hbaff, ydes22, YDES11)
DECLARE SUB depth (gec1, y1, y2, yc) :        ' $DYNAMIC
DIM QDES(5), qspill(5), qslui(5), arr(200), FR1(10), USTIL(200),
YDES1(200)
DIM YDES2(200), kinit(5), ho(200), He(5), Qsluih(5)
DIM fr1s(5), ustils(5), ydes1s(5), ydes2s(5), ua(5), K33(5)
DIM ux(200), xc(200), yc(200), bloka(200), mfd(200), mweig(200)
DIM XLENG(200), YLENG(200), lcrep(200), hx(200), sthead(200), FD(200),
heff(5)
DIM jo(200), k1(200), k2(200), k3(200), weigh(200)
DIM x(4), y(4), us(200), sno(200)
TYPE EFES: jn1 AS SINGLE: JN2 AS SINGLE: JN3 AS SINGLE: END TYPE
TYPE SX: x AS SINGLE: y AS SINGLE: END TYPE
DIM cem(200) AS EFES
DIM coo(200) AS SX: FOR1$ = "####.##": FOR2$ = "#######": FOR3$ =
"####": FOR4$ = "######.##":
51 GOSUB MENU1
10 END
MENU1:
CALL FRAME1
199 LOCATE 16, 45: PRINT "              ": LOCATE 16, 45: INPUT "", sec$
SELECT CASE UCASE$(sec$)
CASE IS = "R": CLS : GOTO 10: CASE IS = "D": GOSUB menu2: CASE IS =
GOSUB st$$Menu: CASE ELSE: GOTO 199: END SELECT: RETURN
```

```
statmenu:
CALL FRAME6
49 LOCATE 17, 45: INPUT "", sec$: SELECT CASE UCASE$(sec$): CASE IS =
"R"
GOSUB MENU1: CASE IS = "S": CEK6 = 1: can = 1: CASE IS = "L": can: = 2
CASE IS = "I": can = 3: CASE ELSE: GOTO 49: END SELECT: filtre = 0
spillcost = 0: blanketcostsp = 0: draincostspill = 0
GOSUB STAT1: RETURN: STAT1:  RESET
FILE$ = "gec"
NO1 = 135: no2 = 136: KONTROL = 1:
GOSUB EMINE: GOSUB SET: NO1 = 173: no2 = 174: KONTROL = 2
IF cek <> 1 THEN
FILE$ = "ELE"
GOSUB EMINE
GOSUB SET
END IF: NO1 = 130: no2 = 131: KONTROL = 3: FILE$ = "NOKTA1"
IF cek = 1 THEN FILE$ = "NOKTA"
       GOSUB EMINE
       GOSUB SET
  AP1 = 19: AP2 = 29: AP3 = 39: NO1 = 30: no2 = 31: NO3 = 32: CLS
        IF can = 2 THEN
        DO
        LOCATE 15, 42: PRINT "                         "
        LOCATE 15, 10: INPUT "ENTER NUMBER OF SLUICEWAY : ", OKU$
        LOOP UNTIL VAL(OKU$) > 0
        numslc = VAL(OKU$)
        END IF
LAB70:        CLS
  RESET

        DO
        LOCATE 2, 13: PRINT "                    "
        LOCATE 2, 2:
        INPUT "FILE NAME : ", name$
        LOCATE 2, 2: PRINT "FILE NAME : ", UCASE$(name$)
        IF name$ = "" THEN BEEP
        LOOP UNTIL name$ <> ""
        NAMIK$ = name$ + ".OUT"
        OPEN name$ FOR RANDOM AS #50
        GET #50, 300, NJ
        FILECHK = NJ
        LOCATE 3, 2: PRINT "NUMBER OF JOINT : ";
        PRINT USING FOR2$; NJ
        DO
        LOCATE 3, 22: INPUT "", OKU$
        knj = VAL(OKU$)
        IF knj < 3 AND knj <> 0 THEN BEEP
        IF knj <> 0 THEN NJ = knj
        LOOP UNTIL NJ >= 3
        LOCATE 3, 22: PRINT USING FOR2$; NJ
        PUT #50, 300, NJ
        GOSUB FRAMEJOINT
        xx1 = 21: xx2 = 35: ZZ = 20: zp = 12
tom = 1
        IF FILECHK <> 0 THEN GOSUB TUSLAR: GOTO fx1
        DO
        IX = IX + 1
        LOCATE ZZ, zp: PRINT "   "
        LOCATE ZZ, zp: PRINT USING FOR3$; IX
        LOCATE ZZ, 19: PRINT "        "
```

```
         LOCATE ZZ, 35: PRINT "        "
         LOCATE ZZ, 19: INPUT "", OKU$
         coo(IX).x = VAL(OKU$)
         LOCATE ZZ, 19: PRINT USING FOR1$; coo(IX).x
         LOCATE ZZ, 35: INPUT "", OKU$
         coo(IX).y = VAL(OKU$)
         LOCATE ZZ, 35: PRINT USING FOR1$; coo(IX).y
         PUT #50, IX, coo(IX)
         LOOP UNTIL IX = NJ
        GOSUB TUSLAR

fx1:     GOSUB cizim10
         DO
         LOOP UNTIL INKEY$ = CHR$(27)
        SCREEN 10
        SCREEN 0
label1: CLS
         LOCATE 2, 2: PRINT "FILE NAME : "; UCASE$(name$)
         OPEN NAMIK$ FOR RANDOM AS #55
         GET #55, 300, nb
         IF nb <= 0 THEN FILECHK = 0
         LOCATE 3, 2: PRINT "NUMBER OF BLOCK : "; nb
         DO
         IF BOMB = 1 THEN LOCATE 3, 21: PRINT "
           "
         LOCATE 3, 21: INPUT "", OKU$
         KNB = VAL(OKU$)
         IF KNB <> 0 THEN nb = KNB
         BOMB = 1
         IF nb > NJ - 2 OR nb < 0 THEN BEEP
         LOOP UNTIL nb <= NJ - 2 AND nb > 0
         LOCATE 3, 21: PRINT USING FOR2$; nb
         PUT #55, 300, nb
LABEL10: GOSUB FRAMEBLOK
tom = 2
         IF FILECHK <> 0 THEN GOSUB TUSLAR: GOTO label2
         IX = 0
         DO
         IX = IX + 1
         LOCATE ZZ, zp: PRINT USING FOR3$; IX
         DO
         LOCATE ZZ, AP1: INPUT "", OKU$
         IF VAL(OKU$) > NJ OR VAL(OKU$) <= 0 THEN BEEP
         LOOP UNTIL VAL(OKU$) <= NJ AND VAL(OKU$) > 0
         LOCATE ZZ, AP1: PRINT USING FOR2$; VAL(OKU$)
         cem(IX).jn1 = VAL(OKU$)
         DO
         LOCATE ZZ, AP2: INPUT "", OKU$
         IF VAL(OKU$) > NJ OR VAL(OKU$) <= 0 THEN BEEP
         LOOP UNTIL VAL(OKU$) <= NJ AND VAL(OKU$) > 0
         LOCATE ZZ, AP2: PRINT USING FOR2$; VAL(OKU$)
         cem(IX).JN2 = VAL(OKU$)
         DO
         LOCATE ZZ, AP3: INPUT "", OKU$
         IF VAL(OKU$) > NJ OR VAL(OKU$) <= 0 THEN BEEP
         LOOP UNTIL VAL(OKU$) <= NJ AND VAL(OKU$) > 0
         LOCATE ZZ, AP3: PRINT USING FOR2$; VAL(OKU$)
         cem(IX).JN3 = VAL(OKU$)
         LOCATE ZZ, AP1: PRINT "        "
         LOCATE ZZ, AP2: PRINT "        "
```

```
        LOCATE ZZ, AP3: PRINT "        "
        PUT #55, IX, cem(IX)
        LOOP UNTIL IX = nb
        GOSUB TUSLAR
label2: yc = 2
        SCREEN 10
       SCREEN 0
        CLS
        DO
        LOCATE 1, AP3: PRINT "                          "
        LOCATE 1, 2: INPUT "NUMBER OF BLOCKS  FOR UPLIFT CHECK : ",
OKUSVAL(OKU$) > nb THEN BEEP
        IF VAL(OKU$) <= 0 THEN BEEP
        LOOP UNTIL VAL(OKU$) <= nb AND VAL(OKU$) > 0
        LOCATE 1, AP3: PRINT USING FOR2$; VAL(OKU$)
        LOCATE , 2: PRINT
"ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë"
        nbu = VAL(OKU$)
        NOB1 = nbu
        FOR i = 1 TO nbu
        yc = yc + 1
        DO
        LOCATE yc, 2: PRINT "BLOCK"; i; " : ";
        INPUT "", OKU$
        IF VAL(OKU$) <= 0 OR VAL(OKU$) > nb THEN BEEP
        LOOP UNTIL VAL(OKU$) > 0 AND VAL(OKU$) <= nb
        us(i) = VAL(OKU$)
        NEXT i
        yc = yc + 2
        IF can = 1 OR chek1 = 1 THEN
        DO
        LOCATE yc, 43: PRINT "                      "
        LOCATE yc, 2: INPUT "NUMBER OF BLOCKS  FOR OVERTURNING CHECK :
", OKU$
        IF VAL(OKU$) > nb OR VAL(OKU$) <= 0 THEN BEEP
        LOOP UNTIL VAL(OKU$) <= nb AND VAL(OKU$) > 0
        LOCATE yc, 43: PRINT USING FOR2$; VAL(OKU$)
        yc = yc + 1
        LOCATE yc, 2: PRINT
"ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë"
        nbo = VAL(OKU$)
        NOB2 = nbo
        FOR i = 1 TO nbo
        yc = yc + 1
        DO
        LOCATE yc, 2: PRINT "BLOCK"; i; " : ";
        INPUT "", OKU$
        IF VAL(OKU$) <= 0 OR VAL(OKU$) > nb THEN BEEP
        LOOP UNTIL VAL(OKU$) > 0 AND VAL(OKU$) <= nb
        sno(i) = VAL(OKU$)
        NEXT i
        END IF
       GOSUB cizim10: GOSUB KEMAL10
       GOSUB liste20: GOSUB STAB1
       RETURN
liste20:
FOR i = 1 TO NJ: GET #50, i, coo(i): jo(i) = coo(i).x: ho(i) = coo(i).y
NEXT i
FOR i = 1 TO nb
GET #55, i, cem(i): k1(i) = cem(i).jn1: k2(i) = cem(i).JN2
```

```
k3(i) = cem(i) * JN3: LPRINT k1(i), k2(i), k3(i): NEXT i
IF cek <> 1 THEN
gw = arr(1): GC = arr(2): gst = arr(3): gs = arr(4)
C = arr(5): FI = arr(6): BET = arr(7): siga = arr(8)
fric = arr(9): EQA = arr(10): URCONC = arr(11): UCONC = arr(12)
USTEEL = arr(13): UDRAIN = arr(14): URIP = arr(15): SHEAR = arr(16)
krip = arr(27): ks = arr(28): sj1 = arr(29): sj2 = arr(30)
jou1 = arr(31): jou2 = arr(32): jom = arr(33): JOME = arr(34)
JOHAC1 = arr(35): JOHAC2 = arr(36): jnuo1 = arr(37): jnuo2 = arr(38)
jnus1 = arr(39): jnus2 = arr(40): UJ1 = arr(41): UJ2 = arr(42)
UJ3 = arr(43): TETA = arr(45): bele = arr(46): LSPILL = arr(47)
SD1 = arr(48): ORTAB = arr(49): BOTELE = arr(44): K33(1) = arr(17)
K33(2) = arr(18): K33(3) = arr(19): K33(4) = arr(20)
K33(5) = arr(21): kinit(1) = arr(22): kinit(2) = arr(23)
kinit(3) = arr(24): kinit(4) = arr(25): kinit(5) = arr(26)
ELSE
FOR i = 1 TO NJ: GET #50, i, coo(i): jo(i) = coo(i).x
ho(i) = coo(i).y: NEXT i
gw = arr(1): GC = arr(2): gst = arr(3): gs = arr(4)
C = arr(5): FI = arr(6): BET = arr(7): siga = arr(8)
fric = arr(9): EQA = arr(10): URCONC = arr(11): UCONC = arr(2)
USTEEL = arr(13): UDRAIN = arr(14): URIP = arr(15): SHEAR = arr(16)
sj1 = arr(17): sj2 = arr(18): jou1 = arr(19): jou2 = arr(20)
jom = arr(21): JOME = arr(22): JOHAC1 = arr(23): JOHAC2 = arr(24)
jnuo1 = arr(25): jnuo2 = arr(26): jnus1 = arr(27): jnus2 = arr(28)
UJ1 = arr(29): UJ2 = arr(30): UJ3 = arr(31)
END IF
RETURN
menu2:
CEK1 = 0: CEK2 = 0: CEK3 = 0: CEK4 = 0: CEK5 = 0:
KEY OFF: KEY 1, "": KEY 2, "": KEY 3, "": KEY 4, "": KEY 5, "": KEY 6,
""
KEY 7, "": KEY 8, "": KEY 9, "": KEY 10, ""
KEY(21) OFF: KEY(20) OFF: KEY(1) OFF: CALL FRAME2
299 LOCATE 18, 45: PRINT "                 ": LOCATE 18, 45
INPUT "", sec$: sec$ = UCASE$(sec$): SELECT CASE sec$
CASE IS = "R": CLS : GOSUB MENU1: CASE IS = "I"
CLS : GOSUB MENU3: CASE IS = "S": CLS : GOSUB MENU12
CASE IS = "P": CLS : GOSUB MENU9: CASE IS = "C"
CLS : GOSUB MENU15: CASE ELSE: GOTO 299
END SELECT: RETURN: MENU3:
RESET: NO1 = 103: no2 = 203: NO3 = 33
FILE$ = "GIR1"
'FILOUT$ = "CANAL.OUT":CEK1 = 1:GOSUB EMINE:GOSUB SET
CALL mcanal(arr(1), arr(2), arr(3), arr(4), arr(5), arr(6), B1, opty,
CLS     f)
LOCATE 10, 5: PRINT "Optimum bottom width (m)..........  "; USING
"###.##"; B1
LOCATE 11, 5: PRINT "Optimum water depth  (m)..........  "; USING
"###.##"; opty
LOCATE 24, 5: PRINT "Press <ESC> to continue"
DO: LOOP UNTIL INKEY$ = CHR$(27)
GOSUB menu2
RETURN
MENU9:
DO: LOCATE 22, 26: PRINT "                                        "
LOCATE 22, 2: INPUT "DO YOU KNOW SPILLWAY HEIGHT  (Y/N) ? ", CR$
CR$ = UCASE$(CR$): LOOP UNTIL CR$ = "Y" OR CR$ = "N"
SELECT CASE CR$: CASE "Y"
GOSUB MENU10: CASE "N"
```

```
LOCATE 22, 2: PRINT "                                  :
                 "
LOCATE 12, 18
PRINT "YOU SHOULD FIND SPILLWAY CREST FIRST ! ";
LOCATE 23, 2: PRINT "<ESC> return to menu ......"
DO: LOOP UNTIL INKEY$ = CHR$(27)
GOSUB menu2
END SELECT
RETURN
MENU10: ku = 0: RESET
CLS : NO1 = 109: no2 = 209
IF cek <> 1 THEN NO3 = 193
FILE$ = "gir4": FILOUT$ = "DISC.out"
IF cek = 1 THEN FILOUT$ = "complete.out"
CEK1 = 0      : CEK2 = 1:IF cek = 1 THEN
LOCATE 15, 5: PRINT UCASE$("Height of the spillway crest (m)=");
PRINT USING "###.##"; HEIGHT
LOCATE 16, 5: PRINT UCASE$("Spillway crest elevation .......=");
PRINT USING "#####.##"; ks
LOCATE 22, 2: PRINT UCASE$("Press Esc to CONTINUE...")
DO: LOOP UNTIL INKEY$ = CHR$(27)
END IF
chek2 = 0: CEK5 = 0
GOSUB EMINE: chek2 = 1: GOSUB SET: QDES(1) = arr(9)
q100 = QDES(1): QDES(2) = arr(10): QDES(3) = arr(11)
QDES(4) = arr(12): QDES(5) = arr(13): BOTELE = arr(3)
T1 = arr(8): ks = arr(2): HEIGHT = arr(1): k3(1) = arr(14)
k3(2) = arr(15):(3) = arr(16):k3(4) = arr(17)
k3(5) = arr(18): krip = arr(19): LSPILL = arr(4)
SD1 = arr(6): SD2 = arr(7): numslc = arr(5)
CLS
LOCATE 17, 2: PRINT "1 FOR 1:3 INCLINATION";
LOCATE 18, 2: PRINT "2 FOR 2:3 INCLINATION";
LOCATE 19, 2: PRINT "3 FOR 3:3 INCLINATION";
LOCATE 20, 2: PRINT "4 FOR VERTICAL SPILLWAY";
LOCATE 22, 2: PRINT "Choose  one .....  ";
DO
LOCATE 22, 22:
PRINT "                    "
LOCATE 22, 22: INPUT INC$
LOOP UNTIL INC$ = "1" OR INC$ = "2" OR INC$ = "3" OR INC$ = "4"
IF INC$ = "4" THEN TETA = 0
IF INC$ = "3" THEN TETA = 45
IF INC$ = "2" THEN TETA = 33.41
IF INC$ = "1" THEN TETA = 18.26
CLS
DO: LOCATE 22, 2: INPUT "BRIDGE ON SPILLWAY CREST (Y/N) : ", OKU$
LOOP UNTIL UCASE$(OKU$) = "Y" OR UCASE$(OKU$) = "N"

IF UCASE$(OKU$) = "Y" THEN
NO1 = 119
no2 = 219
FILE$ = "gir6"
CEK3 = 1: CEK2 = 0: chek2 = 0
GOSUB EMINE
GOSUB SET
NPI = arr(1): TPI = arr(2): KAA = arr(3)
KP = arr(4):END IF
LT = LSPILL + SD1 * numslc + numslc * T1
CLS
```

```
NEXT ll%
U33DES = UMAX
IF ydes22 < ydes33 THEN
CALL bucket(QDES(), kinit(), ks, k3(), YDES1(), ho(), USTIL(), FR1(),
NO3, FILOUT$)
IF cek = 1 THEN
GOSUB stat11
ELSE
GOSUB menu2
END IF

END IF
IF frmax < 2.5 THEN
PRINT #NO3, "ONLY MAT FOUNDATION IS ENOUGH FOR FROUDE NUMBER = ", frmax
lstil = 6 * (ydes22 - YDES11)
PRINT #NO3, "LENGTH OF SETTLING BASIN (m) = ";
PRINT #NO3, USING "###.##"; lstil
drip = U33DES ^ 2 * 1.4 / (1.65 * 19.62)
PRINT #NO3, "DIAMETER OF THE ROCK IN RIPRAP SECTION (m) >= ";
PRINT #NO3, USING "##.##"; drip2
IF cek = 1 THEN GOSUB stat11
GOSUB menu2
ELSEIF frmax >= 4.5 THEN
IF udes < 15 THEN CALL type2(LSPILL, YDES11, ydes22, ydes33, frmax,
FILOUT$, NO3, U33DES): IF cek = 1 THEN GOSUB stat11
IF udes >= 15 THEN CALL type3(LSPILL, YDES11, ydes22, ydes33, frmax,
FILOUT$, NO3, U33DES): IF cek = 1 THEN GOSUB stat11
GOSUB menu2
ELSE
CALL type1(LSPILL, YDES11, ydes22, ydes33, frmax, FILOUT$, NO3, U33DES)
IF cek = 1 THEN
GOSUB stat11:ELSE:GOSUB menu2:END IF
END IF: RETURN: MENU12:         CALL FRAME3
388 LOCATE 16, 45: INPUT "", sec$
sec$ = UCASE$(sec$): SELECT CASE sec$
CASE IS = "R": GOSUB menu2: CASE IS = "O"
GOSUB MENU13: CASE IS = "T"
GOSUB MENU14: CASE ELSE: GOTO 388
END SELECT: RETURN
SET:
FOR i = 1 TO KX
IF can = 1 OR can = 2 OR can = 3 THEN
sex = sex + 1
GET #no2, i, arr(sex)
ELSEIF chek1 = 1 OR chek1 = 2 OR chek1 = 3 THEN
sex = sex + 1
GET #no2, i, arr(sex)
ELSE
GET #no2, i, arr(i)
END IF
NEXT
RETURN
MENU13:
RESET: CLS
TWO = 1
chek2 = 1: NO1 = 113: no2 = 213: NO3 = 133
FILES$ = "gir2": FILOUT$ = "ONESIDED.OUT"
IF cek = 1 THEN
FILOUT$ = "COMPLETE.OUT": NO3 = 194
END IF: GOSUB EMINE
```

```
GOSUB SET: CALL mcanal(arr(1), arr(2), arr(3), arr(4), arr(5), arr(6),
B1, opty, f)
CLS
LOCATE 12, 2: PRINT "OPTIMUM BOTTOM WIDTH OF THE MAIN CANAL (m) : ";
PRINT USING "###.##"; B1
DO
LOCATE 13, 2: INPUT "ENTER CANAL WIDTH AT THE ENTRANCE OF MAIN CANAL (m)
: ", B2
LOOP UNTIL B2 > B1
bele = arr(16)
CALL crest(arr(1), arr(2), arr(3), arr(15), B2, arr(7), arr(8), arr(9),
arr(10), arr(11), arr(12), arr(13), arr(14), arr(16), arr(17), LTRAN,
hr, HA, hc, He, hcc, hge, hg, h, HEIGHT, surele, B4, D, L, y6p, B1,
opty, f, Y5)
ks = surele
CLS
LOCATE 5, 2: PRINT "OPTIMUM BOTTOM WIDTH OF THE MAIN CANAL
(m)..........: "; USING "###.##"; B1
LOCATE , 2: PRINT "BOTTOM WIDTH AT THE ENTRANCE OF MAIN CANAL (m)
......: "; USING "###.##"; B2
LOCATE , 2: PRINT "LENGTH OF TRANSITION
(m)............................: "; USING "###.##"; LTRAN
LOCATE , 2: PRINT "WIDTH OF SETTLING BASIN (m)
........................: "; USING "###.##"; B4
LOCATE , 2: PRINT "LENGTH OF SETTLING BASIN (m)
.......................: "; USING "###.##"; L
LOCATE , 2: PRINT "HEIGHT OF SPILLWAY CREST (m)
.......................: "; USING "###.##"; HEIGHT
LOCATE , 2: LOCATE 24, 5: PRINT "Press <ESC> to continue"
DO: LOOP UNTIL INKEY$ = CHR$(27)
IF cek = 1 THEN GOSUB MENU10
GOTO menu2
RETURN

MENU14:
SET
chek = 2: TWO = 2: CLS : NO1 = 114
no2 = 214: NO3 = 233: FILES = "gir2"
FILOUT$ = "TWOSIDED.OUT"
IF cek = 1 THEN FILOUT$ = "COMPLETE.OUT"
CEK4 = 1: chek2 = 0
can = 0: chek1 = 0
GOSUB EMINE
GOSUB SET
CALL mcanal(arr(1), arr(2), arr(3), arr(4), arr(5), arr(6), B1, opty,
CLS     f)
LOCATE 12, 1: PRINT "MAIN IRRIGATION CANAL OPTIMUM BOTTOM WIDTH FOR
FIRST INTAKE (m) : ";
PRINT USING "###.##"; B1

DO
LOCATE 13, 1: INPUT "FIRST INTAKE CANAL WIDTH AT THE ENTRANCE OF MAIN
CANAL (m)  : ", B2
IF B2 <= B1 THEN
BEEP
LOCATE 16, 1: PRINT
"ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë
ëëëëëëëëë"
LOCATE 17, 1: PRINT "FIRST INTAKE CANAL WIDTH SHOULD BE > OPTIMUM BOTTOM
WIDTH"
```

```
END IF
LOOP UNTIL B2 > B1
bele = arr(16)
CALL crest(arr(1), arr(2), arr(3), arr(15), B2, arr(7), arr(8), arr(9),
arr(10), arr(11), arr(12), arr(13), arr(14), arr(16), arr(17), LTRAN,
hr, HA, hc, He, hcc, hge, hg, h, HEIGHT, surele, B4, D, L, y6p, B1,
opty, f, Y5)
hakki = 1
OPEN FILOUT$ FOR OUTPUT AS #NO3
NO1 = 124: no2 = 224: CEK4 = 0
CEK5 = 1: GOSUB EMINE
GOSUB SET
bele = arr(16)
CALL mcanal(arr(1), arr(2), arr(3), arr(4), arr(5), arr(6), B1I, optyI,
FI)
CLS
LOCATE 12, 1: PRINT "MAIN IRRIGATION CANAL OPTIMUM BOTTOM WIDTH FOR
SECOND INTAKE (m) : ";
PRINT USING "###.##"; B1I
DO
LOCATE 13, 1: INPUT "SECOND INTAKE CANAL WIDTH AT THE ENTRANCE OF MAIN
CANAL (m) : ", B2I
IF B2I <= B1I THEN
BEEP
LOCATE 16, 1: PRINT
"ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë
ëëëëëëëëë"
LOCATE 17, 1: PRINT "SECOND INTAKE CANAL WIDTH SHOULD BE > OPTIMUM
BOTTOM WIDTH"
END IF
LOOP UNTIL B2I > B1I
CALL crest(arr(1), arr(2), arr(3), arr(15), B2I, arr(7), arr(8), arr(9),
arr(10), arr(11), arr(12), arr(13), arr(14), arr(16), arr(17), LTRANI,
hr, HA, hc, He, hcc, hge, hg, h, heightI, sureleI, B4I, DI, LI, y6pI,
B1I, optyI, FI, Y5I)
CLS
LOCATE 2, 2: PRINT " FIRST INTAKE"
LOCATE , 2: PRINT "áááááááááááááááá"
LOCATE , 2: PRINT "OPTIMUM BOTTOM WIDTH OF THE  MAIN CANAL (m)........
"; USING "##.##"; B1
LOCATE , 2: PRINT "LENGTH OF TRANSITION (m).......................... ";
USING "###.##"; LTRAN
LOCATE , 2: PRINT "WIDTH OF SETTLING BASIN (m) ...................... ";
USING "###.##"; B4
LOCATE , 2: PRINT "LENGTH OF SETTLING BASIN (m) ..................... ";
USING "###.##"; L
LOCATE 9, 2: PRINT " SECOND INTAKE"
LOCATE , 2: PRINT "áááááááááááááááá"
LOCATE , 2: PRINT "OPTIMUM BOTTOM WIDTH OF THE  MAIN CANAL (m)........
"; USING "##.##"; B1I
LOCATE , 2: PRINT "LENGTH OF TRANSITION (m).......................... ";
USING "###.##"; LTRANI
LOCATE , 2: PRINT "WIDTH OF SETTLING BASIN (m) ...................... ";
USING "###.##"; B4I
LOCATE , 2: PRINT "LENGTH OF SETTLING BASIN (m) ..................... ";
USING "###.##"; LI
IF HEIGHT >= heightI THEN
ks = surele
ELSE
HEIGHT = heightI
```

```
ks = surelel
END IF
LOCATE 17, 2: PRINT "HEIGHT OF SPILLWAY CREST
........................"; USING "###.##"; HEIGHT
LOCATE 24, 2: PRINT "Press <ESC> to continue"
DO: LOOP UNTIL INKEY$ = CHR$(27)
IF cek = 1 THEN GOSUB MENU10
GOTO menu2: RETURN: MENU15: : cek = 1
GOSUB MENU12: RETURN
EMINE:
hh = 79
HK = 70
CLS
pp = 0
LOCATE 22, 2:
IF chek2 = 1 THEN RE = 43: PRINT UCASE$("file name for intake canal
design : ")
IF CEK1 = 1 THEN RE = 49: PRINT UCASE$("File name for design of
irrigation canal : ")
IF CEK2 = 1 THEN RE = 58: PRINT UCASE$("File name for discharge and
stilling basin design : ")
IF CEK3 = 1 THEN RE = 30: PRINT UCASE$("File name for bridge data : ")
IF CEK4 = 1 THEN RE = 56: PRINT UCASE$("File name for first intake
irrigation canal design : ")
IF CEK5 = 1 THEN RE = 56: PRINT UCASE$("File name for second intake
irrigation canal design : ")
IF can = 1 OR chek1 = 1 THEN RE = 31: PRINT UCASE$("File name for
spillway check : ")
IF can = 2 OR chek1 = 2 THEN RE = 31: PRINT UCASE$("File name for
sluiceway check : ")
IF can = 3 OR chek1 = 3 THEN RE = 30: PRINT UCASE$("File name for intake
check : ")
IF KONTROL = 1 THEN CLS : LOCATE 22, 2: RE = 40: PRINT "FILE NAME FOR
MATERIAL PROPERTIES : "
IF KONTROL = 2 THEN CLS : LOCATE 22, 2: RE = 40: PRINT "FILE NAME FOR
SURFACE ELEVATIONS  : "
'IF KONTROL = 3 THEN CLS : LOCATE 22, 2: RE = 40: PRINT "FILE NAME FOR
SURFACE ELEVATIONS  : "
CEK1 = 0: CEK2 = 0: CEK3 = 0: CEK4 = 0: CEK5 = 0: KONTROL = 0
DO
LOCATE 22, RE: PRINT "                              "
LOCATE 22, RE: INPUT "", file1$
LOOP UNTIL file1$ <> ""
OPEN FILE$ FOR RANDOM AS #NO1
OPEN file1$ FOR RANDOM AS #no2
GET #no2, 1000, masa
CLS : KX = 0: DO
KX = KX + 1
GET #NO1, KX, text$
PRINT text$;
GET #no2, KX, test
LOCATE , HK
PRINT USING FOR4$; test
LOOP UNTIL EOF(NO1)
LOCATE KX, HK: PRINT "            "
KX = KX - 1
LOCATE 22, 1: PRINT
"000000000000000000000000000000000000000000000000000000000000000000000000
00000000"
LOCATE 23, 1: PRINT
```

```
"UUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUU
UUUUUUUU"
IF masa <> 0 THEN
FOR i = 1 TO KX
LOCATE 23, 61: PRINT "              "
GET #no2, i, test
LOCATE 23, 61: PRINT test
LOCATE i, HK: INPUT "", OKU$
test = VAL(OKU$)
IF test = 0 THEN GET #no2, i, test
LOCATE 23, 61: PRINT "              "
LOCATE 23, 61: PRINT test
LOCATE i, HK: PRINT USING FOR4$; test
PUT #no2, i, test
NEXT i: masa = 1
PUT #no2, 1000, masa
END IF: GOSUB KEYS
RETURN: KEYS:           :
KEY ON: KEY 1, "QUIT": KEY 2, "     ": KEY 3, "      ": KEY 4, "
":
KEY 5, "      ": KEY 6, "      ": KEY 7, "      ": KEY 8, "      "
KEY 9, "      ": KEY 10, "      "
KEY 15, CHR$(0) + CHR$(72): KEY 20, CHR$(32) + CHR$(72)
KEY 16, CHR$(0) + CHR$(80): KEY 21, CHR$(32) + CHR$(80)
KEY 18, CHR$(0) + CHR$(57): KEY 17, CHR$(32) + CHR$(57)
DO
KEY(1) ON:
KEY(15) ON: KEY(16) ON: KEY(17) ON:
KEY(18) ON:  KEY(20) ON: KEY(21) ON
ON KEY(15) GOSUB UP: ON KEY(16) GOSUB DOWN:
ON KEY(20) GOSUB UP:
ON KEY(21) GOSUB DOWN
IF pp = 1 THEN ON KEY(17) GOSUB change
IF pp = 1 THEN ON KEY(18) GOSUB change
ON KEY(1) GOSUB menu2
LOOP UNTIL INKEY$ = CHR$(27)
KEY OFF: KEY 1, "": KEY 2, "": KEY 3, "": KEY 4, ""
KEY 5, "": KEY 6, "": KEY 7, "": KEY 8, ""
KEY 9, "": KEY 10, ""
RETURN
DOWN:
pp = 1
k = k + 1
IF KX <= 0 THEN KX = 1
IF k > KX THEN k = KX
IF k <> 1 THEN LOCATE k - 1, hh: PRINT " "
LOCATE k, hh: PRINT " "
LOCATE 23, 61: PRINT "              "
GET #no2, k, test
LOCATE 23, 61: PRINT test
RETURN
UP:
pp = 1
k = k - 1
IF k < 1 THEN k = 1
IF k > 24 THEN k = 24
LOCATE k + 1, hh: PRINT " "
LOCATE k, hh: PRINT " "
LOCATE 23, 61: PRINT "              "
GET #no2, k, test
```

```
LOCATE 23, 61: PRINT test
RETURN
change:
LOCATE k, HK: PRINT "          "
LOCATE k, HK: INPUT "", OKU$
LOCATE k, HK: PRINT USING FOR4$; VAL(OKU$)
LOCATE 23, 61: PRINT "              "
GET #no2, k, test
LOCATE 23, 61: PRINT test
test = VAL(OKU$)
LOCATE 23, 61: PRINT test
PUT #no2, k, test
RETURN


STAB1:
TETAP = TETA * 3.141592654# / 180
LOCATE 23, 1: PRINT "ENTER ALLOWABLE SHEAR  STRESS AT THE FOUNDATION
LEVEL "
DO
KEY$ = INKEY$
IF KEY$ = CHR$(27) THEN LOCATE 23, 56: PRINT "                ": NAM$ =
""
IF KEY$ > CHR$(47) AND KEY$ < CHR$(58) THEN
NAM$ = NAM$ + KEY$: LOCATE 23, 56: PRINT NAM$
SHEAR = VAL(NAM$)
END IF
IF KEY$ = CHR$(13) THEN EXIT DO
LOOP
totalan = 0
FOR j = 1 TO nb
x(1) = jo(k1(j)): y(1) = ho(k1(j)): x(2) = jo(k2(j)): y(2) = ho(k2(j)):
x(3) = jo(k3(j))
y(3) = ho(k3(j)): x(4) = x(1): y(4) = y(1): ALAN = 0: FOR i = 1 TO 3: al
= (y(i) + y(i + 1)) * (x(i + 1) - x(i)) / 2
ALAN = al + ALAN: NEXT i: bloka(j) = ABS(ALAN): weigh(j) = bloka(j) * GC
     :1511   FOR i = 1 TO 3
A(i) = x(i) + (x(i + 1) - x(i)) / 2
b(i) = y(i) + (y(i + 1) - y(i)) / 2
NEXT i
IF ABS(A(1) - A(2)) <= .00001 AND ABS(b(1) - b(2)) <= .00001 AND
ABS(A(1) - A(3)) <= .00001 AND ABS(b(1) - b(3)) <= .00001 THEN
xc(j) = A(1)
yc(j) = b(1)
GOTO ORR
ELSE
FOR i = 1 TO 4
IF i = (4) THEN
x(i) = A(1)
y(i) = b(1)
ELSE
x(i) = A(i)
y(i) = b(i)
END IF
NEXT i
GOTO 1511
END IF
ORR: NEXT j
FOR i = 1 TO nb
totalan = bloka(i) + totalan
```

```
NEXT i

IF can = 2 OR chek1 = 2 OR can = 3 OR chek1 = 3 THEN HEIGHT = kinit(1) -
bele
IF can = 1 OR chek1 = 1 THEN
HEIGHT = ks - bele:
hi = ks - krip
FOR i = 1 TO 5
heff(i) = kinit(i) - K33(i)
IF heff(i) > hi THEN
hefct = heff(i)
ELSE
hefct = hi
END IF
NEXT i
ELSEIF can = 2 OR chek1 = 2 THEN
hefct = kinit(1) - krip
ELSEIF can = 3 OR chek1 = 3 THEN
hefct = kinit(1) - BOTELE
END IF
 lcrep(sj2) = 0
FOR j = sj1 TO sj2 - 1
gec = ABS(jo(j) - jo(j + 1))
gec1 = ABS(ho(j) - ho(j + 1))
XLENG(j + 1) = ABS(jo(j) - jo(j + 1))
YLENG(j + 1) = ABS(ho(j) - ho(j + 1))
IF XLENG(j + 1) = 0 THEN
lcrep(j + 1) = YLENG(j + 1) + lcrep(j)
ELSEIF YLENG(j + 1) = 0 THEN
lcrep(j + 1) = XLENG(j + 1) / 3 + lcrep(j)
ELSE
IF XLENG(j + 1) < YLENG(j + 1) THEN
lcrep(j + 1) = XLENG(j + 1) / 3 + lcrep(j)
ELSE
lcrep(j + 1) = YLENG(j + 1) + lcrep(j)
END IF
END IF
NEXT j
CLS
IF lcrep(sj2) < Lmin THEN
LOCATE 19, 2: PRINT "INCREASE SEEPAGE LENGTH, SINCE Lcreep < Lmin"
LOCATE 20, 2: PRINT "INCREASE SEEPAGE LENGTH, SINCE  "; lcrep(sj2); " <
"; Lmin
LOCATE 23, 1: PRINT " PRESS <ESC> TO CONTINUE"
DO
LOOP UNTIL INKEY$ = CHR$(27)
GOTO LAB70
END IF
hlospl = hefct / lcrep(sj2)
FOR j = sj1 TO sj2
hx(j) = hlospl * lcrep(j)
sthead(j) = ABS(ho(j)) + HEIGHT
ux(j) = sthead(j) - hx(j)
NEXT j
weight = 0
FOR n = 1 TO nbu
weight = weigh(us(n)) + weight
NEXT n
uplift = (gw * (ux(jou1) + ux(jou2)) * ABS(jo(jou2) - jo(jou1))) / 2
IF filtre = 1 THEN uplift = uplift * .7
```

```
FSUP = weight / uplift
IF FSUP < 1.2 THEN
CLS
LOCATE 15, 10: PRINT "FACTOR OF SAFETY AGAINST UPLIFT ="; USING
"##.###"; FSUP
LOCATE 16, 10: PRINT "1: INCREASE UPSTREAM BLANKET"
LOCATE 17, 10: PRINT "2: INCREASE THICKNESS OF APRON"
LOCATE 18, 10: PRINT "3: INSERT FILTER AND DRAINS UNDER THE APRON"
LOCATE 19, 10: PRINT "4: TAKE IT AS IT IS"
DO
LOCATE 21, 13: INPUT "CHOOSE ONE ..........."; sec$
LOOP UNTIL sec$ = "1" OR sec$ = "2" OR sec$ = "3" OR sec$ = "4"
SELECT CASE sec$
CASE "1"
GOTO LAB70
CASE "2"
GOTO LAB70
CASE "3"
filtre = 1
IF cek <> 1 THEN NDRAIN% = (ABS(jo(jou1) - jo(jou2)) / 5)
uplift = uplift * .7
FSUP = weight / uplift
GOTO 441
CASE "4"
GOTO 1028
END SELECT
ELSEIF FSUP > 1.3 THEN
CLS
LOCATE 15, 10: PRINT "FACTOR OF SAFETY AGAINST UPLIFT="; USING "##.###";
FSUP
LOCATE 16, 10: PRINT "Fsup > 1.3, THUS REDUCE ONE OF THE FOLLOWING
DIMENSIONS"
LOCATE 17, 10: PRINT "1: UPSTREAM BLANKET LENGTH AND CUT-OFF DEPTH"
LOCATE 18, 10: PRINT "2: THICKNESS OF THE APRON OR"
LOCATE 19, 10: PRINT "3: TAKE IT AS IT IS"
DO
LOCATE 21, 13: INPUT "CHOOSE ONE ..........."; sec$
LOOP UNTIL sec$ = "1" OR sec$ = "2" OR sec$ = "3"
SELECT CASE sec$
CASE "1"
GOTO LAB70
CASE "2"
GOTO LAB70
CASE "3"
GOTO 1028
END SELECT
END IF
441 IF FSUP < 1.2 THEN
CLS
LOCATE 15, 10: PRINT "FACTOR OF SAFETY AGAINST UPLIFT ="; USING
"##.###"; FSUP
LOCATE 16, 10: PRINT "INSERTING FILTER AND DRAINS IS NOT ENOUGH THUS,IN
ADDITION TO THESE"
LOCATE 17, 10: PRINT "1: INCREASE UPSTREAM BLANKET"
LOCATE 18, 10: PRINT "2: INCREASE THICKNESS OF APRON"
LOCATE 19, 10: PRINT "3: TAKE IT AS IT IS"
DO
LOCATE 21, 13: INPUT "CHOOSE ONE ..........."; sec$
LOOP UNTIL sec$ = "1" OR sec$ = "2" OR sec$ = "3"
SELECT CASE sec$
```

```
CASE "1": GOTO LAB70: : CASE "2": GOTO LAB70: CASE "3"
GOTO 1028: END SELECT
END IF
1028
MRES = 0: VERF = 0
FOR j% = 1 TO nbo
mweig(j%) = weigh(sno(j%)) * ABS(xc(sno(j%)) - jo(jom))
MRES = MRES + mweig(j%)
FD(j%) = weigh(sno(j%)) * EQA
VERF = weigh(sno(j%)) + VERF
mfd(j%) = ABS(yc(sno(j%)) - ho(jom)) * FD(j%)
NEXT j%
fh = HEIGHT ^ 2 * gw / 2
mfh = fh * (HEIGHT / 3 + ABS(ho(jom)))
C = .7 * (1 - TETAP / 1.571)
fw = .726 * C * EQA * gw * HEIGHT ^ 2
mfw = fw * ABS(.412 * HEIGHT - (ho(jom)))
firad = FI * 3.141592654# / 180
ka = (1 - SIN(firad)) / (1 + SIN(firad))
fs1 = gw * HEIGHT * ka * (ABS(ho(JOHAC2) - ho(JOHAC1)))
fs2 = (gs - gw) * ka * (ABS(ho(JOHAC2) - ho(JOHAC1))) ^ 2 / 2
MFS1 = fs1 * (ABS(ho(JOHAC2) - ho(JOHAC1)) / 2)
MFS2 = fs2 * (ABS(ho(JOHAC2) - ho(JOHAC1)) / 3)
IF ux(JOHAC1) < ux(JOHAC2) THEN
fuh1 = gw * ux(JOHAC1) * ABS(ho(JOHAC2) - ho(JOHAC1))
fuh2 = gw * (ux(JOHAC2) - ux(JOHAC1)) * ABS(ho(JOHAC2) - ho(JOHAC1)) /
ELSE    2
fuh1 = gw * ux(JOHAC2) * ABS(ho(JOHAC2) - ho(JOHAC1))
fuh2 = gw * (ux(JOHAC1) - ux(JOHAC2)) * ABS(ho(JOHAC2) - ho(JOHAC1)) /
END IF  2
MFUH1 = fuh1 * ABS(ho(JOHAC2) - ho(JOHAC1)) / 2
MFUH2 = fuh2 * ABS(ho(JOHAC2) - ho(JOHAC1)) / 3
IF ux(jnuo1) > ux(jnuo2) THEN
fu1 = gw * ux(jnuo2) * ABS(jo(jnuo1) - jo(jnuo2))
fu2 = gw * (ux(jnuo1) - ux(jnuo2)) * ABS(jo(jnuo1) - jo(jnuo2)) / 2
ELSE
fu1 = gw * ux(jnuo1) * ABS(jo(jnuo1) - jo(jnuo2))
fu2 = gw * (ux(jnuo2) - ux(jnuo1)) * ABS(jo(jnuo1) - jo(jnuo2)) / 2
END IF
IF TETAP <> 0 THEN
FV = (HEIGHT ^ 2 * TAN(TETAP) / 2 * gw)
MFV = FV * ABS((HEIGHT * TAN(TETAP)) * (1 / 3) - (jo(jom)))
END IF
mfu1 = fu1 * ABS(jo(jnuo1) - jo(jnuo2)) / 2
mfu2 = fu2 * ABS(jo(jnuo1) - jo(jnuo2)) / 3 * 2
MRES = MRES + MFV
move = mfh + mfw + MFS1 + MFS2 + mfu1 + mfu2 + MFUH1 + MFUH2
FOR i = 1 TO nbo
move = move + mfd(i)
NEXT
IF can = 1 OR chek1 = 1 THEN
FSOVE = MRES / move
IF FSOVE < 1.2 THEN
CLS : LOCATE 15, 2: PRINT "FACTOR OF SAFETY AGAINST OVERTURNING WITH
EARTHQUAKE"; USING "##.###"; FSOVE
LOCATE 16, 2: PRINT "1: ENLARGE THE DIMENSIONS OF SPILLWAY OR"
LOCATE 17, 2: PRINT "2: TAKE IT AS IT IS"
DO
LOCATE 21, 13: INPUT "CHOOSE ONE ..........."; sec$
LOOP UNTIL sec$ = "1" OR sec$ = "2"
```

```
fsov = MRES / mov
IF fsov < 1.5 THEN
CLS
LOCATE 15, 10: PRINT "FACTOR OF SAFETY AGAINST OVERTURNING WITHOUT
EARTHQUAKE "; USING "##.###"; fsov
LOCATE 16, 10: PRINT "1: INCREASE THE DIMENSIONS OF SPILLWAY SINCE, FS <
1.5"
LOCATE 17, 10: PRINT "2: TAKE AS IT IS"
DO
LOCATE 19, 13: INPUT "CHOOSE ONE ..........."; sec$
LOOP UNTIL sec$ = "1" OR sec$ = "2"
SELECT CASE sec$
CASE "1"
GOTO LAB70
CASE "2"
GOTO 1033
END SELECT
END IF
1033 MRESE = 0: MOVEE = 0
FOR i = 1 TO nbo
mweig(i) = weigh(sno(i)) * ABS(xc(sno(i)) - jo(JOME))
MRESE = MRESE + mweig(i)
FD(i) = weigh(sno(i)) * EQA
mfd(i) = FD(i) * ABS(yc(sno(i)) - ho(JOME))
MOVEE = MOVEE + mfd(i)
NEXT i
FS = GSD * ka * (ABS(ho(JOHAC2) - ho(JOHAC1))) ^ 2 / 2
MFS = FS * ABS(ho(JOHAC2) - ho(JOHAC1)) / 3
MOVEE = MOVEE + MFS
FSOVEE = MRESE / MOVEE
END IF
tweigh = 0: tfd = 0
FOR j = 1 TO nb
FD(j) = weigh(j) * EQA
tweigh = weigh(j) + tweigh
tfd = FD(j) + tfd
NEXT j
uplift = (gw * (ux(jnus1) + ux(jnus2)) * ABS(jo(jnus1) - jo(jnus2))) / 2
* .5
IF filtre = 1 THEN uplift = uplift * .7
ver = tweigh - uplift + FV
hor = tfd + fh + fw + fs1 + fs2 + fuh1 + fuh2
widthr = ABS(jo(jnus1) - jo(jnus2))
FSSSSE = (fric * ver + .5 * SHEAR * widthr) / hor
IF FSSSSE < 3 THEN
CLS : LOCATE 15, 10: PRINT "FACTOR OF SAFETY AGAINST COMBINED AND SHEAR
SLIDING"
LOCATE 16, 10: PRINT "WITH EARTHQUAKE = "; USING "##.##"; FSSSSE
LOCATE 17, 10: PRINT "1: ENLARGE THE DIMENSIONS OF THE STRUCTURE SINCE,
FS < 1.2"
LOCATE 18, 10: PRINT "2: TAKE AS IT IS"
DO
LOCATE 19, 13: INPUT "CHOOSE ONE ..........."; sec$
LOOP UNTIL sec$ = "1" OR sec$ = "2"
SELECT CASE sec$
CASE "1"
GOTO LAB70
CASE "2"
GOTO 1039
END SELECT
```

```
LOCATE 19, 13: INPUT "CHOOSE ONE ..........."; sec$
LOOP UNTIL sec$ = "1" OR sec$ = "2"
SELECT CASE sec$
CASE "1"
GOTO LAB70
CASE "2"
GOTO 1035
END SELECT
END IF
1035 ver = tweigh
hor = tfd + fs1 + fs2
fsslee = fric * ver / hor
IF can = 1 OR chek1 = 1 THEN
KUTLESPILL = totalan * LSPILL + HACIM
BLANKETSPILL = .3 * LSPILL * (ABS(jo(UJ1) - jo(UJ2)) + ABS(ho(UJ1) -
ho(UJ2)))
END IF
IF can = 2 OR chek1 = 2 THEN
KUTLESLUI = totalan * SD1 * numslc
BLANKETSLUI = .3 * SD1 * numslc * (ABS(jo(UJ1) - jo(UJ2)) + ABS(ho(UJ1)
- ho(UJ2)))
END IF
IF can = 3 THEN kutleintake = totalan * ORTAB
IF chek1 = 3 THEN ORTAB = (B2 + B4) / 2: kutleintake = totalan * ORTAB
BLANKETINTAKE = .3 * (B4 + 2) * (ABS(jo(UJ1) - jo(UJ2)) + ABS(ho(UJ1) -
ho(UJ2)))
IF chek2 = 1 THEN
ORTAB = (B2 + B4) / 2: KUTLEINTAKE1 = totalan * ORTAB
BLANKETINTAKE1 = .3 * (B4 + 2) * (ABS(jo(UJ1) - jo(UJ2)) + ABS(ho(UJ1) -
ho(UJ2)))
END IF
IF chek2 = 2 THEN
ORTAB = (B2I + B4I) / 2: KUTLEINTAKE2 = totalan * ORTAB
BLANKETINTAKE2 = .3 * (B4I + 2) * (ABS(jo(UJ1) - jo(UJ2)) + ABS(ho(UJ1)
- ho(UJ2)))
END IF
IF chek1 = 1 OR can = 1 THEN draincostspill = UDRAIN * NDRAIN% * LSPILL
IF chek1 = 2 OR can = 2 THEN DRAINCOSTSLUI = UDRAIN * NDRAIN% * SD1
IF chek1 = 3 OR can = 3 THEN DRAINCOSTIN = UDRAIN * NDRAIN% * ORTAB
IF chek <> 1 THEN
IF chek1 = 1 OR can = 1 THEN
spillcost = KUTLESPILL * URCONC
blanketcostsp = BLANKETSPILL * UCONC
END IF
IF chek1 = 2 OR can = 2 THEN
sluicost = KUTLESLUI * URCONC / 2
BLANKETCOSTSL = BLANKETSLUI * UCONC / 2
END IF
IF chek1 = 3 OR can = 3 THEN
intakecost = kutleintake * URCONC
BLANKETCOSTIN = BLANKETINTAKE * UCONC
END IF
CLS
LOCATE 3, 10
IF can = 1 OR chek1 = 1 THEN PRINT "STABILITY ANALYSIS OF SPILLWAY "
IF can = 2 OR chek1 = 2 THEN PRINT "STABILITY ANALYSIS OF SLUICEWAY "
IF can = 3 OR chek1 = 3 THEN PRINT "STABILITY ANALYSIS OF INTAKE "

LOCATE 5, 2
 PRINT " èéééééééééééééééùéééééééééééééùééééééééééééùéééééééééééé£"
```

```
PRINT " ¤   FACTOR OF    ¤    WITH    ¤ WITHOUT    ¤   EMPTY    ¤ "
PRINT " ¤    SAFETY      ¤ EARTHQUAKE ¤ EARTHQUAKE ¤ RESERVOIR  ¤"
PRINT " äëëëëëëëëëëëëëëëëöëëëëëëëëëëëëöëëëëëëëëëëëëöëëëëëëëëëëëë¿"
PRINT " ¤ UPLIFT         ¤            ¤            ¤            ¤ "
PRINT " äëëëëëëëëëëëëëëëëöëëëëëëëëëëëëöëëëëëëëëëëëëöëëëëëëëëëëëë¿ "
PRINT " ¤ OVERTURNING    ¤            ¤            ¤            ¤ "
PRINT " äëëëëëëëëëëëëëëëëöëëëëëëëëëëëëöëëëëëëëëëëëëöëëëëëëëëëëëë¿"
PRINT " ¤ SLIDING        ¤            ¤            ¤            ¤ "
PRINT " äëëëëëëëëëëëëëëëëöëëëëëëëëëëëëöëëëëëëëëëëëëöëëëëëëëëëëëë¿"
PRINT " ¤SHEAR/SLIDING   ¤            ¤            ¤            ¤"
PRINT " àëëëëëëëëëëëëëëëëòëëëëëëëëëëëëòëëëëëëëëëëëëòëëëëëëëëëëëë¥"
PRINT
IF can = 1 OR chek1 = 1 THEN
 PRINT "                            èëëëëëëëëëùëëëëëëëëë£"
 PRINT "                            ¤ MAXIMUM ¤ MINIMUM ¤"
 PRINT " èëëëëëëëëëëëëëëëëëëëëëëëëëëöëëëëëëëëëöëëëëëëëëë¿"
 PRINT " ¤ BASE PRESSURE (kN/m») ¤         ¤         ¤"
 PRINT " àëëëëëëëëëëëëëëëëëëëëëëëëëëòëëëëëëëëëòëëëëëëëëë¥"
END IF
IF can = 3 OR chek1 = 3 OR can = 2 OR chek1 = 2 THEN
LOCATE 9, 21: PRINT "-": LOCATE 9, 36: PRINT USING "##.##"; FSUP: LOCATE
9, 49: PRINT "-"
LOCATE 11, 21: PRINT "-": LOCATE 11, 36: PRINT "-": LOCATE 11, 49: PRINT
"-"
LOCATE 13, 21: PRINT USING "##.##"; fssle: LOCATE 13, 36: PRINT USING
"##.##"; fssl: LOCATE 13, 49: PRINT USING "##.##"; fsslee
LOCATE 15, 21: PRINT USING "##.##"; FSSSSE: LOCATE 15, 36: PRINT USING
"##.##"; FSSS: LOCATE 15, 49: PRINT "-"
END IF
IF can = 1 OR chek1 = 1 THEN
LOCATE 9, 21: PRINT "-": LOCATE 9, 36: PRINT USING "##.##"; FSUP: LOCATE
9, 49: PRINT "-"
LOCATE 11, 21: PRINT USING "##.##"; FSOVE: LOCATE 11, 36: PRINT USING
"##.##"; fsov: LOCATE 11, 49: PRINT USING "##.##"; FSOVEE
LOCATE 13, 21: PRINT USING "##.##"; fssle: LOCATE 13, 36: PRINT USING
"##.##"; fssl: LOCATE 13, 49: PRINT USING "##.##"; fsslee
LOCATE 15, 21: PRINT USING "##.##"; FSSSSE: LOCATE 15, 36: PRINT USING
"##.##"; FSSS: LOCATE 15, 49: PRINT "-"
LOCATE 21, 28: PRINT USING "####.##"; pmax: LOCATE 21, 39: PRINT USING
"####.##"; pmin
END IF
IF can = 1 OR chek1 = 1 THEN LOCATE 23, 2: PRINT "SPILLWAY BODY COST",
spillcost, "BLANKET COST", blanketcostsp, "DRAIN COST", draincostspill
IF can = 2 THEN LOCATE 23, 2: PRINT "SLUICEWAY BODY COST", sluicost,
"BLANKET COST", BLANKETCOSTSL, "DRAIN COST", DRAINCOSTSLUI
IF can = 3 THEN LOCATE 23, 2: PRINT "INTAKE BODY COST ", intakecost,
"BLANKET COST", BLANKETCOSTINK, "DRAIN COST", DRAINCOSTIN
LOCATE 24, 2: PRINT "Press <ESC> to continue"
DO: LOOP UNTIL INKEY$ = CHR$(27)
IF can = 1 OR can = 2 OR can = 3 THEN GOTO statmenu
END IF
221 RETURN
stat11:
FOR i = 1 TO 5
K33(i) = k3(i)
NEXT i
CLS
DO
LOCATE 15, 10: PRINT "ENTER DATA FOR SPILLWAY STRUCTURE"
LOCATE 23, 1: PRINT "PRESS <ESC> TO CONTINUE"
```

```
LOOP UNTIL INKEY$ = CHR$(27)
chek1 = 1: filtre = 0
chek2 = 0
GOSUB STAT1
CLS
DO
LOCATE 15, 10: PRINT "ENTER DATA FOR SLUICEWAY STRUCTURE"
LOCATE 16, 10: PRINT "PRESS <ESC> TO CONTINUE"
LOOP UNTIL INKEY$ = CHR$(27)
chek1 = 2: filtre = 0
GOSUB STAT1
CLS
IF TWO = 1 THEN
chek1 = 3: filtre = 0
CLS
DO
LOCATE 15, 10: PRINT "ENTER DATA FOR INTAKE STRUCTURE"
LOCATE 16, 10: PRINT "PRESS <ESC> TO CONTINUE"
LOOP UNTIL INKEY$ = CHR$(27)
GOSUB STAT1
WALL1 = 2
W24 = Y5 + .2 * (1 + Y5)
CALL WALL(WALL1, gw, GC, gs, GSD, siga, BET, FI, fric, W24, W21, W22,
W23, W25, PMIN2, PMAX2, FSS2, FSOV2)
WALLALAN = W21 * W23 + W24 * W25 + W24 * (W23 - W22 - W25) / 2
WALLVOL2 = WALLALAN * (jo(jou1) - jo(jnus2) + LTRAN)
END IF
IF TWO = 2 THEN
CLS
DO
LOCATE 15, 10: PRINT "ENTER DATA FOR FIRST INTAKE STRUCTURE"
LOCATE 16, 10: PRINT "PRESS <ESC> TO CONTINUE"
LOOP UNTIL INKEY$ = CHR$(27)
chek1 = 3: filtre = 0
GOSUB STAT1
WALL1 = 2
W24 = Y5 + .2 * (1 + Y5)
CALL WALL(WALL1, gw, GC, gs, GSD, siga, BET, FI, fric, W24, W21, W22,
W23, W25, PMIN2, PMAX2, FSS2, FSOV2)
WALLALAN = W21 * W23 + W24 * W25 + W24 * (W23 - W22 - W25) / 2
WALLVOL2 = WALLALAN * (jo(jou1) - jo(jnus2) + LTRAN)
CLS
DO
LOCATE 15, 10: PRINT "ENTER DATA FOR SECOND INTAKE STRUCTURE"
LOCATE 16, 10: PRINT "PRESS <ESC> TO CONTINUE"
LOOP UNTIL INKEY$ = CHR$(27)
chek1 = 3: filtre = 0
GOSUB STAT1
WALL1 = 2
W44 = Y5I + .2 * (1 + Y5I)
CALL WALL(WALL1, gw, GC, gs, GSD, siga, BET, FI, fric, W44, W41, W42,
W43, W45, PMIN4, PMAX4, FSS4, FSOV4)
WALLALAN = W41 * W43 + W44 * W45 + W44 * (W43 - W42 - W45) / 2
WALLVOL4 = WALLALAN * (jo(jou1) - jo(jnus2) + LTRAN)
END IF
WALL1 = 3
W34 = K33(1) - krip + .1 * (USTIL(1) + YDES2)
CALL WALL(WALL1, gw, GC, gs, GSD, siga, BET, FI, fric, W34, W31, W32,
W33, W35, PMIN3, PMAX3, FSS3, FSOV3)
WALLALAN = W31 * W33 + W34 * W35 + W34 * (W33 - W32 - W35) / 2
```

```
WALLVOL3 = WALLALAN * (jo(jou1) - jo(jnus2) + 15)
WALL1 = 1
KSLUI = kinit(1) + .2 * (1 + (kinit(1) - BOTELE))
W14 = KSLUI - BOTELE
CALL WALL(WALL1, gw, GC, gs, GSD, siga, BET, FI, fric, W14, W11, W12,
W13, W15, PMIN1, pmax1, FSS1, FSOV1)
WALLALAN = W11 * W13 + W14 * W15 + W14 * (W13 - W12 - W15) / 2
WALLVOL1 = WALLALAN * (jo(jnus1) - jo(jou1))
TOTALWALLVOL = 2 * (WALLVOL1 + WALLVOL2 + WALLVOL3 + WALLVOL4)
TOTALCONCRETEV = KUTLESPILL + numsic * KULESLUI + kutleintake +
KUTLEINTAKE1 + KUTLEINTAKE2 + TOTALWALLVOL
TOTALBLANKET = BLANKETSPILL + BLANKETSLUI + BLANKETINTAKE +
BLANKETINTAKE1 + BLANKETINTAKE2
PIERVOLUME = TPI * (KSLUI - ks) * 3 * NPI
CRESTBRIDGEV = 3 * .2 * LT
INTPIERVOLUME = T1 * (Y5 + .2 * (Y5 + 1)) * 3 * n1 + T2 * (KSLUI - bele
+ .6) * 7 * NUM
BRIDGEVOLUME = .2 * B4 * 3
CLS
LOCATE 15, 10: PRINT "ENTER TYPE OF GATE USED AT THE ENTRANCE OF MAIN
CANAL"
LOCATE 16, 10: PRINT "C: FOR TYPE 'C'"
LOCATE 17, 10: PRINT "D: FOR TYPE 'D'"
LOCATE 18, 10: PRINT "E: FOR TYPE 'E'"
LOCATE 19, 10: PRINT "R: FOR RAPIER GATE"
DO: LOCATE 21, 13: INPUT " Choose one .......", GATE$: GATE$ =
UCASE$(GATE$): LOOP UNTIL GATE$ = "C" OR GATE$ = "D" OR GATE$ = "E" OR
GATE$ = "R"
CALL gatecost(GATE$, B1P, USTEEL, n1, GATECOSTM)
CLS
LOCATE 15, 10: PRINT "ENTER HEIGHT OF GATE USED AT THE ENTRANCE OF MAIN
CANAL";
INPUT HEIGHTGATE
LOCATE 16, 10: PRINT "ENTER WIDTH OF GATE USED AT THE ENTRANCE OF MAIN
CANAL";
INPUT B1P
CLS : LOCATE 15, 10: PRINT "ENTER TYPE OF GATE USED AT THE ENTRANCE OF
INTAKE"
LOCATE 16, 10: PRINT "C: FOR TYPE 'C'"
LOCATE 17, 10: PRINT "D: FOR TYPE 'D'"
LOCATE 18, 10: PRINT "E: FOR TYPE 'E'"
LOCATE 19, 10: PRINT "R: FOR RAPIER GATE"
DO: LOCATE 21, 13: INPUT " Choose one .......", GATE$: GATE$ =
UCASE$(GATE$): LOOP UNTIL GATE$ = "C" OR GATE$ = "D" OR GATE$ = "E" OR
GATE$ = "R"
CALL gatecost(GATE$, B1PE, USTEEL, n1, GATECOSTE)
CLS : LOCATE 15, 10: INPUT "ENTER HEIGHT OF GATE USED AT THE ENTRANCE OF
INTAKE"; HEIGHTGATEE
LOCATE 16, 10: INPUT "ENTER WIDTH OF GATE USED AT THE ENTRANCE OF
INTAKE"; B1PE
VOLUMEWALLM = .6 * (Y5 + .2 * (Y5 + 1) - HEIGHTGATE) * WIDTHGATE * (n1 +
1)
VOLUMEWALLE = .6 * (KSLUI - bele + .6 - HEIGHTGATEE) * WIDTHGATEE * (NUM
+ 1)
CLS
LOCATE 15, 10: PRINT "ENTER TYPE OF GATE USED AT THE SLUICEWAY"
LOCATE 16, 10: PRINT "C: FOR TYPE 'C'"
LOCATE 17, 10: PRINT "D: FOR TYPE 'D'"
LOCATE 18, 10: PRINT "E: FOR TYPE 'E'"
LOCATE 19, 10: PRINT "R: FOR RAPIER GATE"
```

```
DO: LOCATE 21, 13: INPUT " Choose one .......": GATES$: GATES$ =
UCASE$(GATES$): LOOP UNTIL GATES$ = "C" OR GATES$ = "D" OR GATES$ = "E" OR
GATES$ = "R"
CALL gatecost(GATES$, B1P, USTEEL, numslc, GATECOSTS)
CLS
LOCATE 15, 10: INPUT "ENTER WIDTH OF GATE USED AT THE SLUICEWAY"; B1P
CLS
LOCATE 15, 10: INPUT "ENTER NUMBER OF GUDING WALL"; NGUIDE
DIVEDERVOL = .6 * 5 * (KSLUI - bele) * NGIUDE
VOLUMEVOLSLUI = (KSLUI - bele - SD2) * .6 * SD1 * numslc
TOTALCONCVOL = TOTALCONCRETEV + INTPIERVOLUME + BRIDGEVOLUME +
CRESTBRIDGEV + VOLUMEWALLM + VOLUMEWALLE + DIVIDERVOL + VOLUMEVOLSLUI
CONCRETECOST = TOTALCONCVOL * URCONC
BALANKETCOST = TOTALBLANKET * UCONC
OVERCOST = CONCRETECOST + BALANKETCOST + GATECOSTM + GATECOSTE +
GATECOSTS + draincostspill + DRAINCOSTSLUI * numslc + DRAINCOSTIN
CLS : LOCATE 15, 10: PRINT "OVERALL COST=", OVERCOST: SLEEP
GOSUB menu2
'RETURN


KEMAL10:
        IF NOB1 <> 0 THEN
        FOR i = 1 TO NOB1: KEX = us(i): REN = 3: GOSUB LIN10: NEXT i
        END IF
        IF NOB2 <> 0 THEN
        FOR i = 1 TO NOB2: KEX = sno(i): REN = 4: GOSUB LIN10: NEXT i
        END IF
        DO
        LOOP UNTIL INKEY$ = CHR$(27)
        SCREEN 10
        SCREEN 0
        RETURN
LIN10:
        GET #55, KEX, cem(KEX)
        GET #50, cem(KEX).jn1, coo(cem(KEX).jn1)
        GET #50, cem(KEX).JN2, coo(cem(KEX).JN2)
        GET #50, cem(KEX).JN3, coo(cem(KEX).JN3)
        sxx1 = coo(cem(KEX).jn1).x
        syy1 = coo(cem(KEX).jn1).y
        sxx2 = coo(cem(KEX).JN2).x
        syy2 = coo(cem(KEX).JN2).y
        sxx3 = coo(cem(KEX).JN3).x
        syy3 = coo(cem(KEX).JN3).y
        IF ABS(sxx1) > C1 THEN C1 = ABS(sxx1)
        IF ABS(sxx2) > C1 THEN C1 = ABS(sxx2)
        IF ABS(sxx3) > C1 THEN C1 = ABS(sxx3)
        IF ABS(syy1) > C2 THEN C2 = ABS(syy1)
        IF ABS(syy2) > C2 THEN C2 = ABS(syy2)
        IF ABS(syy3) > C2 THEN C2 = ABS(syy3)
        IF C1 <> 0 THEN r1 = 320 / C1
        IF C2 <> 0 THEN r2 = 100 / C2
        IF r1 > r2 THEN r = r2
        IF r2 > r1 THEN r = r1
        sxx1 = sxx1 * r
        syy1 = syy1 * r
        sxx2 = sxx2 * r
        syy2 = syy2 * r
        sxx3 = sxx3 * r
        syy3 = syy3 * r
```

```
        LINE (sxx1, syy1)-(sxx2, syy2), REN
        LINE (sxx2, syy2)-(sxx3, syy3), REN
        LINE (sxx3, syy3)-(sxx1, syy1), REN
RETURN
cizim10:
        SCREEN 8
        WINDOW (0, 100)-(320, -100)
        IF tom = 1 THEN
        FOR j = 1 TO NJ
        GET #50, j, coo(i)
        IF ABS(coo(i).x) > C1 THEN C1 = ABS(coo(i).x)
        IF ABS(coo(i).y) > C2 THEN C2 = ABS(coo(i).y)
        NEXT
        IF C1 <> 0 THEN r1 = 320 / C1
        IF C2 <> 0 THEN r2 = 100 / C2
        IF r1 > r2 THEN r = r2
        IF r2 > r1 THEN r = r1
        FOR j = 1 TO NJ
        GET #50, j, coo(i)
        sxx2 = r * coo(i).x
        syy2 = r * coo(i).y
        IF ot = 1 THEN LINE (sxx1, syy1)-(sxx2, syy2)
        sxx1 = sxx2
        syy1 = syy2
        ot = 1
        NEXT j
        GET #50, 1, coo(1)
        sxx2 = coo(1).x * r
        syy2 = coo(1).y * r
        LINE (sxx1, syy1)-(sxx2, syy2)
        ELSE
        FOR i = 1 TO nb
        KEX = i
        REN = 7
        GOSUB LIN10
        NEXT i
        END IF
        RETURN
FRAMEJOINT:
LOCATE 16, 1: PRINT
"ÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜ
ÜÜÜÜÜÜÜÜÜÜ"
LOCATE , 1: PRINT
"ÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜèëëëëëëëëëëëëëëëùëëëëëëëëëëëëëëë£ÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜ
ÜÜÜÜÜÜÜÜÜÜ"
LOCATE , 1: PRINT "ÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜ¤ X coordinate ¤ Y coordinate
¤ÝÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜ"
LOCATE , 1: PRINT
"Üèëëëëëëëëëëëëëëëöëëëëëëëëëëëëëëëöëëëëëëëëëëëëëëë¿ÝÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜ
ÜÜÜÜÜÜÜÜÜÜ"
LOCATE , 1: PRINT "Ü¤JOINT NO:     ¤               ¤
¤ÝÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜ"
LOCATE , 1: PRINT
"Üàëëëëëëëëëëëëëëëòëëëëëëëëëëëëëëëòëëëëëëëëëëëëëëë¥ÝÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜ
ÜÜÜÜÜÜÜÜÜÜ"
LOCATE , 1: PRINT
"ÜÜÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜ
ÜÜÜÜÜÜÜÜÜÜ"
LOCATE , 1: PRINT
"ÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜ
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        LINE (sxx1, syy1)-(sxx2, syy2), REN
        LINE (sxx2, syy2)-(sxx3, syy3), REN
        LINE (sxx3, syy3)-(sxx1, syy1), REN
RETURN
cizim10:
        SCREEN 8
        WINDOW (0, 100)-(320, -100)
        IF tom = 1 THEN
        FOR j = 1 TO NJ
        GET #50, j, coo(i)
        IF ABS(coo(i).x) > C1 THEN C1 = ABS(coo(i).x)
        IF ABS(coo(i).y) > C2 THEN C2 = ABS(coo(i).y)
        NEXT
        IF C1 <> 0 THEN r1 = 320 / C1
        IF C2 <> 0 THEN r2 = 100 / C2
        IF r1 > r2 THEN r = r2
        IF r2 > r1 THEN r = r1
        FOR j = 1 TO NJ
        GET #50, j, coo(i)
        sxx2 = r * coo(i).x
        syy2 = r * coo(i).y
        IF ot = 1 THEN LINE (sxx1, syy1)-(sxx2, syy2)
        sxx1 = sxx2
        syy1 = syy2
        ot = 1
        NEXT j
        GET #50, 1, coo(1)
        sxx2 = coo(1).x * r
        syy2 = coo(1).y * r
        LINE (sxx1, syy1)-(sxx2, syy2)
        ELSE
        FOR i = 1 TO nb
        KEX = i
        REN = 7
        GOSUB LIN10
        NEXT i
        END IF
        RETURN
FRAMEJOINT:
LOCATE 16, 1: PRINT
"ÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜ
ÜÜÜÜÜÜÜÜÜ"
LOCATE , 1: PRINT
"ÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜèëëëëëëëëëëëëëëëùëëëëëëëëëëëëëëë£ÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜ
ÜÜÜÜÜÜÜÜÜ"
LOCATE , 1: PRINT "ÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜ¤ X coordinate ¤ Y coordinate
¤ÝÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜ"
LOCATE , 1: PRINT
"Üèëëëëëëëëëëëëëëëöëëëëëëëëëëëëëëëëöëëëëëëëëëëëëëëëë¿ÝÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜ
ÜÜÜÜÜÜÜÜÜ"
LOCATE , 1: PRINT "Ü¤JOINT NO:      ¤                 ¤
¤ÝÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜ"
LOCATE , 1: PRINT
"Üàëëëëëëëëëëëëëëëòëëëëëëëëëëëëëëëëòëëëëëëëëëëëëëëëë¥ÝÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜ
ÜÜÜÜÜÜÜÜÜ"
LOCATE , 1: PRINT
"ÜÜÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜ
ÜÜÜÜÜÜÜÜÜ"
LOCATE , 1: PRINT
"ÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜ
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ÚÚÚÚÚÚÚÚÚ"
LOCATE 22, 50: PRINT "<ESC> TO CONTINUE ...."
RETURN
FRAMEBLOK:
LOCATE 16, 1: PRINT
"ÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚ
ÚÚÚÚÚÚÚÚÚ"
LOCATE , 1: PRINT
"ÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚèëëëëëëëëëùëëëëëëëëëëùëëëëëëëëëë£ÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚ
ÚÚÚÚÚÚÚÚÚ"
LOCATE , 1: PRINT "ÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚ¤ JOINT 1 ¤ JOINT 2 ¤ JOINT 3
¤ÝÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚ"
LOCATE , 1: PRINT
"Úèëëëëëëëëëëëëëëöëëëëëëëëëëöëëëëëëëëëëöëëëëëëëëëë¿ÝÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚ
ÚÚÚÚÚÚÚÚÚ"
LOCATE , 1: PRINT "Ú¤BLOCK NO:      ¤          ¤          ¤
¤ÝÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚ"
LOCATE , 1: PRINT
"Úàëëëëëëëëëëëëëëëòëëëëëëëëëëòëëëëëëëëëëòëëëëëëëëëë¥ÝÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚ
ÚÚÚÚÚÚÚÚÚ"
LOCATE , 1: PRINT
"ÚÚÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚ
ÚÚÚÚÚÚÚÚÚ"
LOCATE , 1: PRINT
"ÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚ
ÚÚÚÚÚÚÚÚÚ"
LOCATE 22, 50: PRINT "<ESC> TO CONTINUE ...."
RETURN
TUSLAR:
        KEY 15, CHR$(0) + CHR$(72): KEY 16, CHR$(0) + CHR$(80)
        KEY 17, CHR$(0) + CHR$(75): KEY 18, CHR$(0) + CHR$(77)
        KEY 19, CHR$(32) + CHR$(72): KEY 20, CHR$(32) + CHR$(80)
        KEY 21, CHR$(32) + CHR$(75): KEY 22, CHR$(32) + CHR$(77)
        KEY 23, CHR$(0) + CHR$(57): KEY 24, CHR$(32) + CHR$(57)
        DO
        KEY(15) ON: KEY(16) ON: KEY(17) ON: KEY(18) ON:
        KEY(19) ON: KEY(20) ON: KEY(21) ON: KEY(22) ON:
        KEY(23) ON: KEY(24) ON: ON KEY(15) GOSUB YUKARI
        ON KEY(16) GOSUB ASAGI
        ON KEY(19) GOSUB YUKARI: ON KEY(20) GOSUB ASAGI
        ON KEY(17) GOSUB SOLA10: ON KEY(18) GOSUB SAGA10
        ON KEY(21) GOSUB SOLA10: ON KEY(22) GOSUB SAGA10
        ON KEY(23) GOSUB DEGIS10: ON KEY(24) GOSUB DEGIS10
        LOOP UNTIL INKEY$ = CHR$(27)
        RETURN
ASAGI:
        Y5 = Y5 + 1
        IF tom = 1 THEN
        GOSUB FRAMEJOINT
        IF Y5 > NJ THEN Y5 = NJ: BEEP
        GOSUB BOS6
        ELSE
        GOSUB FRAMEBLOK
        IF Y5 > nb THEN Y5 = nb: BEEP
        GOSUB BOS5
        END IF
        RETURN
YUKARI:
Y5 = Y5 - 1
       IF Y5 < 1 THEN Y5 = 1: BEEP
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        IF tom = 1 THEN
        GOSUB FRAMEJOINT
        GOSUB BOS6
        ELSE
        GOSUB FRAMEBLOK
        GOSUB BOS5
        END IF
        RETURN
SAGA10:
        IF Y5 = 0 THEN Y5 = 1
        IF tom = 1 THEN
        kop = 2
        LOCATE ZZ, zp: PRINT USING FOR3$; Y5
        LOCATE ZZ, xx1 + 10: PRINT " "
        LOCATE ZZ, xx2 + 11: PRINT ""
        ELSE
        BABA = BABA + 1
        IF BABA > 3 THEN BABA = 3: BEEP
        GOSUB BOS2
        END IF
        RETURN
SOLA10:
        IF tom = 1 THEN
        kop = 1
        IF Y5 = 0 THEN Y5 = 1
        LOCATE ZZ, zp: PRINT USING FOR3$; Y5
        LOCATE ZZ, xx2 + 11: PRINT " "
        LOCATE ZZ, xx1 + 10: PRINT ""
        ELSE
        BABA = BABA - 1
        IF BABA < 1 THEN BABA = 1: BEEP
        IF Y5 = 0 THEN Y5 = 1
        GOSUB BOS2
        END IF
        RETURN
DEGIS10:
        IF tom = 1 THEN
        IF kop = 1 THEN LOCATE ZZ, xx1: PRINT "          ": LOCATE ZZ,
xx1: INPUT "", OKU$: coo(Y5).x = VAL(OKU$): LOCATE ZZ, xx1: PRINT USING
FOR1$; VAL(OKU$)
        IF kop = 2 THEN LOCATE ZZ, xx2: PRINT "          ": LOCATE ZZ,
xx2: INPUT "", OKU$: coo(Y5).y = VAL(OKU$): LOCATE ZZ, xx2: PRINT USING
FOR1$; VAL(OKU$)
        PUT #50, Y5, coo(Y5)
        ELSE
        IF BABA = 1 THEN
        DO
        LOCATE ZZ, 19: PRINT "        "
        LOCATE ZZ, AP1: INPUT "", OKU$
        cem(Y5).jn1 = VAL(OKU$)
        IF VAL(OKU$) > NJ AND VAL(OKU$) < 0 THEN BEEP
        LOOP UNTIL VAL(OKU$) <= NJ AND VAL(OKU$) > 0
        LOCATE ZZ, AP1: PRINT USING FOR2$; VAL(OKU$)
        END IF
        IF BABA = 2 THEN
        DO
        LOCATE ZZ, AP2: PRINT "        "
        LOCATE ZZ, AP2: INPUT "", OKU$
        cem(Y5).JN2 = VAL(OKU$)
        IF VAL(OKU$) > NJ AND VAL(OKU$) < 0 THEN BEEP
```

```
        LOOP UNTIL VAL(OKUS) <= NJ AND VAL(OKUS) > 0
        LOCATE ZZ, AP2
        PRINT USING FOR2$; VAL(OKU$)
        END IF
        IF BABA = 3 THEN
        DO
        LOCATE ZZ, AP3: PRINT "        "
        LOCATE ZZ, AP3: INPUT "", OKU$
        cem(Y5).JN3 = VAL(OKU$)
        IF VAL(OKU$) > NJ AND VAL(OKU$) < 0 THEN BEEP
        LOOP UNTIL VAL(OKU$) <= NJ AND VAL(OKU$) > 0
        LOCATE ZZ, AP2: PRINT USING FOR2$; VAL(OKU$)
        END IF
        PUT #55, Y5, cem(Y5)
        END IF
        RETURN
BOS2:
        LOCATE ZZ, zp: PRINT USING FOR3$; Y5
        IF BABA = 1 THEN
        LOCATE ZZ, 26: PRINT ""
        LOCATE ZZ, 36: PRINT " "
        LOCATE ZZ, 46: PRINT " "
        ELSEIF BABA = 2 THEN
        LOCATE ZZ, 26: PRINT " "
        LOCATE ZZ, 36: PRINT ""
        LOCATE ZZ, 46: PRINT " "
        ELSE
        LOCATE ZZ, 26: PRINT " "
        LOCATE ZZ, 36: PRINT " "
        LOCATE ZZ, 46: PRINT ""
        END IF
        RETURN
BOS5:
        LOCATE ZZ, zp: PRINT USING FOR3$; Y5
        GET #55, Y5, cem(Y5)
        LOCATE ZZ, 18: PRINT USING FOR2$; cem(Y5).jn1
        LOCATE ZZ, 28: PRINT USING FOR2$; cem(Y5).JN2
        LOCATE ZZ, 38: PRINT USING FOR2$; cem(Y5).JN3
        RETURN
BOS6:
        LOCATE ZZ, zp: PRINT USING FOR3$; Y5
        GET #50, Y5, coo(Y5)
        LOCATE ZZ, xx1: PRINT USING FOR1$; coo(Y5).x
        LOCATE ZZ, xx2: PRINT USING FOR1$; coo(Y5).y
        RETURN

REM $STATIC
SUB bucket (QDES(), kinit(), ks, k3(), ho(), YDES1(), USTIL(), FR1(),
NO3, FILOUT$)
DIM RMIN(5), FICTIUOS1(5), FICTIUOS2(5), r(10), MAXSU(5), MINSU(5),
ORTASU(5), MINELE(5)
CLS
LOCATE 15, 20: PRINT "DEFLECTOR BUCKET TYPE IS SUITABLE"
LOCATE 16, 20: PRINT "ACCORDING TO TYPE OF FOUNDATION"
LOCATE 18, 20: PRINT "S: SLOTTED BUCKET "
LOCATE 19, 20: PRINT "O: SOLID BUCKET"
LOCATE 22, 23: PRINT "Choose one .....";
DO
LOCATE 22, 40: PRINT "                         "
LOCATE 22, 40: INPUT INC$
```

```
INC$ = UCASE$(INC$)
LOOP UNTIL INC$ = "S" OR INC$ = "O"
SELECT CASE INC$
CASE "S"
MINIMUM = 999999999
FOR i = 1 TO 5
RMIN(i) = 2.19698 - 1.04403 * FR1(i) + .251838 * FR1(i) ^ 2 - .0324961 *
FR1(i) ^ 3 + .00209972# * FR1(i) ^ 4 - .0000534224# * FR1(i) ^ 5
r(i) = RMIN(i) * (YDES1(i) + USTIL(i) ^ 2 / 19.62)
CLS : LOCATE 15, 15: PRINT " ENTER THE FOLLOWINGS FROM FIGURE 4.7"
LOCATE 16, 15: PRINT " FOR"; QDES(i); "(m3/sec) DESIGN DISCHARGE "
LOCATE 17, 15: PRINT " Fr ="; FR1(i)
LOCATE 18, 15: PRINT " Rmin ="; RMIN(i)
LOCATE 19, 15: INPUT " Tmax/d1"; FICTIUOS1(i)
LOCATE 20, 15: INPUT " Tmin/d1"; FICTIUOS2(i)
MAXSU(i) = FICTIUOS1(i) * YDES1(i)
MINSU(i) = FICTIUOS2(i) * YDES1(i)
ORTASU(i) = (MAXSU(i) + MINSU(i)) / 2
MINELE(i) = k3(i) - ORTASU(i)
IF MINELE(i) < MINIMUM THEN MINIMUM = MINELE(i): RADIUS = r(i)
NEXT i
PRINT "RADIUS OF THE SLOTTED BUCKET (m)="; USING "###.##"; r(i)
PRINT "MINIMUM BOTTOM ELEVATION OF SLOTTED BUCKET ="; USING "####.##";
MINIMUM
DO
LOCATE 23, 22: PRINT "ENTER <ESC>TO CONTINUE"
LOOP UNTIL INKEY$ = CHR$(27)
CASE "O"
MINR = 9999999
FOR i = 1 TO 5
r(i) = .6 * (ho(i) * (kinit(i) - ks)) ^ .5
IF r(i) < MINR THEN MINR = r(i)
NEXT i
PRINT " RADIUS OF SOLID ROLLER BUCKET (m) ="; USING "###.##"; MINR
DO
LOCATE 23, 22: PRINT "ENTER <ESC>TO CONTINUE"
LOOP UNTIL INKEY$ = CHR$(27)
END SELECT
END SUB

SUB crest (q, n, sbed, bele, B2, n1, T1, DSILL, sbasin, ratio, NUM, T2,
uent, BOTELE, freebr, LTRAN, hr, HA, hc, He, hcc, hge, hg, h, HEIGHT,
surele, B4, D, L, y6p, B1, opty, f, Y5)
U1 = q / (B1 * opty + 1.5 * opty ^ 2)
s = opty + 1.3 * U1 ^ 2 / 19.62
353 U2I = U1
24 U2 = q / (B2 * s) + (1.3 * U2I ^ 3) / (19.62 * s)
IF U2 > U1 THEN
BEEP
LOCATE 16, 1: PRINT
LOCATE 1[illegible]ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë"
B2; "DOES NOT FIT THE REQUIREMENT !                    "
LOCATE 18, 1: INPUT "INCREASE THE ENTRANCE WIDTH OF MAIN CANAL"; B2
GOTO 353
END IF
IF ABS(U2I - U2) < .005 THEN
y2 = q / (B2 * U2)
hr = .3 * (U1 ^ 2 - U2 ^ 2) / 19.62
LTRAN1 = (B1 + 2 * 1.5 * (opty + f) - B2) / (2 * TAN(.261799387#))
LTRAN2 = (B1 + 2 * 1.5 * (opty + f) - B2) / (2 * TAN(.34906585#))
```

```
LTRAN = (LTRAN1 + LTRAN2) / 2
IF LTRAN < 0 THEN
BEEP
LOCATE 16, 1: PRINT
LOCATE 1[illegible]ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë"
B2; "DOES NOT FIT THE REQUIREMENT !                    "
LOCATE 18, 1: INPUT "REDUCE THE ENTRANCE WIDTH OF MAIN CANAL"; B2
GOTO 353
END IF
DO
LOCATE 20, 1: INPUT "COMPARTMENT SETTLING BASIN IN FIRST INTAKE  (Y/N)
:  ", AA$
AA$ = UCASE$(AA$)
LOOP UNTIL AA$ = "Y" OR AA$ = "N"
GOTO 5
ELSE
U2I = U2
GOTO 24
END IF
5 B3 = B2 - n1 * T1
UP = q / (B3 * y2)
HA = UP ^ 2 / (19.62 * .65 ^ 2)
FIC = y2 + U2 ^ 2 / 19.62 + HA
U3i = U2
3002 U3 = (19.62 * q + B3 * U3i ^ 3) / (B3 * 19.62 * FIC)
IF ABS(U3i - U3) < .0005 THEN
GOTO 3001
ELSE
U3i = U3
GOTO 3002
END IF
3001 y3 = q / (B3 * U3)
IF AA$ = "N" THEN
B4 = B2
Z = y3 + 1.2 * U3 ^ 2 / 19.62
63   B4 = B4 + .5
u4i = U3
78  U4 = q / (Z * B4) + .6 * u4i ^ 3 / (Z * 9.81)
IF ABS(U4 - u4i) < .005 THEN
hc = .2 * (U3 ^ 2 - U4 ^ 2) / 19.62
Y4 = q / (B4 * U4)
ELSE
u4i = U4
GOTO 78
END IF
HEI = hc
66  He = ((q / (2.88 * B4) - 2 / 3 * HEI ^ (3 / 2)) / Y4) ^ 2
IF ABS(HEI - He) > .005 THEN HEI = He: GOTO 66
FICC = Y4 + U4 ^ 2 / 19.62 + DSILL + He
U4PI = U4
3004 U4P = (19.62 * q + B4 * U4PI ^ 3) / (19.62 * B4 * FICC)
IF ABS(U4P - U4PI) < .0005 THEN Y4P = q / (B4 * U4P): GOTO 3003
U4PI = U4P
GOTO 3004
3003 IF U4P >= .3 THEN GOTO 63
ELSE
B4 = B2 + 2
Z = y3 + 1.2 * U3 ^ 2 / 19.62
65   B4 = B4 + .5
b4net = B4 - NUM * T2
```

```
u4i = U3 - .5
79  U4 = q / (Z * b4net) + .6 * u4i ^ 3 / (Z * 9.81)
IF ABS(U4 - u4i) < .005 THEN
hc = .2 * (U3 ^ 2 - U4 ^ 2) / 19.62
Y4 = q / (b4net * U4)
ELSE
u4i = U4
GOTO 79
END IF
HEI = hc
67  hak1 = q / (2.88 * b4net)
hak2 = (2 / 3) * HEI ^ (3 / 2)
He = ((q / (2.88 * b4net) - 2 / 3 * HEI ^ (3 / 2)) / Y4) ^ 2
IF ABS(HEI - He) >= .005 THEN HEI = He: GOTO 67
FICC = Y4 + U4 ^ 2 / 19.62 + DSILL + He
U4PI = U4
3006 U4P = (19.62 * q + B4 * U4PI ^ 3) / (19.62 * B4 * FICC)
IF ABS(U4P - U4PI) < .0005 THEN
Y4P = q / (B4 * U4P)
GOTO 3005
ELSE
U4PI = U4P
GOTO 3006
END IF
3005 IF U4P >= .3 THEN GOTO 65
END IF
Qhalf = q / 2
AB = Qhalf * n / sbed ^ .5
yf = 1
33  yhalf = ((AB ^ .6 * (B1 + 2 * (1 + M ^ 2) ^ .5 * yf) ^ .4 - B1 * yf)
/ 1.5) ^ .5
IF ABS(yf - yhalf) < .005 THEN
r = (B1 * yhalf + 1.5 * yhalf ^ 2) / (B1 + 2 * (1 + 1.5 ^ 2) ^ .5 *
yhalf)
D = 10 * r * sbed
IF D > .0005 THEN D = .0005
ELSE
yf = yhalf
GOTO 33
END IF
'     ****************************************************************
'     Determination of length of settling basin according to DSI, Kop
'     and Random Walk Model
'     ****************************************************************
IF D <= .0001 THEN
Vs = D ^ 2 * 899250
ELSE
Cd = .4
Vs = (53.955 * D) ^ .5
RE = Vs * D / .000001
IF RE > 2.103 THEN
GOTO 35
ELSE
Cd = 24 / RE + 3 / RE ^ .5 + .34
Vs = (21.582 * D / Cd) ^ .5
END IF
END IF
35    L1 = (q) / (Vs * B4)
'c    ****************************************************************
'c    Determination of settling basin length proposed by Sumer
```

```
'c      *****************************************************************
IF AA$ = "N" THEN
r4p = (B4 * Y4P) / (B4 + 2 * Y4P)
ELSE
r4p = (B4 * Y4P - NUM * T2 * Y4P) / (b4net + 2 * Y4P * (1 + NUM))
END IF
USTAR = (9.81 * r4p * sbasin) ^ .5
beta = Vs / (.42 * USTAR)
LAMDA = .304972 * beta ^ 2 + 9.83515 * beta - .734368
L2 = -((6 * (U4P / USTAR) * Y4P) / (.42 * LAMDA)) * LOG(1 - ratio)
IF L1 >= L2 THEN
L = L1
ELSE
L = L2
END IF
u5i = U4P
AC = Y4P + U4P ^ 2 / 19.62 + (L / 2) * ((n * n * U4P ^ 2) / r4p ^ (4 /
3!)) - sbasin * L
IF AA$ = "N" THEN
22  u5 = q / ((AC + L / 2 * ((n * n * u5i ^ 2 * (B4 * B4 * u5i + 2 * q)
^ 1.333) / (q * B4) ^ 1.33) - u5i ^ 2 / 19.62) * B4)
IF ABS(u5i - u5) < .005 THEN
R5 = (q / u5) / (B4 + (2 * q) / (B4 * u5))
hcc = L / 2 * ((n ^ 2 * U4P) / (r4p ^ 1.333) + (n ^ 2 * u5 ^ 2) / (R5 ^
1.333))
ELSE
u5i = u5
GOTO 22
END IF
Y5 = q / (B4 * u5)
hge = .02
B5 = B4 - NUM * T2
ELSE
emi = Y4P + U4P ^ 2 / 19.62 + L / 2 * ((n * n * U4P ^ 2) / r4p ^ 1.333)
- sbasin * L
101  u5 = q / (b4net * (emi + L / 2 * ((n ^ 2 * u5i ^ 2) / (b4net * (q /
(u5i * b4net)) - T2 * NUM * (q / (u5i * b4net))) / (b4net + 2 * (q /
(b4net * u5i)) * (1 + NUM)) ^ 1.33) - u5i ^ 2 / 19.62))
IF ABS(u5i - u5) < .005 THEN
R5 = (b4net * (q / (u5 * b4net)) - T2 * NUM * (q / (u5 * b4net))) /
(b4net + 2 * (q / (b4net * u5)) * (1 + NUM))
hcc = (L / 2) * ((n ^ 2 * U4P) / (r4p ^ 1.333) + (n ^ 2 * u5 ^ 2) / (R5
^ 1.333))
ELSE
u5i = u5
GOTO 101
END IF
Y5 = q / (u5 * b4net)
hge = .02
B5 = b4net
END IF
Y6 = q / (B5 * uent)
hg = uent ^ 2 / (19.62 * .65 ^ 2)
y6p = Y6 + hg
hi = hg
44   h = ((q / (2.88 * B4) - 2 / 3! * hi ^ (2 / 3!)) / y6p) ^ 2
IF ABS(hi - h) < .005 THEN
ELSE
hi = h
GOTO 44
```

```
END IF
surele = bele + opty + hr + HA + hc + He + hcc + hge + hg + h + freebr
HEIGHT = surele - BOTELE
END SUB

 SUB depth (gec1, y1, y2, yc)
 RESET
DIM e1(450), e2(450), gec11(450)
OPEN "num.dat" FOR INPUT AS #1
      FOR i = 1 TO 400
     INPUT #1, gec11(i), e1(i), e2(i)
 NEXT i
      FOR k = 1 TO 400
      IF gec1 = gec11(k) THEN
      y1 = e2(k) * yc
      y2 = y1 * e1(k)
      ELSEIF gec1 < gec11(k + 1) AND gec1 > gec11(k) THEN
      x1 = ((e1(k + 1) - e1(k)) * (gec1 - gec11(k))) / (gec11(k + 1) -
gec11(k))
      e11 = x1 + e1(k)
      x2 = ((e2(k) - e2(k + 1)) * (gec11(k + 1) - gec1)) / (gec11(k + 1)
- gec11(k))
      e22 = x2 + e2(k + 1)
      y1 = yc * e22
      y2 = y1 * e11
      END IF
 NEXT
END SUB

SUB discharge (qim, BOTELE, LT, ks, HEIGHT, k3, krip, INC$, qspill,
qslui, kinit, LSPILL, SD1, SD2, numslc, q100, ho, hgec, co, NPI%, TPI,
KAA, KP, ua)
kinit = ks + 1.5
2  hwat = kinit - BOTELE
ua = qim / (hwat * LT)
hgec = kinit - ks + ua ^ 2 / 19.62
IF qim = q100 THEN
ho = hgec
gec1 = HEIGHT / ho
hak = .018 * (gec1 ^ 7) - .218 * (gec1 ^ 6) + 1.084 * (gec1 ^ 5)
hak1 = -2.872 * (gec1 ^ 4) + 4.37 * (gec1 ^ 3) - 3.847 * (gec1 ^ 2) +
1.889 * gec1
co = hak + hak1 + 1.72
LOCATE 22, 70: PRINT "    "
END IF
gec1 = HEIGHT / hgec
IF INC$ = "1" THEN C1 = 1.01258 - .0189769# * gec1 + .0134882# * (gec1 ^
2) - .00400273# * (gec1 ^ 3)
IF INC$ = "2" THEN C1 = 1.03579 - .057158 * gec1 + .0403213# * (gec1 ^
2) - .01182 * (gec1 ^ 3)
IF INC$ = "3" THEN C1 = 1.05714 - .132715 * gec1 + .100813 * (gec1 ^ 2)
- .0270735# * (gec1 ^ 3)
IF INC$ = "4" THEN C1 = 1
IF qim = q100 THEN
C2 = 1
ELSE
gec2 = hgec / ho
C2 = .788992 + .315793 * gec2 - .135763 * gec2 ^ 2 + .0303816 * gec2 ^
END IF  3
hd = ks + hgec - k3
```

```
D = k3 - krip
gec3 = (hd + D) / hgec
IF gec3 > 1.7 THEN
C3 = 1
ELSE
C3 = -13.3614 + 48.2042 * gec3 - 67.1499 * (gec3 ^ 2) + 47.741 * (gec3 ^
3) - 17.1266 * (gec3 ^ 4) + 2.46285 * (gec3 ^ 5)
END IF
gec4 = hd / hgec
IF gec4 > .7 THEN
c4 = 1
ELSE
c4 = .00757229# + 12.9145 * gec4 - 116.242 * (gec4 ^ 2) + 762.453 *
(gec4 ^ 3) - 3216.17 * (gec4 ^ 4) + 8243.85 * (gec4 ^ 5) - 12357.5 *
(gec4 ^ 6) + 9944.25 * (gec4 ^ 7) - 3314.27 * (gec4 ^ 8)
END IF
C = co * C1 * C2 * C3 * c4
Lnet = LSPILL - NPI * TPI
Leff = Lnet - 2 * (NPI * KP + KAA) * hgec
qspill = C * Leff * (hgec ^ 1.5)
PRINT qim
se = (kinit - BOTELE) / SD2
cp = .3801 + .0962 * se - .02354 * se ^ 2 + .00304 * se ^ 3 - .0002 * se
^ 4 + .00000623# * se ^ 5 - .000000069053# * se ^ 6
qslui = cp * SD1 * SD2 * SQR(19.62 * hwat) * numslc
qtot = qspill + qslui
LOCATE 22, 70: PRINT "WAIT"
IF ABS(qtot - qim) < .05 THEN GOTO 111
IF qtot > qim THEN
kinit = kinit - .00025
GOTO 2
ELSEIF qtot < qim THEN
kinit = kinit + .00025
GOTO 2
END IF
111  END SUB

SUB FRAME1
CALL YAPI
LOCATE 13, 25: PRINT "(R): EXIT TO DOS"
LOCATE 14, 25: PRINT "(D): DESIGN AND COST ANALYSIS"
LOCATE 15, 25: PRINT "(S): STABILITY ANALYSIS "
LOCATE 16, 25: PRINT "Enter Your Choice: "
END SUB

SUB FRAME2
CALL YAPI
LOCATE 11, 25: PRINT "(R): RETURN "
LOCATE 12, 25: PRINT "(I): IRRIGATION CANAL "
LOCATE 13, 25: PRINT "(S): SPILLWAY CREST"
LOCATE 14, 25: PRINT "(P): SPILLWAY SLUICEWAY DISCHARGE "
LOCATE 15, 30: PRINT "AND STILLING BASIN DESIGN"
LOCATE 16, 25: PRINT "(C): COMPLETE DESIGN"
LOCATE 17, 30: PRINT "AND OVERALL COST"
LOCATE 18, 25: PRINT "Enter Your Choice: "
END SUB

SUB FRAME3
CALL YAPI
LOCATE 13, 25: PRINT "(R): RETURN"
```

```
LOCATE 14, 25: PRINT "(O): ONE SIDED"
LOCATE 15, 25: PRINT "(T): TWO SIDED"
LOCATE 16, 25: PRINT "Enter Your Choice : "

END SUB

SUB FRAME6
CALL YAPI
LOCATE 13, 25: PRINT "(R): RETURN "
LOCATE 14, 25: PRINT "(S): SPILLWAY"
LOCATE 15, 25: PRINT "(L): SLUICEWAY"
LOCATE 16, 25: PRINT "(I): INTAKE"
LOCATE 17, 25: PRINT "Enter Your Choice : "

END SUB

SUB froude (qgec, k3gec, krip, LT, ks, kinit, FR1, U1, y1, y2, ua, U3)
3    y3 = k3gec - krip
U3 = qgec / (LT * y3)
hap = U3 ^ 2 / 19.62
den = ua ^ 2 / 19.62
f = kinit + ua ^ 2 / 19.62 - (k3gec + hap)
IF f < 0 THEN
PRINT "Due to the negative value of F"
PRINT "Decrease your riprap section bottom elevation"
PRINT "and please enter now"
INPUT krip
GOTO 3
END IF
qunit = qgec / LT
yc = ((qunit ^ 2) / 9.81) ^ (1 / 3!)
gec1 = f / yc
CALL depth(gec1, y1, y2, yc)
U1 = qunit / y1
FR1 = U1 / SQR(9.81 * y1)
END SUB

SUB gatecost (GATE$, b3p, unitpr, n1, cost4)
IF GATE$ = "C" THEN
IF b3p = .6 THEN cost4 = 357 * unitpr * (n1 + 1)
IF b3p = .75 THEN cost4 = 448 * unitpr * (n1 + 1)
IF b3p = 1! THEN cost4 = 378 * unitpr * (n1 + 1)
IF b3p = 1.15 THEN cost4 = 417.5 * unitpr * (n1 + 1)
IF b3p = 1.3 THEN cost4 = 505 * unitpr * (n1 + 1)
IF b3p = 1.75 THEN cost4 = 472.6 * unitpr * (n1 + 1)
ELSEIF GATE$ = "D" THEN
IF b3p = 1.4 THEN cost4 = 680 * uintpr * (n1 + 1)
IF b3p = 1.7 THEN cost4 = 730 * uintpr * (n1 + 1)
IF b3p = 1.8 THEN cost4 = 672 * uintpr * (n1 + 1)
IF b3p = 1.9 THEN cost4 = 660 * uintpr * (n1 + 1)
IF b3p = 2.2 THEN cost4 = 875 * uintpr * (n1 + 1)
IF b3p = 2.5 THEN cost4 = 950 * uintpr * (n1 + 1)
ELSEIF GATE$ = "E" THEN
IF b3p = 1.76 THEN cost4 = 1190 * unitpr * (n1 + 1)
IF b3p = 2 THEN cost4 = 1310 * unitpr * (n1 + 1)
IF b3p = 2.2 THEN cost4 = 1235 * unitpr * (n1 + 1)
IF b3p = 2.5 THEN cost4 = 1265 * unitpr * (n1 + 1)
IF b3p = 2.8 THEN cost4 = 1485 * unitpr * (n1 + 1)
IF b3p = 3.5 THEN cost4 = 1645 * unitpr * (n1 + 1)
IF b3p = 4 THEN cost4 = 1975 * unitpr * (n1 + 1)
```

```
IF icnt = 0 THEN
CLS : LOCATE 15, 10: PRINT "THERE IS NO STANDART GATE SUITABLE FOR THESE
DIMENSIONS"
LOCATE 16, 10: PRINT "OF MAIN CANAL ENTRANCE THEREFORE"
LOCATE 17, 10: INPUT "ENTER THE WEIGHT OF GATE THAT TO BE USED"; weight
ELSE
CLS : LOCATE 15, 10: PRINT "THERE IS NO STANDART GATE SUITABLE FOR THESE
DIMENSIONS"
LOCATE 16, 10: PRINT "OF INTAKE ENTRANCE THEREFORE"
LOCATE 17, 10: INPUT "ENTER THE WEIGHT OF GATE THAT TO BE USED"; weight
END IF
icnt = icnt + 1
cost4 = weigth * unitpr * (n1 + 1)
ELSE
CLS : LOCATE 15, 10: PRINT "ENTER TYPE OF RAPIER GATE, (1,2,3,4,5)"
DO
LOCATE 16, 10: PRINT "ENTER TYPE OF RAPIER GATE";
INPUT type$
LOOP UNTIL type$ = "1" OR type$ = "2" OR type$ = "3" OR type$ = "4" OR
type$ = "5"
IF type$ = "1" THEN cost4 = 58 * unitpr * (n1 + 1)
IF type$ = "2" THEN cost4 = 72.5 * unitpr * (n1 + 1)
IF type$ = "3" THEN cost4 = 87.5 * unitpr * (n1 + 1)
IF type$ = "4" THEN cost4 = 97 * unitpr * (n1 + 1)
IF type$ = "5" THEN cost4 = 131 * unitpr * (n1 + 1)
END IF
END SUB

SUB Ljump1 (frmax, ydes22, Ljump)
DIM Fr(4), ratio(4)
Fr(1) = 2
Fr(2) = 3
Fr(3) = 4
Fr(4) = 6
ratio(1) = 4.3
ratio(2) = 5.3
ratio(3) = 5.8
ratio(4) = 6
FOR i = 1 TO 4
IF frmax = Fr(i) THEN Ljump = ydes22 * ratio(i)
IF frmax < Fr(i + 1) AND frmax > Fr(i) THEN
x = (ratio(i + 1) - ratio(i)) * (frmax - Fr(i)) / (Fr(i + 1) - Fr(i))
h = ratio(i) + x
Ljump = ydes22 * h
END IF
NEXT i
END SUB

SUB Ljump2 (frmax, Ljump, hbaff, ydes22, YDES11)
DIM Fr(8), r1(8), r2(8), r3(8)
Fr(1) = 4.5: Fr(2) = 5: Fr(3) = 6: Fr(4) = 8: Fr(5) = 10: Fr(6) = 12:
Fr(7) = 14: Fr(8) = 16
r1(1) = 2.217: r1(2) = 2.3: r1(3) = 2.5: r1(4) = 2.6: r1(5) = 2.7: r1(6)
= 2.8: r1(7) = 2.8: r1(8) = 2.8
r2(1) = 1.13: r2(2) = 1.5: r2(3) = 1.7: r2(4) = 2!: r2(5) = 2.3: r2(6) =
2.7: r2(7) = 3!: r2(8) = 3.3
r3(1) = 1.083: r3(2) = 1.2: r3(3) = 1.3: r3(4) = 1.5: r3(5) = 1.6: r3(6)
= 1.7: r3(7) = 1.8: r3(8) = 1.9
      FOR i% = 1 TO 8
      IF frmax = Fr(i%) THEN
```

```
      Ljump = r1(i%) * ydes22
      hbaff = r2(i%) * YDES11
      ELSEIF frmax < Fr(i% + 1) AND frmax > (i%) THEN
      x = (r1(i% + 1) - r1(i%)) * (frmax - Fr(i%)) / (Fr(i% + 1) -
Fr(i%))
      h = r1(i%) + x
      Ljump = h * ydes22
      x1 = (r2(i% + 1) - r2(i%)) * (frmax - Fr(i%)) / (Fr(i% + 1) -
Fr(i%))
      h1 = r2(i%) + x1
      hbaff = h1 * YDES11
      GOTO 55
      END IF
      NEXT
55  END SUB

SUB Ljump3 (frmax, Ljump, ydes22)
DIM Fr(6), r(6)
Fr(1) = 4: Fr(2) = 6: Fr(3) = 8: Fr(4) = 10: Fr(5) = 12: Fr(6) = 14
r(1) = 3.6: r(2) = 4: r(3) = 4.2: r(4) = 4.3: r(5) = 4.3: r(6) = 4.3
FOR i = 1 TO 6
IF frmax = Fr(i) THEN Ljump = r(i) * ydes22
IF frmax < Fr(i + 1) AND frmax > Fr(i) THEN
x = (r(i + 1) - r(i)) * (frmax - Fr(i)) / (Fr(i + 1) - Fr(i))
h = r(i) + x
Ljump = h * ydes22
END IF
NEXT
END SUB

SUB MAX (FRIM, USTILI, YDES1I, YDES2I, frmax, K3I, krip, FRSIM, USILSI,
YDESFI, YDESSI, YDES11, ydes22, ydes33, U3, U3S, UMAX)
IF U3 > UMAX THEN UMAX = U3
IF U3S > UMAX THEN UMAX = U3S
      IF FRIM <= frmax GOTO 12
      frmax = FRIM
      udes = USTILI
      YDES11 = YDES1I
      ydes22 = YDES2I
      ydes33 = K3I - krip
12    IF FRSIM <= frmax THEN GOTO 13
      frmax = FRSIM
      udes = USILSI
      YDES11 = YDESFI
      ydes22 = YDESSI
      ydes33 = K3I - krip
13 END SUB

SUB mcanal (q, n, sbed, cex, clin, cland, B1!, opty!, f)
MINC = 999999999
1 A = q * n / (sbed ^ .5)
icnt = 0
IF q < 2 THEN
b = .1
ELSE
b = 1
END IF
21 yo = 1.4
23 y1 = ((A ^ .6 * (b + 2 * (1 + 1.5 ^ 2) ^ .5 * yo) ^ .4 - b * yo) /
1.5) ^ .5
```

```
IF ABS(yo - y1) <= .0005 THEN
f = .2 * (1 + y1)
YSTAR = y1 + f
IF q < 1 THEN
T = b + 3 * YSTAR + 5
ELSEIF q > 5 THEN
T = b + 3 * YSTAR + 8
ELSE
T = b + 3 * YSTAR + 6.5
END IF
COST = (b * YSTAR + 1.5 * YSTAR ^ 2) * cex + (b + 2 * (1 + 1.5 ^ 2) ^ .5
* YSTAR) * clin + T * cland
x = nc
IF COST < MINC THEN
MINC = COST
B1 = b
opty = y1
nc = nc + 1
END IF
icnt = icnt + 1
IF icnt = 1500 GOTO 11
IF x <> nc THEN nci = 0
nci = nci + 1
IF nci = 5 GOTO 11
b = b + .05
GOTO 21
ELSE
yo = y1
GOTO 23
END IF
11 HAKAN = q / (3.1321 * b ^ 2.5)
emin = (HAKAN / .687811) ^ 2.07995
yc = emin * b
IF opty / yc < 1 THEN
b = b - .01
GOTO 11
END IF
END SUB

SUB type1 (LSPILL, YDES11, ydes22, ydes33, frmax, FILOUT$, NO3, U33DES)
hchute = 2 * YDES11
LCHUTE = 2 * YDES11
wchute = YDES11
VOLCHUTE = hchute * wchute * LCHUTE / 2
HACIM = nchute * VOLCHUTE
space = 2.5 * wchute
hsill = ydes22 - ydes33
IF hsill < .5 THEN hsill = .5
sayi = (LSPILL - gen1 + wchute) / (wchute + space)
nchute% = INT(sayi)
fract = (sayi - INT(sayi)) * wchute
CALL Ljump1(frmax, ydes22, Ljump)
OPEN FILOUT$ FOR OUTPUT AS #NO3
LOCATE 2, 2: PRINT #NO3, "USBR Type 1 basin is suitable for Froude
number =   ";
PRINT #NO3, USING "##.##"; frmax
LOCATE , 2: PRINT "Table 2: Related Dimensions of The Stilling Basin
Type 1"
LOCATE , 2: PRINT
"èëëëëëëëëëëëëëùëëëëëëëëëëëëëëëùëëëëëëëëëëëëëëëùëëëëëëëëëëëëëëëëë£"
```

```
LOCATE , 2: PRINT "¤ STILLING   ¤  HEIGHT OF  ¤  SPACING OF  ¤     NO
OF      ¤"
LOCATE , 2: PRINT "¤  BASIN     ¤ CHUTE BLOCKS ¤ CHUTE BLOCKS ¤ CHUTE
BLOCKS   ¤"
LOCATE , 2: PRINT "¤ LENGTH (m) ¤      (m)     ¤     (m)      ¤
(m)      ¤"
LOCATE , 2: PRINT
"ãëëëëëëëëëëëëöëëëëëëëëëëëëëëëöëëëëëëëëëëëëëëëöëëëëëëëëëëëëëëëë¿"
LOCATE , 2: PRINT "¤            ¤              ¤              ¤
    ¤"
LOCATE , 2: PRINT
"àëëëëëëëëëëëëòëëëëëëëëëëëëëëëòëëëëëëëëëëëëëëëòëëëëëëëëëëëëëëëë¥"
LOCATE 9, 5: PRINT USING "###.##"; Ljump
LOCATE 9, 19: PRINT USING "###.##"; hchute
LOCATE 9, 35: PRINT USING "###.##"; SCHUTE
LOCATE 9, 51: PRINT USING "###.##"; nchute%
drip = U33DES ^ 2 * 1.4 / (1.65 * 19.62)
LOCATE 12, 2: PRINT "DIAMETER OF THE ROCK IN RIPRAP SECTION (m) >= ";
USING "##.##"; drip
LOCATE 24, 5: PRINT "Press <ESC> to continue"
DO:  LOOP UNTIL INKEY$ = CHR$(27)
END SUB

SUB type2 (LSPILL, YDES11, ydes22, ydes33, frmax, FILOUT$, NO3, U33DES)
hchute = YDES11
wchute = YDES11
VOLCHUTE = hchute * wchute * 2 * YDES11 / 2
space = YDES11
gen1 = .5 * YDES11
sayi = (LSPILL - gen1 + wchute) / (wchute + space)
nchute% = FIX(sayi)
TOTVOLCHUTE = nchute% * VOLCHUTE
fract = (sayi - FIX(sayi)) * wchute
hsill = ydes22 - ydes33
IF hsill < .5 THEN hsill = .5
Locat = .8 * ydes22
hbaff = ydes33
wbaff = .75 * hbaff
sbaff = wbaff
TOPT = .2 * hbaff
gen1b = .5 * YDES11
sayib = (LSPILL - gen1b + wbaff) / (wbaff + sbaff)
nbaff% = FIX(sayib)
fractb = (sayib - FIX(sayib)) * wbaff
VOLBAFF = ((2 * TOPT + hbaff) * hbaff / 2) * wbaff
TOTVOLBAFF = nbaff% * VOLBAFF
HACIM = TOTVOLCHUTE + TOTVOLBAFF
CALL Ljump2(frmax, Ljump, hbaff, ydes22, YDES11)
OPEN FILOUT$ FOR OUTPUT AS #NO3
CLS
LOCATE 3, 5: PRINT "USBR Type 2 basin is suitable for Froude number =
"; USING "##.##"; frmax
LOCATE 4, 5: PRINT "Table 2: Related Dimensions of The Stilling Basin
Type 2"
LOCATE , 5: PRINT
"èëëëëëëëëëëëëùëëëëëëëëëëëëëùëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë£"
LOCATE , 5: PRINT "¤            ¤            ¤      CHUTE BLOCKS
   ¤"
LOCATE , 5: PRINT "¤ STILLING   ¤  HEIGHT OF
äëëëëëëëëùëëëëëëëëùëëëëëëëëëëëùëëëëë¿"
```

```
LOCATE , 5: PRINT "¤  BASIN     ¤   END SILL ¤ HEIGHT ¤ WIDTH ¤ SPACING
¤ NO  ¤"
LOCATE , 5: PRINT "¤ LENGTH (m) ¤     (m)    ¤  (m)   ¤   (m) ¤
¤    ¤"
LOCATE , 5: PRINT
"ãëëëëëëëëëëëëëöëëëëëëëëëëëëëëëöëëëëëëëëëëöëëëëëëëëöëëëëëëëëëëëëöëëëëë¿"
LOCATE , 5: PRINT "¤            ¤             ¤        ¤       ¤
¤    ¤"
LOCATE , 5: PRINT
"àëëëëëëëëëëëëëòëëëëëëëëëëëëëëëòëëëëëëëëëëòëëëëëëëëòëëëëëëëëëëëëòëëëëë¥"
LOCATE 11, 8: PRINT USING "###.##"; Ljump: LOCATE 11, 20: PRINT USING
"###.##"; hsill: LOCATE 11, 32: PRINT USING "###.##"; hchute: LOCATE 11,
41: PRINT USING "###.##"; wchute: LOCATE 11, 49: PRINT USING "###.##";
space: LOCATE 11, 59: PRINT USING "###"; nchute%
LOCATE 13, 5: PRINT "èëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë£"
LOCATE , 5: PRINT "¤                BAFFLE BLOCKS              ¤"
LOCATE , 5: PRINT "äëëëëëëëëùëëëëëëëùëëëëëëëëëùëëëëëùëëëëëëëëëë¿"
LOCATE , 5: PRINT "¤ HEIGHT ¤ WIDTH ¤ SPACING ¤ NO  ¤ LOCATION ¤"
LOCATE , 5: PRINT "¤  (m)   ¤  (m)  ¤   (m)   ¤     ¤          ¤"
LOCATE , 5: PRINT "äëëëëëëëöëëëëëëëöëëëëëëëëëöëëëëëöëëëëëëëëëë¿"
LOCATE , 5: PRINT "¤        ¤       ¤         ¤     ¤          ¤"
LOCATE , 5: PRINT "àëëëëëëëëòëëëëëëëòëëëëëëëëëòëëëëëòëëëëëëëëëë¥"
LOCATE 19, 7: PRINT USING "###.##"; hbaff: LOCATE 19, 16: PRINT USING
"###.##"; wbaff: LOCATE 19, 24: PRINT USING "###.##"; sbaff: LOCATE 19,
33: PRINT USING "###"; nbaff%: LOCATE 19, 40: PRINT USING "###.##";
Locat
drip = U33DES ^ 2 * 1.4 / (1.65 * 19.62)
LOCATE 22, 5: PRINT "DIAMETER OF THE ROCK IN RIPRAP SECTION (m) >= ";
USING "##.##"; drip
LOCATE 24, 5: PRINT "Press <ESC> to continue"
DO: LOOP UNTIL INKEY$ = CHR$(27)
END SUB

SUB type3 (LSPILL, YDES11, ydes22, ydes33, frmax, FILOUT$, NO3, U33DES)
Ssill = .15 * ydes22
WSILL = .15 * ydes22
TCSIL = .02 * ydes22
VOLSILL = ((2 * TCSIL + .4 * ydes22) * ydes22) / 2 * WSILL
gen1s = 0
sayis = (LSPILL - gen1s + WSILL) / (WSILL + Ssill)
NSILL% = INT(sayis)
TOTVOLSILL = NSILL% * VOLSILL
fracts = (sayis - INT(sayis)) * WSILL
hsill = ydes22 - ydes33
IF hsill < .5 THEN hsill = .5
wchute = YDES11
SCHUTE = YDES11
hchute = YDES11
gen1c = .5 * YDES11
sayic = (LSPILL - gen1c + wchute) / (wchute + SCHUTE)
nchute% = INT(sayic)
VOLCHUTE = hchute * wchute * 2 * YDES11 / 2
TOTVOLCHUTE = nchute% * VOLCHUTE
HACIM = TOTVOLCHUTE + TOTVOLSILL
fractc = (sayic - INT(sayic)) * wchute
CALL Ljump3(frmax, Ljump, ydes22)
OPEN FILOUT$ FOR OUTPUT AS #NO3
CLS
LOCATE 5, 10: PRINT "USBR Type 3 basin is suitable for Froude number =
"; USING "##.##"; frmax
```

```
LOCATE 6, 10: PRINT "Table 2: Related Dimensions of The Stilling Basin
Type 2"
LOCATE , 10: PRINT
"èëëëëëëëëëëëëùëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë£"
LOCATE , 10: PRINT "¤              ¤              DENTATED END SILL
      ¤"
LOCATE , 10: PRINT "¤ STILLING
äëëëëëëëëëùëëëëëëëëùëëëëëëëëëëëùëëëëëëëëëëëëëëùëëëëë¿"
LOCATE , 10: PRINT "¤  BASIN     ¤ HEIGHT ¤ WIDTH ¤ SPACING ¤
T.THICKNESS ¤ NO  ¤"
LOCATE , 10: PRINT "¤ LENGTH (m) ¤  (m)   ¤   (m) ¤  (m)    ¤     (m)
¤     ¤ "
LOCATE , 10: PRINT
"äëëëëëëëëëëëëöëëëëëëëëëöëëëëëëëëöëëëëëëëëëëöëëëëëëëëëëëëëëëöëëëëë¿"
LOCATE , 10: PRINT "¤             ¤         ¤        ¤          ¤
¤     ¤"
LOCATE , 10: PRINT
"àëëëëëëëëëëëëòëëëëëëëëëòëëëëëëëëòëëëëëëëëëëòëëëëëëëëëëëëëëëòëëëëë¥"
LOCATE 13, 14: PRINT USING "###.##"; Ljump
LOCATE 13, 25: PRINT USING "###.##"; hsill
LOCATE 13, 34: PRINT USING "###.##"; WSILL
LOCATE 13, 42: PRINT USING "###.##"; SSLILL
LOCATE 13, 53: PRINT USING "###.##"; TCSIL
LOCATE 13, 66: PRINT USING "###.##"; NSILL%
LOCATE 15, 10: PRINT "èëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë£"
LOCATE , 10: PRINT "¤            CHUTE BLOCKS        ¤"
LOCATE , 10: PRINT "äëëëëëëëëùëëëëëëëëùëëëëëëëëëëùëëëëë¿"
LOCATE , 10: PRINT "¤ HEIGHT ¤ WIDTH ¤ SPACING ¤ NO  ¤"
LOCATE , 10: PRINT "¤  (m)   ¤  (m)  ¤   (m)   ¤     ¤"
LOCATE , 10: PRINT "äëëëëëëëëöëëëëëëëëöëëëëëëëëëëöëëëëë¿"
LOCATE , 10: PRINT "¤        ¤        ¤          ¤     ¤"
LOCATE , 10: PRINT "àëëëëëëëëòëëëëëëëëòëëëëëëëëëëòëëëëë¥"
LOCATE 21, 12: PRINT USING "###.##"; hchute
LOCATE 21, 21: PRINT USING "###.##"; wchute
LOCATE 21, 29: PRINT USING "###.##"; SCHUTE
LOCATE 21, 39: PRINT USING "###.##"; nchute%
drip = U33DES ^ 2 * 1.4 / (1.65 * 19.62)
LOCATE 23, 10: PRINT "DIAMETER OF THE ROCK IN RIPRAP SECTION (m) >= ";
USING "##.##"; drip
LOCATE 24, 5: PRINT "Press <ESC> to continue"
DO: LOOP UNTIL INKEY$ = CHR$(27)
END SUB

SUB WALL (WALL1, gw, GC, gs, GSD, siga, BET, FI, fric, w4, w1, w2, w3,
w5, pmin, pmax, fss, fsov)
CLS
IF WALL1 = 1 THEN LOCATE 14, 10: PRINT "UPSTREAM SIDE WALL AND INTAKE
SIDE WALL UP TO SETTLING BASIN"
IF WALL1 = 2 THEN LOCATE 14, 10: PRINT "INTAKE SIDE WALL AFTER SETTLING
BASIN"
IF WALL1 = 3 THEN LOCATE 14, 10: PRINT "STILLING BASIN SIDE WALLS "
LOCATE 15, 5: PRINT "IF THERE IS WATER TABLE ENTER WATER TABLE"
LOCATE 16, 5: INPUT "HEIGHT FROM BOTTOM OF THE WALL OTHERWISE ENTER 0";
heig1
siga = 2.05
gamaw = 9.81
GC = 24
gs = 17
gamast = 19
BET = 0
```

```
FI = 33
fric = .58
firad = FI * 3.141593 / 180!
delta = 2 / 3! * firad
beta = BET * 3.141593 / 180!
w2 = .5
w5 = .3
alfa = 1.623
w4 = 5
w1 = 1 / 10
x = w4 / TAN(3.151592 - alfa)
IF heig1 <> 0 THEN
2221 IF w2 = 0 THEN alfa = ATN(w4 / (w3 - w5)): x = w4 / TAN(alfa)
w3 = w5 + w2 + x
ka = SIN(alfa + firad) ^ 2 / (SIN(alfa) ^ 2 * SIN(alfa - delta) * (1 +
SQR((SIN(firad + delta) * SIN(firad - beta)) / (SIN(alfa - delta) *
SIN(alfa + beta)))) ^ 2)
414     IF w2 > w3 THEN w2 = w2 - .025: GOTO 414
15 IF w1 < w4 / 10 THEN w1 = w4 / 10
 x1 = ((w4 + w1 - heig1) / 3 * 2) / TAN(alfa)
x2 = (w4 + w1 - heig1) / TAN(alfa)
x3 = ((heig1 - w1) / 3 * 2) / TAN(alfa)
x4 = (heig1 - w1) / TAN(alfa)
gamasub = gamast - gamaw
we1 = w1 * w3 * GC
we2 = w5 * w4 * GC
we3 = x * w4 * GC / 2
we4 = x2 * (w4 + w1 - heig1) / 2 * gs
we5 = (w3 - x2 - w5) * (w4 + w1 - heig1) * gs
we6 = (w3 - x4 - x2 - w5) * (heig1 - w1) * gamasub
we7 = x4 * (heig1 - w1) / 2 * gamasub
'PRINT "we1=", we1, "we2=", we2, "we3=", we3
'PRINT "we4=", we4, "we5=", we5
'PRINT "we6=", we6, "we7=", we7
'SLEEP
pa1 = surq * ka * (w4 + w1 - heig1) + gs / 2 * ka * (w4 + w1 - heig1) ^
2
pa2 = (surq * ka + gs * ka * (w4 + w1 - heig1)) * (heig1 - w1) + gamasub
/ 2 * ka * (heig1 - w1) ^ 2
pa3 = (surq * ka + gs * ka * (w4 + w1 - heig1) + gamasub * ka * (heig1 -
w1)) * w1
pa4 = gamasub * ka * w1 * w1 / 2
pa1h = pa1 * COS(-1.571 + alfa + delta)
pa1v = pa1 * SIN(-1.571 + alfa + delta)
pa2h = pa2 * COS(-1.571 + alfa + delta)
pa2v = pa2 * SIN(1.571 + alfa + delta)
ph = gamaw * heig1 ^ 2 / 2
pu = heig1 * gamaw * w3 / 2
resmom = we1 * w3 / 2 + we2 * w5 / 2 + we3 * (w5 + x / 3) + we4 * (2 / 3
* x2 + w5) + we5 * ((w3 - w5 - x2) / 2 + x2 + w5) + we6 * ((w3 - x4 - x2
- w5) / 2 + x4 + x2 + w5) + we7 * (x4 / 3 * 2 + x2 + w5) + pa1v * (x1 +
w5) + pa2v * (x3 + x2 + w5)
ovmom = pa1h * (heig1 + (w4 + w1 - heig1) / 3) + pa2h * (w1 + (heig1 -
w1) / 3) + pa3 * w1 / 2 + pa4 * w1 / 3 + ph * heig1 / 3 + Pup * 2 / 3 *
w3
rh = pa1h + pa2h + pa3 + pa4 + ph
rv = we1 + we2 + we3 + we4 + we5 + we6 + we7 - Pup + pa1v + pa2v
baser = (resmom - ovmom) / rv
e = baser - w3 / 2
pmax = ((rv / w3) * (1 + (6 * ABS(e)) / w3))
```

```
pmax1 = pmax * (1000 / 9.81) * .0001
pmin = (rv / w3) * (1 - (6 * ABS(e)) / w3)
fsov = resmom / ovmom
fss = rv * fric / rh
IF pmax1 > siga THEN
w1 = w1 - .1
w2 = w2 + .1
w3 = w2 + w5 + x
GOTO 2221
END IF
IF pmin < 0 THEN
IF pmin > -.5 THEN pmin = 0: GOTO 201
w4 = w4 + .05
w1 = w1 + .1
w2 = w2 + .1
IF w2 < 0 THEN w2 = 0
w3 = w2 + w5 + x
GOTO 15
END IF
IF fss < 1.5 THEN
w1 = w1 + .1
w2 = w2 + .1
w3 = w2 + w5 + x
GOTO 15
'ELSEIF fss > 5 THEN
'w1 = w1 - .2
'w2 = w2 - .2
'IF w2 < 0 THEN w2 = 0: w3 = w3 - .2: GOTO 2221
'w3 = w2 + w5 + x
'GOTO 15
END IF
IF fsov < 1.5 THEN
w1 = w1 + .1
w2 = w2 + .1
w3 = w2 + w5 + x
GOTO 15
END IF
ELSE
w3 = w5 + w2 + x
ka = SIN(alfa + firad) ^ 2 / (SIN(alfa) ^ 2 * SIN(alfa - delta) * (1 +
SQR((SIN(firad + delta) * SIN(firad - beta)) / (SIN(alfa - delta) *
SIN(alfa + beta)))) ^ 2)
x1 = w4 / 3 * 2 / TAN(3.14159 - alfa)
we1 = w1 * w3 * GC
we2 = w5 * w4 * GC
we3 = x * w4 * GC / 2
we4 = x * w4 * gs / 2
we5 = w2 * w4 * gs
pa1 = surq * ka * w4 + 1 / 2 * gs * ka * w4 ^ 2
pa1h = pa1 * COS(-1.571 + alfa + delta)
pa1v = pa1 * SIN(-1.571 + alfa + delta)
pa2 = (surq * ka + gs * ka * w4) * w1
pa3 = 1 / 2 * gs * w1 ^ 2 * ka
rv = pa1v + we1 + we2 + we3 + we4 + we5
rh = pa1h + pa2 + pa3
resmom = we1 * w3 / 2 + we2 * w5 / 2 + we3 * (x / 3 + w5) + we4 * (x / 3
* 2 + w5) + we5 * (w3 - w2 / 2) + pa1v * (w5 + x1)
ovmom = pa1h * (w4 / 3 + w1) + pa2 * w1 / 2 + pa3 * w1 / 3
fss = fric * rv / rh
fsov = resmom / ovmom
```

```
baser = (resmom - ovmom) / rv
e = w3 / 2 - baser
pmax = ((rv / w3) * (1 + (6 * ABS(e)) / w3))
pmax1 = pmax * (1000 / 9.81) * .0001
pmin = (rv / w3) * (1 - (6 * ABS(e)) / w3)
 END IF
201 END SUB

SUB YAPI
CLS
PRINT
"èëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë
ëëëëëë£"
FOR i = 1 TO 19
PRINT
"¤ÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜ
ÜÜÜÜÜÜ¤"
NEXT i
LOCATE 10, 20: PRINT "èëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë£"
FOR i = 1 TO 8
LOCATE , 20: PRINT "¤                                              ¤Ý"
NEXT i
LOCATE 19, 20: PRINT "àëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë¥Ý"
LOCATE 20, 20: PRINT "ÜÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝÝ"
PRINT
"¤ÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜ
ÜÜÜÜÜÜ¤"
PRINT
"¤ÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜ
ÜÜÜÜÜÜ¤"
PRINT
"àëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë
ëëëëëë¥"
END SUB
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