JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

DESIGN AND ESTIMATION OF ENERGY DISSIPATOR AT VAIGAI DAM

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Abstract : Energy dissipation is the dissipation kinetic energy generated at base of a spillway. While the upstream water is directed to dam downstream, a hydraulic energy flow is created. High velocities occur in the hydraulic energy flow. These high velocities create high pressure and friction forces that cause erosion and scouring in the downstream. As a result, structures could collapse or serious damages could occur. Structures that dissipate the energy levels are high in especially spillways, planning energy dissipators requires great caution and knowledge. When hydraulic energy is dissipated, certain disruptions occur in the flow. The disruptions could cause resonance, erosion, wearing of the surfaces and cavitations. Because of these factors, energy dissipator structures are built. The horizontal apron type of stilling basin energy dissipators are adopted in this project. In order to prevent scouring that occurs when high velocity water enters the downstream of the dam. Vaigai dam is a small village in Periyakulam block in Theni district of TN, India. The dam is in near Andipatti at Periyakulam. The stilling basin is provided at the spillway of the dam. The stilling basins with the drops are given in this project. The project is about designing and estimation of stilling basin with drops at Vaigai Dam. The Plan and Elevation is drawn by using AUTOCAD. The design of stilling basin is done by using IS4997:1968 and the estimation was given at this report.

I. INTRODUCTION

The water flowing in dam spillway has a high level of energy. Since this energy creates a high velocity flow in the downstream, it could cause damages such as cavitations and scouring in the riverbed. Thus, it should be dissipated between the spillway and downstream riverbed. Energy dissipation is usually ensured by stilling basins that dissipate energy with hydraulic jump, roller buckets, ejection and energy dissipator. Dissipation of the kinetic energy formed at spillway bed is important for the stability of the river structure at the downstream. Energy dissipation structures are not significant only for prevention of erosion on the riverbed, but also for dam elements such as dam embankment, sluice outlet and spillway structure. The damage that could be caused by high velocity flow with turbulence is prevented by energy dissipating structures. Although energy dissipation is conducted with different methods at spillway bed, the main energy dissipation could be classified internal friction and turbulence or impact and distribution of the high velocity flow in the water mass. The most important safety elements of the dams are spillways and energy dissipation structures. The overflows that could happen at dam upstream are required to be channeled to the dam downstream safely before they could create any damage. To prevent the scouring that could occur in dam downstream due to created energy, the most adequate type should be selected. The types of energy dissipation structures depend on the velocity of the water at spillway toe, Froude number, type of the dam, type of the spillway and geological properties of the downstream.

While the upstream water is directed to dam downstream, a hydraulic energy flow is created. High velocities occur in the hydraulic energy flow. These high velocities create high pressure and friction forces that cause erosion and scouring in the downstream. As a result, structures could collapse or serious damages could occur. Structures that dissipate the energy levels are high in especially spillways, planning energy dissipator requires great caution and knowledge. When hydraulic energy is dissipated, certain disruptions occur in the flow. The disruptions could cause resonance, erosion, wearing of the surfaces and cavitations. Because of these factors, energy dissipator structures are built.

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II. ENERGY DISSIPATORS

When spillway flows fall from reservoir pool level to downstream river level, a large part of static head is converted into kinetic energy. This energy manifests itself in the form of high velocities which if impeded, results in large pressures. On the other hand, if the high energy of flow is not dissipated, serious erosion to stream bed and damage to hydraulic structures may be caused. The device used to protect the river or tail channel and the hydraulic structures on downstream, is called as energy dissipator. The function of energy dissipator is to absorb high energy of spillway flows and discharge these flows to the downstream water course, without causing serious scour or erosion of the toe of the dam or spillway or damage to adjacent structures. In hydraulic engineering numerous devices like stilling basins, baffled aprons & vortex shafts are known under the collective term of energy dissipator. Their purpose is to dissipate hydraulic energy. Dissipators are used to dissipate hydraulic energy which may cause damages like erosion of tail water channels, abrasion of hydraulic structures, generation of tail water waves, or scouring.

III. THE MECHANISM OF ENERGY DISSIPATION

Every moving fluid particle or drop of water loses some of its hydraulic energy along its trajectory. This loss is a result of friction or drag forces that are closely related to turbulence production in hydraulic energy dissipators. The process of energy dissipation can be usefully divided into two cases:

1. A particle of water within a water current,
2. A drop of water in an air current.

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3.1 A PARTICLE OF WATER WITHIN WATER CURRENT

The energy dissipation is related to energy consuming eddies. Such eddies are mainly generated in shear zones, i.e. in zones of large velocity gradients. To induce a considerable loss of energy, the creation of high turbulence zones is important

3.2 A DROP OF WATER IN AN AIR CURRENT

The energy dissipation results from the air resistance exerted to the drop of water. It is large if the drop is small and the relative velocity between the drops, the ambient air is high. Efficient energy dissipation is a matter of disturbing the water current either by increasing its turbulence or by diffusing it into spray. An economical energy dissipator design is the one which affects such an impact within a comparatively small region.

IV. HYDRAULIC JUMP

The hydraulic jump is a natural phenomenon which occurs when supercritical flow changestosubcriticalflow.Thisabruptchangeinflowconditionisaccompaniedbyconsiderableturbulence and loss of energy. Within certain flow ranges, the hydraulic jump is an effective energy dissipation device which is often employed to control erosion at hydraulic structures.

4.1 FUNCTIONS OF HYDRAULIC JUMP

The hydraulic jump has many applications. Chow (1959) and (1988) cited them in the field of open channel flow that they can:

- Dissipateenergyinhydraulicstructuresthuspreventingscourattheirdownstream
- Reduce the net uplift pressure under the hydraulic structures
- Raise the water level on the downstream side of the structures

4.2 CONTROL OF USING STILLING BASINS

The hydraulic jump can be controlled by different methods. The function of these methods is to ensure the formation of a jump within the stilling basin and to control its position under all probable operating conditions.

In other words, "to control" means to force the occurrence of the jump and to control its position ,hence reducing the risk of bed scour after the hydraulic structures.

The design of such controlling structures should consider three interrelated parameters:

- Jump position
- Tail water level
- Jump type

Mainly, there are two different categories to control the hydraulic jump:

- Control by adding structures in the stilling basin
- Control by stilling basin modifications

V. DETAILS OF VAIGAI DAM

ATTRIBUTE	VALUE
Name of the Dam	Vaigai Dam
River	Vaigai
Nearest city	Andipatti
District	Theni
Operated by	Tamil Nadu generation and distribution corporation Ltd
Purpose of the Dam	Flood control, Irrigation
Year of Completion	1959
Type	Medium
Type of Dam	Gravity
Length of Dam	3560m
Height of Dam	111ft
Dam value content	1586TCM
Total storage capacity	6091 million m3
Type of spillway gate	Radial
Power generation capacity	6 MW
Spillway gates	7

VI. DESIGN CALCULATIONS

GIVENDATA

Discharge	Q	=	1200 m^3/s
Velocity	V	=	19 m/s
Breadth	b	=	75 m

SOLUTION

Discharge Intensity	q	=	Q/b
	q	=	1200/75
		=	16 m^2/s
Critical depth	y_c	=	$(q^2/g)^{1/3}$
		=	$(16^2/9.81)^{1/3}$
		=	2.97m
Hydraulic depth	D	=	A/T
		=	$(bxy_c)/b$
	D	=	y_c

6.1 DESIGN OF STILLING BASIN

STEP1

Assume	D_0	=	3m
	D_1	=	$-(D_1/2)+\sqrt{(2q^2/D_1g)+(D_1^2/4)}$
		=	$-(3/2)+\sqrt{(2x16^2/3x9.81)+(3^2/4)}$
	D_1	=	4.43m
Energy loss	H_L	=	$(D_1-D_0)^3/4D_1D_0$
		=	$(4.43-3)^3/4x3x4.43$
	H_L	=	0.055m
Froude no	F_0	=	$V_o/(\sqrt{gd})$
		=	$19/(\sqrt{9.81x3})$
	F_0	=	3.51

According to IS4997-1968,

Lj/D_1	=	5.2
Lj	=	5.2 x D_1

= 5.2x4.43

Lj = 23.03m

STEP-2

D_1/D_0 = $½(\sqrt{(1+8F_0^2)}-1)$

= $½(\sqrt{(1+8(3.51)^2}-1)$

= 4.96

FromIS4997-1968fig4,

K = 1

FromIS4997-1968fig5,

$D_1"/D_0$ = 2

$D_1"$ = $2xD_0$

= 2x3

$D_1"$ =

6mFrom

IS4997-1968 fig8A,

L_b/D_1 = 4

L_b = $4xD_1$

= 4x4.43

= 17.72m

h_s = $0.2xD_1$

= 0.2x4.43

hs = 0.8m

s = $0.15xD_1$

S = 0.66m

w = $0.35xD_1$

= 0.35x4.43

w = 1.55m

Provide 8 rows of concrete blocks of size 1.55x1.55x0.8m with the spacing of 65mm.

6.2 DESIGN OF DROP 1

STEP1

Assume D_1 = 4.43m

D_2 = $-(D_2/2)+\sqrt{(2q^2/D_2g)+(D_2^2/4)}$

= $-(4.43/2)+\sqrt{(2x16^2/4.43x9.81)+(4.43^2/4)}$

D_2 = 2m

Velocity V_1 = (q/D_2)

= (16/2)

= 8m/s

Froude no F_1 = $V_1/(\sqrt{g}D_1)$

= $8/(\sqrt{9.81x4.43})$

= 1

AccordingtoIS4997-1968,

Lj/D_2 = 6

Lj = $6XD_2$

= 6x2

Lj = 12m

STEP-2

D_2/D_1 = $1/2(\sqrt{(1+8F_1^2)}-1)$

= $1/2(\sqrt{(1+8(1)^2}-1)$

= 0.5

FromIS4997-1968fig4,

K = 1

From IS4997-1968fig5,

D_2''/D_1 = 4

D_2'' = $4xD_1$

= 4x2

D_2'' = 8m

From IS4997-1968fig8A,

L_b/D_2 = 9.32

L_b = $9.32xD_2$

= 9.32x2

= 18.64m

h_s = $0.2xD_2$

= 0.2x2

hs = 0.4m

s = $0.15xD_2$

= 0.15x2

s = 0.3m

w = $0.35xD_2$

= 0.35x2

w = 1.5m

Provide 8 rows of concrete blocks of size1.5x1.5x0.9m with the spacing of 375mm.

6.3 DESIGN OF DROP 2

STEP1

Assume D_1 = 2.5m

D_2 = $-(D_2/2)+\sqrt{(2q^2/D_2g)+(D_2^2/4)}$

= $-(2.5/2)+\sqrt{(2x16^2/2.5x9.81)+(2.5^2/4)}$

D_2 = 3.48m

Velocity V_1 = (q/D_2)

= (16/3.48)

= 4.6m/s

Froudeno F_1 = $V_1/(\sqrt{gD_1})$

= $4.6/(\sqrt{9.81x2.5})$

= 0.8

AccordingtoIS4997-1968,

Lj/D_2 = 6

Lj = $6XD_2$

= 6x

Lj = 21m

D_2''/D_1 = 4

D_2'' = $4xD_1$

= 4x2

D_2'' = 8m

From IS4997-1968fig8A,

L_b/D_2 = 9.32

L_b = $9.32xD_2$

= 9.32x2

= 18.64m

h_s = $0.2xD_2$

= 0.2x2

hs = 0.4m

s = $0.15xD_2$

= 0.15x2

s = 0.3m

w = $0.35xD_2$

= 0.35x2

w = 1.5m

Provide 8 rows of concrete blocks of size 1.5x1.5x0.9m with the spacing of 375mm.

Total amount of the estimated quantity = Rs.42561927
Add 5% for contingencies and work charged = Rs.2128096
Grand total = Rs.44690023

VIII. CONCLUSION

- ThestillingbasinoftheVaigaidamhasdesignedandestimationaregiveninthisreport.
- The stilling basin is provided to avoid erosion of the structure.
- In order to controlthehighscouringvelocityinadamandtodissipateitsenergythestillingbasinwith drops has been developed in the Vaigai dam.
- The velocity from the stilling basin is greatly reduced.
- The dam is used for flood control and irrigation purposes.
- The drops are provided to dissipate the energy gradually.
- The horizontal stilling basin with the drops are provided to dissipate the energy from the toe of the spillway to avoid the damaging the overall structure.
- The planning, longitudinal cross section, elevation and half plan at top and bottom ofStillingbasin,Drop-1 and Drop-2are given in this report.
- The designing of the structures like Stilling basin, Drop-1 and Drop-2 are carried out by the references of IS4997-1968. In these designing Froude number, velocity of water, Energy loss ,length of jump and length

of basin are considered as most essential.

- Stillingbasinisusedtodissipateenergyofwaterandvelocityofwater.Velocityofwateris reduced in drop structures compared to stilling basin. So we had provided stilling basin with drops in the dam. Designing of concrete blocks are also carried out.

The estimation of the structures like Stilling basin, Drop-1 and Drop-2 are given in this report. The total amount of the estimated quantity is Rs.42561927, adding 5% for extra contingencies and work charged is Rs.2128096. Grand total is calculated

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