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Methods to Increase Energy Dissipation in Hydraulic Jump

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***Abstract-* Water coming through a spillway gains a lot of kinetic energy due to the transformation of the potential energy into kinetic energy. The water which is flowing at high velocity if discharged into the river it will lead to scouring of the river bed. The scouring of the bed can endanger the spillway and the dam. To protect the channel bed against scouring, the kinetic energy of the water has to be dissipated before it is discharged into the channel. For the dissipation of the excess kinetic energy the two methods that are used-**

(i)By developing a hydraulic jump

(ii)By using different types of buckets

To prevent water bed scouring, which can further lead to soil erosion and can damage the hydraulic structure. An energy dissipator needs to be installed in the right place.

This study analyse hydraulic jump as a energy dissipator in different cases.A stepped weir is designed and used to have a clear hydraulic jump .The energy dissipation while using weir is further compared to energy dissipated through using porous obstacle as energy dissipator, which can be validated using ansys software.

Keywords :* *Hydraulic Jump,Energy Dissipator.

I. INTRODUCTION

The energy dissipators are used to protect the downstream river bed in a canal which will prevent river banks from soil erosion, which can lead to high energy productivity Various Canal projects cannot be implemented in an efficient manner ,due to improper functioning of energy dissipator,which can arise due to its design and its location.

In this study, the experiment is perform in the hydraulic lab open channel, the dimension is 0.3m in wide and 0.5m deep 6m long as shown in figure this was the set of the experiment for the free hydraulic jump and porous abstract of 30% efficiency and 55% and another one for the stepped size have also been done with same dimension . Water pumped with the help of a pump from storage to water collector tank as shown in the figure. Discharge is measured by the help of velocity and area measurement of the flume; also we can measure by the help of the rotameter which we can install on the outlet. Frauds number is varied from 3 to 9.5 as up to the steady flow condition. Experimental calculations have been done on the assumption of the energy loss in the friction as the length of the hydraulic jump is very less which is justified.Experiments have done by measuring the depth using the point gauge average 3 depth in mid of flume for the theoretical calculation equation of the Subramanyam have been used (eg for depth calculation and energy loss).

II. LITERATURE REVIEW

To achieve Sustainable development goal(SDG-7) of clean and affordable energy The Government of India has set up an ambitious target of installing 175 GW of renewable energy capacity by 2022 which also includes a 10 GW energy supply of hydro power. The agriculture sector consumes about 19% of the total electricity available. Using proper energy dissipators to get maximum hydro power energy accompanied by accurate irrigation practices can contribute significantly to the Indian agricultural sector. A detailed study of utilising hydropower is required for significant improvement in the agriculture sector.

B.A. Yadav [2] propose to address the issue of controlling the location of hydraulic jump and evolve a new technique for the same.In the paper titled “Design of hydraulic jump type stilling based on case study at warana canal’’ This paper discusses the design of hydraulic jump type stilling basin for the overflow weir of canal escape at Warana dam (India). It also throws light on the aspect of jump location and percentage energy dissipation. A physical model study is carried out by applying Froude’s model law.

The authors have also tried to determine factors that govern the choice of the type of energy dissipator. In [15],there is a attempt to determine factors, that govern the choice of the type of energy dissipator a re hydraulic considerations, topography, geology, type of dam, layout and other associated structures, economic comparisons, frequency of usage etc

Another author, Siddharth Upadhyay[3] proposed to restrict the location of hydraulic jump inside the stilling basin for maximum energy dissipation. .

In the paper titled “Experimental analysis of the scour profile downstream of flip bucket with change in bed material size ” [1], an effort has been made to determine various parameters ,on which scouring of water bed depends.In our paper, different scenarios have been taken while using stepped weir and porous obstacle to get the proper location of energy dissipator and to have maximum energy dissipation which can further prevent scouring of water bed

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III. EQUATION AND UNITS

Depth and energy calculation have been done by the use of Subramanya Equation as given below

$$\Delta E' = E_2' - E_3' = \left(y_2' + \frac{q^2}{2gy_2'^2}\right) - \left(y_3' + \frac{q^2}{2g2gy_3'^2}\right).$$

ΔE' is energy head loss ;
E2' is energy head at section
E3 is energy head at section 3; y2' is water depth at 2
y3'is water depth at 3; g- acceleration due to gravity
Fr is Froude's Number called conjugate depth of flow. Relation in between the initial depth and conjugate depth is given as by the specific energy above set up measure as average velocity during the experiment and floor depth at the vena contracta is given by

$$\frac{y_3}{y_2} = \frac{1}{2}\left(\sqrt{(1+8F_{r2}^2)} - 1\right)$$

Y=(d) x (Cc) (3)

(where; d is gate opening; Cc is coefficient)

calculation in the section A and B is calculated by the energy equation by the energy principle as there is forming the submerged hydraulic jump as the depth at A can not measure due to the turbulence so \, it given by ;

Ya=Ho-V2/2g (4)
(where; Ho is the depth of water before gate

IV. FIGURES AND TABLE

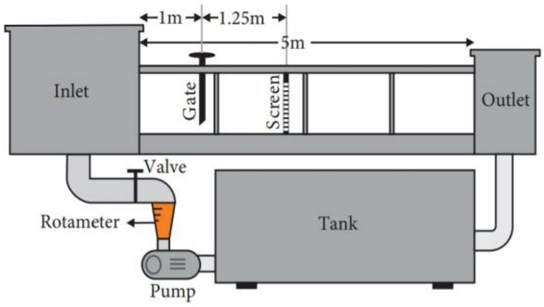
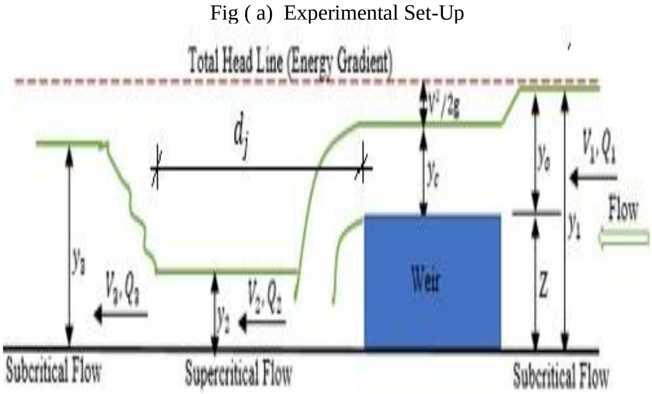
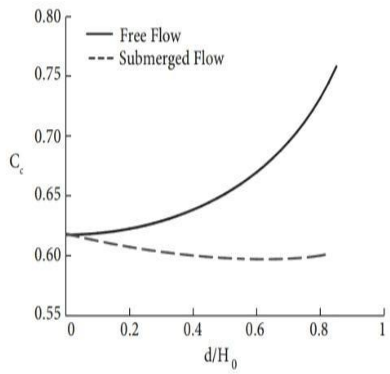


Fig (a) Experimental Set-Up



Fig(b) Set Up For The Energy Dissipation In The Free Jump And Used For Depth Calculation



Fig(**c**)- ariation Of Co-efficient Of Contractionwith d/Ho

At the top of the weir ,the frouds no in the range of the 0.067 to the 0.089 which prove that the flow is subcritical .Before the hydraulic jump froude no is in range of 3.02 to 3.60 which prove flow to be supercritical and jump in the range of oscillating .

After the jump frouds no in the range of 0.36 to 0.42 which lead to the subcritical flow with lower energy and leads to energy loss.
Now we go with the stepped size breaker to form a hydraulic jump in such a manner so that the edge of the breaker touches the previous breaker .The height of the breaker changed form ratio 0.20 ,0.40, 0.60 0.80 1.0 and thickness is 2.0 mm.

Height of breker	Without	hs/hb=0.2	hs/hb=0.4	hs/hb=0.6	hs/hb=0.8
ΔE/E	0.45	0.50	0.55	0.59	0.61

Weir							
F	F_{r1}	F_{r2}	F_{r3}	y_3/y	v_3/v_2	Boundaries	
1	0.068	3.56	0.37	4.26	4.26	F_r>1 Supercritical flow	F_r=1-1.7 undular jump
2	0.082	3.37	0.38	4.29	4.29		
3	0.084	3.56	0.37	4.52	4.52		
4	0.090	3.02	0.41	3.80	3.80	F_r=1 Critical flow	F_r=1.7-2.5 weak jump
5	0.092	2.98	0.35	3.72	3.92		

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Table- II: Experimental Results while performing free hydraulic jump

Weir										
		Upstream of Weir			Upstream of Hydraulic Jump			Downstream of Hydraulic Jump		
1	2	3	4	5	6	7	8	9	10	11
Flow	Z (m)	y_1 (m)	v_1 (m/s)	Q_1 x10-	y_2 (m)	v_2 (m/s)	Q_2 x 10^{-4}	y_3 (m)	v_3 (m/s)	Q_3 x10^{-4}
1	0.073	0.096	0.065	4.85	0.006	0.92	4.86	0.031	0.22	4.90
2	0.073	0.096	0.078	5.60	0.007	0.93	5.62	0.03	0.21	5.66
3	0.073	0.096	0.080	5.90	0.007	0.95	5.91	0.032	0.20	5.91
4	0.073	0.096	0.081	6.00	0.008	0.92	6.00	0.033	0.23	6.12
5	0.073	0.096	0.085	6.29	0.008	0.93	6.33	0.035	0.23	6.53
6	0.073	0.097	0.082	6.50	0.008	0.95	6.51	0.036	0.19	6.40

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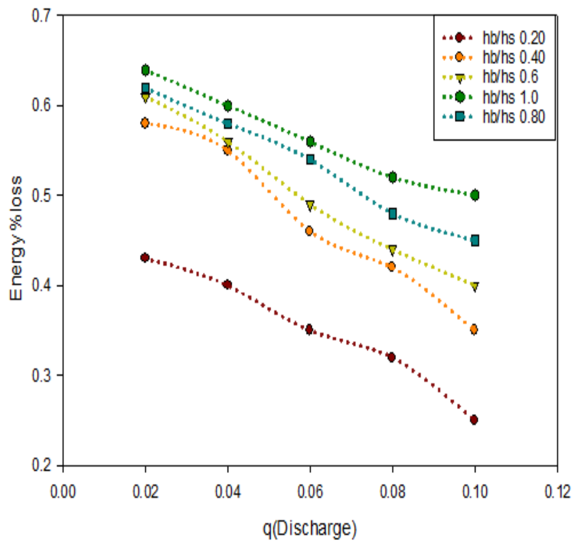
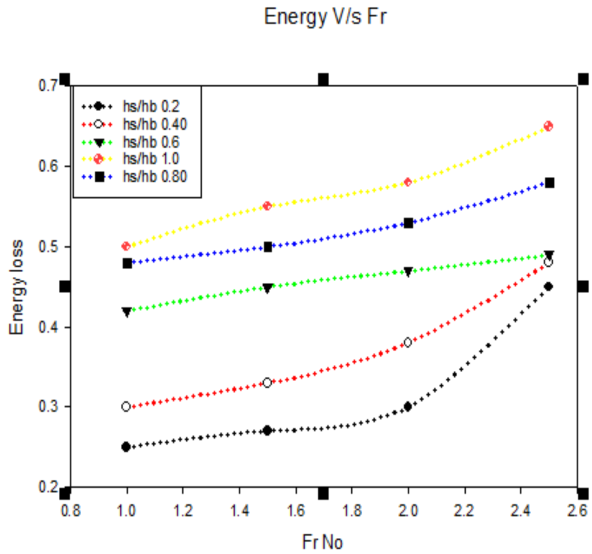
V .GRAPHS AND CALCULATIONS

As the graph shows when we plot the relationship between the energy loss and the breaker height ratio it increase upto certain value and then decrease, it is measured maximum for the 0.8 height ratio



Variation for the energy loss and frauds no is shown



In the experiment with the porous obstruct, we get energy loss and with respect to the frouds no which calculated for the obstruct and fig is showing the result of that experiment . The experiment is performed by using the 35% efficiency and 55% efficiency screen in these calculations. A comparison graph is made for free jump loss and also with respect to energy loss when the screen is installed at the downstream and upstream side .Blue line is showing free jump

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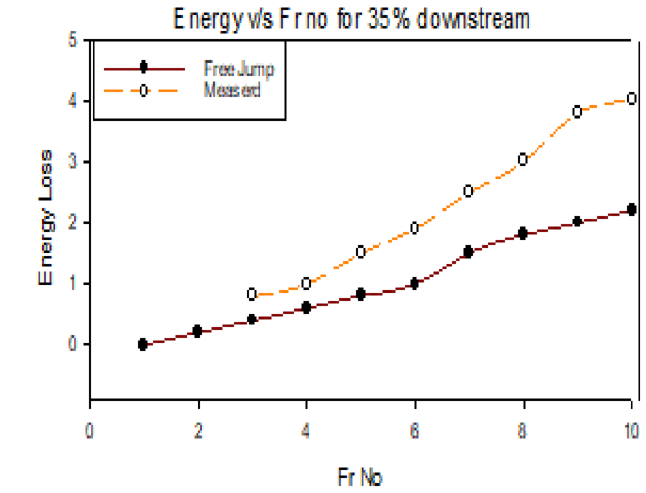
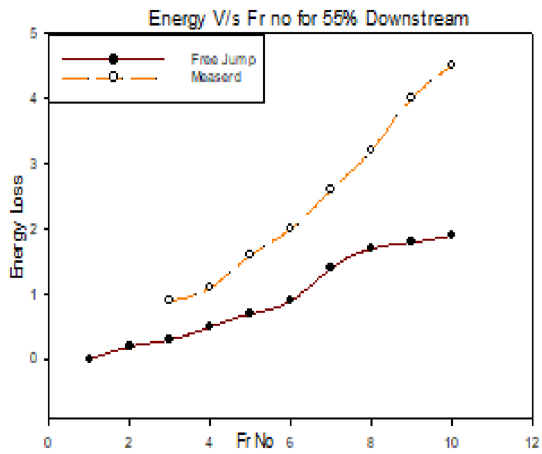
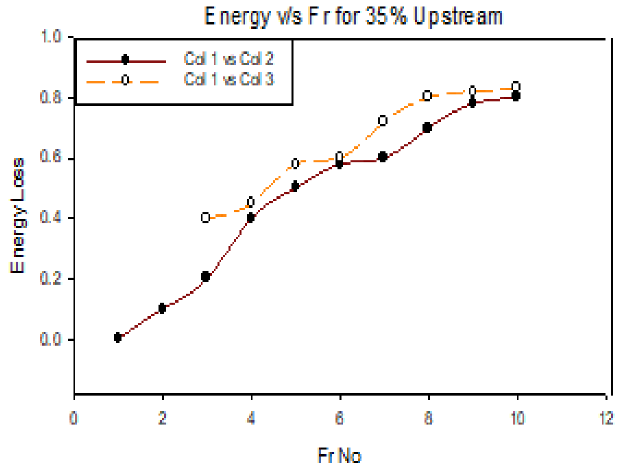
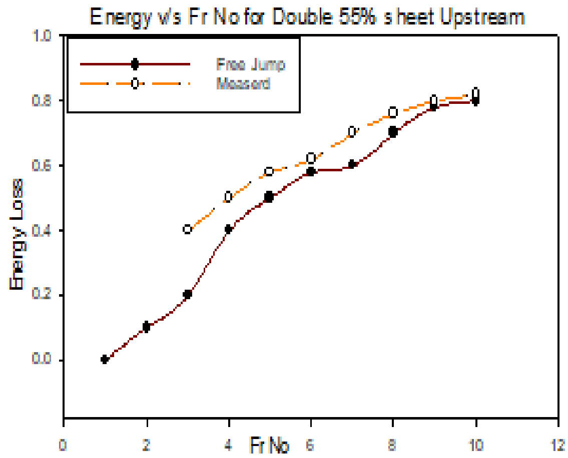
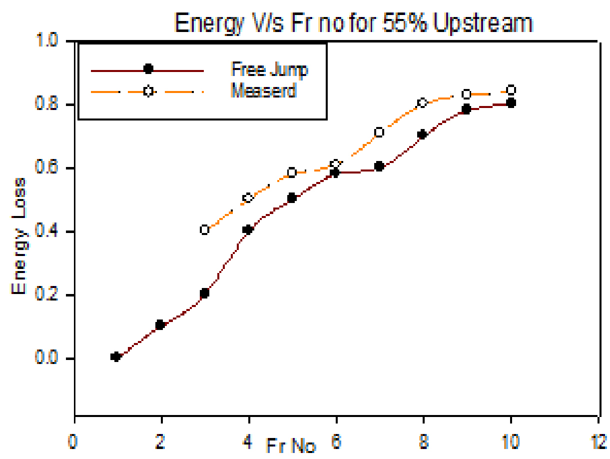


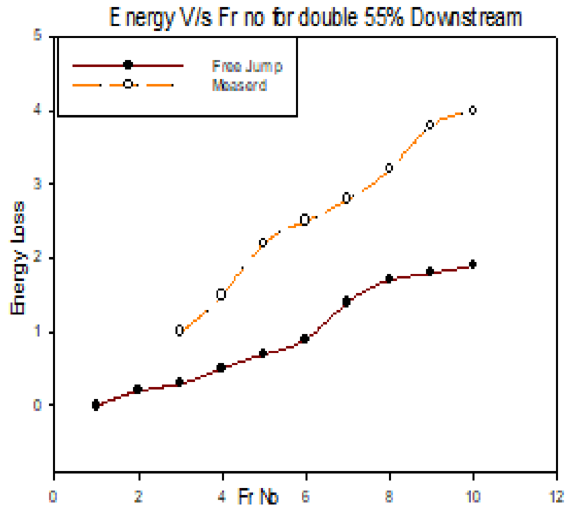








(1)



VI .CONCLUSION AND FUTURE SCOPE

This paper shows an experimental study based on energy dissipation in hydraulic jump through different methods like stepped weir and screens. Experimental results have clearly shown that using stepped size with ratio of height of stepped size to height of breaker equal to 0.8 produce maximum energy dissipation.Similarly another experimental work shows that while using screens as a form of energy dissipator,the energy dissipation increases with froude's number. And using double screen with efficiency 55 percent with regard to down stream produces maximum energy dissipation as compare to single screen and free jump

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So to have proper designed energy dissipator installed at an accurate location is necessary to prevent scouring of water bed and to prevent damage of hydraulic structures . This will have positive impact on canal projects which are directly related to proper irrigation practices for agriculture

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