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STUDY AND DESIGN OF SKI JUMP FOR ENERGY DISSIPATION

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ABSTRACT

The design of ski-jump bucket for a particular dam is very complex in nature, as it involves variables such as discharge intensity, head over spillway, lip angle, bucket radios and frictional losses. Prototype jet trajectory length is found significantly shorter than the theoretical distance computed using various empirical equations. One of the most effective and economical methods for the dissipation of hydraulic energy from flood waters is to project the flows into a free trajectory jet form to a location where the impact creates a plunge pool in the downstream river bed.

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I. INTRODUCTION

Ski jumps are a major element of each dam spillway because these are the only structures able to accomplish satisfactory energy dissipation for take-off velocities in excess of some 20 m/s. This research aims to add to several hydraulic problems with Ski jumps that have not yet been systematically solved so far. Although Ski jumps were introduced in the 1930s in France, several questions have so far not been systematically addressed. The origins of Ski-jumps can be dated back as far as the mid-1930s where they were successfully introduced on the Dordogne hydraulic scheme in France. This revolutionary scheme designed a circular arc spillway over the power plant with the intention of conveying high velocity flow in the form of a trajectory jet over power plant and plunge down onto the riverbed at a substantially far distance away from any dam apparatuses as to mitigate potential structural damage. Due to the success of this design, it became very popular in France, Spain and Portugal.

SKI JUMP ENERGY DISSIPATER

One of the most effective and economical methods for the dissipation of hydraulic energy of water overflowing dam walls from flood waters is to project the flows into a free trajectory jet form to a location where the impact creates a plunge pool in the downstream river bed. In dam engineering, ski-jumps are common hydraulic structures with the function of deflecting high velocity discharge from large dam spillways and chutes to produce a free jet trajectory. The main component of a ski-jump energy dissipater is the ski-jump bucket or flip bucket which is not an energy dissipater in itself but plays an integral part of the energy dissipation process. The primary purpose of the flip bucket is to deflect high velocity flow up and into the air in the form of a jet trajectory.

II. PROBLEM STATEMENT

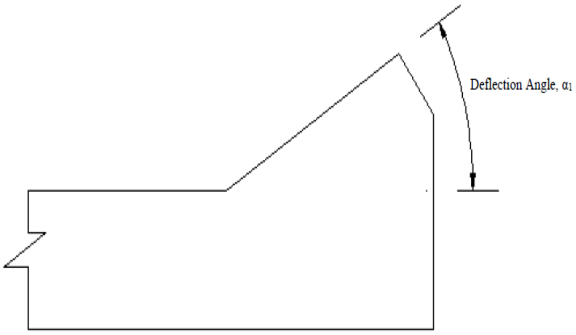
The results of the Ski jump in the laboratory and practically performing it on the site are slightly different. There is a need to design Ski jump for maximum energy dissipation.

OBJECTIVE

1. Design and Model of the Spillway and Ski jump bucket using IS codes 7365(2010), 6934(1998).

2. Measuring Throw Distance in tilting flume of Bharati Vidyapeeth University, Katraj, Pune.

3. Comparing Computed Throw Distance and Observed Throw Distance.



Triangular Shaped Flip Bucket

III. METHADOLOGY

Design Criteria for the Ski jump/ flip Bucket-

The design criteria should be adopted by the bureau of Indian Standard (2010) and the U.S Army Corps of Engineers (1990).

1. Bucket shape,

2. Bucket invert elevation,

3. Principal geometrical parameters of the bucket including radius, lip trajectory angle, lip height, bucket termination and sidewall termination,

4. Alignment,

5. Bucket pressures,

6. Trajectory distance and impact angle,

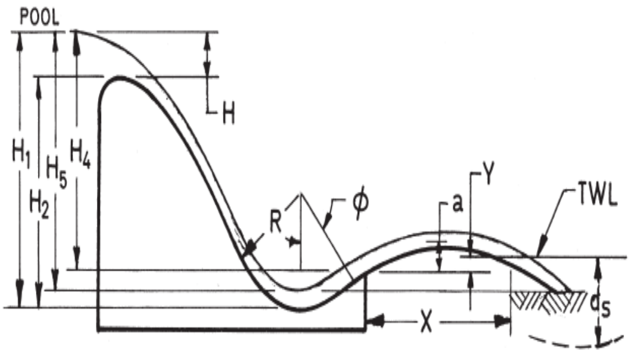
7. Discharge and other design considerations including design discharge, low flow operation and bucket drainage, and

8. Estimation of scour downstream of the spillway.

SCOPE OF WORK

In the design of hydraulic structures, determining the location of a hydraulic jump is very important. As previously described, the hydraulic jump plays a critical role in fluid channels. For example, a chemical purification point should be constructed right before the toe of hydraulic jump. Therefore, a location of the jump should be determined first. In designing a stilling basin, the sequent depth of the jump should be known.

This type of energy dissipation has become an increasingly popular form of hydraulic energy dissipation for large dams in recent years.



Energy Dissipation through circular bucket

CIRCULAR SHAPED FLIP BUCKET

The circular-shaped flip bucket is the traditional flip bucket used for ski-jump energy dissipaters. This bucket is utilized the most because of its simplistic design including a uniform radius and deflection angle. Extensive research has been conducted on this type of ski-jump bucket by countries such as America, China and India, each with their own guidelines. Steiner investigated the ski-jump hydraulics of the circular-shaped flip bucket in a physical model that resulted in generic design criteria for the flip bucket geometry angle and radius, as well as jet trajectories and bucket pressures.

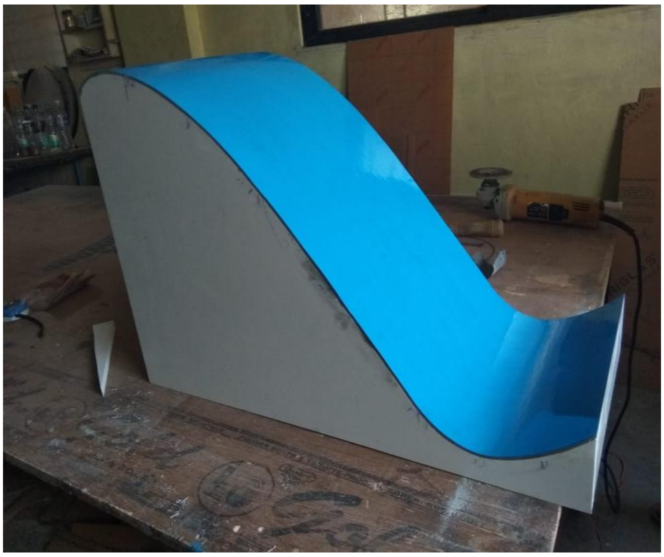
BUCKET SHAPE

The shape of the ski-jump bucket is an aspect of the energy dissipation system that has very little effect on the geometric performance. Performance of the trajectory bucket according to the Bureau of Indian Standards (2010), is based mainly upon the trajectory distance and jet dispersion. As stated previously in there are specifically two distinct shapes; the triangular wedge-shaped bucket and the circular-shaped bucket both of which have identical trajectory performance. The preferred bucket shape is the circular-shaped bucket and is the main focus of this specific thesis.

BUCKET INVERT ELEVATION

For optimal performance, the U.S. Army Corps of Engineers (1990) states that the flip bucket must be operating in free flow conditions where submergence does not exist. According to the Bureau of Indian Standards (2010), by designing the invert elevation to remain above the maximum tail water a clear flip action can be experienced. The fixation of the invert or lip elevation of the flip bucket is dependent on the shape of the tail water discharge curve specific to the site and may need to be adjusted accordingly.

A recommendation by the Bureau of Indian Standards (2010) is that the bucked elevation is beneficial to be situated close to the natural bed level. One benefits of this is that less construction materials such as concrete and steel reinforcing would need to be utilized thereby reducing the costs of the project.



Model

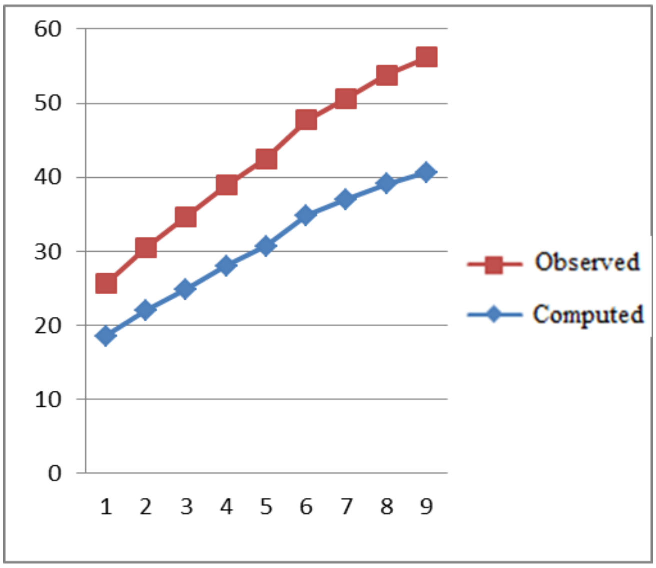
IV. EXPERIMENTAL ANALYSIS AND RESULT

Computed throw distance

Discharge (Q) (LPS)	**Effective Head (H_e)** (cm)	**Throw Distance** (cm)
2	2.1	7.11
3	2.7	8.48
4	3.3	9.81
5	3.8	10.88
6	4.3	11.80
7	4.8	12.86
8	5.2	13.68
9	5.7	14.69
10	6.1	15.49

Observed throw distance

Discharge (Q) (LPS)	**Effective Head (H_e)** (cm)	**Throw Distance** min-max (cm)	**Throw Distance** avg. (cm)
2	2.1	5.0-32	18.5
3	2.7	7.1-37	22.5
4	3.3	7.8-42	24.9
5	3.8	8.1-48	28.05
6	4.3	8.4-53	30.7
7	4.8	8.7-61	34.85
8	5.2	9.0-65	37
9	5.7	9.2-69	39.1
10	6.1	9.4-72	40.7



Comparison between Computed and Observed Values

Ski Jump Formation

V. CONCLUSION

This thesis gives a detailed account into the design and construction of ski-jump energy dissipating structures. Energy dissipation is a function of various factors and one cannot make a decision for the most suitable ski-jump bucket by considering these factors individually.

It is find that theoretical and experimental values differs but not to the large extent. Experimental values of throw distance are more than theoretical values.

The spillways are design to flow the water smoothly over the surface. The lip angle, radius, lip level of the bucket is the most important parameter that governs the throw distance of the water.

The model study in the tilting flume shows the variation in the throw distance computed practically and theoretically.

Design of ski bucket is a critical part as it requires lots of experience and judgment. The hydraulic engineers face many challenges while designing the ski-bucket.

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