THESIS

ANALYSIS OF HYDRAULIC JUMP AND EFFECTIVENESS OF ENERGY DISSIPATION DEVICES AT JINNAH BARRAGE

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ABSTRACT

ANALYSIS OF HYDRAULIC JUMP AND EFFECTIVENESS OF ENERGY DISSIPATION DEVICES AT JINNAH BARRAGE

The hydraulic jump is one of the most interesting phenomena in the field of hydraulics. Hydraulic jump is formed whenever flow changes from supercritical to subcritical, surface rollers are formed and usually a large amount of energy is dissipated. Hydraulic jump is mostly used for energy dissipation in stilling basins below dams and barrages. Its proper formation and location is very important for efficient energy dissipation otherwise serious damages can occur.

Jinnah Barrage has to face serious problems due to improper jump location. The barrage is located in the northern part of the country in Mianwali District of Punjab Province, on the River Indus about 215 km below Terbela dam and about 5 km from the town of Kalabagh. It was constructed in 1946 as a part of Thal Irrigation Project to irrigate 2.3 Million Acres of land through Thal canal, taking off from its left flank.

Due to excessive retrogression, the downstream water levels of Jinnah barrage has fallen far below the permissible limits causing very high velocities on the downstream glacis. As a result the hydraulic jump cannot form ideally (i.e. on the downstream glacis toe) and a lot of energy of supercritical flow remains undissipated which is absolutely undesirable. Further more, Thal canal is being remodeled to increase its capacity to 10,000 cusecs from 6000 cusecs, and the barrage pond level to 694.0 ft a.m.s.l. from 692.5 ft a.m.s.l. This new situation can worsen the flow conditions.

The specific purpose of this study is to analyse the hydraulic jump formation and performance of energy dissipation devices for both the barrage operation scenarios (i.e. Pond levels of 692.5 ft and 694 ft a.m.s.l.) and to devise remedial measures on the basis of this analysis for mitigation of the problem.

To achieve the objectives of the study first of all exact location of hydraulic jump was determined. Then available data was used to analyze the hydraulic jump formation and adequacy of downstream impervious floor level and length using Conjugate depth method, Crump's curves method, Blench curves method, Energy of flow curves and Computer model HEC-RAS for two scenarios i.e. existing condition of Barrage with a pond level of 692.5 ft a.m.s.l. and proposed condition with a pond level of 694.0 ft a.m.s.l., starting with the design discharge of 9,50,000 cusecs and then decreasing it by 50,000 onwards up to 50,000 for first three methods. The fourth method was used to locate hydraulic jump position for a discharge range other than used for first three methods for both the above-mentioned scenarios. Computer model HEC-RAS was used to simulate Jinnah barrage for analysing hydraulic jump formation for 10 observed flows.

The performance of the energy dissipation devices was examined on the basis of energy dissipation efficiency (jump efficiency) and Montague's criteria (based on values of Froude no. of different flows passing over the friction blocks) for above-mentioned scenarios and for the same discharge range as for first three methods.

Then on the basis of the above analysis various options to improve the present condition of Barrage were worked out and their suitability was discussed. The results showed that hydraulic jump is not forming properly but is repelled away from the downstream glacis toe for most of the flow values except for very low flows. The downstream impervious floor level seems much higher than the required level (4ft higher for both Weir and Undersluices for present conditions and 5ft for proposed conditions) and the downstream impervious floor is short in length (by 21ft for Weir and 23ft for Undersluices under present conditions and 25ft for Weir and 32ft for Undersluices under proposed conditions respectively) to diminish safely the jump turbulences. Hydraulic jump efficiency is less than, minimum required, 30% for most of the discharges and the flow passing over the downstream friction blocks is either critical or supercritical which allows the formation of undesirable secondary jump.

On the basis of the results, suggested remedial measures to mitigate the problem are; lowering or extending downstream cistern floor, changing the shape of the downstream friction blocks, providing 4ft high endsill or secondary weir and changing the downstream glacis to Montague's curved glacis.

The remedial measures should be carried out as soon as possible and the Indus River reach from Tarbela dam to Kotri barrage should be simulated to avoid such kind of problems in future.

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