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COMPARISON OF PRE-CONSTRUCTION AND POST CONSTRUCTION SEEPAGE FOR 17.4 MW SATPARA DAM PROJECT, SKARDU

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Abstract — *This research has addressed typical geological complexities through performance evaluation of selective foundation seepage control features for embankment dams. Many researchers like Pack (2000) introduced use of hazard/factual examination through proper site-explicit designing evaluations as the standard methodology for foundation assessment of dams regardless of the restricted extent of examinations. In that capacity, 2-D seepage examination replicas for heterogeneity foundations either utilize a similar foundation with a careful K-esteem/K-work related with two-sheet methodology, for example a prevailing foundation sheet by moderately permeable region in middle. The haphazardness of deposition conditions identified with greatest heterogeneity foundations isn't tended to all things considered for traditional 2-D drainage examinations.*

The study is based on case history of Satpara Dam Project founded over moraine deposits. Seepage modelling was carried for 'as-designed' seepage mitigation measures under 2-D sectional flow model for different case scenarios using Plaxis 8.6. Available project data from Seven years of consecutive operation showed that conservation level and consequently a steady state condition was not achieved. Model study shows that as the Water level increases the seepage value increases simultaneously whereas, real time data collected shows that seepage decreases with the passage of time so both are inversely proportional to each other. Actual Seepage percentage has reduced upto 13% corresponding to the same levels achieved during the last seven impounding which shows that with time seepage reduces. Data for almost 80 instruments was used to develop state reservoir and the analysis was done by taking level for a particular period which was retained for at least 5 days for the last 6 impounding's. Model study shows that as the Water level increases the seepage value increases simultaneously whereas, real time data collected shows that seepage decreases with the passage of time so both are inversely proportional to each other. It was observed that during the course of operation of the Dam the seepage measured indicating that seepage control measures taken for the dam is effective and working properly.

Keywords- *Dam; Instruments; Impounding; Seepage; Plaxis 2D; Standpipe; Geology*

I. INTRODUCTION

Earthen dams are a kind of Dams structures obliged by on ground physical environment of the site. These are established and covered by normally thought up conditions and are designed for similarity at the base and flanks. The common course of action (visit disarrangement) of foundation materials now and again prompts unexpected and troublesome results requiring broad remediation of drainage issues from side to side of the foundations.

Significant parts of planning and building safe water retaining structures (dams) and filling their expected need for putting away water are strategies for dissecting leakage through the foundations or under drainage, which is the ordinary phrasing with this impact. The favored deterministic methodology for under drainage examination incorporates creating foundation profiles from site examinations, trailed by allotting of pressure driven conductivity esteems. Limited component leakage examinations are then led thinking about various cross-segments, to contrast anticipated inclinations with channeling criteria. The consequences of such examinations are understandings of electronic stream nets.

The best vulnerability of a dike dam lies in the condition & viability for foundation medications for drainage control. Foundation seepage through profound characteristic foundations faces the penchant for genuine structure and security issues. This viewpoint is bothered with heterogeneity of the

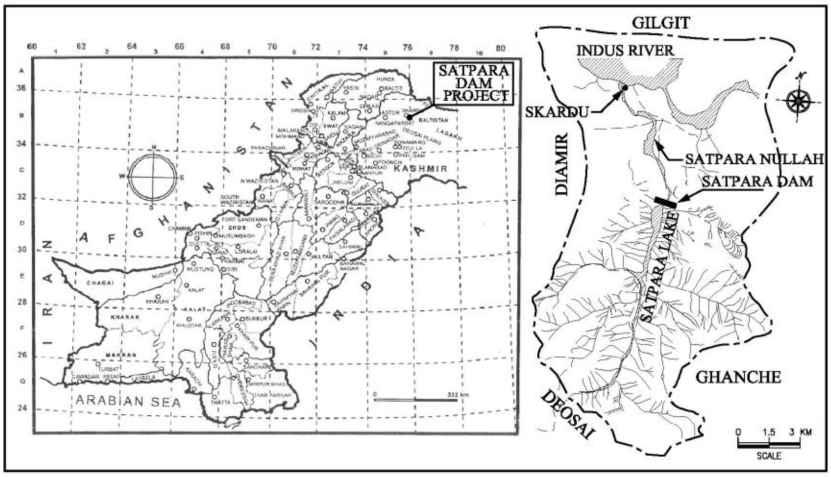
foundations for nonappearance of bed shake for reasonable impenetrable stratum at shallow profundities.
When all is said in done practice, hypothetical answer for such physical irregularities is tended to accepting the foundations being made out of at least one homogeneous strata with well-characterized 'layered' limits. Scaled changes as well as factor comparable conductivity suppositions are utilized in progression as an issue of guess. This comprehension highlights 'capability' over 'evaluation' of drainage, in planning, surveying, and observing of control measures for foundation leakage. In the expressions of Terzaghi and Peck (1967), "Security of a dike as for disappointment by seepage has no direct correlation with measure of escaping water. Expansive misfortunes of water might be related to increase in security against channeling."
Foundation leakage is an immediate reaction of the pressure driven weight 'head' applied profundity of supply water behind the dike. The related pore water weights and pressure driven angles go about as an impetus for starting interior disintegration or channeling, along vulnerable sub-surface stream ways. Foundation drainage issues are commonly founded on suppositions of an 'unfaltering state' stream, which exists when the store level has been at a similar height (the protection water level) sufficiently long for the most elevated/greatest pore water weights to grow wherever in area of leakage. All things considered, the pre-development foundation leakage investigations are not generally kept up or reached out for correlation with the real foundation reaction amid and aftermdam development.

A. Literature Overview

Pack (2000) [3] introduced use of hazard/factual examination through proper site-explicit designing evaluations as the standard methodology for foundation assessment of dams regardless of the restricted extent of examinations. Talbet et al. (2000)[4] quickly portray typical remedy of drainage issues. Elkatab et al. (2003)[5] feature parts of parameter evaluation in troublesome foundation situations. These referred feature multifaceted assignment for enough characterizing the foundations as best delegate of the genuine issue space to be embraced before the real displaying and affectability investigations. In that capacity, 2-D seepage examination replicas for heterogeneity foundations either utilize a similar foundation with a careful K-esteem/K-work related with two-sheet methodology, for example a prevailing foundation sheet by moderately permeable region in middle. The haphazardness of deposition conditions identified with greatest heterogeneity foundations isn't tended to all things considered for traditional 2-D drainage examinations. Average down to earth thought with respect to essential proportions of drainage control through the foundations from that point refers to Mukhopadhyey (2008)[6] in respects of end point divider and Gohernejed et al. (2010)[7] aimed at impenetrable upstream cover. The rest of the writing audit shows distributed writing recognized straightforwardly encounters plus execution assessment in pertinence to this investigation. There is restricted distributed writing sequentially identified with the examination, investigation, structure and execution assessment for a blend tactic of drainage regulator through profound porous foundations. Normally this is because of the accessibility of impenetrable base at low profundities for a confident end point.

B. Case Study

Satpara Dam is a Project aimed at various purposes, located at Longitude: 75º 46’ 12” E and Latitude: 35º16’ 12” N on Satpara Nullah, D/s and north of the present Satpara Lake Project layout is presented in Fig. 3.1. The dam is having height of 39 m high and zoned rock filled was perceived here. This project is aiming the provision of 0.098 MAF of water for irrigation covering 15,000 Acre’s of land, 3.1 MGD supply of drinking water to local inhabitants for municipal purpose land energy generation of 17.4 MW. Satpara Dam was from the start worked around 45 m D/s of Satpara Lake as an earthen bank, with stone spillway. To hold onto water & utilize the proportionate, a fleeting strategy of check passages through a channel along the upstream of the bank was created and put to use. On endorsement from (NAPWD), Planning and Investigation (P&I) Division of WAPDA, finished starting field assessments and orchestrating examinations of Satpara Multipurpose Project in 1988. In like way, Hydro Electric Power Organization (HEPO) of WAPDA envisaged arrangement in 2002 for a 39 m high ECRD (Earth Core Rock fill Dam, for instance a zoned dam) D/s of the old dam. Fig. 1 exhibits the endeavor configuration plan and the evident succession. Thusly, a joint undertaking of expert firms SDC was named towards the completion of 2002 for study of the arrangement and advancement supervision of the endeavor. Arrangement review was done in 2004 and advancement delineations were prepared. Dam improvement continued from 2004 to 2011. [1]



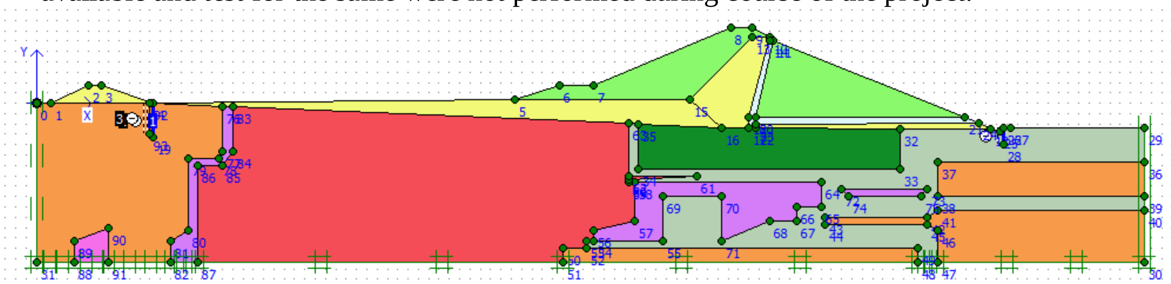
C. Method

B.1. *Foundation Perviousness*

Perviousness (K) is the most common material property for evaluating leakage study & its precautionary measures. 2-dimensional Steady state leakage analyses were performed for case history, using Plaxis 2D. PLAXIS 2D is a FEM software used for geotechnical modeling prepared by Delft university Netherland. To get a best answer for the leakage control along the pre-existing moraine kept establishment of Satpara.

The fundamental blueprint of the issue was at first outlined in Plaxis 2D distinctive material locales were separately characterized. Limited components and hubs were auto-created toward the finish of every locale.

In PLAXIS 2D 14 No. Material properties are to be defined which are Hydraulic conductivity in both directions, unit weight of the material both saturated and bulk, stiffness and strength of the material and modulus of elasticity etc. these data were collected from different sources as most of the data was not available and test for the same were not performed during course of the project.

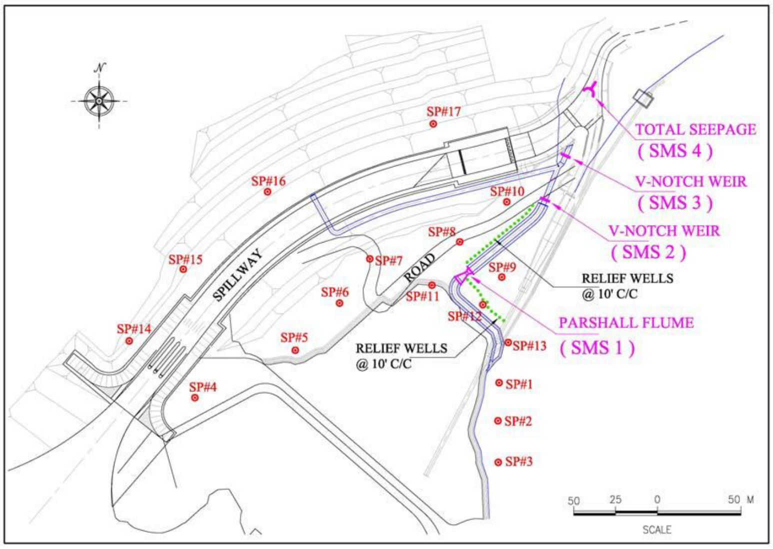


Plaxis model for Satpara Dam Project

B.2. *Instrument data*

The instrumentation framework set up for Satpara Dam was gone for elite observing of the presentation of received drainage control measures as far as respectability, adequacy, pore water weights and leakage designs. The information and data utilized for the ensuing exhibition assessment as per the destinations of this exploration was acquired from the WAPDA staff deputed for the reason.

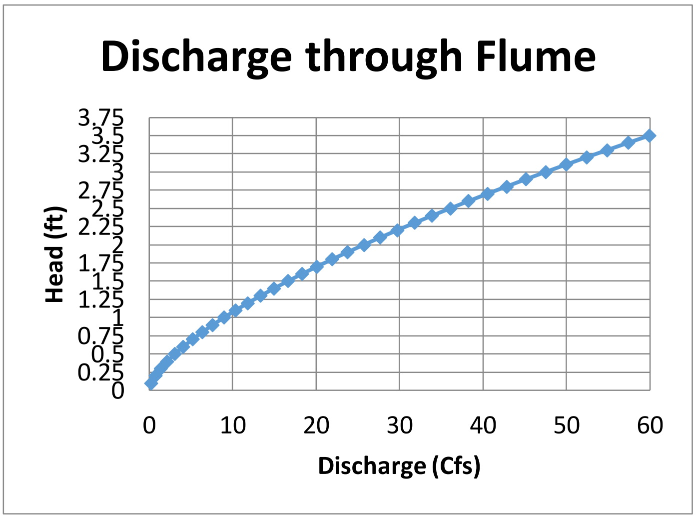
The number & circulation of the instruments was preplanned in order to improve the general information by relating estimations & following speculative leakage ways. A sum of 63 vibrating wire piezometers and 20 standpipe piezometers were introduced at various areas all through the task. [2]



Seepage Monitoring Stations (SMS)

SMS-1 Parshall Flume

SMS-2 V- Notch at toe of Dam



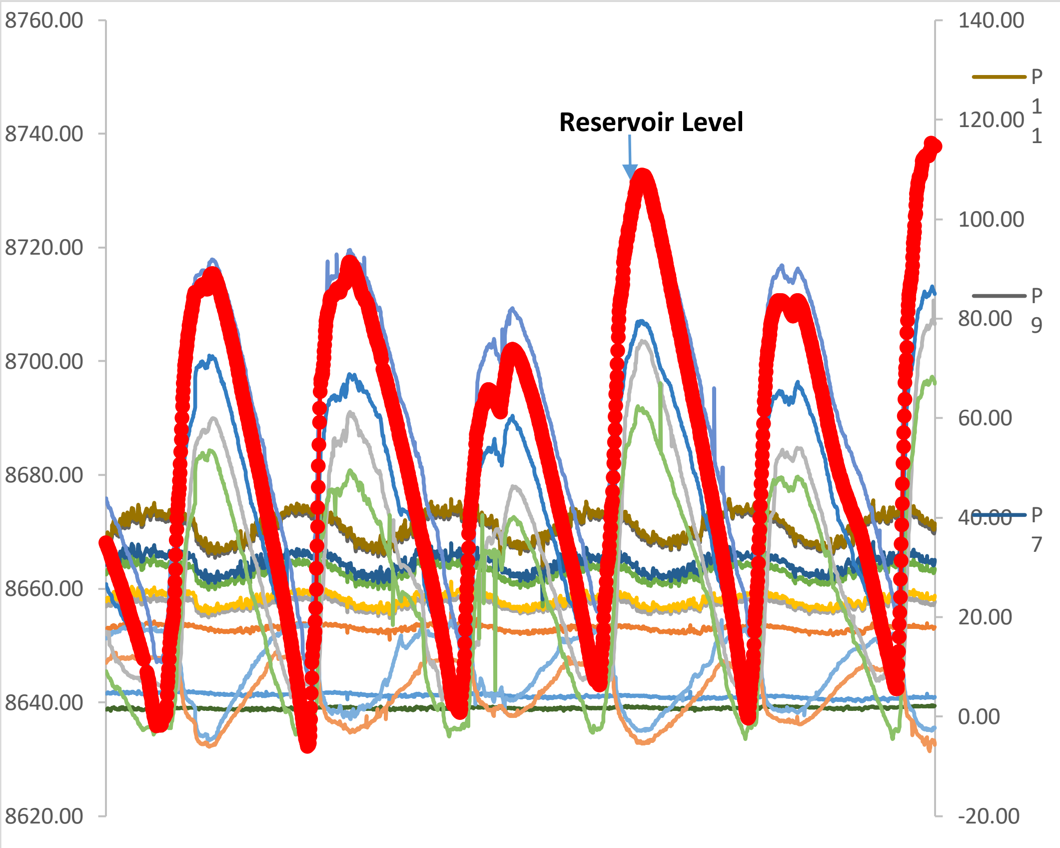
[8] Basic design of Replogle flumes, Irrigation Training & research center, California polytechnic state university, San Luis Obsipo, California

Discharge through Flume [8]

D. Results and Discussion

Plaxis 2-d model indicate that as water level increases the seepage also increase which is directly proportional to each other. Whereas, as per site data the seepage has reduced upto 13% during the course of operation of the Dam. The main reason for this reduction is the during operation treatment of sinkholes created after drawdown of the reservoir.

Various trials were made on the model keeping in mind that impervious layer was not found upto 200 ft. pervious layer and impervious layer were provided after 200 ft and subsequently model was run on different levels attained during the last 07 impounding's. The results showed that if impervious boundary condition is applied the seepage path through the heterogeneous layers decrease and results generated are close to the real time data. Whereas, if pervious boundary condition is applied, extreme velocity increases drastically.



Measured Piezometeric Record P1 to P24 vs Reservoir impounding Data from 2010 to 2018

On the plaxis model two scenarios have been taken for modeling and comparing the results for seepage behavior which are as under:

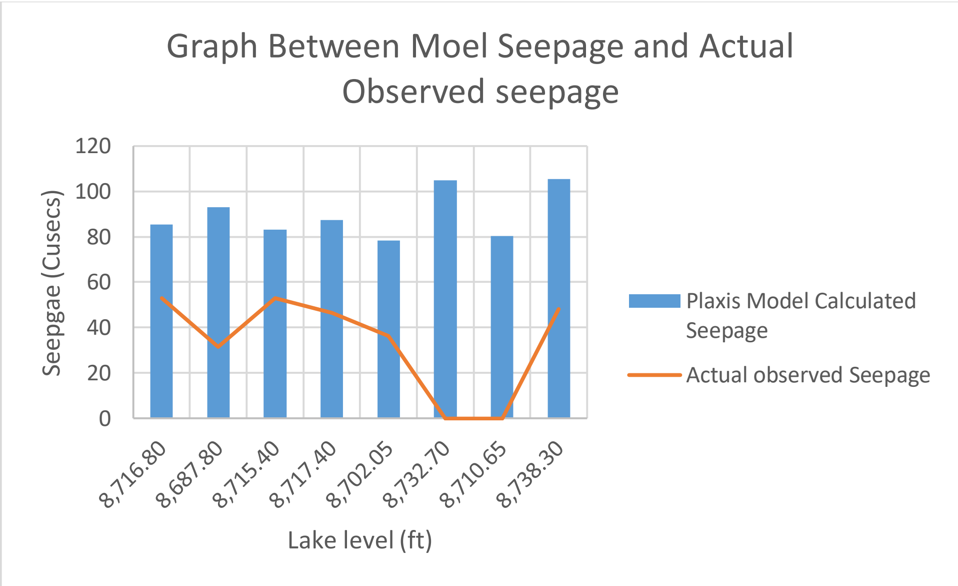
- Taking soil strata at 200 ft depth as pervious
- Taking soil strata at 200 ft depth as impervious.

Results for the above two scenarios for model vs Actual seepage measures is as under:

Year	Reservoir level (Ft. a.s.l)	Min. Operating level (Ft. a.s.l)	Depth of water (Ft)	Seepage (cusecs)	Actual Seepage Measured as per site (Cusecs)
2010	8,716.80	8612	104.8	85.33	53
2011	8,687.80	8612	75.8	92.89	31.48
2012	8,715.40	8612	103.4	83.25	53
2013	8,717.40	8612	105.4	87.33	46.4

2014	8,702.05	8612	90.05	78.22	36.34
2015	8,732.70	8612	120.7	104.77	0
2016	8,710.65	8612	98.65	80.25	0
2017	8,738.30	8612	126.3	105.56	48.13

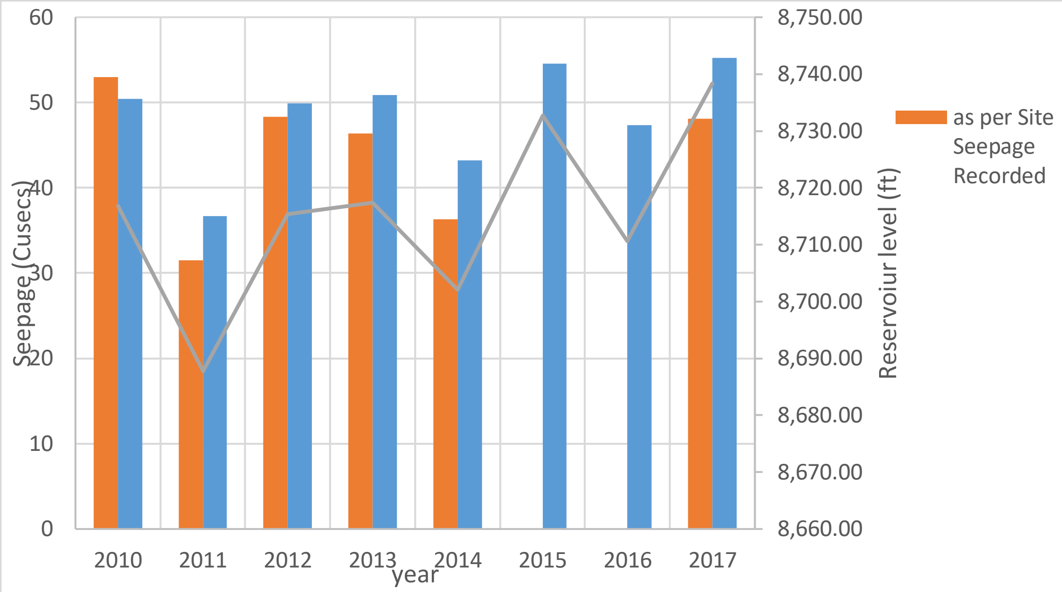
Results for Scenario 1: Taking soil strata at 200 ft depth as pervious



Graph for Scenario 1: Taking soil strata at 200 ft depth as pervious

Year	Reservoir level (Ft. a.s.l)	Min. Operating level (Ft. a.s.l)	Depth of water (Ft)	Seepage (cusecs)	Actual Seepage Measured as per site (Cusecs)
2010	8,716.80	8612	104.8	50.4	53
2011	8,687.80	8612	75.8	36.65	31.48
2012	8,715.40	8612	103.4	49.88	53
2013	8,717.40	8612	105.4	50.91	46.4
2014	8,702.05	8612	90.05	43.21	36.34
2015	8,732.70	8612	120.7	54.54	-
2016	8,710.65	8612	98.65	47.32	-
2017	8,738.30	8612	126.3	55.23	48.13

Results for Scenario 2: Taking soil strata at 200 ft depth as impervious



Graph for Scenario 2: Taking soil strata at 200 ft depth

Conclusions

Structures like dike dams have developed through period from experimental guidelines depended on watched exhibitions to system of steady & intelligent investigation of drainage. Impressive issues engaged with contemplations for drainage under dams incorporate heterogeneous foundations & agreeableness for similar treatment/control highlights. Model study shows that as the Water level increases the seepage value increases simultaneously whereas, real time data collected shows that seepage decreases with the passage of time so both are inversely proportional to each other. Actual Seepage percentage has reduced upto 13% corresponding to the same levels achieved during the last 7 impounding's which shows that with time seepage reduces. It has been observed that during the course of operation of the Dam the seepage measured indicating that seepage control measures taken for the dam is effective and working properly. Model studies show that pervious boundary conditions have more seepage value than impervious boundary conditions.

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