DECLARATION

I, **Lubilo Foster**, hereby declare that the contents of this dissertation represent my own work and that it has not previously been submitted to this or any other university for any academic qualification.

…… ……

Signed **Date**

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CERTIFICATE OF APPROVAL

This thesis by **Lubilo Foster** is approved as partial fulfilment of the requirements for the award of the Master's Degree of Engineering (MEng) in Geoinformatics and Geodesy by the University of Zambia.

Examiners:	**Signature**	**Date**
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Supervised by:

Dr. P. Nsombo	…….	….....

Abstract

Geodetic Deformation Monitoring (GDM) plays a vital role in project safety and management. Geodetic measurements on dams are done to monitor change and rate of change in order to ensure safety. Kariba Dam suffers normal stresses, and strains mainly from temperature and hydrostatic pressure seasonal changes. These loads deflect the dam upstream/downstream in summer and winter, respectively. The deflections are currently monitored using a traditional deformation monitoring system by Zambezi River Authority (ZRA). However, more unexpected factors which were not catered for at design stage have rendered the traditional methods obsolete. These unexpected factors are: Reservoir Induced Seismicity (RIS), Plunge Pool scouring, Alkali Aggregate Reaction (AAR), landslide and earth-work vibrations. Thus, in this study, the dam was assessed to have new deformation patterns: Clockwise (southward) horizontal rotation of the north abutment, tangential movements of the dam northwards, increased upstream/upward swelling of the dam crest, and southward vertical rotation of the south and north bank . Due to the above deflections, the Kariba Dam arch has lost its original shape, with the arch ends buckling more than the spillway section. Human-related errors may worsen these deformations. The vertical and horizontal rotational tendencies resulted from anchor cables and landslide moments of forces on the south bank. AAR effect was analyzed as being of less concern because past findings proved it's subsiding. Poor geology destabilized the control points, thus rendering the classical monitoring system less accurate. To address the new deformations, a real-time, automated GNSS/LPS Online-based Control and Alarm System (GOCA) was designed for an early detection, alerting of landslide and its effects on the dam to classified users. This system applies GNSS and classical Local Positioning Sensors (LPS) such as Total Stations, and geotechnical instruments. It was recommended that prism array be installed urgently for use even under the classical methods for more deformation detection. This research has explained the puzzling new dam behaviour and substantiated the effects of the landslide which might have been worsened by earth work activities in the area with poor geology. Hence this research formed a basis for future studies and monitoring system improvements at the Kariba Dam through easy-to-understand analysis and visualizations of concepts and past deformation data presented mainly in form of tables by ZRA. The analysis included computations of rates of change of current deformations compared to the previous ones. The past and current deformation results were visualized in form of drawings and illustrations which helped link landslide forces to new dam deformations.

Key words: GDM, Kariba Dam, GNSS, RIS, AAR, GOCA, LPS, ZRA, Landslide, visualization techniques, prism array, south bank and traditional methods.

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Abbreviations/Acronyms

AAR……...Alkali Aggregate Reaction

BoQs……..Bill of Quantities

BOCs……..Bill of Countings

BOR……..Bureau of Reclamation

CAPCO……..Central African Power Corporation

CORS……Continuous Operating Reference Station

GCPs……Geodetic Control Points

GNSS……Global Navigation Satellite System

GDM……..Geodetic Deformation Monitoring

GOCA……....GNSS/LPS-based Online Control and Alarm System

LPS……...Local Positioning Sensors

NB…….…...North Bank

PAN……..Prism Array Network

RIS……..Reservoir Induced Seismicity

RTS……..Robotic Total Station

SB……South Bank

UNZA……..University of Zambia

ZRA……...Zambezi River Authority