Analysis And Modeling Of Impact Of Flood On A Dam Using Midas Software
(A Case Study Of University Of Ilorin)

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Abstract

This project examined the computer aided modelling, analysis, and design, of a concrete gravity dam using MIDAS GTS software. A manual design based on stability analysis against sliding, overturning and shear friction of the dam due to a flood level of 7.6 m (same as the height of the dam) and a flood level of 10.5 m were included. Data used was collected from project planning unit (PPU) of the University of Ilorin for the analysis. Based on the manual design of the typical concrete gravity dam analysis carried out, the factors of safety against, Overturning, Sliding and Shear Friction Factor were 2.5, 2.3, and 47 (for the flood level of 7.6 m) and 1.5, 1.2, and 26 (for the flood level of 10.5 m) which are all greater than the allowable factors. . The principal stresses at the toe of the dam using manual and MIDAS software are 2.5 X 10^5 kN/m^2 and 2.43 X 10^5 kN/m^2 respectively and the shear stresses using manual and MIDAS software are 1.1 X 10^5 kN/m^2 and 1.6 X 10^5 kN/m^2 respectively (for the flood level at 7.6 m)

1.0 Introduction

A Flood can be described as a natural or man-made hazard which occurs when a drainage or reservoir overflows its natural or artificial bank leading to destruction of lives and properties and most especially water retaining structures such as dams. A Dam is a barrier constructed across a natural waterway (river, stream etc.) to create a storage which is generally called a lake or a reservoir (Salami et al., 2012). Dams are constructed such that they have sufficient strength to stand their own weight, to resist forces to which they may be subjected e.g. shaking from earthquake or minor earth movement, vibrations due to industrial machines in the vicinity and most importantly to resist the water pressure upstream in the lake of the dam. The water pressure upstream exerts a force on the dam wall tending to wash it off against the earth gravity force pulling down on the mass of the dam. Danger of failure arises when the water becomes too much for the dam to hold or discharge through the spillways.

The behaviour of different types of dam under various loading had made it necessary to study the cause of dam failure. There are many reasons why dams fail part of which is due to the impact of flood on dams. Considering the rate of increase in rainfall and frequent occurrence of flood in recent years in Nigeria, it became necessary to analyse the impacts of flood on dams to determine the various points of possible failure from imposed stress on the dam. Due to the complexity and time consumption of manual designs, computer aided design was adopted for ease, accuracy, and speed. MIDAS GTS NX software was used to design a concrete gravity dam in this project. To achieve the analysis, design and construction of the dam, the knowledge of structural engineering, structural design which is a sub-division of structural engineering and the software method of analysis which in

this case is finite element was required. The project focused on the analysis of the structural stability of a gravity dam due to the impact of flooding.

1.2 Description of Study Area

The University Of Ilorin as the study area is located in the ancient city of Ilorin, about 500 kilometres from Abuja, the Federal capital of Nigeria (figure1). University of Ilorin dam site is located within the university campus which lies entirely within the basement rocks in the Western part of Central Nigeria bounded by longitudes 4° 39′51.6″- 4° 40′02.50″E and latitudes 8° 27′54.2″- 8° 28′4.7″N.

Figure 1.1 Unilorin Dam

2.0 Methodology

MIDAS GTS software was used for the structural modelling and analysis of the dam. A manual analysis and design was also included for comparison.

MANUAL METHOD OF ANALYSIS AND DESIGN
As the University of Ilorin Dam is already operational, the stability of the dam was calculated for a flood level of 7.6 m (the same height as the dam) and a flood level of 10.5 m. The codes of practice employed are the U.S.B.R recommendation and BS 8007.

The analytical method of gravity analysis was considered with the following procedures:

1. Consider a unit length of dam.
2. Calculate all the vertical forces acting on the dam, viz., self-weight of the dam, weight of water acting on the inclined face, uplift pressure and inertia forces due to vertical acceleration. Compute their algebraic sum ($\sum V$).
3. Calculate all the horizontal forces acting on the dam and their algebraic sum ($\sum H$) and the horizontal pressure due to hydrodynamic pressure.
4. Calculate the lever arm of all these forces from the toe.
5. Calculate the sum of overturning moments ($\sum Mo$) and the sum of righting moments ($\sum Mr$) at the toe.
6. Calculate the algebraic sum of all those moments ($\sum M = \sum Mr - Mo$).
7. Calculate the location of the resultant force by determining its distance from the toe, x.
8. Calculate the eccentricity, e of the resultant R from the centre of the base width b, which must be less than b/6 for no tension to develop.

9. Calculate the normal compressive stresses at the toe.
10. Calculate the normal compressive stresses at the heel.
11. Calculate the principal stresses at the toe and the heel.
12. Calculate the factor of safety against sliding.
13. Calculate the factor of safety against overturning.
14. Calculate shear friction factor.

Method Of Software Analysis

The method of analysis applied is known as the finite element method (FEM) or finite element analysis (FEA), which is a computational technique used to obtain approximate solutions of boundary value problems in engineering.

The procedure of the computer aided analysis using MIDAS software consists of the following steps:
1. Modelling the dam structure either by using AutoCAD and importing the model into the MIDAS GTS environment or modelling the structure directly from the MIDAS GTS environment by selecting the Geometry/surface & solids
2. The boundary conditions which could be rock or consolidated soils
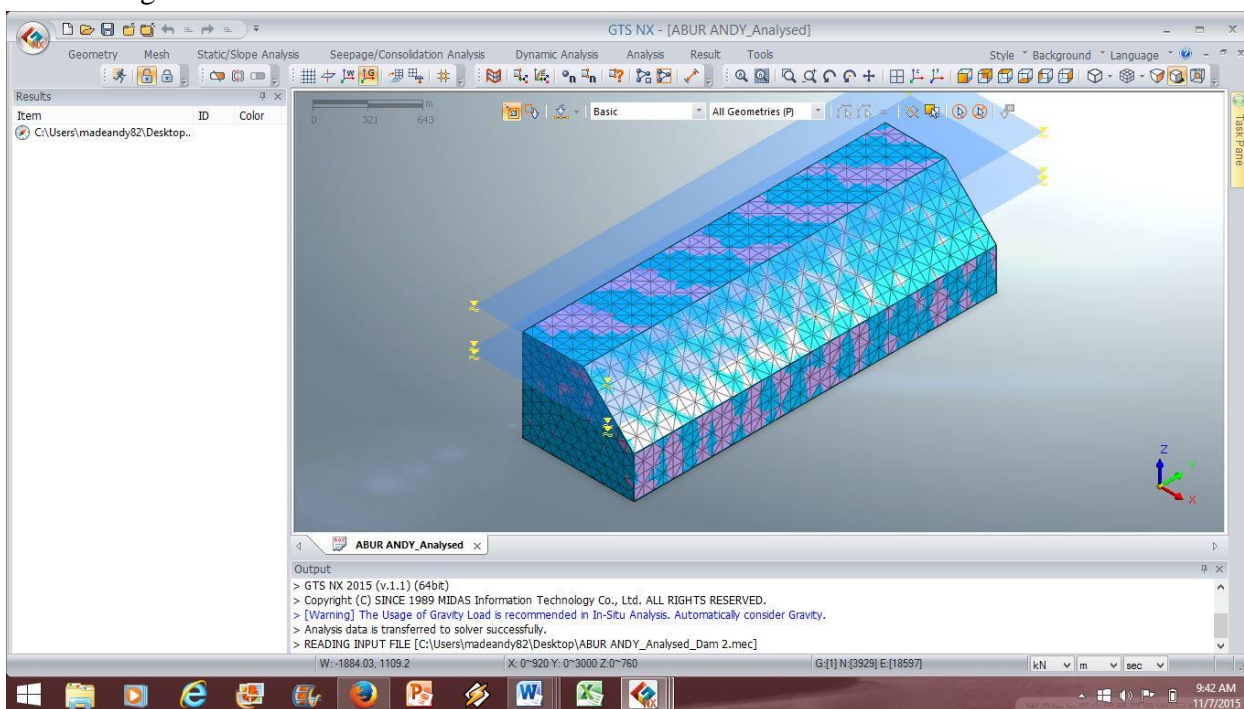3. Meshing of the dam structure into finite elements

Figure 2.1 Meshing of dam structure

4. Application of loads-dam self-weight and constraints were applied from picking Static/Slope Analysis/Constraints/Fixed
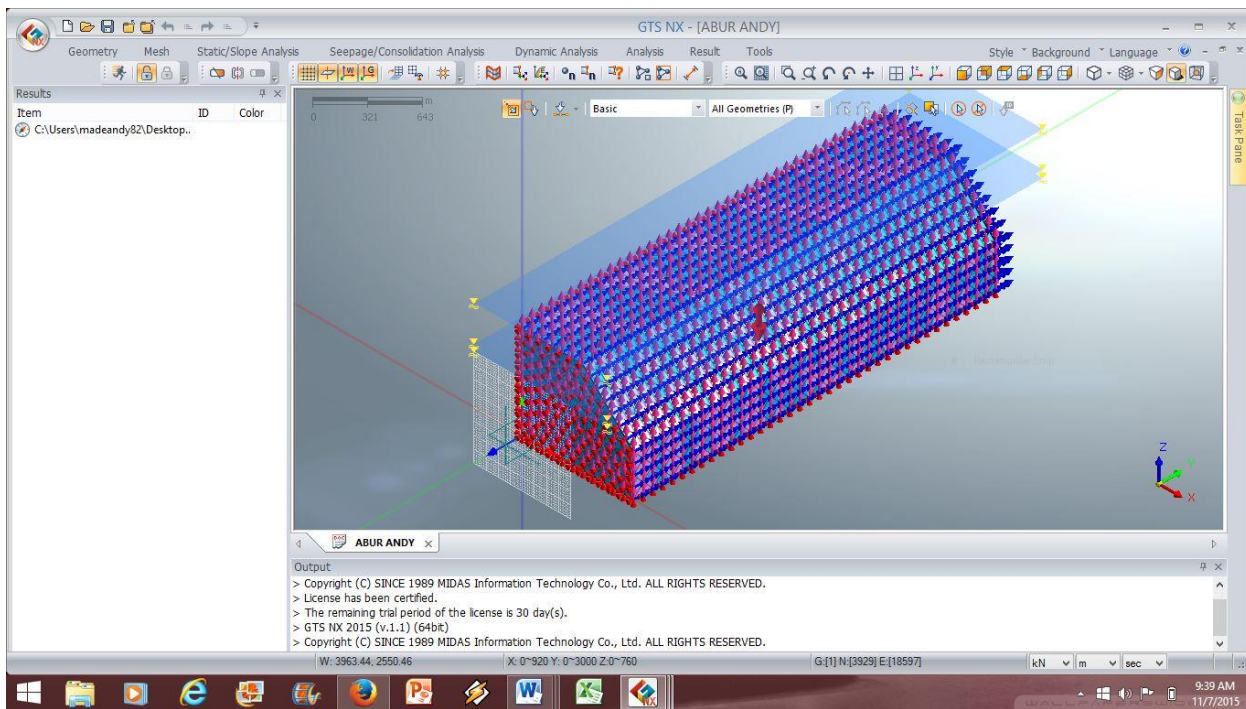5. The water or flood level was also added from Static/Slope Analysis/Water Level

Figure 2.2 Application of self-weight, constraints and water level
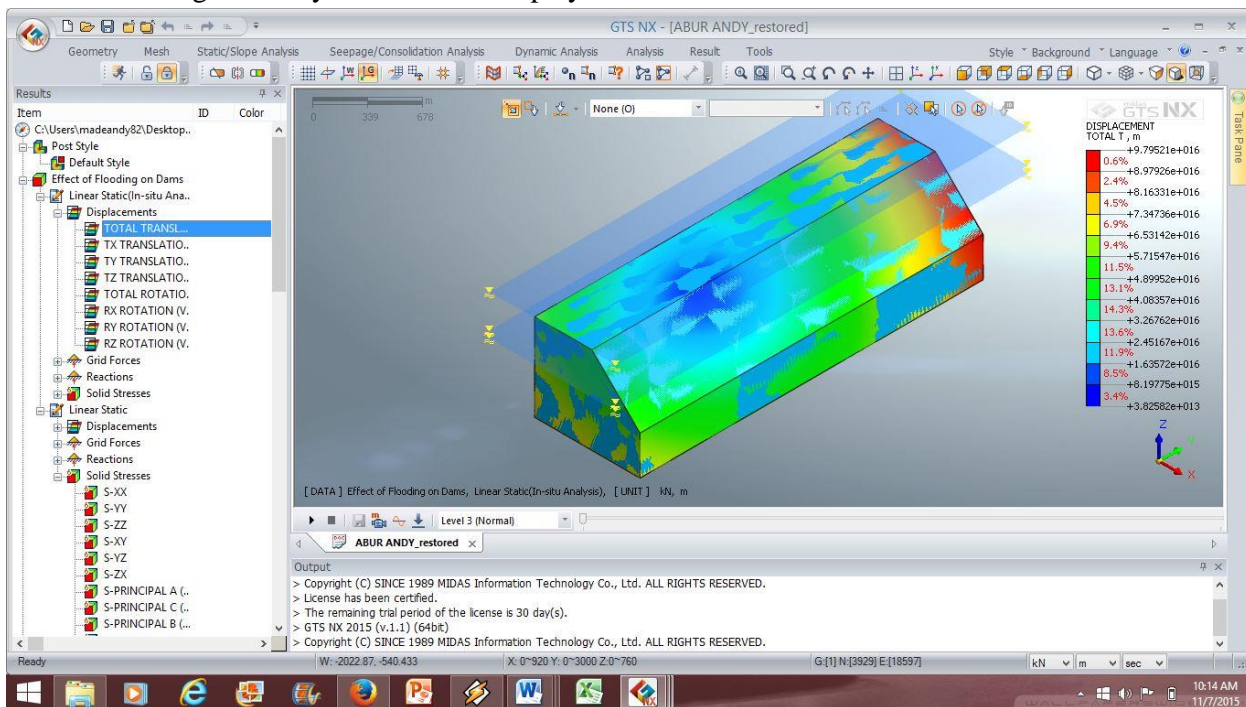
6. Running the analysis and result display
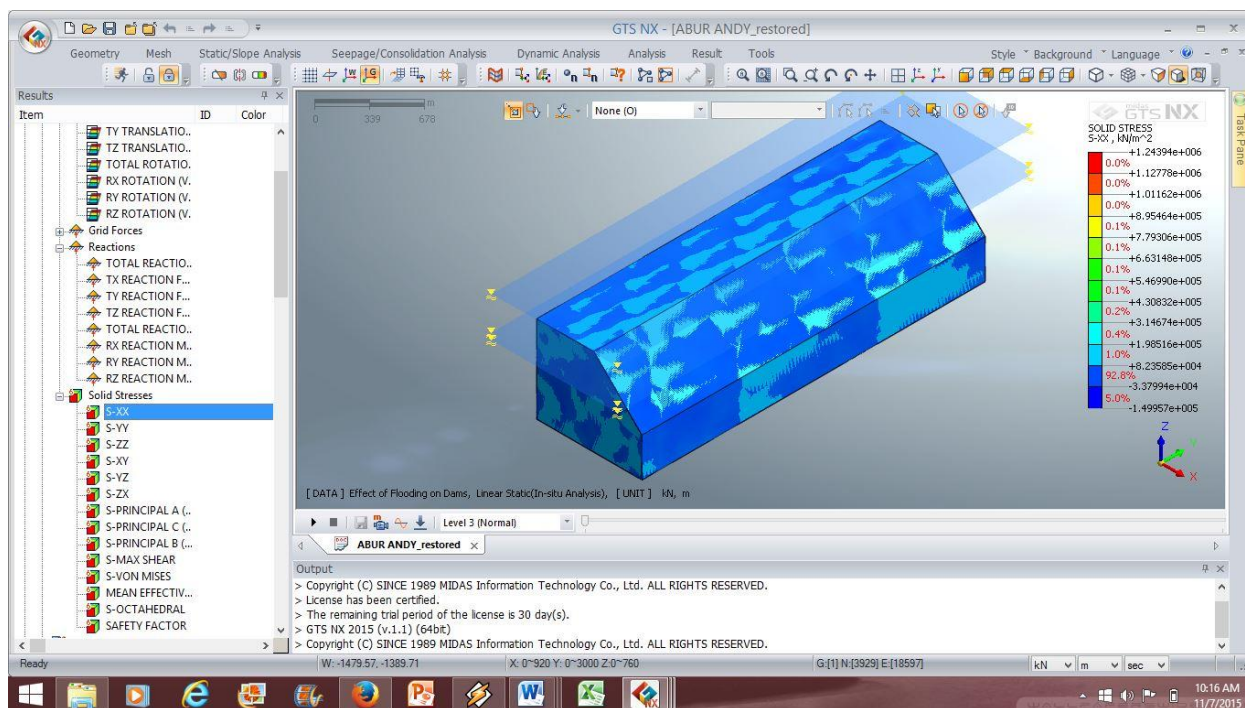

Figure 2.3 Total displacement

Figure 2.4 Stress in XX direction

3.0 Results And Discussions

3.1 Results from manual computation and MIDAS GTS

Table 3.0 Comparison of result from MIDAS GTS Software with manual considering a length of 3000m for design purpose (for flood level @ 7.6 m)

	APPLIED FORCES (KN)		STRESSES (KN/m2)	
	Manual	MIDAS	Manual	MIDAS
Vertical load	1303	1303		
Horizontal load	289	289		
Principal stress at toe			2.5×10^5	2.43×10^5
Shear stress			1.1×10^5	1.6×10^5

As shown in the results above in Table 3.0, the total applied vertical load and horizontal load of the manual is almost in a close range with that of MIDAS GTS NX Software. Also the principal stress at the toe and shear stress of the dam of both the manual of computer aided analysis and design are almost similar. The slight difference in the results can be due to modelling and methods used

From the manual stability computation of the dam, at flood level 7.6 m, the factor of safety against overturning = 2.5 > 1.5 hence safe,

Factor of safety against sliding = 2.3 > 1 hence safe.

4.0 Conclusion

The stability status of a dam is based on the factors of safety against Sliding, Overturning, and Shear friction factor. Based on the manual design of the typical concrete gravity dam analysis carried out, the factors of safety against, Overturning, Sliding and Shear Friction Factor were 2.5, 2.3, and 47 (for flood level @ 7.6 m) which are all greater than the Allowable factors of 1.5, 1, and 2 respectively. The results of the vertical and horizontal loads using the manual and MIDAS design are: The vertical loads are 1303 KN and the horizontal loads are 289 KN respectively. The principal stresses at the toe of the dam using manual and MIDAS software are 2.5×10^5

kN/m^2 and 2.43 X 10^5 kN/m^2 respectively and the shear stresses using manual and MIDAS software are 1.1 X 10^5 kN/m^2 and 1.6 X 10^5 kN/m^2 respectively (for the flood level at 7.6 m)

4.1 Recommendation

A thorough and in-depth knowledge of the MIDAS GTS NX software is highly recommended to produce practical and working results.

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