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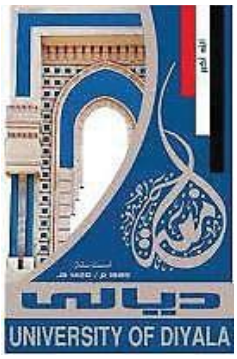

EARTH DAM STABILITY WITH VERTICAL AND HORIZANTAL DRAINAGE COLUMN UNDER SEISMIC LOAD

A Thesis Submitted to the Council of College of Engineering, University of Diyala in Partial Fulfillment of the Requirements for the Degree of Master of Science in Civil Engineering

By

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CHAPTER ONE
INTRODUCTION

1.1 General

dams are one of the oldest techniques people have used for water retention often built all over the world due to their important characteristics **(Sammen et al., 2021).** It was either organized and managed by humans to suit their demands for drinking water and agricultural water and avoid recurring dangers such as floods or torrents or accomplish both purposes at once.

Since the end of the nineteenth century AD, the concept of dams has significantly advanced, and the purpose of their construction has been expanded to many other aspects such as generating, improving river navigation, and developing tourism areas from the shores of artificial lakes and water reservoirs behind dams as well as reaping their benefits in fisheries, and other purposes **(Hadi, 2015).**

Whilst also designing earth-fill dams and other important geotechnical projects, earthquake effects must be considered. Many embankment dam collapses have been attributed to seismic loads, making this a critical circumstance for embankment design. Taking into account that the collapse of another structure is significantly less harmful to a community than the failure of a dam. The effects of earthquakes on embankment dams might range from settlement to instability to internal cracking to differential motions to damage to nearby structures.

1.2 Statement of Problems

When building dam structures in seismic zones, stability, and safety are crucial considerations. Any structure's performance and stability are always

its top priorities, especially large structures like dams that can fail and cause serious property losses in addition to putting people's lives in danger.

Several earthquakes that were categorized as moderate to relatively strong happened in some locations in light of the recent events in Iraq. This occurrence, which had a considerable impact on the dam body, is a key event in the history of facilities in general and dams in particular. It causes the dam to fail, which causes calamities to happen that destroyed infrastructure and human life. Because the Hemrin Dam, which serves as the case study, is situated in the steep Hemrin mountain range and is thought to be the current active seismic line, it is imperative to research the direct and indirect effects of earthquakes on dams.

In the present study, the stability of the Hemrin Dam was studied, under the influence of earthquakes with the existence of a vertical drainage column, and with different levels of water, in the dam reservoir. Two types of earthquakes have been taken namely (El-Centro and Kobe).

1.3 Objective of Thesis

The main objective of this study is to study the effect of the drainage column on the stability of the earthen dam in the event of earthquakes. Hemrin Dam was taken as a case study as it is located in an area with seismic activity.

1.4 Methodology

To achieve the main objective, the following steps are followed:

1. Data collection for the case study which includes the set of information used in the software and material properties was taken from the (Hemrin Dam project final report), and some properties are assumed based on experience and references.

2. Using the finite element method, the Geo-Studio computer program is used in the analysis by its subprograms SIGMA/W, SEEP/W, SLOPE/W, and QUAKE/W.

3. The earthquakes that were picked for analysis were the Kobe earthquake and the El-Centro earthquake, both of which lasted for 20 seconds.

4. Several scenarios, including the following situations, were created to demonstrate the effects of employing drainage columns:

A. When the water level in the reservoir is a quarter.

B. When the water level in the reservoir is half full.

C. When the water level in the reservoir is full, and

D. When the dam reservoir experience a rapid drawdown.

5. The dam is analyzed with and without a drainage column within the cases mentioned in paragraph (4) with the presence of seismic force.

6. the main factors to be analyzed are displacements, pore water pressure, effective stresses, and factors of safety.

1.5 Layout of Thesis

The general layout of this study consists of six chapters as explained below:

Chapter One: Presents a brief introduction of dams and the problem and demonstrates the objectives of the study and methodology of the thesis.

Chapter Two: Presents the types of earth-fill dams and the types of waves and the theory of filters, and after that, presents the background of previous works depending on the literature review of the recent studies.

Chapter Three: Lists the common equations that govern the dynamic analysis and the computer program used in this study was also described briefly showing some of its common capabilities.

Chapter Four: Provides a full description of the case study area and some of the characteristics and earthquakes used for this study.

Chapter Five: The analysis results were viewed and discussed using the program Geo-Studio.

Chapter Six: includes the main conclusions obtained from the analysis and recommendations for future studies.

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ABSTRACT

Stability and safety are crucial considerations when building dam structures in seismic zones, any structure's performance and stability are always its top priorities, especially large structures like dams that can fail and cause serious property losses in addition to putting people's lives in danger. Seismic loads have been implicated in several embankment dam collapses. Many effects of earthquakes can be seen on embankment dams, such as settlement, instability, internal cracking, differential motions, or damage to nearby structures.

The vertical drainage column is crucial for the stability of the dam as the water is drained using the existing vertical and horizontal filters which eventually improve the value of the effective stress using different scenarios. Different water levels (quarter, half, and full) were used with or without a vertical drainage column.

In the present study, the stability of the Hemrin Dam was studied, under the influence of earthquakes with the existence of a vertical drainage column, and with different levels of water, in the reservoir dam. Two types of earthquakes have been taken namely (El-Centro and Kobe), the Geo-Studio computer program is used in the analysis by its subprograms SEEP/W, SLOPE/W, and QUAKE/W.

The value of pore water pressure before using a vertical drainage column is significantly higher than the value after using a vertical drainage column. This is because the gravel material in the vertical filter dissipate the pore water pressure caused by particle rearrangement under seismic loading .

The maximum horizontal displacement is reduced to (0.12m) for the water level is a quarter, (0.13m) the water level is half full, and (0.19m) the water level is full when using a vertical drainage column for the El-Centro earthquake. While when using a vertical drainage column for the Kobe earthquake, the maximum horizontal displacement is reduced to (0.07m) for the water level is a quarter, (0.1m) for the water level is half-full, and (0.13m) for the water level is full.

The values of the safety factor are increased from (1.439) to (1.583) the water level is a quarter, from (1.365) to (1.549) the water level is half full, and from (1.084) to (1.317) the water level is full, without and with a vertical drainage column, because the pore water pressure is reduced and the effective stress is increased.

The value of the safety factor decreases from 1.371 to 1.306 for the initial time, while decreasing from 1.406 to 1.363 for the second day time, in the case of rapid drawdown of water from the dam reservoir when the vertical drainage column exists. Because there is a delay between the process of the reservoirs' water level dropping and the water level lowering on the earthen dam's side.