AIN SHAMS UNIVERSTIY
FACULTY OF ENGNEERING

USING OF PRECAST RC IN SILO DAMS

BY
ENG. TAREK ABD EL RADI MAHMOUD HUSSIEN
B.Sc IN CIVIL ENGINEERING 1988
AIN SHAMS UNIVERSTIY

SUBMITTED IN PARTIAL FULFILMENT FOR THE REQUIRMENT OF THE DEGREE OF MASTER OF SCIENCE
CIVIL ENGINEERING

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LIST SYMBOLS

P_H	Water pressure in the upstream side
w_D	Weight of silo dam
B	Length of silo dam
H	Height of water in the upstream side
I_D	Coefficient of relative density
ε_{max}	Coefficient of porosity of extremely loose soils
ε_{min}	Coefficient of porosity of dense soils
ε	Actual value of porosity coefficient
v	velocity
k_p	Coefficient of percolation
I	Hydraulic gradient
m	$1 < m < 2$ determines seepage flow
P	Pressure on soil layer downward
(p+ dp)	Pressure on soil layer upward
dy	Thickness of soil layer
y	Depth of soil layer
w	$c_o b_o$ where c_o and b_o the length width of cell
u	$2 (c_o + b_o)$ parameter of cell
δ_1 wdy	Dead weight of cell
t	Forces of friction
Φ	Angle of internal friction of soil
Ƒ	Coefficient of friction of soil with wall
E	2.72
K	Coefficient $0.16 < k < 0.35$
$Ƒ_1$	Coefficient of friction with back fill
$Ƒ_2$	Coefficient of friction of wall and back fill
S	Weight of walls with live load
Q	Shear force at bottomless of silo dam
p_w, p_t	Vertical forces acting on the wall
H_s	depth of layer for soil under foundation
δ_o	Initial load
δ	Increase in load
c_c	Log c - c_o
c_o	Final void ratio
S_{24}	Final settlement after 24 hour of the application of the previous increment
e_o	Initial void ratio
e_1	Final void ratio`
$p_H{}^{/}$	Water pressure in the downstream side

$H^{/}$	**Height of water in the downstream side**
g	**Acceleration due to gravity**
α_v	**Acceleration due to earth quake**
k_v	**fraction gravity adopted for vertical acceleration**
p_e	**Hydronamic pressure**
c_m	**Pressure coefficient**
Ɵ	**Angle that the upstream face of the dam makes with the horizontal**
M_e	**The moment of the force about the base**
K_h	**The friction of gravity adopted for horizontal acceleration**
K_s	**The coefficient of active earth pressure**
w_s	**Submerged unit weight of silt material**
h	**Weight of silt deposited**
h_w	**Height of water from top of crest to bottom of trough in meters**
Ƒ	**Fetch or straight length of water expanse in km**
p_w	**Maximum pressure intensity due to wave action**
$k_{Ƒi}$	**Soil stiffness at node I**
A_e	**Area of element surrounding node 1**
$k_{Ƒe}$	**Coefficient of sub grade reaction for element under consideration**

CHAPTER I
INTRODUCTION

CHAPTER I
INTRODUCTION

This chapter is devoted to give an overview about the problem challenging the researcher. The objectives of the research are given, as well. The chapter also presents the proposed structural system (i.e. silo dam) so as an overview to massive dams together with silo dams and their implementation in Egypt. Also, the methodology followed by the researcher, to reach an optimum dimension to this system, is presented. Finally, an overview to the thesis layout is given.

The above is given, in this chapter under the following headlines:

- Problem definition
- Research objectives
- Proposed structural system
- Silo dam and massive dams
- implementing silo dams in Egypt
- Thesis layout

I.1. PROBLEM DEFINITION

Dams usually have big volumes of construction materials. This adds to the total cost of the dam. For example, some dams cost the nations a lot of currency at the time of their construction.

As engineers, it is always desired to achieve constructions within the economic range.

For example, if these dams were constructed with another structural system, this would have, most probably, reduced the used construction material and consequently, the total cost.

I.2. RESEARCH OBJECTIVES

For the above reason, this research was initiated with the objectives of establishing formulas, to dimension dams according to the water depth of the channel so as the soil properties, and determining a structural system that might reduce the cost of the dam construction. The researcher was also determined to reach an optimum dimension of this structural system of the dam. This system is presented, as follows.

I.3. PROPOSED STRUCTURAL SYSTEM

The researcher proposed the silo dam to be the structural system of the dam. This type of dams consist of longitudinal and transverse walls of concrete or reinforced concrete that form cells that are filled with earth, rock, or some other ballast.

This is an economic structural system as its body consists of a mixture of concrete and the available soil at the construction site.

This issue should be taken into consideration during the design where during the design phase, the dimensions of the dam are determined.

I.4. SILO DAMS AND MASSIVE DAMS

Unlike massive dams, silo dams consist of longitudinal and transverse walls of concrete or reinforced concrete that form cells that are filled with earth, rock, or some other ballast. This is an economic structural system as its body consists of a mixture of concrete and the available soil at the construction site.

Massive dams are used for hydro-technical structures. They have complicated nature of loading. Water does not create large horizontal pressures along the water side of the structure but also it gives a considerable vertical uplift pressure which takes place as a result of filtration flow.

It is clear that both horizontal pressures and uplift forces define the main dimensions of massive gravity dams. The weight of dam has to satisfy the safety requirements against sliding. Also, it should be clear that water does not give static pressure forces, but also it gives dynamic forces that cause vibration of the structure as a result of high velocities of water passing through the structure.

I.5. IMPLEMENTING SILO DAMS IN EGYPT

It is to be noted that the idea of the silo dam was first implemented in Naga Hammadi Barrage and its lock. Voids were created within the body of the barrage, lock and pier. These voids were filled by sand. This reduced the concrete quantity.

In Egypt, silo dams could be implemented in flashflood paths to retain water in order to prevent hazards to roadways, properties and infra structures. Such danger affects the nation economy and people that construct settlements in the flood pathway. Alexandria, Sinai, Hurghada and Aswan are examples that faced such hazards.

At flashfloods locations, dams of embankment type were used to be constructed. These dams usually need repair due to the continuous body erosion from flood water attack. These repairing processes are very expensive. Another alternative was the implementation of gravity type which is also a very costly solution.

In case of flash floods, water treatment plant should be constructed to improve the water quality to use it in drinking, irrigation or as a coolant for power plants in deserts. Moreover, limited power could be generated by installing turbines and retaining water upstream the dam. This retained water should be raised by pumps into the turbines. Manholes could be created within the dam body. Also, gates could be placed to regulate the flow.

Silo dam could be placed between two mountains, on condition that the upstream side is wide enough to encompass a suitable (i.e. according to the flashflood water quantity that should be estimated, in the coming 30 years, by researchers) storage volume.

I.6. RESEARCH METHODOLOGY

The researcher designed a certain methodology to achieve the above objective. Primarily, literature, in the field of dams, was reviewed. Then the applicability of implementing silo dams in Egypt was investigated. Once this type was found to be applicable, economic dimensions to such dam could be further determined. Consequently, the forces exerted, on that type, were outlined and studied from which formulas were deduced. These formulas define the dimensions of the silo dam. The formulas related the depth of the channel (i.e. which is usually equals the height of the dam) so as the specific density of the dam and the dimensions of the dam. Three tables were established from which dams dimensions could be deduced, knowing the specific density of the dam and water depth in the channel.

Finally, as a verification of these deduced formulas, SAP 90 was applied to 4 dams with different water heads (i.e. 10, 20, 30 and 40 m) and the stresses underneath them so as the settlement were obtained. Moreover; the settlement, soil stiffness, dimensions of foundation and affected depth were investigated in order to determine the influence of these aspects.

The results of SAP 90 were in good agreement with the deduced formulas and established tables. This indicated the possibility of implementing these formulas and tables in designing of PCRC silo dams.

I.7. THESIS LAYOUT

The above investigation phases are displayed in this thesis in chapter form. The thesis consists of ***7*** chapters. These chapters are as follows:

Regarding ***Chapter I "Introduction"***, it presents the problem definition, research objectives, proposed structural system (silo dam), implementing silo dams in Egypt and thesis layout.

As for ***Chapter II "Literature Review"***, it cites the literature of many topics (i.e. historical dams, Aswan High Dam, construction materials of dams, dam failure, precast concrete in dams, design for precast concrete dams, design requirements of concrete in dams, history of precast concrete dam's implementation, forces on precast concrete dams, types of dams, dam classifications, factors governing the selection of particular dam type, selection of dam site, problems in dam construction, scour protection below overflow spillways and precast together with precast – monolithic silo dams so as transition wing walls of abutments. Also, formulas, that could estimate the silo dam dimensions, were presented (i.e. Yansen formula). Finally, comments are given at the end of the chapter to reflect the researcher's opinion on the assembled literature.

Chapter III " Design considerations for silo dam", presents the silo dam. The chapter displayed the properties, the applications, type of foundation and the way of construction so as the construction materials of such dams. The chapter also provides the soil-structure (i.e. silo dam) interaction so as the design of such structures. The design of silo dam is given together with the formulas for silo dam dimensioning (i.e. Yansen Formula). Also, the chapter outlines the cases where the silo dam is implemented in Egypt. Finally, comments are given at the end of this chapter to express the author's point of view and to reveal the possibility of implementing such dam in Egypt.

Regarding ***Chapter IV "Deducing formulas and establishing tables",*** it presents the acting forces, on the dam body, together with the design of silo dam. It also presents the deduced formulas and the established tables that could be used in silo dam dimensioning. Finally, comments are given to outline the researcher's point of view on this phase.