Available online at www.sciencedirect.com

SciVerse ScienceDirect

Journal of Taibah University for Science 7 (2013) 216–224

Journal of Taibah University for Science

www.elsevier.com/locate/jtusci

Geological and geotechnical properties of soil materials at Tannur dam, Wadi Al Hasa, South Jordan

Mousa Gougazeh [a,*], Ali Al-Shabatat [b]

[a] *Natural Resources and Chemical Engineering Department, Faculty of Engineering, Tafila Technical University, P.O. Box 179, Tafila 66110, Jordan*

[b] *Humanities and Social Sciences Department, Faculty of Arts, Tafila Technical University, P.O. Box 179, Tafila 66110, Jordan*

Received 6 April 2013; received in revised form 7 July 2013; accepted 7 July 2013

Available online 30 July 2013

Abstract

Tannur dam, sited about 150 km south of Amman on Wadi Al Hasa with a reservoir capacity of 17×10^6 m^3, forms part of the Southern Ghors project for water supply and irrigation in the Jordan valley. Values obtained for plastic limit (PL) ranged from 9.8 to 30.3 mass %, liquid limit (LL) 20–42 mass % and plasticity index (PI) 7.3–16.3 mass % for alluvium materials, while values obtained for PL ranged from 10 to 32 mass %, LL 28–58 mass % and PI 12–43 mass % for landslide materials. PSD analysis shows that the materials at the dam site falls into the sandy to clayey silt grain size range. XRD analysis revealed that the landslide materials are composed of smectite as major component with minor amounts of calcite and quartz, while the alluvium materials are mostly composed of quartz, calcite and smectite. Based on the plasticity characteristics, the alluvium materials are slightly to moderately plastic, while the landslide materials are classified as moderate to high plasticity. Accordingly, it is evident that the landslide materials reflect high swell potential due to the presence of considerable amount of expansive clays (smectite).

Keywords: Tannur dam; Smectite; Atterberg limits; Landslide; Alluvium; Expansive clays

1. Introduction

Jordan is part of arid and semi-arid region of the Middle East, where its natural resources are scarce. Water is precious and vital to maintaining the socio-economic development of Jordan. Comprehensive planning is foreseeable and must be applied in an equitable way, taking into consideration various water rights and priority needs for competing development sectors such as domestic, agriculture, industry and tourism.

Jordan depends to a large extent on dams to store water from surface flow, to be used later for irrigation, domestic supply, industrial supply and groundwater recharge. Most of the constructed and proposed dams in the country are of embankment type because certain geological features and economy favors that kind of dam. Tannur dam is part of a water supply and irrigation project serving farmland in the Southern Ghors area in Jordan, which also includes Wala and Mujib dams as well as a conveyance system toward the Dead Sea.

Tannur dam, located 150 km south of the Jordanian capital Amman, The dam site is located in a narrow V-shaped valley with abutment sides rising at about 30° for up to 100 m above Wadi bed level (Figs. 1 and 2). It is located in a semi-arid region of central Jordan at an elevation of 400 m., between plateau at level 1000–1100 m and

* Corresponding author. +962 776731158.
E-mail addresses: dr_eng_mhag@yahoo.com, mgougazeh99@gmail.com (M. Gougazeh).
Peer review under responsibility of Taibah University

ELSEVIER Production and hosting by Elsevier

1658-3655
http://dx.doi.org/10.1016/j.jtusci.2013.07.001

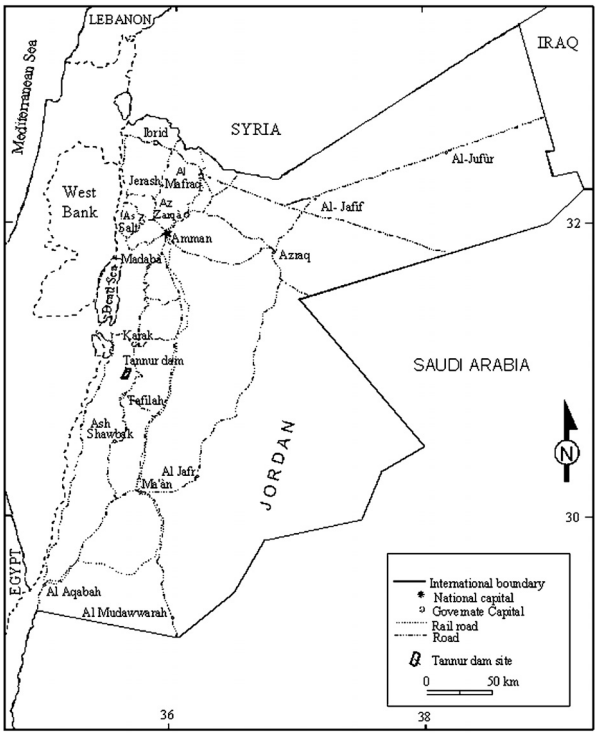

Fig. 1. Location map of the Tannur dam site.

the Dead Sea at level 400 m, with rainfall and runoff only occurring in the winter months between October and April. Annual rainfall is low, generally varying between 63 and 115 mm on the catchment basin. Temperatures can vary from up to 43 °C in summer to less than 5 °C, and occasionally freezing, in the winter. The relative humidity is low, between 40 and 65%.

Tannur dam is 69 m height, 230 m length and 12 m width at its crest roller compacted concrete (RCC) gravity dam, which impounds a reservoir of 17×10^6 m^3 on

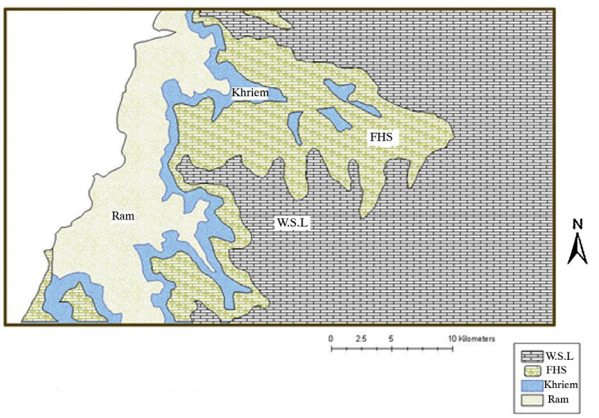

Fig. 2. Geological map of the dam and reservoir sites. W.S.L: Wadi Es Sir Limestone; FHS: Fuheis, Hummar and Shueib Formation.

Wadi Al Hasa, one of the major wadis (watercourses) discharging to the southern Dead Sea area [1]. This type of dam was proposed by Mott Macdonald Company, who advised the Ministry of Water and Irrigation and supervised the construction of such a dam at the southern part of the Dead Sea [2].

The filed investigations included geological mapping of the area, field investigations for the 17 continuous sample borings. Whereas, the laboratory investigations included the measurements of the physical and geotechnical properties of the samples such as grain size distribution and Atterberg limits of undisturbed samples of typical soil deposits at the site.

Field and laboratory data were analyzed and then utilized to describe and evaluate the engineering characteristics of the soil, alluvium and landslide materials at the dam site and reservoir area, which affect the stability of the dam abutments. Stability condition was evaluated at the dam site.

2. Geology of the dam site

The geology of the study area is dominated by a sedimentary succession ranging in age from Upper Cambrian to Quaternary, with exposures of igneous rocks belonging to the Late Paleozoic and Early Mesozoic (Fig. 2). The area of the dam site and reservoir is underlain Kurnub Sandstone of Lower Cretaceous, which overlies unconformably the Umm Ishrin Sandstone of Upper Cambrian age. The Tannur dam is situated a few kilometers west of Wadi Al Hasa Bridge. The site consists entirely of Upper Cretaceous strata. The whole site is occupied by an anticline plunging northwards. The following rock units crop out in the dam site and reservoir area (Fig. 2): (1) Top Na'ur Formation, these rocks are massive, fossiliferous, cliff-forming strata. Accordingly, these are considered excellent foundations; (2) Marl–Shale Formation, these formations overlies the top Na'ur Formation. These rocks are not a good foundation, but can be tolerated when present in small thicknesses; (3) Limestone Formation, this is again a good rock, which makes the foundation of the shoulders of the dam in the left abutment; (4) thick sequence of Marl–Clay–Gypsum, this is the worst part of the sequence. Landslides have taken place on certain parts of this horizon. Fortunately, this horizon is higher than the topmost part of the dam except for few meters in the left shoulder. In the right abutment, the same rock units are present, but because of a higher dip of strata the situation is much better than the left abutment except for the two clay beds, which have been treated to ensure the safe stability of the dam. The dam area was investigated