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Construction and Testing of a 500 m3 store

Hansen, Kurt K.; Hansen, Preben N.

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SEASONAL HEAT STORAGE IN UNDERGROUND WARM WATER STORES (CONSTRUCTION AND TESTING OF A 500 M^3 STORE)

Authors : Kurt K. Hansen, Preben N. Hansen

Contract number : ESA-S-162-DK (G)

Duration : 20 months 1 November 1981-30 June 1983

Total budget : Dkr. 1.000.000 CEC contribution : 50%

Head of project : Preben N. Hansen

Contractor : Thermal Insulation Laboratory

Address : Technical University of Denmark
Building 118
DK - 2800 Lyngby
Denmark

Summary

The project contains the projection, the construction and the testing of the efficiency of a 500 m^3 warm water store. The aims of the project are:

- gathering practical experience with the actual realization of the pilot plant;
- monitoring the overall behaviour of the storage system;
- verification and modification of the digital computer program.

In this paper the results of the first phase, the examination of the soil conditions on the site of the store and the projection of the storage system, are given.

1. Introduction

On the basis of the preliminary studies done by Preben N. Hansen et al. [1], [2], [3], [4] concerning the heat losses from the store and on the basis of a work [5] done by the Danish firm Dipco Engineering, Virum, concerning possible principles of construction, projection of a 500 m^3 store is carried out. The site of the store is on our University campus, see figure 1.

The project contains the following phases:

a. Detailed examination of the soil conditions on the site of the store.

b. Using the results from a) detailed projection is performed.

c. Execution of the construction. The construction is financed by the Danish Ministry of Energy.

d. Experimentation. Tests are made to determine the storage efficiency.

e. Verification and modification of the digital computer program.

f. Reporting.

The results of phase a. and b. will be given in this paper.

2. Examination of the soil conditions

The soil conditions are determined by the Danish Geotechnical Institute. Two continuous borings are made to collect samples for identification of the soil types in order to determine the porosity of the soil in the field. In the laboratory the water content, the dry density, the shear strength, the grainsize distribution, the degree of saturation and the thermal properties are determined.

In one of the boreholes a standpipe is installed to check the case of a secondary groundwater pressure (the primary groundwater is situated more than 40 m below the surface of the ground). In the other borehole a tube with five temperature sensors is placed. A photograph of the boring is shown in figure 2.

2.1 Determination of the thermal properties

To determine the thermal conductivity of moist soil a diagram is given in the literature [6]. The diagram is shown in figure 3 and the entry values are the quartz-content, the dry density and the degree of saturation. Depending on "course-grained" or "fine-grained" soil in the example in the diagram the conductivity is found to be 1.15 W/m^{o}C or 0.90 W/m^{o}C.

It should be mentioned that some of the conductivities found by the diagram are checked in the laboratory using the instrument shown in figure 4.

To determine the heat capacity of moist soil a diagram is given in the literature [7]. The diagram is shown in figure 5 and the entry values are the porosity and the degree of saturation. From the knowledge of the thermal conductivity and the heat capacity, the thermal diffusivity α is found by the relation $\alpha = \lambda/C$.

The results are given in figure 6. The soil can be described roughly as a 4-5 m thick layer of clay. Below this layer of clay is water saturated sand (different degrees of saturation). The thermal conductivity lies between 0.8 W/m^{o}C and 2.2 W/m^{o}C, and the thermal diffusivity lies between 17.0 m^2/year and 31.4 m^2/year.

3. Projection of the storage

The store is digged into the ground ending up with a pyramidal geometry (see figure 7). The ground surface is made waterproof by use of a plastic liner. (No insulation materials are used on this surface). The top is heat insulated and protected against evaporation and against the weather by use of a plastic liner.

The heat input is generated by an oil burner simulating one or more different types of solar collectors.

4. Conclusion

A detailed examination of the soil conditions and a detailed projection of the storage have been made. The construction of the storage has started this month.

5. Literature references

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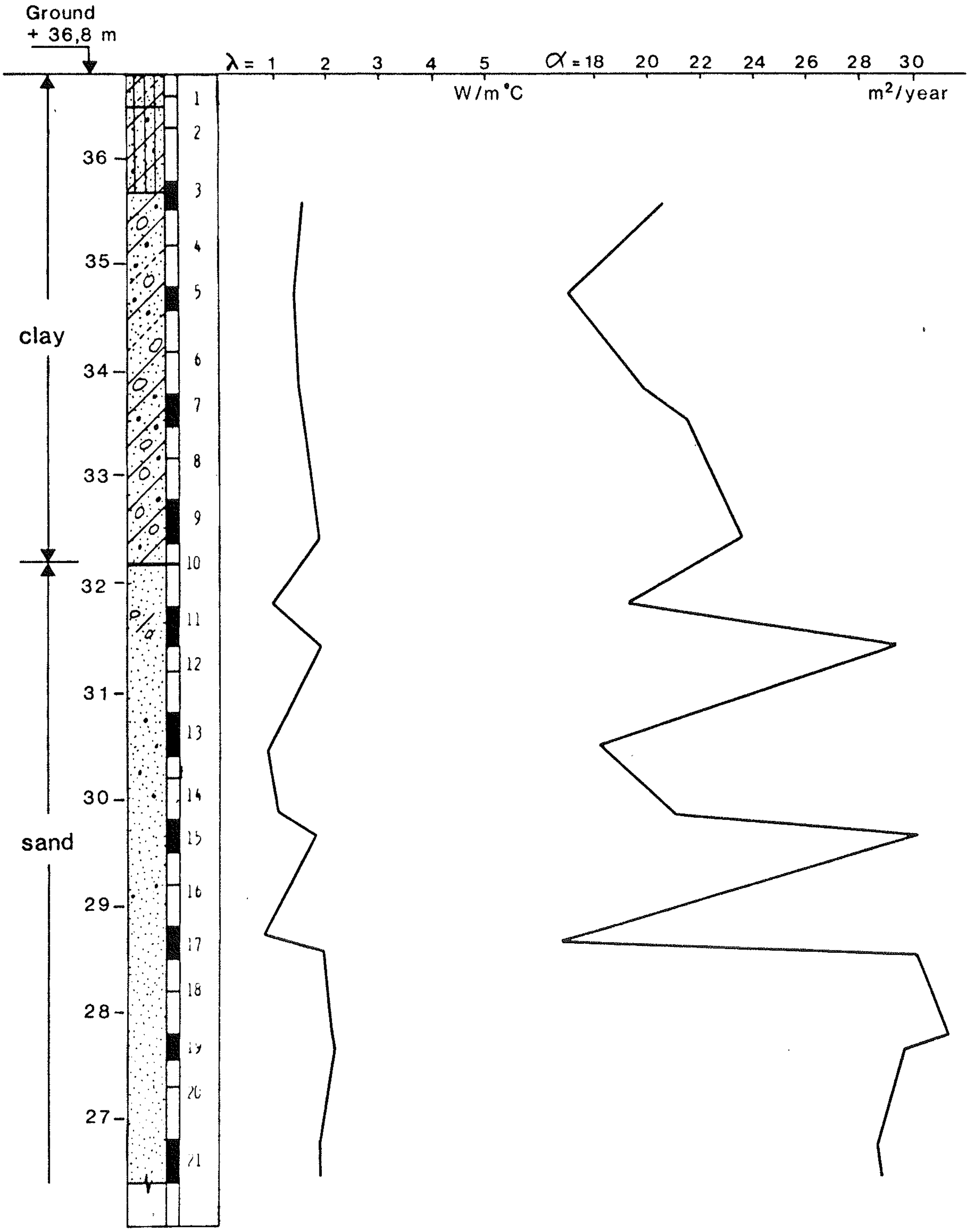
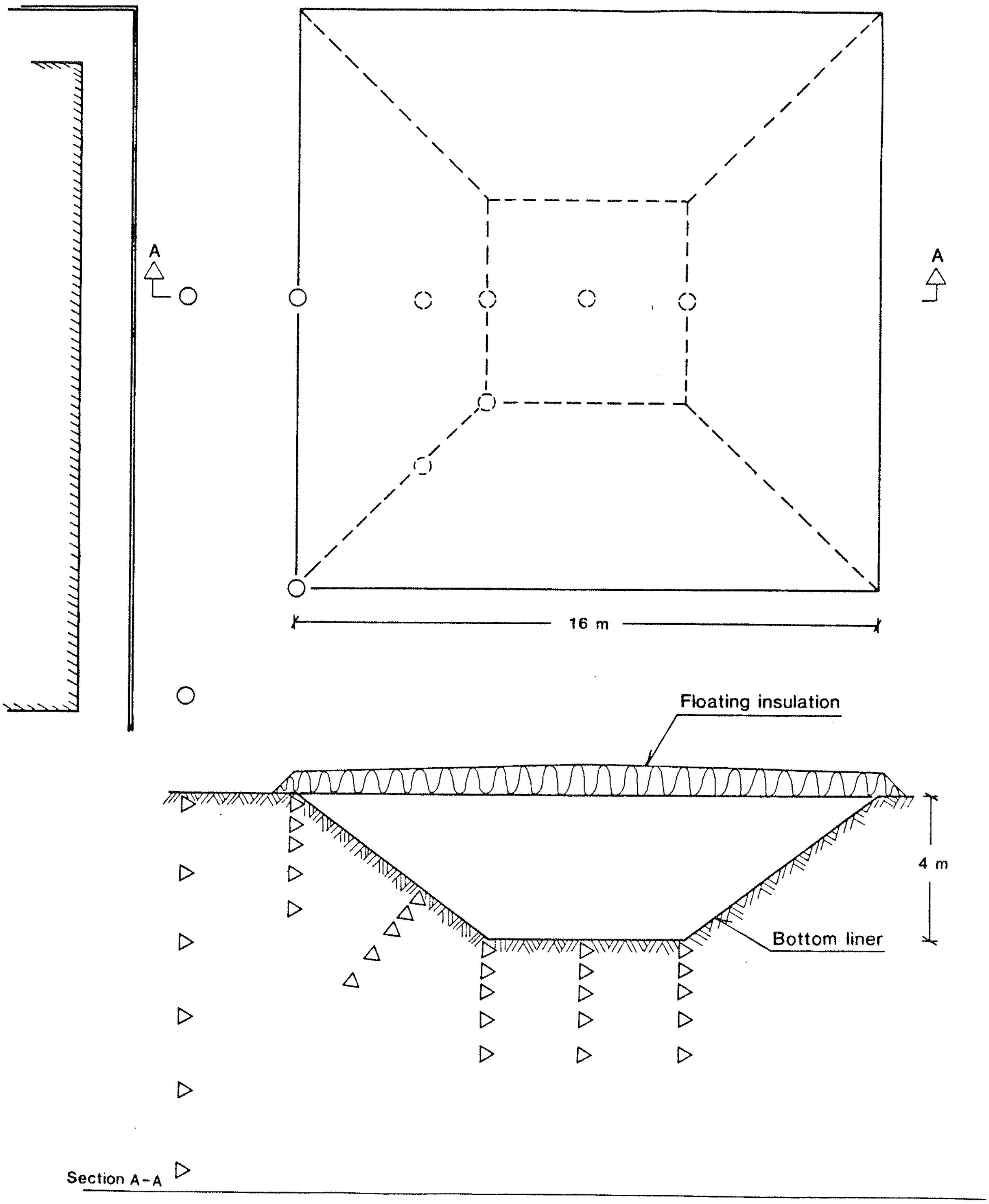


NOTE: λ is thermal conductivity

α thermal diffusivity

Figure 6. Schematic soil strata and the thermal properties.



NOTE:

○ Boring with temperature sensors

▷ Temperature sensor

Figure 7. The 500 m³ heat storage