STUDY OF THE TEMPERATURE DISTRIBUTION IN THE BITUMINOUS CONCRETE FACING USED IN FILL DAMS IN THE SEMI ARID REGION OF WEST ALGERIA

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ABSTRACT

The main objective of this research was first of all to establish a mathematical relationship for the maximum temperature on the surface of the bituminous concrete facing used in existing and future earth dam's construction in the semi arid region of the west of Algeria without taking any in-situ experimental measurements. Secondly it was to study the influence of some factors on this temperature. The results which have been obtained showed that the maximum temperature on the surface of the bituminous concrete facing was proportional to the air temperature of the site and also depends on the climatic, geographical and geometric factors.

KEY WORDS: Bituminous, concrete facing, fill dams, temperature

RESUME

Une relation destinée au calcul de la température maximale sur la surface des masques en béton bitumineux des barrages est proposée. Cette relation, établie pour les barrages situés en zone semi aride de l'Ouest algérien, permet d'éviter d'effectuer des mesures expérimentales in situ. L'influence des paramètres tels que les facteurs climatiques, géographiques et géométriques sur la température maximale est mise en évidence.

Mots clés : Bitumineux, masques, barrages en remblais, température

1 INTRODUCTION

Bituminous surfacing techniques were the subject of a significant development in France particularly in the field of fill dams were bituminous concrete facing are used. Dams such as *Dorlay* (1972), Plan d'*Arem* (1970) and *Carabonne* (1970) are good examples of this use [1].

The Genekel dam in Germany (1952) is the first example in which the bituminous facing consists of a sandwich structure made of a draining bituminous concrete bed lain between two impervious layers of dense bituminous concrete [2]. The external coating is generally made of such these two layers laid on an opened asphaltic concrete drainage or on a binder course (Figure.1). The main objective of this structure is to collect and measurement of the water infiltration [2], [3]. The Montgomery dam in the United States (1957) is one of the first examples whose protecting surface was constructed with an open asphaltic concrete drainage and a binder course generally supporting two impermeable dense bituminous concrete beds whose joints are alternate [3], [4]. The whole unit rests on a layer which adjusts of the upstream face. In the last sixty years more than 300 dams of 30m height and water tanks with more than 15m height have been sealed by the asphaltic concrete. 63 dams among then are located in Germany.

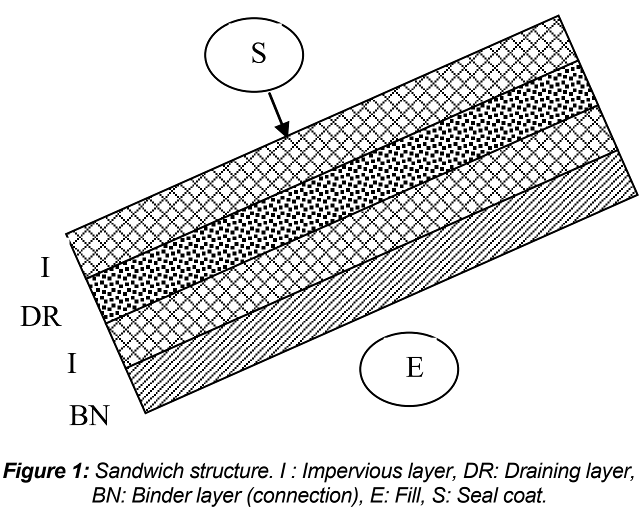

Figure 1: *Sandwich structure. I : Impervious layer, DR: Draining layer, BN: Binder layer (connection), E: Fill, S: Seal coat.*

In Algeria, the upstream asphaltic concrete blankets waterproof is not widely used in construction of dams. Only few have used this technique. Those are: Ghrib dam (1926-1938), Bouhnifia dam (1930-1941) and Sarno dam (1947-1954) [5].

This technique did not have much attention because of the rise of the country climate temperature.

Therefore main objective of this research is to find out some means to evaluate the surface temperature of the bituminous concrete facing of earth dams in these region and the different factors which controls it.

2 TEMPERATURE VARIATION WITH THE DEPTH

The temperature T versus the depth X relationship in a vertical cross section at the instant T [5], is given by the Fourier relationship:

$$\frac{dT}{dt} = a\frac{d^2T}{dX^2} \tag{1}$$

where a is the coefficient of heat propagation calculated as follows:

$$a = \frac{\lambda}{\rho c}(m^2/s) \tag{2}$$

In which λ is the coefficient of conductivity of heat (w/m.k), ρ is the bulk density (kg/m^3) and c is the specific heat (ws/kg.k).

The factors a, λ, c and ρ are defined in table.1 for each material used [5].

***Table 1:** Materials characteristics values*

Materials	a (m^2/s)	λ (w/m.k)	c (ws/kg.k)	ρ (kg/m^3)
Asphaltic Concrete	56.17x10^{-8}	1.165	930	2230
Drainage Layer	58.34x10^{-8}	1.270	942	2310
Sand and gravel	131.12x10^{-8}	2.488	1206	1990
Concrete	55.56x10^{-8}	1.63	1047	2000

3 THE SUN RADIATION ASSESMENT

The sun radiation assessment shown in figure 2 is generally the algebraic sum of the various factors as given by the equation 3 [6]:

$$\left[I+D-A-\left(E-GW\right)\pm K\right]\Delta t\pm B=0 \tag{3}$$

where Δt is the time increment.

Equation (3) shows that the determination of the maximum temperature does not take into account the water content in the air on the level of the bituminous screen surface and thus the possibility of reaching a maximum of temperature decreases.

To estimate the surface temperature at various depths by the equation (3), the previous sun radiations are subdivided in two major groups.

The first group is independent of the surface temperature. It includes the following sun radiations: GW, A, D and I which are defined as:

i. GW: Reflexion or Albedo of the ground

ii. A: Reflected solar radiation

iii. D: Diffused solar radiation

iv. I: Direct solar radiation.

The second group however is related to the surface temperature and includes sun radiations B, K and E defined as follows:

i. B: Absorbed or released earth energy,

ii. K: Calorific exchange between the facing and the atmospheric mass,

iii. E: The facing radiation transmitted in the atmospheric.

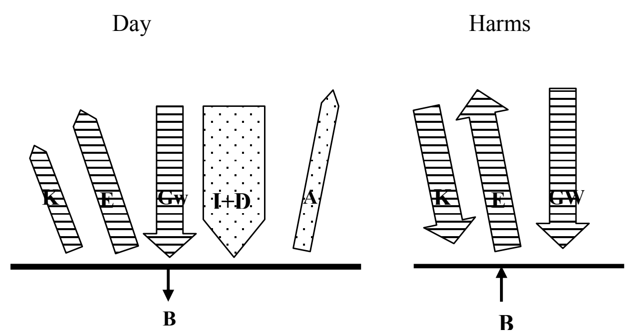

***Figure 2:** Explanatory diagram of equation (3)*

4 SURFACE TEMPERATURE COMPUTATION

Let us assume T_o as the surface temperature. To calculate T_o with various depths, equations (1) and (3) have been solved by using the model given by [7].

5 MODEL VALIDATION

To validate the model given by [7], the measurements obtained in 1959 by EDF «Electricité de France" on the GHRIB dam [8] were used. Calculations are foccussed on what follows:

i. Variation in the maximum temperature measured and calculated on surface

ii. Variation in the maximum temperature on the surface of the facing with and without white paint coating.

iii. Variation in the maximum temperature on the surface of the facing with and without concrete bed

The EDF measurements and the model results are given in table 2.

Table 2 shows that the results obtained from EDF measurements and those given by the model are very close and can be thus considered as practically the same.

Table 2: *EDF measurements and model calculated results*

References	EDF	Model	Deviation (%)
Maximum temperature on the facing surface (°C).	65.0	66.7	2.6
Maximum temperature to 6cm of depth facing under coat of paint (°C).	34.2	34.7	1.4
Maximum temperature to 10cm of depth facing under concrete layer (°C).	35.8	36.7	2.5

Table 3: *Angular, geographical and geometrical characteristics of the considered dams*

Characteristics	BOUHANIFIA	OUIZERT	DAHMOUNI	SARNO	BAKHADA	SMBA	K. ROSFA
T_L (°C)	46.0	46,0	45.0	45.0	43.5	42.5	43.0
α (°)	30	30	25	25	25	25	25
δ (°)	15.80	15.65	15.30	18.20	16.99	18.54	16.42
AF (°)	359	354	355	352	353	358	356
FI (°)	35.36	35.18	35.25	35.34	35.35	35.55	35.75
P/P_0	0,92	0.89	0.93	0.95	0.94	0.89	0.90
T	2.5	2.5	3.0	3.0	3.0	2.5	2.5
ε	1.0	1.0	1.0	1.0	1.0	1.0	1.0
r_u	0.1	0.1	0.2	0.1	0.2	0.1	0.2
r_o	0.05	0.05	0.05	0.05	0.05	0.05	0.05

6 DAMS STUDY CHARACTERISTICS

The dams studied in the present paper are namely: Bouhanifia (Mascara), Ouizert (Mascara), Dahmouni (Tiaret), Sarno (Sidi Bel Abbes), Bakhada (Tiaret), Sidi Mhamed Ben Ada (Relizane) and Koudiat Rosfa (Chlef). In all these dams, the facing used is similar to that of Genekel dam in Germany. The angular, geographical and geometrical characteristics of the above mentioned dams are: 1. Air temperature T_L, 2. Dam's slope α, 3. Solar variation δ, 4. Azimuth AF, 5. Latitude Fi, 6. Atmospheric pressure on sea level P_0, 7. Atmospheric pressure P in situ, 8. Pressures ratio P/P_0, 9. Pollution factor T, 10. Color factor ε, 11. The region reflexion factor r_u, 12. The facing reflexion factor r_o.

The values of these parameters are circumstantially reported in table 3 for the studied dams.

7 DISCUSSION AND RECOMMENDATIONS

To evaluate the stability of the concrete bituminous surfacing of earth dams discussed above and the construction of dams in the future in the semi arid region of west Algeria, some calculations have been made on the basis of the in situ maximum air temperature (T_L) data and the angular, geographical and geometrical characteristics shown on table 3. These calculations have shown that the difference of the maximum air temperature and the maximum surface temperature are in the range of 30 to 33°C. Table 4 shows the obtained results which can be modelled by the following relationship:

$$T_0 = T_L + (30:33) \tag{4}$$

in which T_0 is the stability maximum bituminous layer temperature evaluated in °C and T_L is the in situ maximum air temperature studied given in °C.

***Table 4:** Maximum temperatures of the air and the facing surface of the studied dams*

Dams	Maximum temperature of the air T_L (°C)	Maximum temperature on the facing surface T_0 (°C)	Difference in temperature ($T_0 - T_L$) (°C)
BOUHANIFIA	46.0	76.00	30.00
OUIZERT	46.0	76.00	30.00
DAHMOUNI	45.0	77.00	32.00
SARNO	45.0	76.50	31.50
BAKHADA	43.5	76.50	33.00
S.M.B.A	45.5	76.00	30.50
KOUDIAT ROSFA	45.0	75.50	30.50

Figure (3) shows that the maximum temperature decreases with the increase of depth. For a depth of one centimetre the temperature decreases by 2°C.

Figure (4) shows that the maximum temperature on the surface of the facing increases to a maximum value then decreases with the increase of the slope of earth dam. A maximum value of the temperature is reached for a slope of 1/3.5, corresponding to $\alpha = 15°$.

Figure (5) reveals that the maximum temperature on the surface of the facing decreases with the increase of atmospheric pollution factor. An atmospheric pollution factor of 1.0 gives a decrease in temperature in the range of 2 to 2.5 °C in the maximum temperature on the surface of the facing of the earth dam.

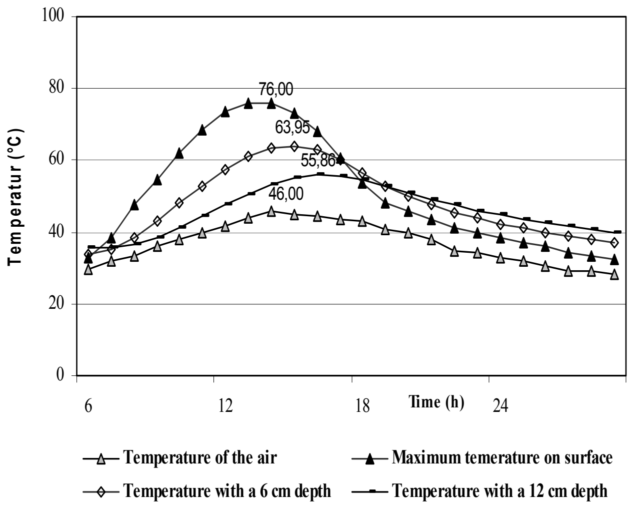

***Figure 3:** Distribution of the maximum temperature on surface of the facing with various depths*

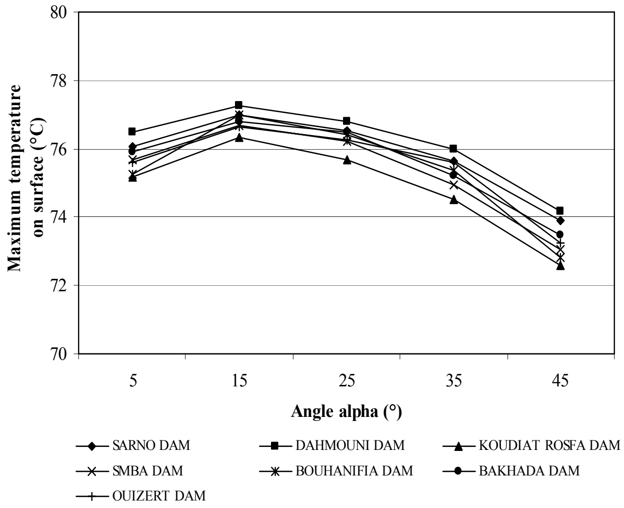

***Figure 4:** Variation of the maximum temperature on the surface of the facing with the slope dam's*

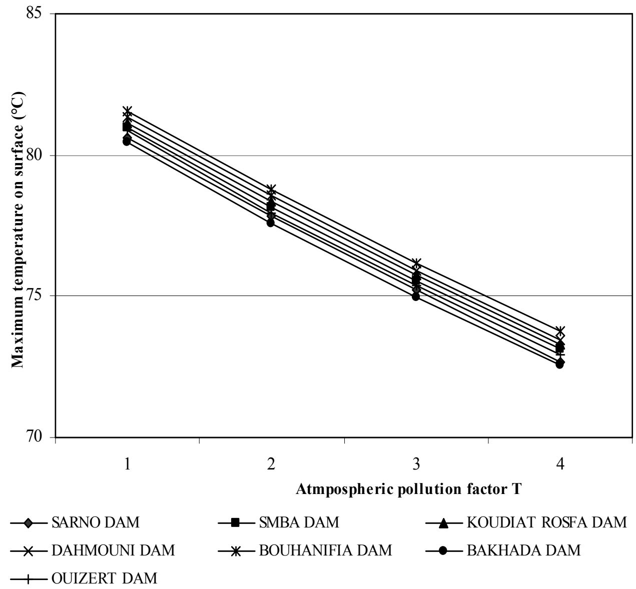

***Figure 5:** Variation in the maximum temperature on the surface of the facing with the increase of atmospheric pollution factor.*

8 CONCLUSION

The study of seven dams located in semi arid region of the west of Algeria allowed the determination of the maximum temperature relationship of the bituminous concrete facing surface. The obtained relation can be applied for similar dams considered in this paper, without requiring any in situ measurements.

Taking into account the influence of twelve parameters, we were able to highlight what follows:

i. The maximum temperature decreases with the increase of the depth.

ii. The maximum surface temperature decreases with the increase of the dams slope.

iii. It is recommended to use a slope of dam which provides both stability and minimum surface facing temperature.

iv. The maximum surface temperature of the surfacing decreases with the increase of atmospheric pollution.

v. The use of T_0 relationship to evaluate the maximum temperature at the concrete bituminous facing seems to be appropriate in the semi arid regions of west Algeria.

ACKNOWLEDGEMENT

The authors are very grateful to the National Agency of Dams in Algeria for its collaboration in dealing with such problems.

REFERENCES

[1] CFGB. (1973) "L'expérience Française des masques amont en béton bitumineux", XI ICOLD, Madrid, Q. 42, R. 7, pp 101-124.

[2] Asbeck WFV. (1969) "Le bitume dans les travaux hydrauliques", vol II, Dunod, Paris.

[3] CIGB, ICOLD. (1999) "Barrages en remblai avec masque en béton bitumineux", Bulletin n° 114, pp 13-91.

[4] CIGB, ICOLD. (1982) "Masques amont en béton bitumineux pour barrages en terre et en enrochement", Bulletin n°32a, pp 7-35.

[5] Estienne P., Godard A. (1998) "Climatologie", Nouvelle Présentation, Armand Collin.

[6] Belbachir K., Montel B., Chervier L. (1973) " Comportement des masques d'étanchéité en béton bitumineux des barrages du Secrétariat d'Etat à l'Hydraulique Algérien", XI ICOLD, Madrid, Q. 42, R. 51, pp 1053-1073.

[7] Chiblak M. (1989) "Essais sur la stabilité du bitume dans des conditions chaudes", Thèse de Doctorat, Université Technique Dryden, Allemagne.

[8] Djemili L., Boudoukha A., Chiblak M., et Aoun H. (2005) "Simulation numérique de la température des masques en béton bitumineux. Barrage Ghrib Algérie", Annales du Bâtiment et des Travaux Publics, n° 4, pp 23-29.

[9] Kreitmann M. (1959) "Variation journalière de la température dans le masque en béton bitumineux", Laboratoire du Bâtiment et des Travaux Publics d'Algérie, Rapport n°III, pp 2-8.