Concrete	σ _{bars}	Ua	л 10 ⁻⁶ /day
Quartzite	50	3885	5650
	100	3881	10000
Porphyry	50	3706	7000
	100	3716	12200
	150	3720	16400
Expanded clay	50	3755	5000
	100	3755	8650
	150	3755	12000
Siliceous concrete	64	3500	8000
Siliceous	50	3180	4600
limestone	100	3200	9300
concrete	150	3180	22000

Table nº 1

If we attempt to explain further the constant A, we can try, as did WEERTMAN for metals, to include the dependence of stress and temperature in creep by the equation

 $\frac{de}{dt} = C \sigma \qquad \frac{\alpha/KT}{e} = \frac{U_a/KT}{e}$

If we apply this equation to results obtained on porphyry concrete (Figure 6) we obtain a coefficient $\frac{\alpha}{KT}$ quite constant to 0.820. We have checked that this value could fulfil

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the expression of A for all the other concretes and it follows that if $\frac{\alpha}{\nu_m}$ is a constant, α varies like T.

Il we try to check reversibility of the creep of dry concrete with temperature, does concrete treated at a certain temperature reveal different creep if we lower the temperature ? Test - pieces heated at 150, 250, 400 and 500°C have been loaded and measured for creep at temperatures below their test temperatures. The results (Figure 7) show that the velocities of creep are lower, although stress applied is the same. Since the activation energy is constant, we can ask ourselves why the action of lowering the temperature after the changing to a certain state lowers the velocity of deformation. It is probable that the number of bonds liable to be activated has decreased.

We have just examined the case of creep in concrete dried at 105°C. Let us now investigate results obtained at 20°C on concrete cured at 98% relative humidity, where desorption has been obtained by placing loaded and unloaded samples in enclosures at different hygrometries.

The loss of water in the samples has been measured during the whole test period. We saw at the beginning of this paper that for a certain time the shrinkage and the shortenings under load are proportional until shrinkage begins negligible compared with the measured shortenings. We also notice that the slope of shortenings, compared with log t is the same as that of previous shortenings if we subtract shrinkage. In short this means that shrinkage is directly linked to desorption and to free energy of water whilst creep depends on the strong applied and the slope of strain as a function of log t varies with the state of hygrometric equilibrium applied. If we examine the results obtained on porphyry concrete for hygrometries of 60, 30, 10 et 0.07 % relative humidity (Figure 8), we find that the creep slopes vary with $\frac{p}{p_0}$ with a maximum around $\frac{p}{p_0} = 0.6$, a minimum at $\frac{p}{p_0} = 0.1$ and a new increase for $\frac{p}{p_0} \approx 0.07$.

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If we remember the desorption curves shown with the previous paper, we notice that the steepest desorption slope occurs before $\frac{P}{P_0} = 0.1$, that is to say that the water affecting the pores has been desorbed up to a certain point and a certain number of molecular water layers and that after the decrease in the creep velocity caused by this change of configuration, the desorption of fixed layers with highest energies brings about an increase in the creep slope.

If we compare these results with those obtained with the action of temperature as well as that of partial vapour pressure, we observe that the creep slope variation (dotted line) instead of increasing as before, decreases from $\frac{p}{p_a} = 0.1$ on. This

would seem to indicate the higher quantities of water, desorbed (cf. Topic 3) under the influence of temperature, help to set up fragiles hydrates bonds. These fragiles hydrates, responsible for the increase of erecp in relation to desorption, would be transformed or decomposed under the influence of heat which would lead in the latter case to a decrease of creep.

We have briefly investigated the behaviour at high temperature of dried concrete and wet concrete in relation to water desorption. There now remains a case interesting for massive construction : the behaviour of sealed concrete in relation to temperature.

Concrete test - samples cured at 98% relative humidity were shut in boxes made of thin sheets of copper soldered and proof against water vapour leaks. These test - pieces were put to ereep tests at 20, 50, 70, 95°C and, whatever the temperature, give $\frac{p}{p_0} = 1$, that is to say saturation. The shortenings measured can be called ereep, since there is no shrinkage. If we trace the variation of strains in relation to log t, we discover straight lines again.

The variation of the slope of these straight lines in relation to temperature lead to an exponential curve in the opposite direction to that of dried concrete (Figure 9).

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The curve of dried concrete leads to an activation energy revealing the viscous flow of concrete, while the curve of scaled concrete follows an exponential law of the same kind as that representing the viscosity of water in relation to temperature. If we plot on the Graph.(10) the variation of the creep slopes in relation to the viscosity of water at test temperature, we find points spread on the straight lines for each strass applied. We have treated the results obtained by HANNANT /6/ in the same way and plotted them on the same graph. The concretes are not the same; the cement proportions are different and HANNANT's concrete contains plastocrete. We can however discern good correlation between these various results. Without letting ourselves be tempted by too easy a conclusion, we can estimate by intuition that in a saturated environment the water films trapped in the structure overgoing no desorption stress are of prime importance in the mechanism of creep. We lack time to go into detail; let us say however that the calculations undertaken to evaluate activation energy in the creep process lead to lower values than those found for the activation process of dried concrete. There is another point that we must also mention, this is the apparent absence of the transformation of hydrates at test temperatures. We have carried out supplementary investigations, using small samples of pure coment past cured at 98% relative humidity, then heated to different temperatures in saturated environment. Desorption tests undertaken ofter heating, that is to say the measurement of the loss of water according to the hygrometry at 20°C have revealed that the samples undergo the same kind of desorption as the samples not subjected to temperature. We may therefore draw the conclusion for the moment that the action of desorption alone at 20°C or that of temperature in saturated environment does not bring about serious modification of the cement hydrates, while the combined action of temperature and desorption leads to transformations.

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