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Influence of Temperature on the Properties of Fresh Mortars

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Original Research Article

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Abstract: The influence of the temperature of the environment to the properties of fresh mortar has been investigated. Compressed air machine has been used. The result shows that the temperature of the environment has certain effects on the retention of the mortar in fresh state. At low temperature (below 20°C), the hydration rate remains moderate. This is why this value is chosen for all rheology tests. With the same percentage of coarse sand, the mass loss at high temperature is higher. For high temperatures, the high hydration rate leads to a rapid formation of hydrates, resulting in an increase in the friction between particles causing a rise in the values of τ_0 and μ.
Keywords: Temperature, mortar, Vane-Cylinder test, mortar retentivity.

INTRODUCTION

Fresh mortars are extremely fluid materials that settle without vibration. However, because of their fluidity, mortars have a significant risk of segregation, ie a risk of separation between the suspending phase and large aggregates. We speak of dynamic segregation when this separation occurs during the filling phase of the formwork and static segregation once the material is in place. Stability is an essential feature since it ensures the durability of the structure and the homogeneity of the mechanical properties once the material has hardened. It is therefore a question of finding a compromise between two characteristics that may seem contradictory: fluidity and stability.

A BAP must also be able to flow, without adding vibration, through confined areas (in a much scraped formwork, to the right of a diaphragm ...) and a high fluidity of the concrete is not a sufficient condition for this.

Indeed, during the flow of a fluid concrete to the right of an obstacle, gravel shear mortar and tend to come into contact with each other if the latter is not resistant enough to shear. Arches can thus be formed by solid contacts, clogged with fine parts, and interrupt the flow. It is therefore necessary for a BAP to have good resistance to segregation during the flow phase in a confined zone [1].

It must also have good resistance to static segregation (once in place) until its setting, for obvious reasons of homogeneity of its mechanical properties. As a corollary, it must not undergo a settling or bleeding too strong because this can generate a drop in adhesion of the reinforcements in the upper part of the levies compared to those in the lower zone during casting, and the appearance of cracks.

In conclusion, the main difficulty faced by the mortar formulator is to be able to reconcile a priori conflicting properties: the fluidity and the resistance to the segregation and bleeding of the mortar.

If there is instability, ie a separation between large aggregates and the suspending phase during implementation in the formwork, it is called dynamic segregation. Static segregation can occur once the material is in place and up to the point of capture [1, 2].

Segregation can be detrimental to mechanical strength but also to the durability of the structure. But it is not visible on the siding unless it is accompanied by bleeding. It is therefore necessary to ensure upstream of the stability of the mortar and to have verification tests before casting.

The dynamic segregation is a separation between the aggregates and the suspending phase during the flow. Certain formulation precautions, such as the reduction of the maximum diameter of aggregates, can limit the risk of blockage to the reinforcement. This segregation depends mainly on the viscosity of the material which makes it possible to drive the aggregates correctly during the flow. We have seen that the viscosity depends on the volume fraction. This characteristic must be sufficiently weak for the material to flow at a relatively high flow rate. In this part, a new constraint appeared. Not only must the granular extent be limited, but the particle size must also be continuous and well distributed. The amount of sand must therefore be adjusted to obtain a satisfactory compromise.

MATERIALS AND EXPERIMENTAL METHODS

Apparatus

Central Air Handling Machine: compressed air treatment

The purpose of the machine is to determine the influence of the environment on the properties of the mortar. A system of air resistance and air pressure of this machine can modify the temperature of the environment. With this machine you can have a desired temperature. The mass loss of the mortar is then determined using a scale just next to the Central machine.

Rheometer AR2000ex

To measure rheological properties of mortars, flow tests were performed using a high-accuracy rheometer (figure 1), a commercial rheometer called AR2000ex of TA instrument series.

Fig-1: Vane-cylinder used for the rheology test

This rheometer includes a unique ultra-low inertia drag cup motor and porous carbon air bearings for outstanding controlled stress, direct strain and controlled rate performance. The high resolution optimal encoder, high stiffness low inertia design make the AR2000ex extremely versatile and appropriate for a wide variety of applications including characterization of delicate structures in fluids of any viscosity, polymer melts, solids, and reactive materials.

Rheometer AR2000ex can be used for characterizing cement pastes in fresh state. Different geometries are used to test for rheological properties by simply changing fixtures. In this study, coaxial cylinders (vane and cylinder) were used, represented in figure 3, which was used for characterizing fresh mortar in shearing condition.

Mixer

After the preparation of the mortar components in prescribed quantity, dry-mortar was blended with water by a vertical axis mixer. This mixer is capable of preparing the cement pastes in the laboratory.

The mixing has an important role in obtaining a homogeneous cement pastes. In order to have a reliable investigation of the fresh mortar, a uniform mixing procedure must be made. In our study, the mixing procedure includes the following steps:

- Mixing of the dry components at low speed (60 rpm) for 30s
- Addition of the required quantity of water
- Mixing at low speed for 30s
- Stop the mixer in 30s. During this time, the material is mixed by hand to recover the sticking material to the container's wall
- Mix at high speed (125 rpm) for 60s.

In order to minimize the difference between the obtained mortars pastes, the above step (4) must be paid attention that the action of hand mixing is almost the same for all cases. This ensures that mortars pastes in the same state will be obtained in all cases.

The mortar sample was poured into the rheometer after 5 minutes resting from the end of mixing to start the experiments. The measurements were performed during the induction period, characterized by a very low hydration rate, which may not influence the properties of the test material.

MATERIALS

The total weight of one sample is taken 300g in order to obtain a homogeneous mortar paste. The mortar formulation is given in Table 1. The purpose of present investigation is to determine the weight loss according to the variation of the percentage of the coarse sand. It is the retentation of water in the environment. The influence of the environment on the properties of fresh mortar, including the water retention, will be investigated.

- The simplified formulation is 80% sand, 15% cement, 5% lime and 15% water.
- The content of coarse sand is varied among these values: 100%, 80%, 70%, 60%, 40% and 0%.

- The temperature of the environment is chosen among the following value (˚C): 6, 13, 25, 32, 37, 46.
- Experiment duration: 20 minutes for each measurement of the weight loss.
- The formula of weight loss [2]:

$$\eta = \frac{\Delta M_i}{M_i} \tag{3}$$

$$\Delta M_i = M_{i+1} - M_i \tag{4}$$

In which :

- M_i : Initial weight of the mortar paste at time i (g)
- M_{i+1} : Final weight of the mortar paste at time i+1 (g)

Table-1: Mortar formulation

Mortar composition	Sand	Cement	Lime	Water
Quantity (%) Total mass = 300 g	80	15	5	15

The sands used in the experiments are sieved. In order to determine the influence of the distribution, sands are the mixture of different sizes. The D/d ratio is of the largest and the smallest sizes. In this study, sands are mixture of D1, D4 and D5. The dimensions of the sands are indicated in table 2.

Table-2: The dimension of sand

Sand	Diameter max (mm)	Diameter min (mm)	Average diameter(mm)	Ratio D/d
D1	0,16	0,315	0,240	
D4	1	1,25	1,130	4,708
D5	1,25	1,6	1,425	7,833

EXPERIMENTAL RESULTS

The weight loss of the mortar pastes is plotted as a function of the percentage of coarse sand and represented in figure 2. The increasing of the temperature in the mortar causes dehydration of the hydrated compounds of the hardened cement paste and possibly deterioration of the aggregates. It leads to a formation of free water in the porous network of the material that can evaporate and thus generate a loss of weight for a given sample. The microstructural modifications accompanying this dehydration also lead to a modification of the mechanical and thermal properties of the mortar [3].

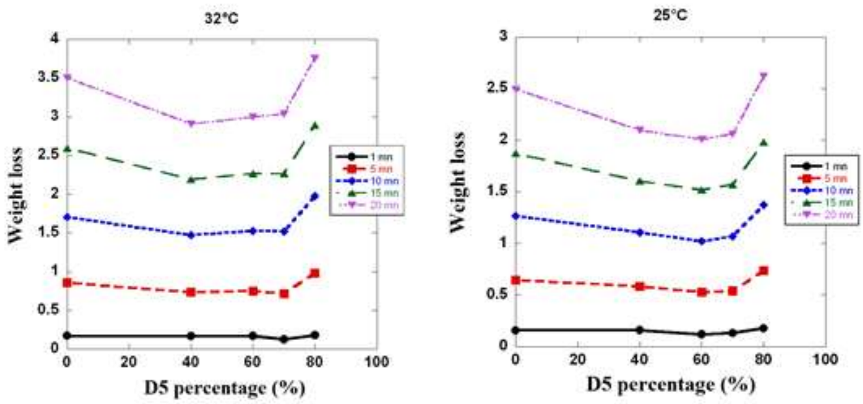

Fig-2: Loss weight versus the percentage of coarse sand

The test is taken after 5, 10, 15, 20 minutes to compare the weight loss as the percentage of coarse sand. The loss of weight increases together with the temperature of the environment. At low temperatures, the permeability of the mortar should be low. That leads to less departure of the water.

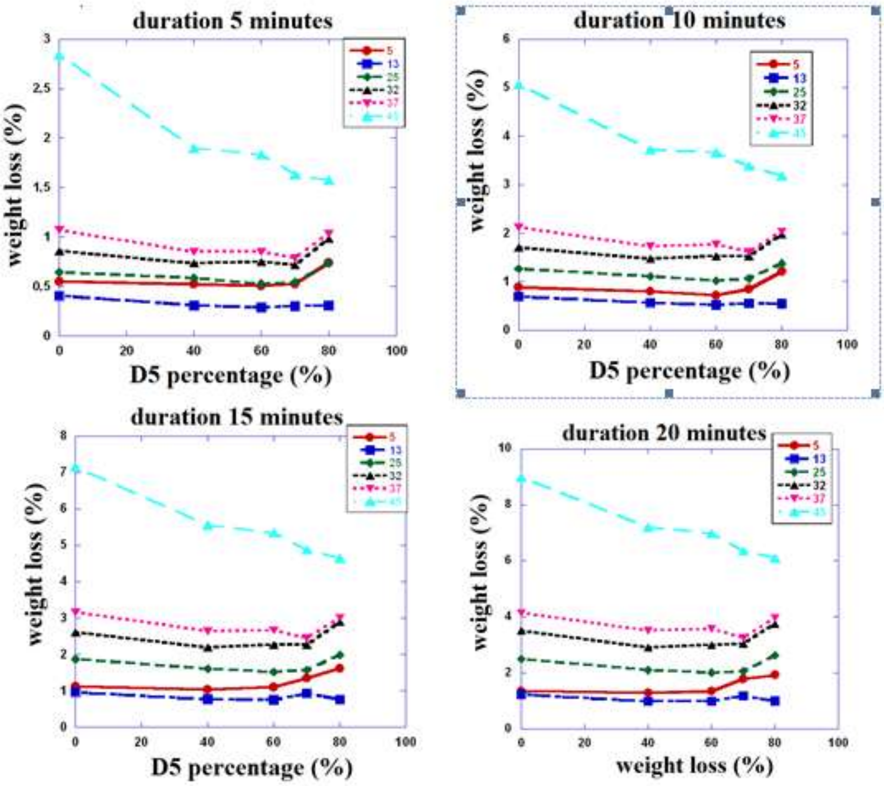

Fig-3: Comparison of the weight loss versus the percentage of coarse sand D5 at various relaxation time

The temperature influences the loss of mass. At low temperature (below 20°C), the hydration rate remains moderate. With the same percentage of coarse sand, the mass loss at high temperature is higher. The higher the temperature, the faster the hydration. For high temperatures, the high hydration rate leads to a rapid formation of hydrates, resulting in an increase in the friction between particles causing a rise in the values of τ0 and μ. The formulation 70% D5 large sand and 30% D1 small sand with the minimum mass loss is an optimal formulation [4].

CONCLUSIONS

The influence of the temperature of the environment to the properties of fresh mortar has been investigated. Compressed air machine has been used. The result shows that the temperature of the environment has certain effects on the retention of the mortar in fresh state. At low temperature (below 20°C), the hydration rate remains moderate. This is why this value is chosen for all rheology tests. With the same percentage of coarse sand, the mass loss at high temperature is higher. For high temperatures, the high hydration rate leads to a rapid formation of hydrates, resulting in an increase in the friction between particles causing a rise in the values of τ0 and μ.

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