Pergamon

Cement and Concrete Research, Vol. 28, No. 6, pp. 811–814, 1998

0008-8846/98 $19.00 + .00

PII S0008-8846(98)00047-7

INVESTIGATION OF A MAGNESIA BINDER IN THE SYSTEM $MgO\text{-}Mg(CH_3COO)_2\text{-}H_2O$

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(Received February 19, 1998; in final form March 23, 1998)

ABSTRACT

Usually the liquid component of a magnesia binder system is a solution of magnesium chloride or magnesium sulfate. With respect to waste disposal, an organic magnesium salt is desirable. This work shows that magnesia binders in the system $MgO\text{-}Mg(CH_3COO)_2\text{-}H_2O$ develop a considerable strength that is lower than that of a sulfatic binder system. A similar setting behavior can be achieved. Further investigations should include other organic salts of magnesium and focus on the hardening mechanism. *© 1998 Elsevier Science Ltd*

Introduction

Magnesia binders in the systems $MgO\text{-}MgCl_2\text{-}H_2O$ and $MgO\text{-}MgSO_4\text{-}H_2O$ have been known for decades. Today they are mainly applied for flooring plasters, grindstones, and wood wool boards. To prevent steel corrosion, a sulfatic binder system is used in most cases. Wood wool boards with a sulfatic magnesia binder have the advantage of being bio-degradable. Nevertheless, for composting and thermal disposal an organic binder system helps to avoid pollution by sulfates or sulfur dioxide.

For the present investigation, an industrial caustic magnesia produced from alpine magnesite was used. The content of free MgO was 52.1 wt%, and the total MgO content was 68.4 wt%. Other main components were: 8.4 wt% SiO_2, 3.5 wt% Fe_2O_3, 1.7 wt% Al_2O_3, and 2.8 wt% CaO. Ignition loss (mainly CO_2) was 15.0 wt%. The grain-size distribution of the caustic magnesia showed approximately 80 wt% below 31 μm. The specific surface determined with the Blaine device was 1.7 m^2/g. This characterizes the grain-size distribution rather than the reactive surface area. For determination of the latter, the BET method was applied, which yielded a value of 36.8 m^2/g. For the preparation of the magnesium acetate solution, $Mg(CH_3COO)_2 \cdot 4H_2O$ of high purity (99,8%) was used. The results have been compared with those of a sulfatic binder, which was prepared from the same caustic magnesia. The magnesium sulfate solution was prepared from high purity $MgSO_4 \cdot 7H_2O$.

Communicated by F.W. Locher.

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TABLE 1
Mixture compositions (caustic magnesia: acetate or sulfate: aggregate: water).

M1	**M2**	**M3**	**M4**
2.17:0.74:9.85:1	2.53:0.38:7.32:1	2.71:0.20:7.32:1	1.67:0.25:5.0:1
M5	**M6**	**M7**	**M8**
1.0:0.67:5.0:1	1.24:0.43:5.0:1	1.42:0.25:5.0:1	1.55:0.11:5.0:1
M9	**M10**	**M11**	**M12**
1.67:0.0:5.0:1	0.92:0.3:4.17:1	1.06:0.16:4.17:1	1.14:0.08:4.17:1

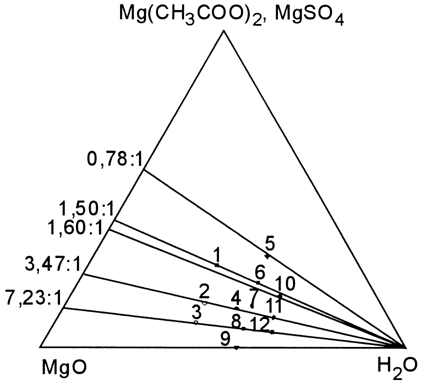

FIG. 1.

Composition of the mixtures in the system MgO-Mg$(CH_3COO)_2$, $MgSO_4$-H_2O. All mixes have been compacted by vibration. The prisms were stored at 20°C; the relative humidity was 100% for the first 24 h and 75% afterwards. The strength was investigated at the age of 1 to 5 days. At first the flexural strength was determined; afterwards both halves of each prism were used for the compression test. The determination of the setting behavior was performed according to (1) using the vicat device.

TABLE 2
Flexural and compressive strength of the mixtures investigated.

	Acetatic binder system				Sulfatic binder system			
	Flexural strength		Compressive strength		Flexural strength		Compressive strength	
Mixture	1 day	5 days	1 day	5 days	1 day	5 days	1 day	5 days
1	1.35	1.20	3.89	7.84	0.64	2.33	2.84	12.56
2	1.10	1.54	4.79	10.30	1.37	3.90	5.91	9.86
3	0.42		2.85					
4	2.24	1.97	6.25	7.99	3.65	4.64	14.30	19.72
5		0.44	0.66	0.99	0.69	2.42	3.75	6.80
6	0.55	0.99	1.72	2.29	3.53	3.32	12.13	19.20
7	1.53	1.73	4.41	5.38	2.89	3.17	10.30	16.66
8	1.07	1.01	4.17	5.61	2.35	2.80	10.52	14.93
9	0.21	0.59	0.92	2.83	0.21	0.59	0.92	2.83
10	0.52		1.35					
11	0.71		2.29					
12	0.63		2.19					

TABLE 3
Development of the strength in dependence of the age.

M1 Ac.	M1 Sulf.	M2 Ac.	M2 Sulf.	M4 Ac.	M4 Sulf.	M7 Ac.	M7 Sulf.	M8 Ac.	M8 Sulf.	M9
3.89	2.84	4.79	5.91	6.25	14.3	4.35	10.3	4.18	10.52	0.92
3.73	6.9	6.26	7.36	6.35	15.78	4.15	11.37	5.45	11.69	1.78
3.74	3.18	8.01	13.61	6.8	15.45	4.47	14.01	5.72	12.79	2.2
5.63	10.14	8.97	11.19	7.61	21.23	4.85	15.15	5.61	14.85	2.33
7.84	12.56	10.3	9.86	7.99	19.72	5.38	16.66	6.86	14.93	2.83

Experimental Procedures

The investigations had the goal of determining the strength and the setting behavior of the acetatic binder system in dependence of the composition. An optimum range of composition should be determined. All results had to be compared with a sulfatic binder. Both the tensile strength in a three-point bending test and the compressive strength under uniaxial compression have been determined. The testing procedure was following the Austrian Standard ÖN B3310 (4), which is valid for ordinary Portland cements. This procedure uses three prisms with dimensions $40 \times 40 \times 160$ mm^3 for each mixture. The tests were performed on mortars with a maximum aggregate size of 2 mm (standard aggregate according to (1)). The same mixture compositions have been investigated for both binder systems. They are characterized in Table 1. This table denotes the mass ratio of caustic magnesia: acetate or sulfate: aggregate: water. In this case, acetate or sulfate is calculated as the pure substance free of water, its water content is included in the total amount of water.

As can be seen from Table 1, mixture 9 contains neither acetate nor sulfate. This mixture acts as a standard to evaluate the effectiveness of the acetate binder. Even this mixture is expected to develop some strength due to hydration and carbonation of the magnesia and to desiccation. The composition of the mixtures in the system MgO-$Mg(CH_3COO)_2$, $MgSO_4$-H_2O is shown in Figure 1.

Experimental Results

The flexural and compressive strength of all mixtures at the age of 1 to 5 days are shown in Table 2.

The development of the strength in dependence of age is shown in Table 3 for the mixtures with the most favorable results.

TABLE 4
Time t_1 for the initial set and t_2 for the final set.

	Acetatic binder system		Sulfatic binder system	
Mixture	Initial set	Final set	Initial set	Final set
1	193 min.	300 min.	25 min.	35 min.
4	20 min.	50 min.	22 min.	47 min.
8	26 min.	46 min.	17 min.	45 min.
9	160 min.	300 min.	160 min.	300 min.

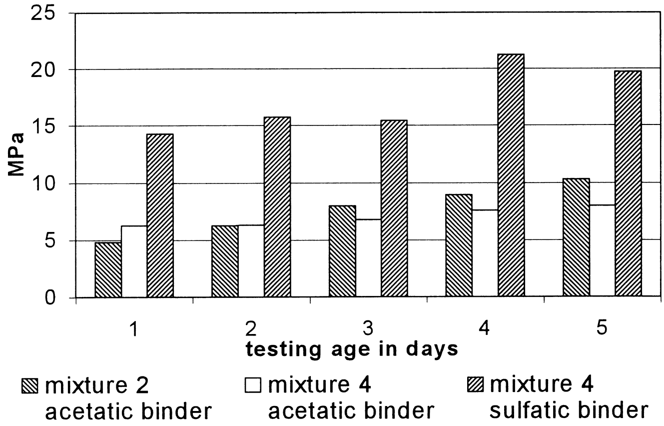

FIG. 2.
Compressive strength of mixtures 2 and 4 (acetatic binder) and mixture 4 (sulfatic binder).

The setting time was determined for the three mixtures with the highest flexural strength. Table 4 shows the time t_1 for the initial set and t_2 for the final set.

Discussion and Conclusions

The most favorable results have been obtained for the mixtures 2 and 4 with the acetatic and for mixture 3 with the sulfatic binder. At all ages, the acetatic binder shows a by far lower strength compared with the sulfatic binder. Figure 2 shows the compressive strength of mixtures 2 and 4 with acetatic binder together with mixture 4 with sulfatic binder in dependence of the testing age.

The effectiveness of the acetatic binder is proven by comparison of the strength with that of mixture 9; in all cases the strength of the acetatic binder is a multiple of that of mixture 9. The setting time shows a different behavior. Mixtures 1 (acetatic binder) and 9 (no acetate or sulfate) show similar setting behavior, in all other cases the setting time is by far shorter.

This investigation does not include any considerations about the mechanism of setting and hardening. No attempts have been made to identify the phase formation. This could be a goal for further research. Moreover, other organic acids, including carbonic and hydroxi carbonic acids of different molecular weight, should be included.

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