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INFLUENCE OF SOME TECHNOLOGY PARAMETERS ON THE STRUCTURES OF AUTOCLAVED LIME-SAND CONCRETE

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ABSTRACT

Autoclaving schedule, calcium-silicate (C/S) ratio and water-solid (W/S) ratio are considered as the important technology parameters affecting the properties of autoclaved lime-sand concrete. Furthermore, the properties of autoclaved lime-sand concrete depend on its microstructures, such as pore structures and calcium silicate hydrates. This paper examines the effect of the above-mentioned important parameters on pore structure, the contents of calcium silicate hydrates and $Ca(OH)_2$ in autoclaved lime-sand concrete. The results show that W/S ratio affects both total pore volume and the volume of pores larger than 500Å radius of autoclaved lime-sand concrete. When an autoclaving schedule is stronger than a critical autoclaving schedule at a given mix, it exhibits less effect on pore structure, the contents of $Ca(OH)_2$ and calcium silicate hydrates. An insufficient autoclaving schedule, specially 'peak autoclaving schedule', causes coarseness of pore structure, more $Ca(OH)_2$ and lower content of calcium silicate hydrates. The structure-property relationships are discussed.

Introduction

Lime-sand concrete is a new type of free-cement concrete material of which the essential constituent materials are lime and various kinds of sand. This type of concrete is cured under high-temperature-and-high pressure steam (170°C~190°C, 0.8 MPa~1.2 MPa, or even higher) in an autoclave. During the autoclaving process, $Ca(OH)_2$ reacted with the dissolved SiO_2 from the surface of the sand in solution to form various types of calcium silicate hydrates, depending on the fineness of the materials, C/S ratio and autoclaving schedule. Meanwhile, as in OPC concrete, there are a large number of pores with different sizes in autoclaved lime-sand concrete. Generally, the porosity of lime-sand concrete ranges from 15% to 35%, and is slightly larger than that of Portland cement concrete(1). The pore struc-

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ture of lime-sand concrete is one of the most important microstructures affecting the material's strength and durability.

Apart from pore structure, the content of calcium silicate hydrates is another important factor influencing the properties of autoclaved lime-sand concrete. Much work has been conducted to investigate the calcium silicate hydrates in $CaO-SiO_2-H_2O$ system under autoclaving treatment(2,3). Recently some researchers have paid more attention to the quantitative relationships between the contents of calcium silicate hydrates and the properties of autoclaved materials (3-6). However, it is very difficult to quantitatively determine the contents of the major calcium silicate hydrates of autoclaved lime-sand concrete. It is more convenient to determine the total content of calcium silicate hydrates with a chemical analysis method (5) than to measure the contents of various calcium silicate hydrates with X-ray diffraction methods.

The strength and durability of autoclaved lime-sand concrete are controlled mainly by some technology parameters, such as autoclaving schedule, mix proportion and the properties of the constituent materials (2). It was reported (7) that there was a suitable autoclaving schedule for a given mix proportion. Generally, the larger the C/S ratio, the higher the autoclaving pressure and the longer the holding temperature period required. Water-solid ratio has a great effect on the strength and carbonation of autoclaved lime-sand concrete, and there is a suitable range of W/S ratio for a given autoclaving schedule and production technology.

The objective of this work is to further investigate the effect of the technology parameters such as autoclaving schedule, water-solid ratio and calcium-silicate ratio on the microstructures of autoclaved lime-sand concrete, such as pore structure, specific surface area the contents of $Ca(OH)_2$ and calcium silicate hydrates of autoclaved lime-sand concrete.

Experimental Programme

Materials and Mix Proportions. Ground lime: active CaO% = 65%, fineness = 6400 cm^2/g (specific surface area). Ground sand: fineness = 5050 - 5270 cm^2/g (specific surface area). Superfine sand: fineness modulus =0.63, specific gravity = 2.69; chemical composition is given in Table 1. Gypsum: CaO_2 content = 75.2%.

Preparation and Autoclaving of Specimens. After casting in steel moulds, vibrating 90 seconds and resting in room temperature for 24 hours, the specimens were put into an autoclave for treatment. The autoclaving schedules used for A1~A8 and B1~B8 specimens are given in Table 3. The autoclaving schedule for other specimens is as follows: autoclaving pressure = 1.0 MPa (corresponding autoclaving temperature is 183 °C), rising temperature period = 2 hours, holding temperature period = 6 hours, dropping temperature period = 2 hours.

TABLE 1
Chemical Composition of Sand (percentage)

SiO_2	Al_2O_3	TiO_2	CaO	Fe_2O_3	MgO_2	LOI
78.7	4.5	0.48	5.65	3.2	2.98	4.1

TABLE 2
Mix Proportions of Lime-Sand Concrete

Specimen No.	C/S (mol.)	L/A	W/S	G/AL
A1 - A8	0.50	1:2	0.17	5%
B1 - B8	1.00	1:2	0.17	5%
D8	0.75	1:2	0.17	5%
G8	0.50	1:2	0.14	5%
H8	1.50	1:2	0.20	5%
E8	1.25	1:2	0.17	5%
F8	1.50	1:2	0.17	5%

Note: C/S = the ratio of active CaO to SiO_2 in ground sand; L/A = the ratio of lime and ground sand to superfine sand; W/S = the ratio of water to all mixture; G/AL = the ratio of gypsum to active CaO.

The specimens for the measurement of the compressive strength and the carbonation depth were 100 mm cubes. After testing compressive strength, the small pieces of concrete were taken from the specimens to prepare the samples for the measurement of the pore structure, BET specific surface area, the contents of calcium silicate hydrates and Ca(OH).

Measurement of Pore Size Distribution and BET Specific Area. The samples were immersed in methanol for 14 days, followed by heating for 24 hours at 105°C in an oven. Mercury Intrusion Porosimetry technique(MIP) was employed to measure the porosity and the pore size distribution of autoclaved lime-sand concrete. The contact angle between mercury and the surface of the samples was supposed to be 130° The weight of samples tested was 1.5~2.5g. The data were recorded and computed by a computer automatically.

The specific surface area of autoclaved lime-sand concrete was measured with BET nitrogen absorption method.

Measurement of Calcium Silicate Hydrates. The free-Ca(OH), soluble calcium and silicate were measured following the relative chemical analysis method for cement. The total content of the calcium silicate hydrates was calculated according to the method proposed by Sung (5).

TABLE 3
The Autoclaving Schedules for A and B Series Specimens

Specimen No.	Autoclaving Pressure, MPa	Holding Temperature °C	Rising Temperature Period ,hours	Holding Temperature period, hours	Dropping Temperature period, hours
A1 & B1	0.8	174.5	2	4	2
A2 & B2	0.8	174.5	2	6	2
A3 & B3	0.8	174.5	2	8	2
A4 & B4	1.0	183.0	2	4	2
A5 & B5	1.0	183.0	2	6	2
A6 & B6	1.2	190.7	2	0	2
A7 & B7	1.2	190.7	2	4	2
A8 & B8	1.2	190.7	2	6	2

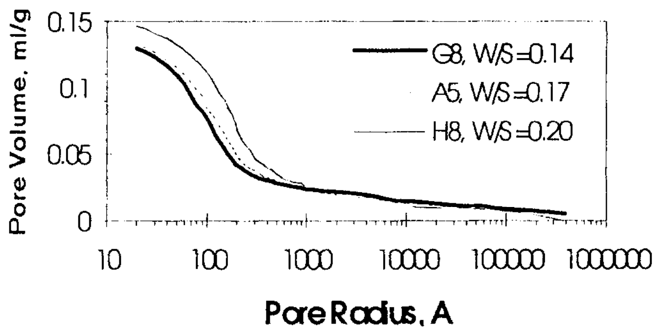

FIG. 1.
Pore size distributions of lime-sand concrete at different W/S ratios.

Measurement of Properties of Autoclaved Lime-Sand Concrete. As reported in a previous paper (7), the compressive strength and carbonation depth were measured. The experimental details can be found in references (7).

Results and Discussions

Pore Size Distribution. The pore size distribution curves for the concretes with different W/S ratios are shown in Fig.1. In addition, for ease of comparison, their total pore volume and the volumes of pores larger than 500Å radius are given in Table 4.

From Fig.1 and Table 4, it can be observed that total pore volume and the volume of pores larger than 500Å radius decreases with the decrease in W/S ratio. The total pore volume decreases from 0.1477 ml/g to 0.1325 ml/g with a reduction of W/S ratio from 0.20 to 0.17, while a further reduction of W/S ratio from 0.17 to 0.14 gives only a reduction of total pore volume from 0.1325 ml/g to 0.1295 ml/g. W/S ratio has the same influence on the volume of pores larger than 500Å radius as on total pore volume. As shown in Table 4, the volume of pores larger than 500Å radius exhibits a sharp reduction while W/S ratio decreases from 0.20 to 0.17, and the further decreasing W/S ratio from 0.17 to 0.14 causes only marginal reduction in the volume of pores larger than 500Å radius. This result shows that although both total pore volume and the volume of pores larger than 500Å radius decrease with the decrease in W/S ratio, their relationship is not linear.

This result gives an important message that the W/S ratio can only be decreased to a limit value in order to form a good pore structure in autoclaved lime-sand concrete. Our experience in casting specimens of lime-sand concrete showed that when W/S was 0.14, the setting

TABLE 4
Pore Size Distribution and Some Properties of Specimens at Different W/S Ratio

No. of Specimens	W/S Ratio	C/S Ratio	Total Pore Volume, ml/g	r>500 Å Pore Volume, ml/g	Compressive Strength, MPa	Carbonation Depth, mm
G5	0.14	0.5	0.1295	0.0281	43.7	24.7
A5	0.17	0.5	0.1325	0.0298	38.9	26.8
H5	0.20	0.5	0.1477	0.0381	32.9	47.0

TABLE 5

Pore Size Distribution and Some Properties of A and B Series Specimens

NO. of Specimens	C/S Ratio (mol.)	Autoclaving Schedules		Total Pore Volume (ml/g)	r>500 Å Pore volume (ml/g)	Compressive Strength (MPa)	Carbonation Depth (mm)
		Pressure (MPa)	Holding Period (hrs)				
A1	0.5	0.8	4	0.1276	0.0291	34.5	28.9
A2			6	0.1506	0.0338	35.9	26.8
A3			8	0.1216	0.0302	36.6	32.8
A4		1.0	4	0.1404	0.0345	42.1	32.6
A5			6	0.1325	0.0298	38.9	30.1
A6		1.2	0	0.1480	0.0498	25.7	37.6
A7			4	0.1197	0.0316	33.8	27.2
A8			6	0.1462	0.0315	36.9	30.5
B1	1.0	0.8	4	0.1259	0.0429	26.7	31.9
B2			6	0.1207	0.0364	45.8	40.4
B3			8	0.1360	0.0413	32.9	44.5
B4		1.0	4	0.1422	0.0469	35.7	33.5
B5			6	0.1362	0.0397	48.2	27.0
B6		1.2	0	0.1264	0.0707	24.5	50.0
B7			4	0.1194	0.0379	51.3	22.4
B8			6	0.1392	0.0379	53.7	24.9

time of the lime-sand mixture was very short, and longer vibrating time was required to compact fresh concrete. When the W/S ratio was smaller than 0.14, the setting time of the lime-sand mixture was too short to compact fresh concrete. On the one hand, high W/S ratio causes larger pore volume and coarseness of pores due to evaporation of water during the autoclaving process. On the other hand, too low a W/S ratio causes loose structure of lime-sand concrete due to bad workability of the lime-sand mixture. Therefore, the W/S ratio must be carefully chosen to produce quality lime-sand concrete with good structure. In our study, 0.17 is a suitable W/S ratio.

Table 5 summarises the total pore volume and the volume of pores larger than 500Å radius for the lime-sand concrete samples autoclaved under different autoclaving schedules, and Figs. 2 - 4 show their pore size distributions.

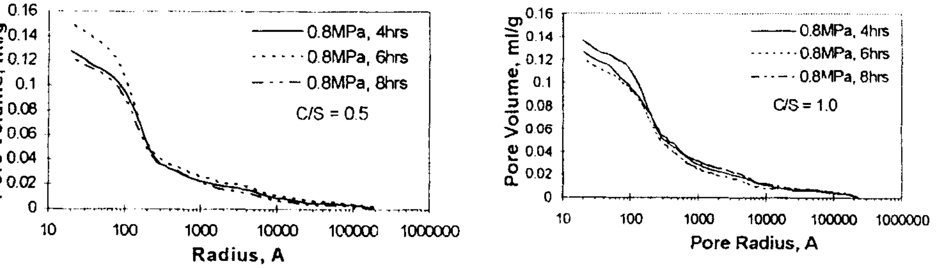

FIG. 2.

Pore size distributions at 0.8 MPa autoclaving pressure.

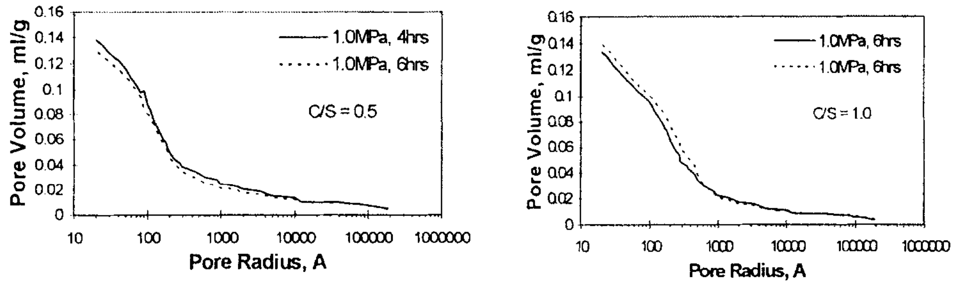

FIG. 3.
Pore size distributions at 1.0 MPa autoclaving pressure.

Fig. 2 shows the influence of the holding temperature period on the pore size distribution when autoclaving pressure is 0.8 MPa. At the C/S ratio of 0.5, the specimens autoclaved with 4, 6, 8 hour holding temperature period have almost the same pore size distributions for the pores larger than about 200Å radius. There is little difference exhibited in the volumes of pores larger than 500Å radius, as shown in Table 5. Although the specimen autoclaved with 6 hours holding temperature period has the larger total pore volume than those of the specimens autoclaved for 4 hours and 8 hours, it only exhibits the increasement in the volume of pores smaller than 200Å radius, as shown in Fig. 1. When the C/S ratio is 1.0, the specimen autoclaved with 6 hours holding temperature period has both a lower total pore volume and a volume of pores larger than 500Å radius, compared with both specimens autoclaved with 4 hours and 8 hour holding temperature period respectively, as shown in Fig. 1 and Table 5. The specimen autoclaved with 8 hours holding temperature period has a larger total pore volume, but almost the same volume of pores larger than 500Å radius, compared with the specimen with 4 hours holding temperature period.

Fig. 3 shows a comparison of the pore size distributions for the specimens autoclaved with 4 hours and 6 hours holding temperature periods respectively when autoclaved pressure is 1.0 MPa. The results show that at both C/S ratios the specimens with 6 hours holding temperature period have less total pore volume and a smaller volume of pores larger than 500Å radius, compared with the specimen with 4 hours holding temperature period. In other words, both total pore volume and the volume of pores larger than 500Å radius decrease with the increase in holding temperature period.

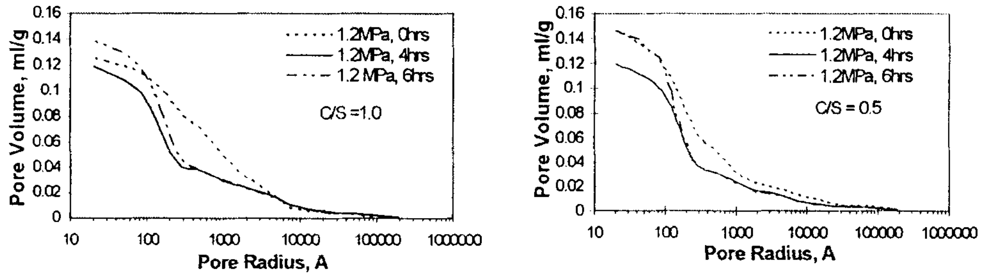

FIG. 4.
Pore size distributions of lime-sand concrete at 1.2 MPa.

Fig. 4 gives the pore size distribution curves for the specimens autoclaved with an autoclaving pressure of 1.2 MPa. It is interesting to note that the specimens autoclaved with 0 hours holding temperature period (or so-called 'peak autoclaving schedule' in production of lime-sand concrete) exhibit an apparent coarseness of pore structure, compared with other specimens. As shown in Table 5 and Fig. 3. It has a much larger volume of pores larger than 500Å radius than the specimens treated with 4 hours and 6 hours holding temperature periods. This apparent coarseness of pore structure is more pronounced at a C/S ratio of 1.0. For example, when C/S is 1.0, the volume of pores larger than 500Å radius is 0.0707 ml/g, much greater than the 0.0379 ml/g of the specimens with 4 hours and 6 hours holding temperature period. It is surprising to note that at a C/S of 0.5, beyond 200°C and at a C/S ratio of 1.0, beyond 500Å, the pore size distribution curves for specimens with 4 hours and 6 hours holding temperature are very similar, as shown in Fig. 3. These results demonstrate that when autoclaving pressure is 1.2 MPa, 4 hours-holding-temperature-period autoclaving can ensure the formation of good pore structures, and longer autoclaving only caused an increase in the volume of finer pores which little affect the properties of concrete.

It can be concluded from the above-mentioned results that there is a minimum holding temperature period for the formation of a good pore structure for a given C/S ratio and a given autoclaving pressure. This information is important for understanding the effect of autoclaving schedules on the properties of autoclaved lime-sand concrete. A holding temperature period longer than the corresponding minimum holding temperature contributes less to further improvement in the pore structure, or only causes an increase in the volume of finer pores in some cases. This is because once the reaction between calcium and silicate is completed and the calcium silicate hydrates with low C/S ratio are formed, continuous autoclaving only causes changes in the crystallinity of calcium silicate hydrates. And this process

TABLE 6

Phase Analysis and BET Specific Surface Area for A and B Series Specimens

No. of Specimens	C/S Ratio	Autoclaving Schedules		$Ca(OH)_2$	Hydrated Products	BET Specific Surface Areas
	(mol.)	Pressure (MPa)	Holding Period (hrs)	(%)	(%)	(m^2/g)
A1	0.5	0.8	4	0.10	14.42	17.59
A2			6	0.12	15.20	18.78
A3			8	0.16	13.56	16.36
A4		1.0	4	0.15	13.84	23.30
A5			6	0.11	14.31	21.80
A6		1.2	0	0.22	14.10	16.43
A7			4	0.17	14.55	20.85
A8			6	0.23	18.29	19.55
B1	1.0	0.8	4	3.24	13.78	14.37
B2			6	0.84	19.68	20.00
B3			8	0.48	19.24	16.12
B4		1.0	4	0.62	20.00	22.64
B5			6	0.22	18.60	22.02
B6		1.2	0	4.42	10.03	8.93
B7			4	0.41	16.96	18.83
B8			6	0.16	18.17	18.65

Unlike in Portland cement concrete, there is little $Ca(OH)_2$ in autoclaved lime-sand concrete, provided that the autoclaving schedule used is strong enough to achieve the complete reaction of $Ca(OH)_2$ with SiO_2 in sand. Therefore, the content of Ca(OH) indicates whether or not the $Ca(OH)_2$ has completely reacted with SiO_2 in sand.

TABLE 7
Phase Analysis and BET Specific Surface Area at Different C/S Ratios

No.	C/S	$Ca(OH)_2$ %	Hydrated Products, %	BET Specific Surface Area, m^2/g
A5	0.50	0.11	14.31	21.80
D8	0.75	0.20	18.59	24.07
B5	1.00	0.22	18.60	22.02
E8	1.25	0.35	21.37	23.10
F8	1.50	0.50	22.22	17.11

could not transform coarse pores into fine pores. When the C/S ratio is 0.5, a 4 hours holding temperature period seems to be enough for the formation of good pore structure under all the autoclaving pressures used in this study. When the C/S is 1.0, this minimum holding temperature period is 6 hours for both 8 MPa and 1.0 MPa autoclaving pressures, and 4 hours for 1.2 MPa autoclaving pressure respectively.

On the other hand, holding temperature periods shorter than the minimum holding temperature period, such as ‘‘peak autoclaving schedule’, causes coarseness of pore structure due to the incomplete reaction between $Ca(OH)_2$ and dissolved SiO_2 in sand and the existence of a larger amount of $Ca(OH)_2$. In these specimens, the content of calcium silicate hydrates is not enough to form the densified microstructure of lime-sand concrete, also some of these hydrates exists in the form of C_2SH (A) with a high C/S ratio (2). This is why autoclaved lime-sand concrete autoclaved with ‘peak autoclaving schedule’ has a low compressive strength and low resistance to carbonation.

$Ca(OH)_2$, Calcium Silicate Hydrate and BET Specific Surface Area. Table 6 shows the content of $Ca(OH)_2$, the content of calcium silicate hydrates and BET surface area at various autoclaving schedules.

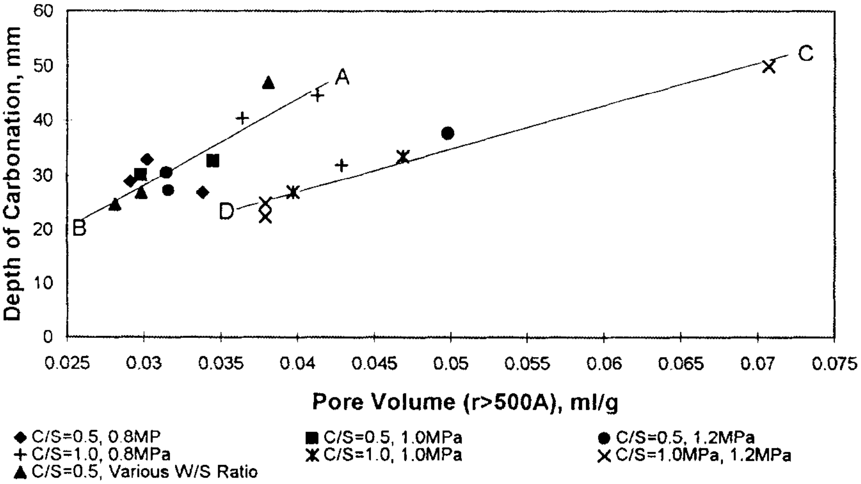

FIG. 5.
Depth of carbonation versus pore volume (r>500Å).

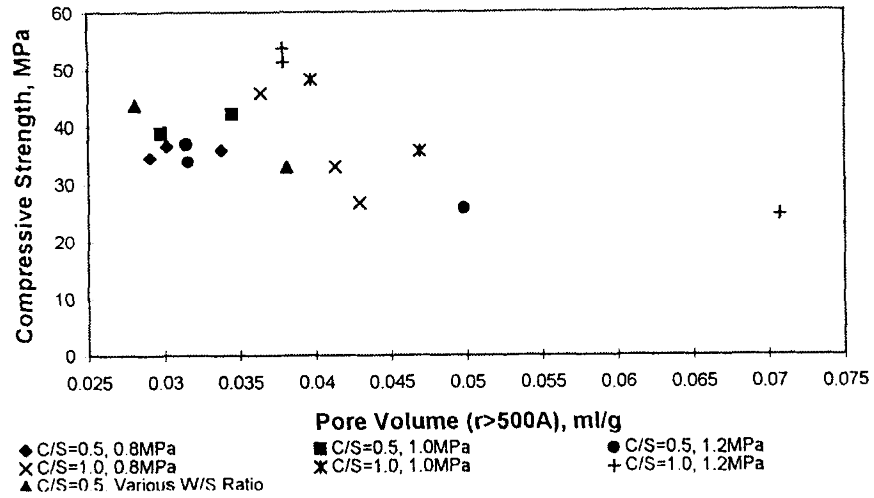

FIG. 6.
Compressive Strength Versus Pore Volume (R>500Å)

Unlike in Portland cement concrete, there is little $Ca(OH)_2$ in autoclaved lime-sand concrete, provided that the autoclaving schedule used is strong enough to achieve the complete reaction of $Ca(OH)_2$ with SiO_2 in sand. Therefore, the content of Ca(OH) indicates whether or not the $Ca(OH)_2$ has completely reacted with SiO_2 in sand.

As seen from Table 6, when the C/S ratio is 0.5, there is only a low content of $Ca(OH)_2$ (0.1 - 0.23%) in all samples, even in the specimen treated with 'peak autoclaving schedule'. The content of calcium silicate hydrates is little affected by autoclaving schedule, except for specimen B8 which shows more calcium silicate hydrates than other specimens. This result shows that at a C/S ratio of 0.5, the content of $Ca(OH)_2$ in the mixture could react with the SiO_2 in sand completely.

When the C/S ratio is 1.0, the content of $Ca(OH)_2$ decreases with the increase in holding temperature period at the same autoclaving pressure or with the increase in autoclaving pressure at the same holding temperature period. The specimens autoclaved with 0.8 MPa-4 hours and 1.2 MPa-0 hours autoclaving schedules exhibit a much higher content of $Ca(OH)_2$, and a much lower content of calcium silicate hydrates, compared with other specimens. On the other hand, there is no substantial difference in the content of $Ca(OH)_2$ and the content of calcium silicate hydrates among other specimens. It should be particularly noted that the specimens treated with 'peak autoclaving schedule' contained the largest content of $Ca(OH)_2$ and the lowest content of calcium silicate hydrates in all specimens with a C/S ratio of 1.0. In this specimen, the content of $Ca(OH)_2$ is 4.42%, in the corresponding mix, the content of $Ca(OH)_2$ is about 16%. Therefore, it can be roughly estimated that one fourth of total $Ca(OH)_2$ did not react. Table 6 also shows that the specimens with a C/S of 1.0 contained more $Ca(OH)_2$ than the specimens with a C/S of 0.5 when the autoclaving schedule is the same. Table 7 confirms that $Ca(OH)_2$ slightly increases with C/S ratio.

Table 7 shows that both the content of calcium silicate hydrates and the content of $Ca(OH)_2$ increase with the increase in C/S ratio at 1.0 MPa-6 hours autoclaving. However, contents of $Ca(OH)_2$ are in the range of 0.11-0.50. This shows that almost all $Ca(OH)_2$ reacted with SiO_2 in all specimens.

The above-mentioned results indicate that the contents of $Ca(OH)_2$ in lime-sand concretes is affected by C/S ratio and autoclaving schedule. For a given C/S ratio, when the autoclaving schedule can ensure the complete reaction of $Ca(OH)_2$ with SiO_2 to form hydrates, there is only a negligible quantity of $Ca(OH)_2$ in lime-sand concrete. By contrast, lime-sand concrete treated with an insufficient autoclaving schedule, such as specimens B1 and B8, contained large contents of $Ca(OH)_2$, and thus had lower strength and poorer durability.

The specific surface area of the autoclaved lime-sand concrete mainly depends on the contents of various types of calcium silicate hydrates. It has been reported (2) that specific surface areas of major calcium silicate hydrates in lime-sand concrete are as follows; CSH(B): 80 - 100 m^2/g; $C_5S_6H_5$ (tobermorite): 60 m^2/g; $C_2SH(A)$:2.6 m^2/g. Therefore, the content of amorphous CSH(B) has the greatest effect on the specific surface areas, and tobermorite has the second greatest effect. When the C/S ratio is 0.5, at both 0.8 MPa and 1.2 MPa autoclaving pressures, the specific surface area increases with the increase in holding temperature period from 4 hours to 6 hours, but then further increasing this period to 8 hours causes a reduction in specific surface area. The same trend is found when increasing holding temperature period from 0 hours to 6 hours at 1.2 MPa autoclaving pressure. At 1.0 MPa, the increasing holding temperature pressure from 4 hours to 6 hours caused a reduction in specific surface area. The change of specific surface area is related to transformation of calcium silicate hydrates. Transforming $C_2SH(A)$ into CSH(B) caused increases in specific surface area. By contrast, transforming CSH(B) to tobermorite resulted in a decrease in specific surface area. When the C/S is 1.0, at 0.8 MPa autoclaving pressure, the specimen cured with a 4 hours holding temperature period has the lower specific surface area due to the lowest content of hydrates and presence of $C_2SH(A)$ hydrates with small specific surface areas. Increasing holding temperature period from 4 to 6 hours causes an increase in specific surface area due to the formation of more hydrates and the transformation of partial $C_2SH(A)$ into CSH(B). Further increasing this period from 6 hours to 8 hours causes an increase in specific surface area due to transformation of CSH(B) into $C_5S_6H_5$. The same trend occurred at 1.2 MPa autoclaving pressure.

Relationships Between Carbonation Depth, Compressive Strength and Pore Structure. It has been suggested (8, 9, 10)that permeability or durability was related to the volume of pores larger than specific radii (in a range of 300 - 790Å for different researchers). Therefore, apart from the volume of pores larger than 500Å radius, the results of carbonation depth and compressive strength (7) are also shown in Table 4 and Table 5 to elucidate the relationships between the properties and the pore structures of autoclaved lime-sand concrete.

Depth of carbonation versus the volume of pores larger than 500Å radius is plotted in Fig. 5. No unique relationship is found between them. However, it should be noted that there are essentially two lines, as shown in Fig. 5. Line AB represents the specimens with a C/S ratio of 0.5, and Line CD represents the specimens with a C/S ratio of 1.0. the results of the depths of carbonation for most specimens are fitted with these two lines except for a few specimens. This result demonstrates that in most cases, the depth of carbonation increases with the volume of pores larger than 500Å radius for the specimens with the same C/S ratio.

Therefore, it can be concluded that the volume of pores larger than 500 Å radius is a critical factor affecting carbonation, but it is not the only factor. Perhaps the density, C/S ratio of calcium silicate hydrates and $Ca(OH)_2$ also affect carbonation. Fig. 5 confirms that the C/S ratios of mix proportion affect carbonation.

Fig. 6 shows the relationships of compressive strength versus the volume of pores larger than 500Å radius. In most cases, linear relationships were found for the specimens with the same C/S ratios and same autoclaving pressures. No unique relationship was found. This result shows that pore size distribution is not only factor that controls strength, but it can be related to porosities. In addition, it may also be related to types of bonding with the bulk materials, or between crystallites (11).

Conclusions

The major conclusions of this investigation are as follows:

1. W/S ratio affects the pore structure of the lime-sand concrete very much. Generally, both the total pore volume and the volume of pores lager than 500Å radius decrease with the decrease in W/S ratio. However, there is a suitable W/S ratio, which depends on the fineness of the constituent materials. In our study, the optimum C/S ratio is 0.17. Lower C/S ratios than 0.17 , such as 0.14, caused less change in the pore structure of lime-sand concrete, but poor workability of fresh concrete.
2. There is a minimum holding temperature period which ensures the formation of a good pore structure in autoclaved lime-sand concrete, which depends on autoclaving pressure and C/S ratio. Generally speaking, this minimum holding temperature period increases with either the increasing C/S ratio or the lowering autoclaving pressure. Longer holding temperature periods than this minimum period cause less further improvement in the pore structure. At a C/S of 0.5 ratio, the minimum holding temperature period is 4 hours under all autoclaving pressures used in this study. Moreover, at a C/S of 0.5 ratio, this minimum period is 6 hours under both 0.8 MPa and 1.0 MPa autoclaving pressures. On the other hand, shorter holding temperature periods than the minimum period cause coarseness of pore structure due to either an incomplete reaction between calcium and silicate or incomplete transformation of $C_2SH(A)$. It is particularly important to note that 'peak autoclaving schedule' (0 hours holding temperature period) caused coarseness of pores under all autoclaving pressures used in this study, especially at C/S ratio of 1.0.
3. The content of $Ca(OH)_2$ mainly depends on both autoclaving schedule and C/S ratio. At a C/S of 0.5, there was only negligible content of $Ca(OH)_2$ and less difference in the content of calcium silicate hydrates for the specimens cured with all the schedules in this study. At a C/S of 1.0 ratio, the content of free $Ca(OH)_2$ decreases with the autoclaving pressure and holding temperature period. However, only the specimens autoclaved with 0.8 MPa-6 hours and 1.2 MPa-0 hours (or 'peak schedule) autoclaving schedules respectively exhibit high contents of $Ca(OH)_2$ and very low contents of calcium silicate hydrates compared with other specimens. Both Ca(OH) and total hydrated products increased with C/S ratio.
4. The volume of pores lager than 500Å radius is an important factor controlling the carbonation and strength of autoclaved lime-sand concrete, but it is not the only factor. Perhaps the other factors, such as density, average C/S ratio of hydrates etc., also have an effect on these properties.

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