Different accelerated curing methods of concrete

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Abstract— Accelerated curing and testing of concrete specimens came into being because of the need for faster evaluation of the quality control of the concrete. This was a result of accelerated construction schedules and increased volumes of concrete required in structures, so that it was not practical to await the standard 28-day strength results. Many studies have been made to investigate the accelerated strength of concrete. The acceleration of strength is usually through application of outside heat, or through insulation that conserves the heat of hydration which acts then in a manner similar to the applied outside heat, to accelerate the rate of hydration and thus the gain in strength.

Index Terms— Curing; Halogen curing; Heat coil curing; Mechanical properties

1 Introduction

Buildings are the largest consumers of energy worldwide and sustainable development has become a serious concern in this sector. The major challenge is to reduce the energy consumption linked to heating and cooling throughout the life of the building system. At the same time, the need to select raw materials with lower embodied energy is growing [1].

The combination of water, hemp hurd aggregates and a lime-based binder produces a building material with an excellent thermal and sound insulation. LHC buffers temperature and humidity, prevents condensation and allows buildings to breathe. Moreover, it is a natural and solvent-free material that provides a comfortable healthy environment and a good air quality [2].

Also [2] stated that, Casting of pervious concrete may be subjected to hot and dry environment condition depending on the region. In Malaysia, the average daily temperature is estimated to be about 27^{O} C being hot and humid throughout the year. This could create problem for fresh and hardened properties of a concrete, because concrete subjected to hot weather conditions often exhibit reduced durability. Putting into consideration the reduced amount of cement and water used in a PC mix as well as the high porosity, fresh PC may lose moisture rapidly due to evaporation resulting in low strength and rapid desiccation among others. For this reason, knowledge on how the POCPC will respond to different weather conditions especially at the early stage is an essential study to look into.

2 Experimental Programme

The experimental program carried out in this study was to investigate the effect of three methods on acceleration of curing of concrete cubes and get relationships between these accelerated curing methods and 28 days compressive strength. These accelerated curing methods are:

1- Infra-Red curing
2- Halogen curing
3- Heat coil curing

2.1 Materials

Ordinary Portland cement (CEM - 42.5 N) was used. The sand used was local siliceous natural sand with a specific gravity of 2.54 and a fineness modulus of 2.60, the coarse aggregate was both natural coarse aggregate dolomite with a nominal maximum size of 20 mm, specific gravity of 2.63 and gravel with a nominal maximum size of 10-12 mm and specific gravity of 2.61. Special glass box was used in accelerated curing process, with dimension of 100 cm length, 60 cm width and 60 cm height. A summary of (CEM - 42.5 N) chemical composition of cement in Table 1.

TABLE 1
Chemical composition of Cement

Oxides Cont.	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	K_2O	SO_3	TiO_2	P_2O_5	L.O.I.
	21	6.1	3	61.5	3.8	0.4	0.3	2.5	1.68	1.27	1.6

The main parameter studied were:-

1- Type of heating method. Infra-red, halogen and heat coil
2- Type of coarse aggregate. Gravel and dolomite
3- Cement content. 250, 350 and 450 kg/m^3
4- Concrete mix proportions.

2.2 Concrete mixes

In this study, 12 concrete mixes were used. No admixture were used in any of these concrete mixes. The mix proporyions for the concrete mixes were selected after several trial mixes to achieve a desired slump around the range of (5-8) cm for the control mixes.

Concrete mixes proporyions used in tests are shown in table 2.

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3 Results & Discussion

The main parameter in this study are summarized in the following:-

1- Cement content in the concrete mix.
2- Type of coarse aggregate.
3- Water-Cement ratio.
4- Curing method.
5- Concrete mix proportions.

TABLE 2
Concrete mix proportions

No. of Mix.	Cement Kg/m^3	C. agg. Type	Slump cm	W/C	C. agg. Kg/m^3	F. agg. Kg/m^3	Mix. ID
1	250	Gravel	7	0.65	1360	680	M1- 250
2	350	Gravel	6	0.5	1360	680	M1- 350
3	400	Gravel	6	0.45	1360	680	M1- 400
4	450	Gravel	5.5	0.42	1360	680	M1- 450
5	250	Gravel	6	0.6	1190	935	M2- 250
6	350	Gravel	5	0.5	1190	935	M2- 350
7	400	Gravel	5	0.45	1190	935	M2- 400
8	450	Gravel	5	0.42	1190	935	M2- 450
9	250	Dolomite	7	0.84	1280	680	M3- 250
10	350	Dolomite	8	0.5	1280	680	M3- 350
11	400	Dolomite	8	0.45	1280	680	M3- 400
12	450	Dolomite	8	0.42	1280	680	M3- 450

3.1 Infra-Red Curing

The specimens were placed in the curing box to accelerate curing immediately after casting and were tested in compression at age of (4, 8, 12, 24, 36, 48 and 72) hours. Table (3-1) shows the mix proportions for one cubic meter of concrete as well as the test results for concrete mixes at differen ages of testing.

TABLE 3-1
Test results for concrete mixes IR

Mix. ID	W/C	C. agg. Kg/m^3	F. agg. Kg/m^3	C. agg. Type	Slump cm	Age Hour	Fcu - calc. Kg/m^2	Fcu - exp. Kg/m^2
M1 - 250	0.65	1360	680	Gravel	7	4	47.37	72
						8	52.75	48
						12	59.05	62
						24	76.67	92
						36	94.02	110
						48	110.4	116
						72	144.94	129
M1 - 350	0.5	1360	680	Gravel	6	4	118.42	90
						8	129.41	110
						12	141.28	154
						24	173.04	199
						36	205.5	224
						48	237.74	252
						72	301.1	274
M1 - 450	0.42	1360	680	Gravel	5.5	4	146.77	91
						8	160.92	140
						12	175.44	200
						24	218.49	260
						36	261.26	290
						48	304.76	320
						72	388.89	350

3.2 Halogen Curing

The specimens were placed in the curing box to accelerate curing immediately after casting and were tested in compression at age of (4, 8, 12, 24, 36, 48 and 72) hours. Table (3-2) shows the mix proportions for one cubic meter of concrete as well as the test results for concrete mixes at differen ages of testing.

TABLE 3-2
Test results for concrete mixes Halogen

Mix. ID	W/C	C. agg. Kg/m^3	F. agg. Kg/m^3	C. agg. Type	Slump cm	Age Hour	Fcu - calc. Kg/m^2	Fcu - exp. Kg/m^2
M1 - 250	0.65	1360	680	Gravel	7	4	45.95	17
						8	52.81	47
						12	59.46	66
						24	78.36	105
						36	97.39	112
						48	116.04	123
						72	155.17	135
M1 - 350	0.5	1360	680	Gravel	6	4	97.22	35
						8	108.42	103
						12	120.37	130
						24	155.04	200
						36	190.91	231
						48	225.47	239
						72	294.19	253
M1 - 450	0.42	1360	680	Gravel	5.5	4	165.12	71
						8	180.39	184
						12	195.54	219
						24	237.3	299
						36	263.16	300
						48	322.22	348
						72	406.89	354

From such comparison we can conclude that the rate of gaining compressive strength in case of using halogen is faster than that in case of using infra-Red.

3.3 Heating coil Curing

The specimens were placed in the curing box to accelerate curing immediately after casting and were tested in compression at age of (4, 8, 12, 24, 36, 48 and 72) hours. Table (3-3) shows the mix proportions for one cubic meter of concrete as well as the test results for concrete mixes at differen ages of testing.

TABLE 3-3
Test results for concrete mixes heating coil

Mix. ID	W/C	C. agg. Kg/m^3	F. agg. Kg/m^3	C. agg. Type	Slump cm	Age Hour	Fcu - calc. Kg/m^2	Fcu - exp. Kg/m^2
M1 - 250	0.65	1360	680	Gravel	7	4	74.63	50
						8	80.65	75
						12	86.36	95
						24	105.93	125
						36	123.85	135
						48	142.86	150
						72	181.32	165
M1 - 350	0.5	1360	680	Gravel	6	4	97.01	65
						8	103.26	95
						12	110.09	120
						24	130.08	160
						36	150	165
						48	169.9	175
						72	208.79	190
M1 - 450	0.42	1360	680	Gravel	5.5	4	129.03	80
						8	141.03	110
						12	150.94	160
						24	184.21	245
						36	216.67	260
						48	250	265
						72	317.65	270

4 Conclusion

We can concluded that the specimens were cured by infra-red method immediately after casting and were tested in compression strength at testing ages of (4, 8, 12, 24, 36, 48 and 72

hours):-

1. The increase of cement content causes increase in the rate of gaining strength.
2. Change in concrte mixes properties such as ratio between coarse aggregate and fine aggregate does not affect in the rate of gain of compressive strength.
3. For all concretemixed used, compressive strength at the age of 7 days could be predicted provided that the compressive strength is determined at any earlier age, namely after 4 to 72 hours after casting.

Also, We can concluded that the specimens were cured by Halogen method immediately after casting and were tested in compression strength at testing ages of (4, 8, 12, 24, 36, 48 and 72 hours):-

4. The increase of cement content causes increase in the rate of gaining strength.
5. Change in concrte mixes properties and cement content is effect in the rate of gain of compressive strength.
6. Changing the type of coarse aggregate, gravel or dolomite do not affect the rate of gaining strength.
7. For all concretemixed used, compressive strength at the age of 7 days could be predicted provided that the compressive strength is determined at any earlier age, namely after 4 to 72 hours after casting.

Also, We can concluded that the specimens were cured by Heat coil curing method immediately after casting and were tested in compression strength at testing ages of (4, 8, 12, 24, 36, 48 and 72 hours):-

8. The increase of cement content causes increase in the rate of gaining strength.
9. The rate of gain compressive strength is decrease when the time elapse.
10. For all concretemixed used, compressive strength at the age of 7 days could be predicted provided that the compressive strength is determined at any earlier age, namely after 4 to 72 hours after casting.

Also, we can concluded that the comparison between the different methods used:-

11. The gain of strength for concrete specimens when Halogen curing was used faster than the gain of strength for concrete specimens when Infra-Red was used because the rate of heating for halogen faster than infra-red

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