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EFFECT OF THERMAL AND MICROWAVE OVEN CURING ON CONCRETE

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Abstract-Curing has a strong influence on the properties of hardened concrete. Proper curing will increase durability, strength, water tightness, abrasion resistance, volume stability and resistance to freezing. In this project is used to attain the compressive strength of concrete in early stage. Normally 99.2% of concrete strength will attain in 28 days. The thermal and microwave oven curing is something different from ordinary curing. These curing condition are maintained mainly in prefabricated and prestressed construction. The temperature of these curing is naturally below 100˚C. Our aim is to attain the same strength of concrete at short duration by thermal and microwave oven curing method. The grade used is method is M40 and M20 grade. The test is done by various temperature and duration. The temperature used in this test is 75˚C, 65˚C, 55˚C and in the duration of 12,14,16,18 hours. The compressive strength attain in the concrete is gradually increased in increasing of temperature and duration. Comparing thermal and microwave oven curing the microwave oven curing attains higher strength at 18 hours.

Index Terms -

I. Introduction

Curing is the process in which the concrete is protected from loss of moisture and kept within a reasonable temperature range. The result of this process is increased strength and decreased permeability. Curing is also a key player in mitigating cracks in the concrete, which severely impacts durability.

Curing is the maintenance of a satisfactory moisture content and temperature in concrete for a period of time immediately following placing and finishing so that desired properties may develop. The need for adequate curing of concrete cannot be overemphasized. Curing has a strong influence on the properties of hardened concrete.

Proper curing will increase durability, strength, water tightness, abrasion resistance, volume stability and resistance to freezing

A. Curing Methods

There are various methods of curing. The adoption of a particular method will depend upon the nature of work and the climaticconditions. It may different withtemperature changes. The following methods of curing of concrete are generally adopted by the following.

- Shading concrete work
- Covering concrete surfaces with hessian or gunny bags
- Sprinkling of water
- Ponding method
- Membrane curing
- Steam curing

A typical steam-curing cycle consists of an initial delay prior to steaming, A period for increasing the temperature, A period for holding the maximum temperature constant, and a period for decreasing the temperature

II. Methods of Curing Used

A. Thermal Curing

Steam curing is advantageous where early strength gain in concrete is important or where additional heat is required to accomplish hydration, as in cold weather. Two methods of steam curing are used: Live steam at atmospheric pressure (for enclosed cast-in-place structures and large precast concrete units) and high-pressure steam inautoclaves (for small manufactured units). Only live steam at atmospheric pressure will be discussed here.

Steam curing at atmospheric pressure is generally done in an enclosure to minimize moisture and heat losses. Tarpaulins are frequently used to form the enclosure. Application of steam to the enclosure should be delayed ntil initial set occurs or delayed at least 3 hours after final placement of concrete to allow for some hardening of the concrete. However, a 3- to 5- hour delay period prior to steaming will achieve maximum early strength. Steam temperature in the enclosure should be kept at about 60°C (140°F) until the desired concrete strength has developed. Strength will not increase significantly if the maximum steam temperature is raised from 60°C to 70°C (140°F to 160°F). Steam-curing temperatures above 70°C (160°F) should be avoided; they are uneconomical and steam temperature in the enclosure. Steam-curing periods are normally much shorter, ranging from a few hours to 3 days; but generally 24-hour cycles are used. Since all the

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desirable properties of concrete are improved by curing, the curing period should be as long as necessary.

B. Microven Curing

Microwave heating, which is based on dissipation of internal energy due to the excitation of molecular dipoles when exposed to an electromagnetic field, offers a significantly higher rate of temperature increase and more uniform heating when compared to the traditional heating methodsHence, a much shorter exposure time (typically less than 60 minutes) is required to achieve high early age compressive strength. Various studies of the effect of microwave curing on the early and later age strength of OPC mortars made withdifferent w/c ratios have confirmed the ability of microwave curing to significantly increase early age strength. The MCure project of the European Commission 7th Framework Programme, which is the basis of this paper, aims to provide a scientific framework for the microwave accelerated curing process of concrete repairs. It will define the primary characteristics of concrete repairs and deteriorated concrete substrates which influence microwave curing and derive relationships between the key parameters of concrete repairs and of microwave energy input. It will develop a prototype mobile microwave curing system for onsite use which is compatible with EC standards.

C. Thermostat

A thermostat simply switches the heating system on and off as necessary. It works by sensing the air temperature, switching on the heating when the air temperature falls below the thermostat setting, and switching it off once this set temperature has been reached. Turning a room thermostat to a higher setting will not make the room heat up any faster. How quickly the room heat up depends on the design of the heating system. For example, the size of boiler and radiator.Neither does the setting affect how quickly the room cools down. Turning a room thermostat to a lower setting will result in the room being controlled at a lower temperature, and saves energy.

D. Thermometer

An instrument for measuring temperature, especially o ne having a graduated glass tube with a bulb containing a li quid,typically mercury or colored alcohol, that expands an d rises in the tube as the temperature increases.

III. Measured Grade

M_{20} GRADE

Quantity for per mould

Cement = 0.438g/m3

Fine aggregate = 0.657kg/m3

Coarse aggregate = 1.314kg/m3

Water = 0.153ml

M_{40} GRADE

Quantity for per mould

Cement = 0.4375g/m3

Fine aggregate = 1.12kg/m3

Coarse aggregate = 1.425kg/m3

Water = 0.14ml

Chemical admixture = 0.007

IV. Mechanism of Curing

The extent of hydration of cement and the resultant microstructure of hydrated cement influences the physical properties of concrete. The microstructure of cement is more or less similar to that of silicate phases. When the cement comes in contact with water, the hydration of cement proceeds both inward and outward in the sense that hydration products get deposited on the outer periphery and the nucleus of the unhydrated cement inside gets gradually diminished in volume. The reaction proceeds slowly for 2-5 hours before accelerating as the surface skin breaks. At any stage of hydration, the cement paste consists of gel, the remnant of unreacted cement, calcium hydroxide Ca $(OH)^2$,and water, besides some other minor compounds. The crystals of various resulting compounds form an interlocking random three-dimensional network gradually filling the space originally occupied by the water, resulting in stiffening and subsequent development of strength. Accordingly, the hardened cement paste has a pores size varying from very small (4×10^{-4}µm) to a much larger value, the pores being called gel pores and capillary pores, respectively. The pore system inside the hardened cement paste may or not be continuous. As the hydration proceeds, the deposit of hydration products on the original cement grain makes the diffusion of water to unhydrated nucleus more difficult thus reducing the rate of hydration with time.

$2(3CaO.SiO_2) + 6H_2O \rightarrow 3CaO.2SiO_2.3H_2O + 3Ca\ (OH)_2$

Symbolically $2C_3S + 6H \rightarrow C_3S_2H_3 + 3Ca\ (OH)_2$

$2(2Cao.SiO_2) + 4H_2O \rightarrow 3CaO.2SiO_2.3H_2O + Ca\ (OH)_2$

$2C_2S + 4H \rightarrow C_3S$

Table I. ORDINARY PORTLAND CEMENT

Constituents	%

Cao	60-67
Silica	17-25
Alumina	3-8
Iron oxide	0.5-6
Magnesia	0.1-4
Sulphur trioxide	1-3
Soda/potash	0.5 -1.3

V. Effect on Properties of Concrete

A. Effect of Microven Curing Conditions on High Strength Concrete Properties

The present paper reviews suitable MWs curing method and processes for rapid thermal curing application of concrete which could be implement in a reasonable way to improve the rate of strength development. It furtherprovides a deeper understanding of concrete technology and proposes suitable points for future study. The first part describes the necessity of curing on the strength development of concrete at early age and then discusses its factors affecting. Also describes about high strength concrete and reactions occurring in the concrete. The second part reports the implementing method for achieving this purpose covering dielectric properties involved and related heating mechanisms.

B. Thermal Stresses in The Microwave Heating of Concrete

The significance of compressive thermal stresses generated during microwave heating on concrete surface delimitation is investigated analytically in this paper. Microwave energy acts as an internal heating source that causes concrete to heat up. The amount of microwave energy dissipated in concrete depends on microwave frequency, microwave power and the electromagnetic properties of the concrete. Electromagnetic properties of concrete change as a function of concrete water content, microwave frequency and temperature. The variation in microwave energy dissipation of concrete can be modeled using Lambert's law which assumes an exponential decay in energy dissipation with distance. The exponent of energy dissipation function depends on the electromagnetic properties of concrete. The decay in microwave energy dissipation gives rise to temperature gradient in the concrete which results in compressive stresses being generated in the heated zone. Another factor that is postulated to affect concrete elimination by microwave heating is the generation of pore pressure within the concrete. However most of the previous studies have overlooked the importance of thermal stresses. In this paper a finite element modeling is used to examine the temperature distribution and thermal stresses generated within the concrete. Results show high compressive stresses being generated especially at high frequencies and in concrete with high water content. The results also reveal that the water content of concrete plays a very important role in the microwave heating process.

VI. Test Conducted

Compression Test

PREPARATION: Check all the things necessary are ready. Check concrete compression machine is in working order.

SAFETY: Wear hand gloves and safety goggles.Taking measurement: Take the measurement of concrete specimens (which are sent to laboratory for testing). Calculate the cross sectional area (unit should be on mm2) and put down on paper.

Do the same for each specimen.

START MACHINE: Turn on the machine. Place one concrete specimen in the centre of loading area.

LOWERING PISTON: Lower the pistonagainst the top of concrete specimen by pushing the lever. Don't apply load just now. Just place the piston on top of concrete specimen so that it's touching that.

APPLYING LOAD: Now the piston is on top of specimen. It is the time to apply load. Pull the lever into holding position. Start the compression test by pressing the zero buttons on the display board.

INCREASING PRESSURE: By turning pressure increasing valve counter-clockwise, adjust the pressure on piston so that it matches concrete compression strength value. Apply the load gradually without shock.

TEST IS COMPLETE: Observe the concrete specimen. When it begins to break stop applying load.

RECORDING: Record the ultimate load on paper displaying on machine's display screen.

Clean the machine: When the piston is back into its position, clean the creaked concrete from the machine.

TURNING OFF MACHINE: Match your record once again with the result on display screen. The result should still be on display screen. And then turn off the machine.

CALCULATE CONCRETE COMPRESSIVE STRENGTH: The result we got from testing machine is the ultimate load to break the concrete specimen. The load unit is generally in lb.

We have to convert it in newton (N). Our purpose is, to know the concrete compressive strength.We know, compressive strength is equal to ultimate load divided by cross sectional area of concrete specimen. We took the concrete specimen's measurement before starting the testing and calculated cross sectional area. Now we got the ultimate load. So wecan now calculate the concrete compressive strength.

Compressive strength = Ultimate load (N) / cross sectional area (mm2).

The unit of compressive strength will be N/mm2.Normally 3 samples of concrete specimens are tested and average result is taken into consideration. If any of the specimen compressive strength result varies by more than 15% of average result, that result is rejected.

VII. Figures and Graph

Figure 1: Thermal Curing

Figure 2: MicrovenCring

VIII. Result of Thermal Curing

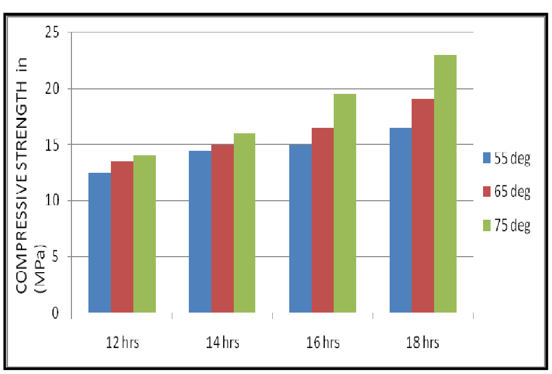

Figure 3: Compressive strength of thermal curing – M_{20}

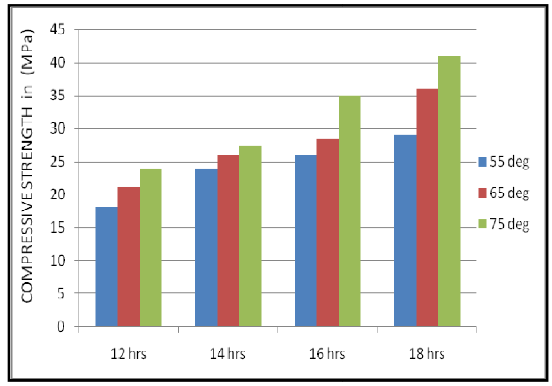

Figure 4: Compressive strength of thermal curing – M_{40}

IX. Result of Microwave Oven Curing

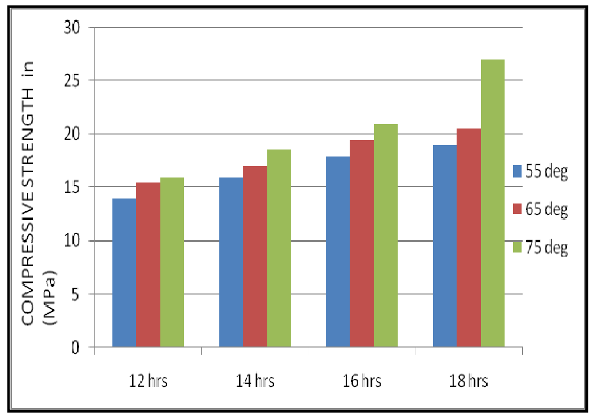

Figure 5: Compressive strength of microwave oven curing – M_{20}

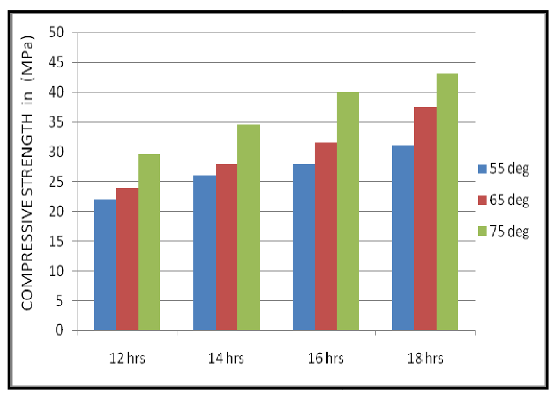

Figure 6: Compressive strength of thermal curing – M_{40}

X. Comparision Between Thermal and Microwave Oven

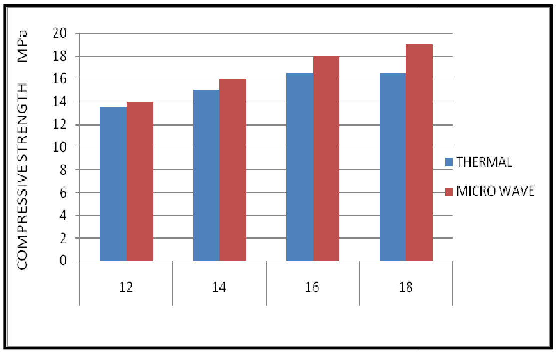

Figure 7: Comparative graph between Thermal and microwave oven M_{20} grade at 55˚C

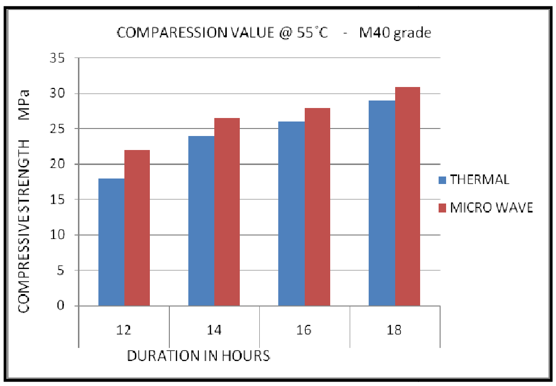

Figure 8: Comparative graph between Thermal and microwave oven M_{40} grade at 55˚C

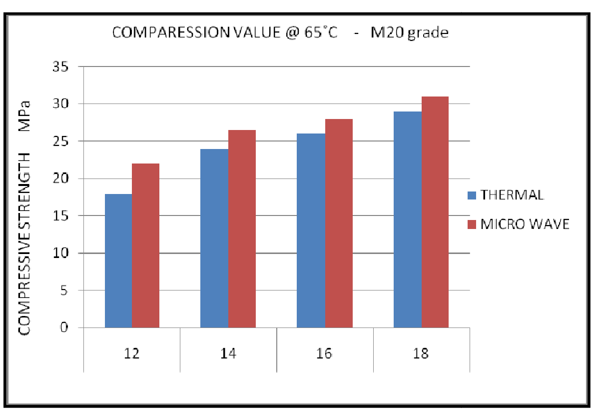

Figure 9: Comparative graph between Thermal and microwave oven M_{20} grade at 65˚C

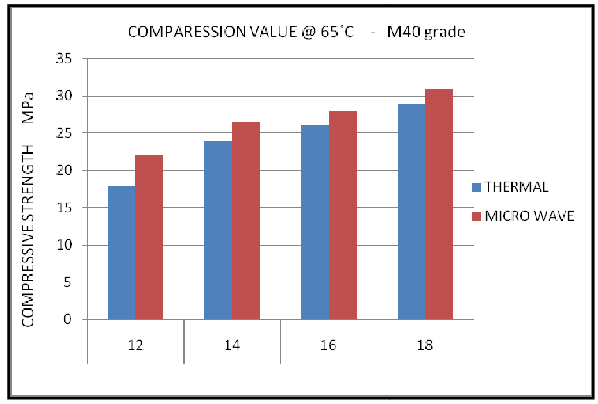

Figure 10: Comparative graph between Thermal and microwave oven M_{40} grade at 65˚C

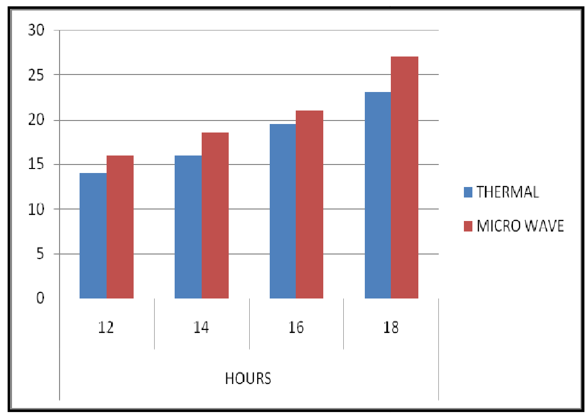

Figure 11: Comparative graph between Thermal and microwave oven M_{20} grade at 75˚C

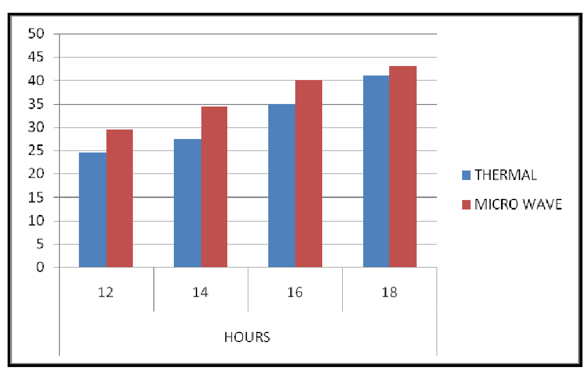

Figure 12: Comparative graph between Thermal and microwave oven M_{40} grade at 75˚C

XI. CONCLUSION

- By increasing the temperature and duration simultaneously the strength of concrete is increased.
- Thermal curing gives the compression strength at the peak value of 23MPa at 75˚C in 18 hours for M_{20} grade concrete.
- Thermal curing gives the compression strengthat the peak value of 41 MPa at 75˚C in 18 hours for M_{40} grade concrete.
- Microwave oven curing gives the compression strengthat the peak value of 20.5 MPa at 65˚C in 18 hours for M_{20}grade concrete.
- Microwave oven curing gives the compression strength at the peak value of 37.5 MPa at 65˚C in 18 hours for M_{40} grade concrete.
- The target mean strength crossed at the compression strength of 27 MPa at 75°C in18 hrs for M_{20}grade concrete in Microwave oven curing.
- While compared to both thermal and microwave oven curing, the strength obtained at earlier stage in microwave oven curing.

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