EXPERIMENTAL INVESTIGATION OF CONCRETE QUALITY CONDITION BY IMPACT WAVEFORM

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1. INTRODUCTION

This research is being carried out to investigate the capability of an impact waveform generated by a concrete non-destructive testing method called mechanical impedance in detecting concrete durability condition with respect to air permeability by keeping the compressive strength relatively constant. Concrete deterioration will be simulated by heat action. Fire action is one of the most serious and rapid concrete deteriorating agent. The Mechanical properties of concrete are affected by high temperature, but due to impressive resistance of concrete at elevated temperature, concrete may experience marginal reduction in compressive strength to a maximum temperature 400°C, which is followed by a sharp decline in compressive strength thereafter. Concrete exposed to a maximum of about 400°C might be said to retain its one of the most desired properties which is the compressive strength but, its durability condition might be affected.

2. METHODOLOGY

The mechanical impedance method estimates the in-situ compressive strength of concrete by hammering the concrete specimen/structure with a special hammer with installed sensor. Concrete is assumed to be as elastic body i.e. a spring system, therefore, on hammering the concrete surface both the Active and Reactive Mechanical impedance values are generated from an Impact Waveform based on the condition of the Concrete. The Active impedance is calculated when the hammer is pushed into the concrete, while the reactive impedance is calculated as the reactive effect of the concrete pushing back the hammer. The Mechanical Impedance calculated by mathematically combining the impact force, F_{max}, velocity of the hammer on both active and reactive phase and also the contact time of the hammer during the two phases. The Active and Reactive Impedance mathematical equation (1) and (2) [1].

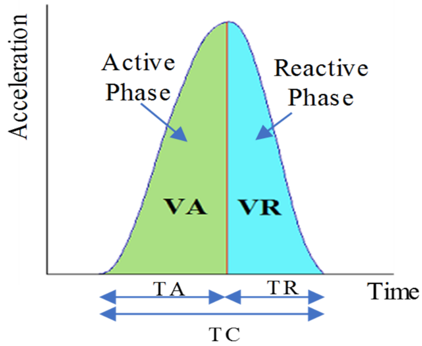

Fig.1 A Typical Waveform generated after impact

Table 1 Concrete Mix Proportion

W/C (%)	s/a (%)	Unit Weight (kg/m³)					
		W	C	G1	G2	SP	AE
50	45	165	33	787	962	2.2	0.004

Table 2 Mechanical Properties

Temperature (°C)	Compressive Strength (N/mm²)	Elastic Modulus (kN/mm³)	Tensile Strength (N/mm²)
20	46.2	23.8	3.3
200	48.3	22.3	3.9
400	47.3	15.7	3.0

$$ZA = \frac{F_{Max}}{V_A} \approx \frac{F_{max}}{\left(\int_{T_1}^{T_2} A(t)dt\right)^{1.2}} \cdots\cdots\cdots (1)$$

$$ZR = \frac{F_{Max}}{V_R} \approx \frac{F_{max}}{\left(\int_{T_2}^{T_3} A(t)dt\right)^{1.2}} \cdots\cdots\cdots (2)$$

Where:

$\mathbf{F_{max}}$: Maximum Impact Force, $\mathbf{V_A}$: The velocity of the hammer as it pushes into the concrete.
$\mathbf{V_R}$: The Velocity of the Hammer as the concrete pushes back the hammer. **T**: Time Interval

1 (one) 200x200x200mm concrete cube and 6(six) standard concrete cylinder were cast according to the mix ratio in **Fig 1,** and placed in an electric furnace and heated up to a with a temperature gradient of 5°C/min until the desired temperature is attained i.e. 200°C and another set for 400°C. This temperature was maintained for 4 hours, in order to achieve even distribution of the heat effect throughout the concrete specimen, afterwards the concrete specimens were allowed to cool in the furnace gradually to 20°C so as not to induce further damage due to rapid Cooling. After 24 hours of cooling the concrete specimens, the concrete residual mechanical properties were carried on the cylindrical specimen by destructive method while non-destructive test were performed on the cubic specimen by test mechanical impedance method. The durability of the cubic specimen was evaluated by carrying out air permeability on one surface the specimen by Torrent Air Permeability Test apparatus.

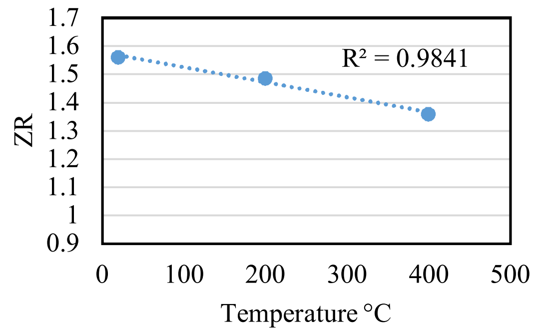

Fig.2 Reactive mechanical Impedance

3 RESULTS AND DISCUSSIONS

The 28th day compressive strength of the concrete as measured by a destructive compressive strength test on the cylindrical specimen was 46.4 N/mm^2. After exposure to 200°C heating action, the value of the compressive strength increased to 48.3 N/mm^2. The elastic modulus values of the cylindrical specimen did not increase in response to the increase in the compressive strength value as temperature increases. The fall in the elastic modulus value as shown in **Table 2** might be due to little changes in the near microstructure of the concrete during exposure to the heating action. This phenomenon might be due to development of micro cracks, which would increase porosity of the concrete. Active and reactive mechanical impedance results show decline with good correlation as temperature increases as shown in **Fig. 2**, It had been reported and established that the reactive impedance (ZR) value as calculated by the impact hammer could be used in estimating to a greater accuracy the elastic modulus and further to estimates the compressive strength of concrete structures, but in this research, the reactive impedance value decreases with temperature increase which shows a good correlation with the elastic modulus of the concrete as presented in **Fig. 3**. Furthermore, it could be suggested that the compressive strength estimation by mechanical impedance might be affected by the near surface condition of the concrete. The Deterioration Index (ZR/ZA), was them compared with the measured Air permeability estimated by torrent method. was shown in **Fig 4.**

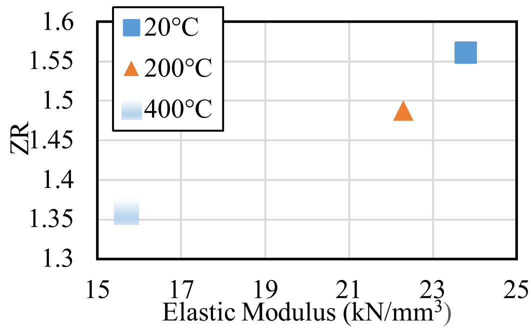

Fig.3 Elastic Modulus.

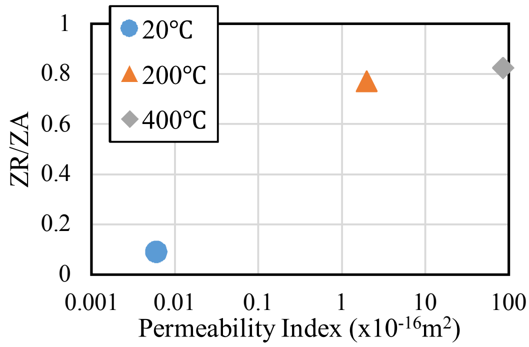

Fig 4 Permeability Index

4 CONCLUSION

Mechanical impedance value which suggest the in-situ compressive strength of concrete it could also relate to the durability condition of tested structure. Therefore, the Mechanical Impedance parameter should be further investigated against different concrete deterioration conditions.

Reference

[1] Non-destructive testing of concrete – Impact testing method. Part 3 Test Method for measuring mechanical Impedance. NDIS3434-3^{2017}