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Innovative Technique to Intensify Strength and Sustainability of Concrete by Shock Wave Application

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***Abstract*:- A simple yet an efficient technique to increase the strength properties of the concrete is focused here. The major outcome of this paper is to enhance the sustainability along with the strength properties of the concrete. The shock waves are allowed to pass through the concrete and those specimens are tested for compressive strength at the age of 7 and 28 days in comparison with the standard control specimen. Thus, as a result of shockwave application, we shall expect the increase in strength properties of the concrete which will be more beneficial to the construction industries as well as the consumers. For the experimental study and investigation, M25 grade concrete is used which is also mostly utilized for various construction applications such as beams, columns, roof slabs etc. of residential and industrial structures. This strategy upgrades the performance of the concrete as a whole and such concrete can be implemented even in large-scale construction such as bridges, dams, roads, pavements and embankments.**

INTRODUCTION

Concrete is immensely used in building construction and has the composition of many materials such as cement, coarse aggregate, fine aggregate and water. Concrete has the hard substances that are chemically inert and are referred to as aggregate. Compressive strength is the numerical based denotation of a structure or a material to withstand loads that might even reduce the size of the structure. Compressive strength of concrete confides on certain factors such as quality of concrete ingredients, cement strength, water-cement ratio and quality control during the preparation or production of the concrete. For an engineer, the strength properties of the concrete are the basic and the most important consideration that has to be done while planning the structures. The concrete is classified into different grades based on the compressive strength after 28 days. This grade has a great impact on structure's lifetime. The Samples of cube or cylinder are usually casted and allowed to cure in the curing tank for 28 days and then the CTM (Compression Testing Machine) is used to test the compressive strength of the concrete in general. The test methods and requirements differ country to country based on the design code. In this experiment, shock waves are applied to the concrete with the shock tube instrument soon after casting in the mould. This process of application of shock waves in concrete has increased its strength properties providing a great opportunity to research further in this field.

SHOCK TUBE

A simple shock tube is of rectangular or circular in cross-section, usually constructed of metal, in which a gas at low pressure and a gas at high pressure are separated using some form of diaphragm. The shock tube is an interesting instrument that is used to stimulate and direct blast waves at a model or sensor in order to imitate actual explosions and their effects, mostly on a smaller scale. A shock wave inside a shock tube may be generated by a small explosion usually blast driven or by the production of high pressures which cause diaphragm to explode and a shock wave to travel down the shock tube (compressed-gas driven). The diaphragm suddenly opens up under predetermined conditions to produce a propagating wave that propagates through the section having low pressure. The shock that eventually forms increases the pressure and temperature of the gas under test and induces a flow in the direction of the shock wave. This instrument also has a wide scope of application in interdisciplinary fields.

The application of vibration with the table vibrator usually compact the concrete and reduces the honey-comb formation. But, applying the shock waves in the concrete increases the bonding, compaction and sustainability as the velocity of the shock waves passed is higher than the velocity of the sound waves in general.

EXPERIMENTAL PROCEDURE

NOMENCLATURE	
A	M25 Grade of concrete
B	f_{ck}-Compressive Strength of Concrete at 28days
C	f_b -Flexural Strength of Concrete

Cube Casting:

1. Measure the dry proportion of ingredients (Cement, M Sand & Coarse Aggregate) as per the design requirements. The Ingredients should be sufficient enough to cast test cubes. Thoroughly mix the dry ingredients to obtain uniform mixture
2. Add design quantity of water to the dry proportion (water-cement ratio) and mix well to obtain uniform texture Fill the concrete to the mould with the help of vibrator for thorough compaction
3. Finish the top of the concrete by trowel & tapped well

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till the cement slurry comes to the top of the cubes.
4. Six cubes were chosen for applying shock waves and 10 shock waves are applied for each cube continuously

Curing:

1. After some time, the mould is kept undisturbed for 24 hours at a temperature of 27 ° Celsius ±2. After 24 hours remove the specimen from the mould.
2. Keep the specimen submerged under fresh water at 27 ° Celsius. The specimen should be kept for 7 or 28 days. Every 7 days the water should be renewed. The specimen should be removed from the water 30 minutes prior to the testing.
3. The specimen should be in dry condition before conducting the testing.
4. The Cube weight should not be less than 8.1 Kilograms.

Testing:

1. Now place the concrete cubes into the testing machine. (centrally)
2. The cubes should be placed correctly to the machine plate (check the circle marks on the machine). Carefully align the specimen to the spherically seated plate.
3. The load will be applied to the specimen axially. Now slowly apply the load at the rate of 140kg/cm2 per minute till the cube collapse. The maximum load at which the specimen breaks is taken as a compressive load.

EXPERIMENTAL RESULTS

Age of concrete	Specification of the cube	Specimen	Load at first crack	Ultimate load	Ultimate stress
days	15cmx15cm x15cm	-	KN	KN	N/mm^2
7	Without Shock waves	I	243	258	11.47
		II	241	266.8	11.86
		III	238	263	11.69
	With shock waves	i)	262	286.4	12.73
		ii)	267	294	13.07
		iii)	254	290	12.89
28	Without Shock waves	I	617	632	28.09
		II	638	660.6	29.36
		III	631	647.3	28.77
	With Shock waves	i)	727	754.2	33.52
		ii)	749	784.7	34.87
		iii)	735	769	34.18

Table 1 Experimental Results for Compressive Strength of Concrete Cubes with and without Shock waves.

In the above table 1, the average compressive strength is found to be as follows,

Average compressive strength at 7 days:
i) without shock waves = 11.67 N/mm^2
ii) with shock waves = 12.90 N/mm^2
Average compressive strength at 28 days:
i) without shock waves = 28.74 N/mm^2
ii) with shock waves = 34.19 N/mm

The increase in compressive strength of the shock wave applied concrete in comparison with the conventional concrete is found to be 10.53 % at 7 days and 18.96 % at 28 days.

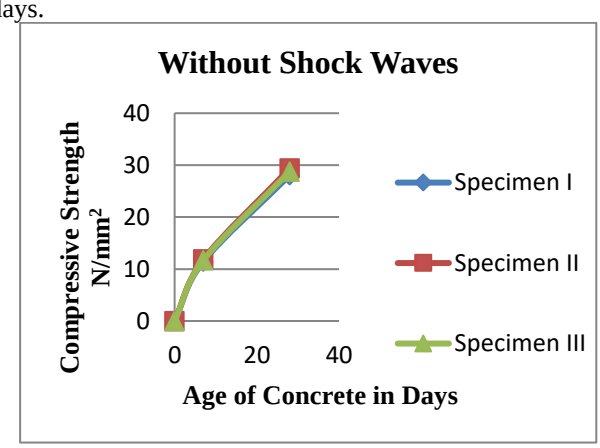

Fig 1 Compressive strength of concrete in 7 and 28 days without shock wave

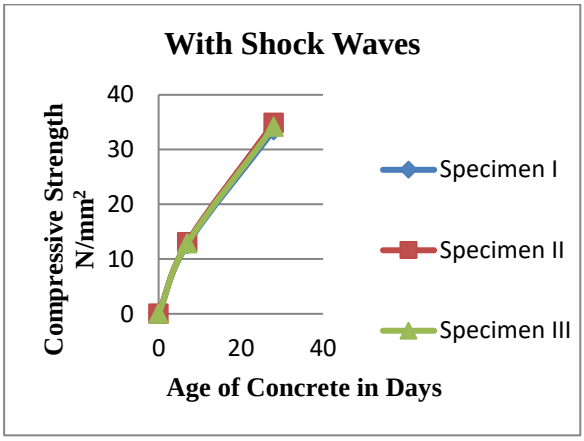

Fig 2 Compressive strength of concrete in 7 and 28 days with shock wave

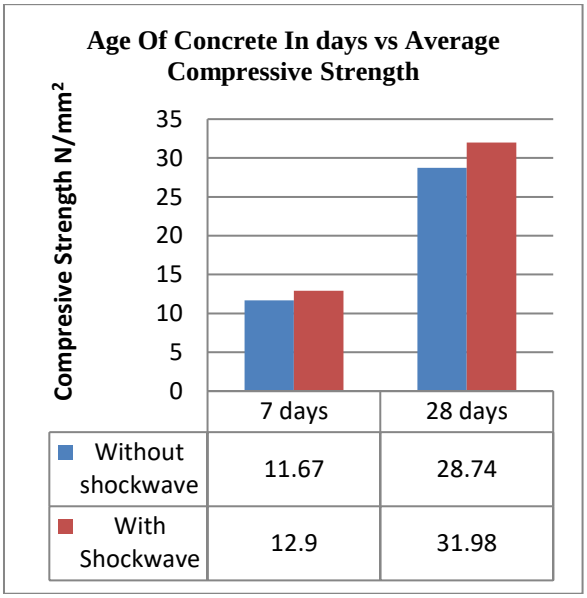

Fig 3 Mean compressive strength of concrete in 7 and 28 days

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Flexural Strength of Concrete:

The flexural strength of concrete also arrived from the compressive strength as per IS 456:2000 are as follows:
Flexural strength of concrete (f_b) = (0.7 x $\sqrt{f_{ck}}$) N/mm^2

Average flexural strength at 7 days:
i) without shock waves = 2.39 N/mm^2
ii) with shock waves = 2.51 N/mm^2

Average flexural strength at 28 days:
i) without shock waves = 3.75 N/mm^2
ii) with shock waves = 4.09 N/mm

Age of concrete (days)	**Specification of the specimen**	**Flexural Strength (N/mm^2)**
7	Without shock wave	2.39
	With shock waves	2.51
28	Without Shock wave	3.75
	With shock waves	4.09

Table 2 Flexural strength of concrete

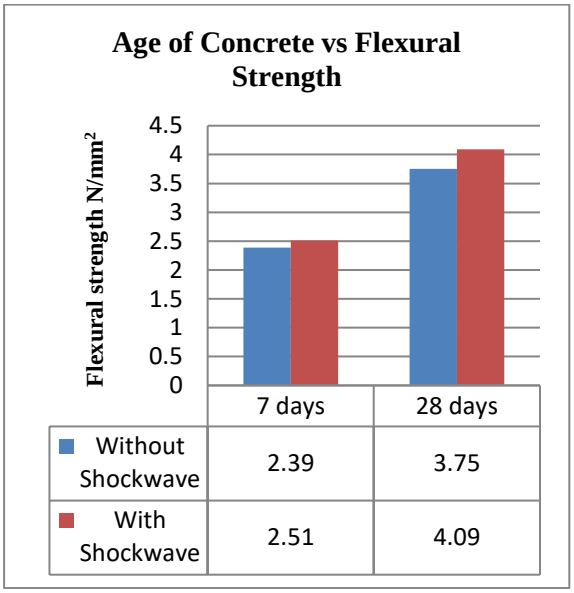

Fig 4 Flexural strength of concrete in 7 and 28 days without and with shock waves

Fig 5 Shock Tube Instrument

Fig 6 Compression Testing Machine

Fig 7 Concrete cube after testing

CONCLUSION

From the experimental investigation of compressive strength of M25 grade concrete by application of shock waves,

1. There is a significant increase in compressive strength of 5.45 MPa (18.96 %) at the age of 28 days and 1.23 MPa (10.53 %) at the age of 7 days.
2. The flexural strength of concrete increases with shock

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waves by 9 % compared to normal concrete at 28 days.
3. The observed vital increase in Compressive strength of concrete by the application of shock waves can be utilized enormously by the construction industries to obtain the better grade (M30) with the existing grade of M25 which will be more beneficial to the common public or society in terms of both economy and sustainability.
4. In future, the same techniques can be extended to the higher grades of concrete for various applications like construction of dams, bridges, road pavements etc.

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REFERENCES

[1] https://en.wikipedia.org/wiki/Shock_wave.
[2] Ajit GeeVarghese John, Study of Blast Wave Impact on Concrete.
[3] Igra, O., Britan, A., Ben-Dor, G., & Shapiro, E. (2004). “Shock wave attenuation by screens and perforated plates.” Symposium on Interdisciplinary Shock Waves Research, Sendai, Japan, 196-209
[4] Shock properties of Conventional and high strength Concrete: Experimental and mesomechanical analysis, International Journal of Impact Engineering, Volume 36, Issue 3, March 2008.
[5] Larcher, Martin & Stempniewski, Lothar. (2005). A model for shock-wave loaded concrete with discrete cracks.
[6] Larcher, Martin & Stempniewski, Lothar. (2006). Simulation of Shock Wave Loaded Concrete with Discrete Cracks. 5-8.
[7] M. Otsuka et al., "A Study on Shock Energy for Concrete Destruction Using Underwater Shock Wave", Materials Science Forum, Vol. 566, pp. 225-230, 2008
[8] Ekström, Jonas & Rempling, Rasmus & Plos, Mario. (2016). Spalling in concrete subjected to shock wave blast. Engineering Structures. 122. 72-82. 10.1016/j.engstruct.2016.05.002.
[9] Ali Jahami,, Yehya Timsah, “Characteristics of Shock waves and its effect on structural elements”.
[10] Bakken, J., Slungaard, T., Engebresten, T., & Christensen, S.O. (2003). “Attenuation of shock waves by granular filters”. Shock Waves, Vol. 13, P. 33-40.