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Evaluation of Concrete in Marine Environment by Non Destructive Techniques

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Abstract:

Structural health monitoring with rebound hammer is being widely used by many consultants. But the rebound hammer alone is not sufficient for old structure to evaluate the service life and structural damage assessment. However, in addition Ultrasonic Pulse Velocity which is more reliable can also be used. The Estimation of concrete strength by combined methods of non destructive testing is presented in the paper. Both the traditional well-known rebound hammer and Ultrasonic Pulse Velocity tests were employed in the study, for three different types of concrete made from 53 grade Ordinary Portland Cement, Portland Pozzolana Cement and Portland Slag Cement both factory blended; for M30 grade of concrete mix with W/C ratio 0.45. From the study it can be concluded that blended cement concrete is performing well when compared to conventional concrete.

Keywords: Blended cement concrete, Marine environment, Artificial sea water, Schmidt Hammer rebound hammer, Ultrasonic pulse velocity.

I. INTRODUCTION

There is a continuous need to investigate the strength of the concrete structures like buildings, dams, bridges, tunnels etc. At present, the investigation of non destructive testing technique is very popular. Rebound hammer and Ultrasonic Pulse Velocity tests were among the non destructive testing techniques and are employed for evaluating the quality of in situ concrete structures [1]. Being concrete is a heterogeneous material and affected by many factors any established standard curve or correlation can not be used to assess the quality or strength of concrete [2]. Development of Special techniques are needed to evaluate concrete properties because in conventional method of evaluating the properties of concrete the specimens are to loaded to failure. This procedure gives good results but the specimens are to be carried to the laboratories [3]. Concrete having higher density will have higher strength if aggregate is of same specific gravity [4].

II. SCHMIDT REBOUND HAMMER

The Rebound Hammer (RH) test [5] is used to assess the compressive strength of concrete as per IS:13311 (Part 2)–1992 specifications. The Schematic representation of Rebound Hammer Test is shown in figure 1. The rebound number reflects only the surface of concrete up to 30 mm depth. The rebound number given by the equipment is related to strength of concrete. At least 10 to 12 readings must be recorded on the prepared concrete surface area. However, the results depend upon factors affecting concrete surface such as surface preparation, temperature and location. The result is also affected by the type of concrete, honeycombing, surface texture, porosity etc.

III. RESEARCH SIGNIFICANCE

In the present investigation Rebound Hammer and Ultrasonic Pulse Velocity tests were conducted to assess the strength and quality of concrete for various age (days) and to ascertain the type of concrete that is less susceptible to deterioration under marine environment, which in turn helps us to know the type of concrete which is best suited for marine environment.

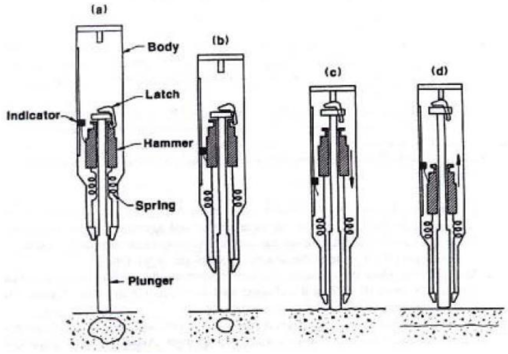

Fig. 1: Schematic representation of Rebound Hammer Test

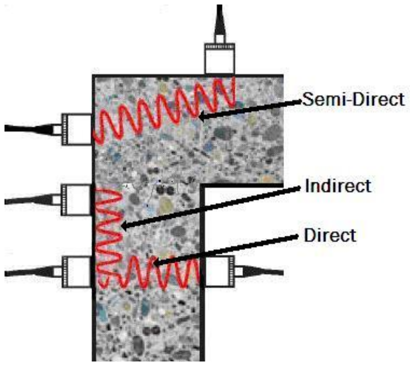

Fig. 2: Schematic representation of Ultrasonic Pulse Velocity test

IV. EXPERIMENTAL PROGRAMME

The experimental programme is divided into the following phases.

- Rebound hammer test on hardened concrete.
- Ultrasonic Pulse Velocity test on hardened concrete.

V. MATERIALS USED

Cement: 53 grade Ordinary Portland Cement confirming to IS:12269 - 1987 [7], factory blended fly ash based Portland Pozzolana Cement confirming to IS:1489 (part 1) [8] and slag based Portland Slag Cement confirming to IS:455-1989 [9] were used throughout the investigation, for all concrete mixes.
PPC: Fly ash addition is 25% as furnished by the manufacturer.
PSC: GGBS addition is 45% as furnished by the manufacture.
Aggregates: Locally available river sand of specific gravity 2.65, fineness modulus and 2.61 confirming to zone II and crushed and quarried granite stones of specific gravity 2.68 and fineness modulus 7.4 and maximum size 20mm were used as fine and coarse aggregate, respectively in all concrete mixes throughout the investigation.
Water: Potable tap water available in laboratory (for mixing, curing and immersion).
Artificial sea water confirming to ASTM D1141-98 (2003) (for immersion) [10].

VI. MIX PROPORTION OF M30 GRADE CONCRETE

The important criteria kept in view while proportioning concrete mixes are strength, durability and workability of concrete. IS [11] method was employed for concrete mix proportioning parameters and mix proportions were arrived and are listed in Table 1.

Parameters	Description
Grade of concrete	M30
Type and shape of aggregate	Granite, angular
Maximum size of aggregate, mm	20
Characteristic compressive strength at 28 days, Mpa	30
Slump	75-100
Exposure condition	Severe
Degree of quality control	Good
Target mean strength, Mpa	38.25
Water-cement ratio	0.45

Table 1.Mix proportion of M30 grade concrete

Type of concrete	Designation	W/C:C:FA:CA
53 grade OPC Concrete	A	0.45:1:1.55:2.67
PPC Concrete	B	0.45:1:1.52:2.62
PSC Concrete	C	0.45:1:1.54:2.64

VII. DETIALS AND DESIGNATION OF THE SPECIMENS

The specimen include concrete cubes of 150mm size. The specimens were designated as A, B and C for the concrete prepared from 53 grade OPC, PPC and PSC respectively. Further they are designated as AN, BN, CN and AS, BS, CS for concrete immersed in potable tap water and artificial sea water respectively.

VIII. TESTS ON HARDENED CONCRETE

Testing of Specimens

Specimens were tested after curing for 28 days in normal water and then immersed in both normal and artificial sea water for 28, 45, 90, 180 and 365 days by both Schmidt rebound hammer and ultrasonic pulse velocity techniques.

Schmidt Rebound Hammer Test

The rebound hammer was placed horizontally throughout the test. The results were tabulated in Table 2 and graphical variations with time (days) are shown in Fig. 3 and 4.

Table 2: Rebound Hammer compressive strength of concrete in MPa

Age, Days	Normal Water			Artificial Sea Water		
	AN	**BN**	**CN**	**AS**	**BS**	**CS**
28	52.18	51.77	52.24	52.11	51.15	52.2
45	53.78	56.75	58.12	53.35	55.12	57.95
90	55.89	59.67	62.11	55.15	59.74	61.26
180	63.06	66.07	68.55	60.75	64.91	66.15
365	67.54	69.95	73.34	62.98	68.16	72.14

Note: Size of the specimen -70.6mm x 70.6mm x 70.6mm

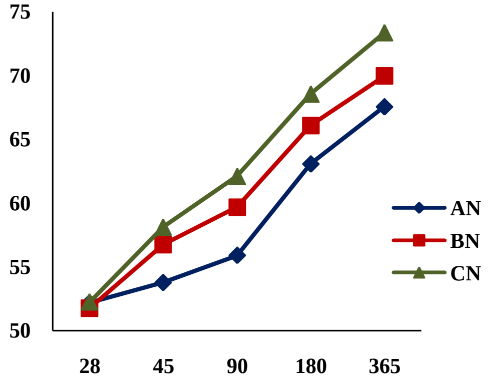

Fig. 3: Rebound Hammer Compressive Strength of concrete cubes immersed in Normal Water

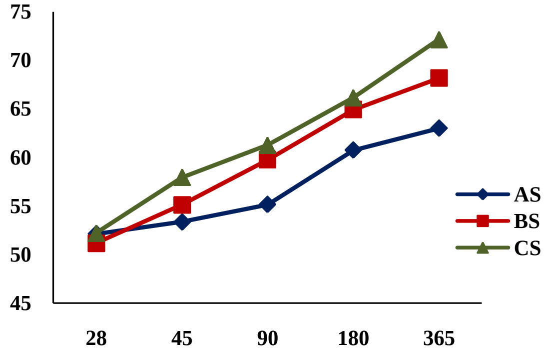

Fig.4: Rebound Hammer Compressive Strength of concrete cubes immersed in artificial Sea Water

Ultrasonic Pulse Velocity

Direct method was used in the test. The results are tabulated in Table 3 and graphical variations with time (days) are shown in Fig. 5 and 6.

Table 3: Ultrasonic Pulse Velocity at Different Ages

Days	Normal water			Artificial sea water		
	AN	BN	CN	AS	BS	CS
28	4508	4555	4585	4353	4408	4457
45	4535	4579	4687	4340	4438	4493
90	4572	4618	4701	4320	4510	4599
180	4707	4882	4900	4323	4595	4643
365	4780	4973	4999	4320	4635	4697

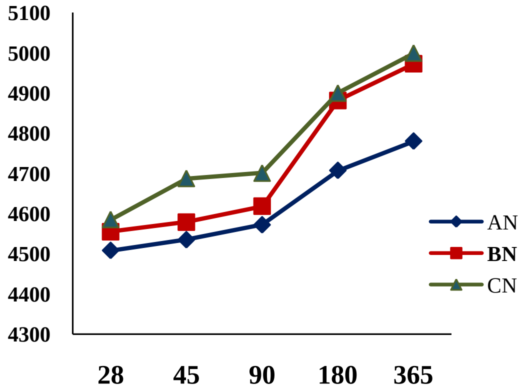

Fig. 5: Pulse Velocity of concrete cubes immersed in Normal water

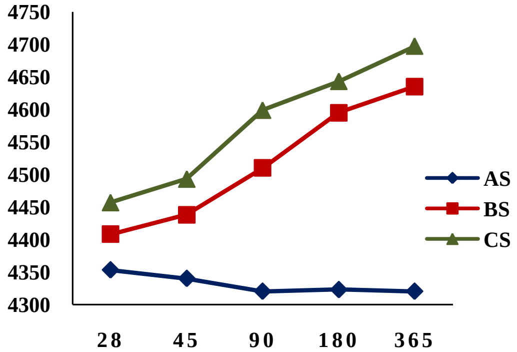

Fig. 6: Pulse Velocity of concrete cubes immersed artificial sea water

IX. RESULTS AND DISCUSSIONS

Rebound Hammer Test

From the test results, it has been observed that, there is an increase in the RH number in case of blended cement concrete compared 53 grade OPC concrete both in normal and artificial sea water which obviously indicates that higher compressive strengths are recorded for blended cement concrete. However, PSC concrete has more rebound number followed by PPC and OPC concrete. This may be due to the fact that PSC concrete is more dense compared to other two types of concrete because of the micro filler effect of Silica Fume.

Ultrasonic Pulse Velocity Test

From the results of UPV, it is evident that UPV is maximum in case of blended cement concrete, compared to conventional concrete. This may be due to the fact that the secondary hydration reaction in case of blended cement concrete improves the performance characteristics at later ages. The pozzolanic materials (SCM's) in blended cement concrete fills the micro pores of the concrete, thus make it dense. However, in PSC concrete denseness of the concrete is much more than that of other two types of concrete because of the presence of silica fume which is more fine and causes the micro filler effect thus makes the concrete dense compared to other two types of concrete.

X. CONCLUSIONS

Based on the above investigation the following conclusions are drawn

Rebound Hammer Test

RH number in more in case of blended cement concrete compared to OPC concrete at all age group both in normal and artificial sea water. PSC concrete has more rebound number followed by PPC and OPC concrete. Which indicate PSC concrete is recorded higher compressive strength.

Ultrasonic Pulse Velocity Test

Pulse velocity is more at early age (28 days) for OPC concrete but decreases with time in artificial sea water and same trend is observed at 45, 90, 180 and 365 days in normal water and artificial sea water. For PSC and PPC concrete pulse velocity shows marginal difference in both normal and artificial sea water, which indicates PSC and PPC concrete are denser than the conventinal.

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