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An Investigation of Physico-Mechanical Properties of Some Chosen Concrete Mixtures by Ultrasonic Pulse Velocity (UPV) Techniques

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Abstract: ***On a human time-scale, small usages of concrete go back for thousands of years. Structures made of concrete can have a long service life. Concrete is the most widely manufactured and durable construction material. Use of concrete produces a wide range of environmental and social consequences. Some are harmful, some welcome, and some both, depending on circumstances but the evaluation of concrete properties is of great interest, whether to detect altered areas or to control the concrete quality and estimate its compressive strength i.e. Physico Mechanical Properties. The standard methods used to assess the quality of concrete in concrete structures on specimens cannot be considered. The disadvantage of destructive technique is that results are not immediately known, the number of specimens or samples is insufficient for an economic reason, still does not reflect the reality of the structure [1]. One of the principal objectives of the development of Non Destructive Testing (NDT) techniques is a reliable assessment of defects of concrete members even when they are accessible only from a single surface. The Ultrasonic pulse velocity (UPV) and Rebound Hammer (RH) tests are often used for assessing the quality of concrete and estimation of its compressive strength. Several parameters influence this property of concrete as the type and size of aggregates, cement content, the implementation of concrete, etc. The main advantage of Ultrasonic Pulse velocity method is to avoid the concrete damage on the performance of building structural components. Additionally, their usage is simple and quick and the test results are available on site and also the cores cannot be drilled. So that, In this present study, we would like to investigate the Physico-Mechanical Properties of the chosen five numbers of Concrete Specimens namely, C1, C2, C3, C4 and C5 i.e. Aggregates replaced by broken bricks, Waste ceramic tiles, Aggregates Partially replaced by waste tyres, Aggregates with Quarry dust and Addition of Sisal fibres and Addition of Poly Ethylene Glycol (PEG) 400 respectively by using the NDT Techniques of Ultrasonic Pulse Velocity (UPV) and Rebound Hammering (RH). We also interested to correlates the Macro level futures of these chosen Concretes to their micro properties and conclude which is the best replacer of partial aggregates to made eco friendly and quality as well as economically suitable concrete mixtures for general purpose building constructions.***

Keywords: Quality of Concrete, UPV Test in Concrete, Ultrasonic Pulse Velocity, Rebound Hammer Test, Concrete with PEG400, Civil NDT, UPV, RHT, etc.,

1. Introduction

Ultrasonics is one of the major branch in Physics and most powerful tool in Non destructive Testing (NDT). Nowadays worldwide all type of Industries like, Automotives, Railways, Aerospace, Petrochemical, Power plants, Fertilizers, Chemicals, Solar, Civil, Mechanical, Electrical & Electronics are widely using Ultrasonics for Flaw Detections, Thickness

Measurement, Velocity Measurement, NDT, Welding, Cleaning, Sieving, Particle Size Reducing and atomization, etc., But its contribution has major important in Non Destructive Testing and Civil Engineering. Concretes takes place a major role in civil engineering and building constructions. We know that, the Concrete is a three-phase composite: hydrated cement paste, aggregate, and the transition zone between the two. Hydrated cement paste (hcp) functions as the matrix that holds the composite together. The aggregate serves as filler which normally occupies 70% of the volume of the concrete. The transition zone is the interface between the hcp and the aggregate, and is one of the critical factors in establishing the composite's strength. Most concrete used in buildings is based on Portland cement. Portland cement is made by combining limestone and clay, which is then fired in a cement kiln until a "clinker" is formed containing the following compounds: calcium oxide (CaO), silica (SiO_2), alumina (Al_2O_3) and ferrous oxide (Fe_2O_3). The clinker is ground finely to a powder. This anhydrous powder is in a high energy state, which will undergo hydration to form the stable, waterproof hydration product. The hcp consists of a highly crystalline calcium hydroxide (CH) and amorphous calcium silicate hydrate (C-S-H). The curing process can take 6-12 months until full strength is achieved. Admixtures such as fly ash, gypsum, and pozzalonic materials influence the amount of cement paste required for a given strength and the reaction time, but they do not change the overall hydration reaction process. The density of the final product (normal concrete) is between 2600 and 3200 kg/m^3 [2, 3]. Several parameters influence this property of concrete as the type and size of aggregates, cement content, the implementation of concrete, etc.,[1]. One of the principal objectives of the development of NDT techniques is a reliable assessment of defects of concrete members even when they are accessible only from a single surface [4]. Ultrasonic pulse velocity (UPV) and Rebound Hammer (RH) tests are often used for assessing the quality of concrete and estimation of its compressive strength.

Increasing population density and building wastages and pollutions are caused as well as accelerated to the civil engineers and researchers to develop an environmentally, eco friendly, economically suitable concrete mixtures. So

that, we interested to partially replace the aggregates by broken bricks, Waste ceramic tiles, waste tyres, Quarry dust and Addition of Sisal fibres and Addition of Poly Ethylene Glycol (PEG) 400 respectively C1, C2, C3, C4 and C5 are made as 150 mm cubes of concretes at various mixing ratio of grades. All these chosen concrete samples are taken for Ultrasonic Pulse velocity studies and Rebound hammering Studies and correlates the results i.e. macro level futures of these chosen Concretes to their micro properties and conclude which is the best replacer of partial aggregates to made eco friendly and quality as well as economically suitable concrete mixtures for general purpose building constructions.

2. Experimental Methodology

In this present study, we investigate the Physico-Chemical Properties for chosen five numbers of Concrete Specimens namely, C1, C2, C3, C4 and C5 shown in Fig.2.1. Test specimens were made of concrete cube of 150mmx150mmx150mm. The details of specimens along with their Mix proportions was made for Mix Design of M30 & M40 Grade of concrete as per IS 10262 [5] and the NDT Methods Ultrasonic Pulse Velocity (UPV) (*Used Pandit lab model, Proceq Make Equipment was shown in Fig2.2*) and Rebound Hammer Test (*Used Schmidt model, Proceq Make Equipment shown in Fig 2.3*) were carried out as per IS 13311(Part1) and (Part2) [6, 7]. The age of Concrete specimens is 28 days.

Figure 2.1: Chosen Specimens C1, C2, C3, C4 andC5

Figure 2.2: UPV Tester

Figure 2.3: Rebound Hammer

3. Results and Discussions

3.1 Rebound Hammer Test

The Prepared Specimens C1, C2, C3, C4 and C5 were taken and the Rebound Hammer Test was carried out at M/s.Hitech Concrete Solutions and the results are given in Table 3.1. The observed results are found satisfactory but the replacement of aggregates by fibre is very low 14 RH Value comparatively other Replacement Items and Aggregates Replaced by PEG400 is obtained Maximum of 30 RH Value. It gives authenticate results of PEG 400 is improve excellent physical Properties of Concrete.

Table 3.1: Observed values of Rebound Hammer Test

S. No	Identification Aggregates Replaced Material	No .of Points	Average Rebound Hammer Value
1	C1: Brick	36	19
2	C2: Tile	36	23
3	C3: Fibre	36	14
4	C4: Tyre	36	16
5	C5: PEG 400	36	30

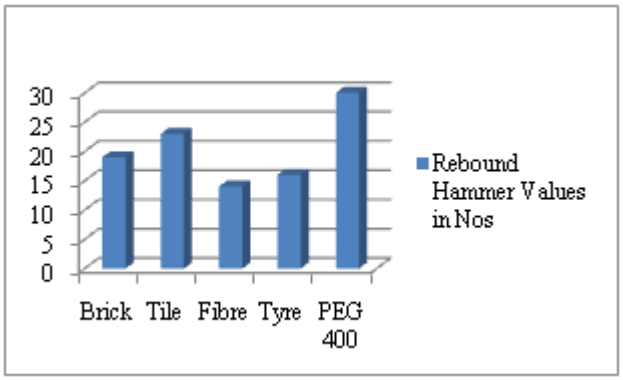

Figure 3.1: Comparisons of Average Rebound Hammer Values

3.2 Ultrasonic Pulse Velocity (UPV)

We are Prepared Specimens C1, C2, C3, C4 and C5 were taken and the Ultrasonic Pulse Velocity Test was carried out at M/s.Hitech Concrete Solutions. The observed results are found satisfactory but the direct and Semi Direct method of UPV supports PEG 400 has excellent for Concrete and bricks are Moderates remaining Tyre, Fibre, Tile are good for concrete. The Obtained results are tabulated in Table 3.2 and the table is given below also sketched graph for the same shown in Fig 3.2.

Table 3.2: Observed values of Ultrasonic Pulse Velocities

S. No	*Identification Replacement Material*	*No .of UPA Points*	*Average UPA (km/s)*	*Concrete quality as for IS 13311-1992 (Part 1)*
1	Brick	4	3.73	Good
2	Tile	4	4.49	Excellent
3	Fibre	4	4.38	Good
4	Tyre	4	3.70	Good
5	PEG 400	2	5.01	Excellent

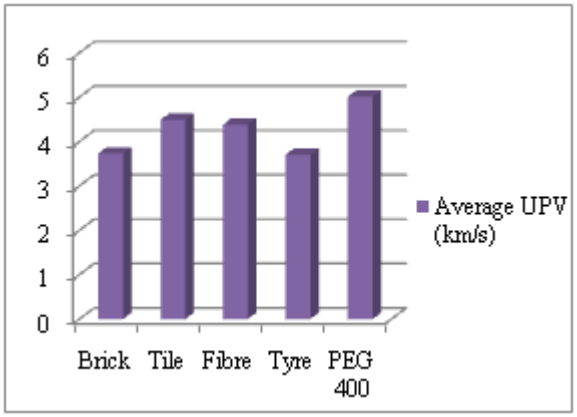

Figure 3.2: Comparisons of Ultrasonic Pulse Velocities

4. Summary and Conclusion

From the results of Rebound Hammer and Rebound Hardness Test, The replacement of aggregates in concrete mix by fibre is very low 14 RH Value comparatively other Replacement Items C1, C2, C3 & C5 and Aggregates Replaced by C5 i.e. PEG400 is obtained Maximum of 30 RH Value.

From the Ultrasonic Pulse Velocity Measurement, The observed results are found satisfactory but the direct and Semi Direct method of UPV supports PEG 400 has excellent for Concrete and Moderated for bricks remaining Tyre, Fiber, Tile are good.
From the Overall Study, We conclude that the Best Replacement of Aggregate is PEG400 in Concretes Eco friendly, environmentally as well as economically from the selected Specimens C1, C2, C3 and C4. Replacement of aggregate by Fiber and Tyre are not gives much effect of physico-mechanical property comparatively other chosen specimens and also we conclude the Ultrasonic Pulse Velocity (UPV) Techniques are the Best Qualitative Techniques for assessment of life of Concretes.

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