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Damage Detection of Recycled Coarse Aggregate Using Ultrasonic Pulse Velocity: a review

[1]Suraj Gupta, [2]Alka Tomar

[1]Student, [2]Assistant Professor

[1]Department of Civil Engineering Parul Institute of Technology Faculty of Engineering and Technology

[1]Parul Institute of Engineering and Technology, Vadodara, Gujarat 391760, India

Abstract: The concept of ultrasonic pulse velocity method are used in concrete to self-sense and cracks through the measurement of quality of concrete. The recycled concrete obtained from recycling the concrete waste by the help of crushing and providing new concrete but there should be changing the compressive strength and internal damage occur inside the concretes. This paper conducted the literature review on ultrasonic pulse velocity method that determine the mechanical properties of recycled aggregate concrete. The further result affect the durability and compressive strength in the recycled concrete. The strength of concrete is determining by destructive and non-destructive method. As compare both method non-destructive method of ultrasonic pulse velocity consumer less time and less cost. This test determine the modulus of elasticity, quantity, defects, crack and honey comb void that present in the specimen. The pulse velocity depend upon concrete properties like length, path length of specimen, temperature and moisture content.This paper also discussed the recycled concrete and ultrasonic pulse velocity method which used to determine the internal damage and quality of concrete. The ultrasonic pulse velocity use in recycled coarse aggregate to determine quality of concrete and also measure the damage in concrete. The ultrasonic pulse velocity done by different method such as direct, indirect and semi direct method. The fundamental concepts Ultrasonic pulse velocity, recycled coarse aggregate and damage detection base on ultrasonic test are review in this paper. Further, it is also highlighted the differences in the current state of knowledge between RCA and Ultrasonic pulse velocity and offer several future research suggestions. This review will be provided more knowledge about recycled coarse aggregate and different method of ultrasonic pulse velocity.

Index Terms **- Recycled coarse aggregate, Compressive strength, Ultrasonic pulse velocity, Non-destructive**

I. INTRODUCTION

The concrete is a material which use in the construction of any types of structure like bridge, channel, dam and multi storey building. The natural resource decrease day by days due to the population increase which can be remove in one days. After the end of II world war the most of the building, road and other concrete structure is demolition. Most old buildings are demolition where waste is obtained from old buildings directly thrown on land. However, that waste generates an environmental problem. The research is conducted regarding replaced the recycled coarse concrete with unused natural aggegate. The waste concrete is recycling by the help of crushing the waste which is obtain from demolition. The RCA use as a large scale in construction site which help to reduced the waste concrete and its preventing more natural aggregate.. This leads to an increase in construction and demolition waste (C&DW), which is a serious environmental problem and has a huge impact on natural resources. Recycling Coarse aggregate plays an important role in recycling concrete waste from landfills. Within a few years, concrete recycling will play a major role in reducing total natural resources. The main reason of RCA use in the concrete structure is to make the green and friendly environment. Some issues are present in environment are solve with construction started by Oikonomou (2005), raw material taken 50%, toatal energy 10% and 50 % total waste. The main factor affecting properties of RCA concrete like density, water observation and porosity. The density of NCA is more than RCA density.The density of RCA is lower 7-9% than NCA. The ultrasonic pulse velocity is a non-destructive test are use in many countries that most important for civil engineering to check the quantity and properties of concrete in the construction sites and laboratory. There are two method mostly use to check the quantity, density, crack and other defect in the concrete. Nowadays non-destructive method mostly use in construction site its give the accuracy result without damage the structure. The non-destructive method doesnot affect the workability & appearance of the concrete so that is used in various construction site. There are many non-destructive method test which use in to check the quantity, strength, honeycombs voids & cracks in the cube specimen such as impact- echo, eddy current, ultrasound and acoustic emission etch out of them ultrasonic give accuracy result as compare to other method. This method are use to measure the properties of concrete, modulus of elastic, poission's ratio and detect the damage of structure such as crack. There are so many non-destructive methods they are visual method, ultrasonic, eddy current, magnetic particle method out of them ultrasonic pulse velocity are gave accuracy result. The electrical pulse passing through the concrete from transducer. The ultrasonic pulse velocity has two component such as transmitting and receiver. The transmitting is used to convert the electrical pulse to mechanical pulse as from of signal or wave. The signal through inside the concrete to detect the damage of concrete and receiver use for to receives the signal from the

concrete that signal or waves convert into electrical pulse by the help of receiver transducer. The travel time of electronic pulses measured when they travel from transmitting and receiver transducer. The ultrasonic waves don't travel through air and vacumn so that the grease is used in both side of concrete its help to travel the pulse through the concrete. The time travel pulse measured by the help of ultrasonic pulse velocity its help to detect the internal damage and properties of concrete. This paper discuss the various technique and various of probing.

Various technique used in non-destructive testing

The various technique is used in non-destructive method are given below:

1. Impact Echo test

2. Visual Inspection

3. Ultrasonic testing

1. Impact Echo Test

The impact echo test is advance non-destructive test method is used to check, defects, crack depth and estimate thickness of walls and slabs. the properties of concrete In this method transducer are used in one face of specimen and another side rebound hammer which provide the waves or signal is passing through the specimen. The reflected waves or signal received by transducers and signal show as a from shown in screen. From the signature we determine the crack. The impact echo test help to determine the crack formation inside the concrete. The rebound hammer produce the vibration as form of wave or signal inside the concrete. The thickness of the concrete is define by the help of sound wave velocity.

2. Visual Inspection

Visual inspection is also non-destructive test method which we to determine the damage at the surface of concrete by the help of observation. Its help to identify the defect in surface like cracks, holes, corrosion, impact damage etc. It is also identify the correct size or shape of component. The insection done by looking, listening, twisting and feeling.

3. Ultrasonic pulse velocity

The ultrasonic pulse velocity is also called nondestructive test method which is used to determine the modulus of elasticity, quantity, defects, crack and honey comb void that present in the specimen. Its consists the two transducer such as receiver and transmitter, transmitter is used to convert the electrical energy to mechanical energy as a from of signal and receiver are used to convert the mechanical energy to electrical energy as a from of signal that signal passing through the screen it give the time travel between the two transducer this device measure the time travel between transducer are shown in Figure .

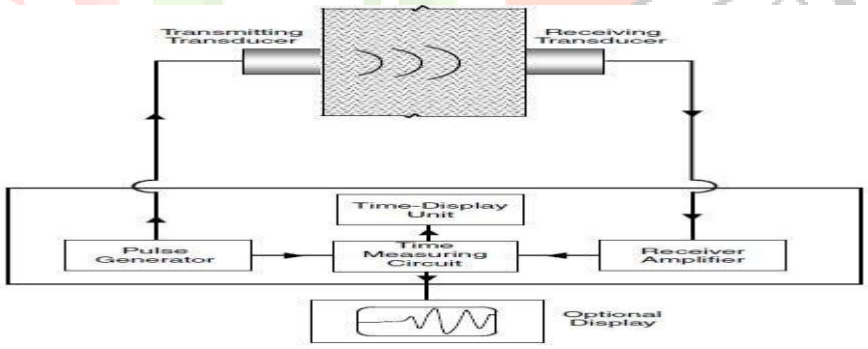

Figure 1: Pluse velocity test Circuit

II. TESTING MACHINE AND METHODOLOGY

- **Testing machine**

The UVP test shown in figure and its component

a. Transmitting transducer

b. Receiver transducer

c. Calibration bar

d. Oscillatory to see the signal and measuring time

Figure 1 Transducer and Oscillatory signal measuring time

- **Methodology**

Three method mostly use for ultrasonic test:
1. Direct Testing:

This method are mostly use in testing of concrete. The transmitter are place one surface of concrete and receiver place opposite of concrete cube. The wave and signal are easily passing through between the transducers.
2. Indirect Testing:

The indirect method are also use for testing the concrete cube or beam. Its also help to determine the depth of crack in the concrete. The transmitter and receiver both are placing planar face. The transmitter remain same place but receiver move eachtime.
3. Semi-Direct Testing:

This test are also use for testing the concrete. The transmitter and receiver are placing perpendicular to each other. The distance between two transducer should be more because its help to transfer the wave or signal at whole structure.

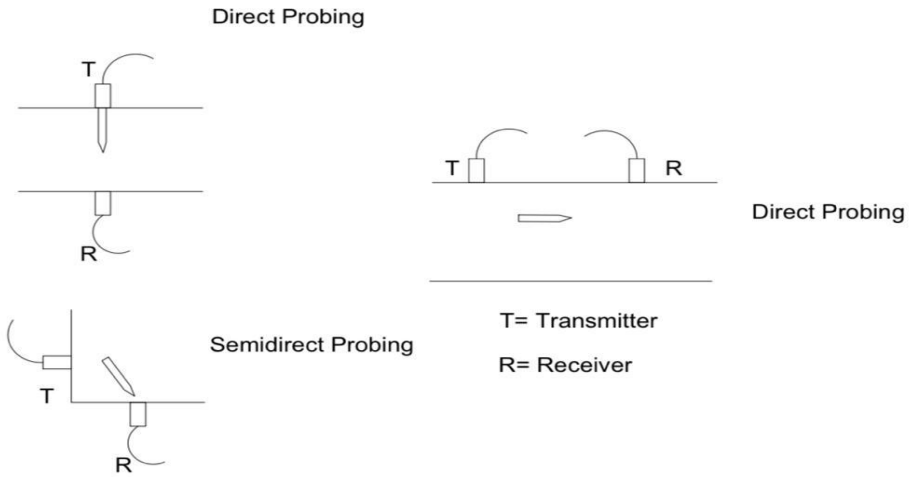

Figure 2. Various positions of the transmitter and receiver probes**.**

Advantage of Ultrasonic Pulse Velocity.

› The ultrasonic pulse velocity is highly sensitive as compare to other method.
› The ultrasonic pulse velocity gave highly accurate values.
› The ultrasonic pulse velocity easy to carry in construction sites.
› It is cheapest method

Disadvantage of Ultrasonic Pulse Velocity

› It is required skill worker to do this test done manually.
› The ultrasonic test need grease at specimen surface because time easy to travel one surface to another surface.
› The ultrasonic need to test should be water resistance.

Application of Ultrasonic Pulse Velocity

› It is used to measure the properties of concrete.
› It's use to development of crack in various concrete specimen and also check the internal flaw such as crack.
› It is also use to determine the strength of concrete.
› The modulus of elastic determines by the help this method.
› It determines the thickness of slab and road which made by concrete.

III. LITERATURE REVIEW

A.Thirumalaiselvi, Saptarshi Sasmal, Tribikram Kundu (2021),The beam sample is monitoring by the help of linear and non-linear method. The load is applied in the beam sample while the ultrasonic pulse velocity decrease when load increase. This method use to measure damage in beam sample. Different level of damage are use in RC structure and investigated using linear and non-linear ultrasonic technique. Result shows that all nonlinear technique considered here, SPC-I technique provide highest sensitivity.

Lee Choon Onn, Mustaqqim Abdul Rahim (2020), the work in this paper they consider the variation concrete grade which compare to strength of concrete and ultrasonic method. The concrete size cube is 100x100x100 mm is subjected to curing the cube for 7, 14, 21 and 28 days to obtained compression test and ultrasonic pulse velocity. The result shows that pulse velocity obtain from concrete cube is inversely proportional by time travel by pulse.

Dr.Raman Nateriya ,Prafulla Kumar Tiwari (2016),The natural aggregate is replacement according to percentage with recycling coarse aggregate. The natural aggregate is replacing with 0%, 50%, and 100% with recycled coarse aggregate. The result shows that the velocity pulse is inversely proportional to time travel pulse. The 50% replacement could not achieve targeted strength.

Jubum Kim, John T.Petro. Jr (2011), the work in this paper focus on detection of delamination in concrete using ultrasonic pulse velocity test. They use both direct and indirect method. Direct method used to determine the dynamic young modulus and poisson's ratio of concrete. Indirect method is use to determine location and size in the slab.

L. Senni, M. Ricci, S. Laureti, M.N.I.B. Mohamed (2017), the work in this paper focuses on rebar detection in concrete using an advanced ultrasonic pulse compression technique. Combinations of piezoelectric composite transducers, pulse compression and post-processing are shown. The results show this rebar image.

Arun Narayana, Amartea Kocherla, Kolluru V.L. Subramaniam (2019), the work in this article is dedicated to concrete damage detection using surface-mounted PZT sensors. PZT is used to monitor damage in concrete structures due to local stresses. He inspects six samples of concrete beams. The composition of the sample used in the experiment was 1: 0.45: 2.9: 1.85 (by weight). Method An image analysis method is used to measure crack width. The interference field of the received voltage wave was analyzed in terms of time and frequency. Results showed that the coherent part of the resulting stress wave was highly sensitive to changes in fracture depth and least sensitive to changes in time.

Amand Aru, Dsvsmrk Chekravarty, K. Murali. (2021), the work in this article focuses on a comparative analysis of concrete and helping to reduce the amount of concrete waste in landfills. The focus of this paper is to determine the change in strength of concrete and to compare the strength (RCA) to that of concrete using natural coarse aggregate (RCA). A cube measuring 150x150x150 mm and having a water-cement coefficient of zero is tested. Cubes of primary coarse aggregate and RCA concrete cubes for compressive strength are tested for 3, 7, 14 and 28 days. The concrete brand used for concrete preparation is M20. As a result, at 3, 7, 14, and 28 days of age, the compressive strength of the recycled concrete aggregate was weaker than that of the natural concrete aggregate. The ratio of water to cement is higher in RCA as compare to NCA.

Mohammad Rezaie-Pajand, Javad Mohebi Najm Abad, Arash Karimipur (2021), the work in this article focuses on model implementation to determine the compressive, tensile and flexural strengths of recycled coarse concrete using competing algorithms. They use the results of 1348 available experiments used to create the formula. The equation is based on the contents of water, cement and RCA, natural coarse aggregate and natural fine aggregate. The relationship between compressive strength, tensile strength and bending develops when using different RCA. The equation give accuracy value of different test of RCA. Results showed that the average absolute errors of the proposed formulated compression, tension and bending estimates were approximately 0.54, 0.36 and 0.48 respectively.

M.Lezy-Nazargah, S.Saeidi-Aminabadi,M.A.Yousefzadeh (2018), the objective of this article is to accurately measure the internal forces of concrete structures and the internal stresses of concrete structures under dynamic loads. The material used with the sensor is actually a new matrix composed of Portland cement, resin, water and the sensor's sensitivity to high stresses. The results show that the proposed fabricated sensor is inexpensive, does not require special techniques and is easy to installation.

IV. CONCLUSION

The natural aggregate is replacement by recycled coarse aggregate that can be reuse in construction site. As a result of literature review 3,7,14 and 28days of compressive strength of concrete in RCA is weaker than that of Natural aggregate at age of testing. The strength of concrete is lower with and without fiber. The percentage 0%, 50% and 100% of replacement increase than compressive strength of concrete decrease. The 50% replaced doesn't achieve target strength. The load applied in beam when load increase than velocity decrease damage level in RC structure investigated using linear and non-linear ultrasonic technique. During hydration process and temperature crack occur inside the concrete. The crack is measured by help of ultrasonic pulse velocity method done by three method direct, indirect and semi direct method out of them two methods are use more direct and semi direct method its help to determine concrete properties, young modulus elasticity, depth of crack of concrete. Direct method used to measure modulus of elastic, dynamic poission ratio. Natural aggregate is more expensive as compare to recycle coarse aggregate.

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