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Chapter 1 : IS Part 1 â€“ Jet Materials

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There are occasions when the various performance ,characteristics of concrete in a structure are required to be assessed. In most of the cases, an estimate of strength of concrete in the structure is needed, although parameters like overall quality, uniformity, etc, also become important in others. The various methods that can be adopted for in-situ assessment of strength properties of concrete depend upon the particular aspect of the strength in question. For example, if the load-carrying capacity of a structural ensemble is to be assessed, carrying out a full-scale load test as per IS However, both these methods are relatively cumbersome and the latter method may leave the structure damaged locally in some cases. Use is, therefore, made of suitable non-destructive tests, which not only provide an estimate of the relative strength and overall quality of concrete in the structure but also help in deciding whether more rigorous tests like load test- ing or core drilling at selected locations are required. In addition, radiographic, radiometric, nuclear, magnetic and electrical methods are also available. Since such non-destructive tests are at best indirect methods of monitoring the particulars, characte-ristic of concrete and the measurements are influenced by materials, mix and environmental factors, proper interpretation of the results calls for certain degree of expertise. It is more so, when the data on the materials and mix proportions used in the construction are not available, as is often the case. In view of the limitations of the methods for predicting the strength of concrete in the structure it is preferable that both ultrasonic pulse velocity and rebound hammer methods given in Part 2 of the standard are used in combination to alleviate the errors arising out of influence of material, mix and environmental parameters on the respective measurements. Relationships between pulse velocity, rebound number and compressive strength of concrete are obtained by multiple regression of the measured values on laboratory test specimens. However, this approach has the limitation that the correlations are valid only for the materials and mix proportions used in trials. The intrinsic difference between the laboratory test specimens and in-situ con- crete, for example, surface texture, moisture condition, presence of reinforcement, etc, also affect the accuracy of results. The correlation is valid only within the range of values of pulse velocity rebound number and compressive strength employed and any extrapolation beyond these is open to question. Because of the above limitations, the combined use of these two methods is made in another way. When the quality of concrete is doubtful, no assessment of concrete strength is made from rebound indices. In addition, influence of test conditions and some general guidance on the interpretation of test results are also given. NOTE - In view of the limitations of each method of non-destructive testing of concrete, it is essen! A complex system of stress waves is developed which includes longitudinal comp- ressional , shear transverse and surface rayleigh waves. The receiving transducer detects the onset of the longitudinal waves, which is the fastest. Because the velocity of the pulses is almost independent of the geometry of the material through which they pass and depends only on its elastic properties, pulse velocity method is a convenient technique for investigating structural concrete. In case of poorer quality, lower velo- cities are obtained. If there is a crack, void or flaw inside the concrete which comes in the way of transmission of the pulses, the pulse strength is attenuated and it passes around the discon-tinuity, thereby making the path length longer. Consequently, lower velocities are obtained. The actual pulse velocity obtained depends primarily upon the materials and mix propor- tions of concrete. Density and modulus of elasticity of aggregate also significantly affect the puise velocity. Piezoelectric and magneto-strictive types of transducers may be used, the latter being more suitable for the lower part of the frequency range. TWO forms of the electronic timing apparatus are possible, one of which uses a cathode ray tube on which the leading edge of the pulse is displayed in relation to the suitable time scale, the other uses an interval timer with a direct reading digital display. If both the forms of timing apparatus are available, the interpretation of results becomes more reliable. For this, it is necessary to check the overall performance by making measurements on two standard reference specimens in which the pulse transit times are known accurately. The two reference specimens usually steel bars should have pulse transit times of about 25 micro-seconds to microseconds respectively; these times. The shorter of the reference specimens should be used to set the zero for the apparatus and the longer one should be used to check the accuracy of transit time measurement of the apparatus. This is to ensure a sharp pulse onset. After traversing a known path length Q in the concrete, the pulse of vibrations is converted into an electrical signal by the second transducer held in contact with the other sur- face of the concrete member and an electronic 2 timing circuit enables the transit time T of the pulse to be measured. The pulse velocity V is given by: However, in many situations two opposite faces of the structural member may not be accessible for measurements. In such cases, the receiving transducer is also placed on the same face of the concrete members surface probing. Surface probing is not so e5cient as cross probing, because the signal produced at the receiving transducer has an amplitude of only 2 to 3 percent of that produced by cross probing and the test results are greatly influenced by the surface layers of concrete which may have different properties from that of concrete inside the structural member. The indirect velocity is invariably lower than the direct velocity on the same concrete element. This difference may vary from 5 to 20 percent depending largely on the quality of the concrete under test. For good quality concrete, a difference of about 0. To ensure that the ultrasonic pulses generated at the transmitting transducer pass into the concrete and are then detected by the receiving transducer, it is essential that there be adequate acoustical coupling between the concrete and the face of each transducer. Typical couplants are petroleum jelly, grease, liquid soap and kaolin glycerol paste. If there is very rough concrete surface, it is required to smoothen and level an area of the surface where the transducer is to be placed. If it is necessary to work on concrete surfaces formed by other means, -for example trowelling, it is desirable to measure pulse velocity over a longer path length than would normally be used. A minimum path length of mm is recommended for the direct trans-mission method involving one unmoulded sur- face and a minimum of mm for the surface probing method along an unmoulded surface. Generally, high frequency trans- ducers are preferable for short path lengths and low frequency transducers for long path lengths. Transducers with a frequency of 50 to 60 kHz are useful for most all-round applications. Each junction point of the grid becomes a point of observation. Transducers are held on corresponding points of observation on opposite faces of a structural element to measure the ultrasonic pulse velocity by direct transmission, i. If one of the faces is not- accessible, ultrasonic pulse velocity is measured on one face of the structu- ral member by surface probing. For most concrete surfaces, the finish is usually sufficiently smooth to ensure good acoustical contact by the use of a coupling medium and by pressing the transducer against the concrete surface. When the concrete surface is rough and uneven, it is necessary to smoothen the surface to make the pulse velocity measurement possible. In general, pulse velocity through concrete increases with increased moisture content of concrete. This influence is more for low strength concrete than high strength concrete. The pulse velocity of saturated concrete may be up to 2 percent higher than that of similar dry concrete. In general, drying of concrete may result in somewhat lower pulse velocity. In field work, this does not pose any difficulty as the pulse velocity measurements are carried out on thick structural concrete members. However, in the laboratory where generally small specimens are used, the path length can affect the pulse velocity readings. IS Part 1: Table 1 gives the guidance on the choice of the transducer natural frequency for different path lengths and mini- mum transverse dimensions of the concrete members. Below freezing temperature, the free water freezes with- in concrete, resulting in an increase. This influence is likely to be the greatest when the pulse path is normal to the predominent direction of the planes of such micro-cracks. This occurs when the pulse path is perpendicular to the direction of a uniaxial compressive stress in a member. This influence is generally insignificant unless the stress is greater than about 60 percent of the ultimate strength of the concrete. This is because, the pulse velocity in steel is 1. The apparent increase in pulse velocity depends upon the proximity of the measurements to the reinforcing bar, the diameter and number of the bars and their orientation with respect to the path of propagation. This in turn, depends upon the materials and mix proportions ti in making 3. For example, if the concrete is not compacted as thoroughly as possible, or if there is segrega- tion of concrete during placing or there are internal cracks or flaws, the pulse velocity will be lower, although the same materials and mix proportions are used. However, when the comparison is made amongst different parts of a structure, which have been built at the same time with supposedly similar materials, construction practices and supervision, the assessment of quality becomes more meaningful and reliable. The reason is that a large number of parameters are involved, which influence the pulse velocity and compressive strength of concrete to different extents. The estimated strength may vary from the actual strength by f 20 percent. The correlation so obtained may not be applicable for concrete of another grade or made with different types of materials. The above relationship may be expressed as: However, it is desirable to have an independent measure of it for the particular type of concrete under test. From these measurements, the factor f ,,, is calculated by the relation: Rangarajan Alternate DR P. Therefore, considerable improvisation has to be done in evolving the testing scheme and use is made of comparative measurements made on adjoining portions of the structure or even other structures in the vicinity of the one in question. In doing so, an approach is taken that if the same. If the nominal grades of concrete or mix proportions are known to be different in either case, suitable allowance is made for the same in interpretation of results. The test results on ultrasonic pulse velocity and rebound indices -are analysed statistically and plotted as histograms and the lower fractiles of results are taken for assessing the. The composition of the technical committee responsible for the formulation of this standard is given in Annex A. For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2: The number of-significant places retained in the rounded off value should be the same as that of the specified value in this standard. Bureau of Indian Standards BIS is a statutory institution established under the Bureau ofIndian Standards Acr, to promote harmonious development of the activities of standardization, marking and quality certification of goods and attending to connected matters in the country. Copyright BIS has the copyright of all its publications. No part of these publications may be reproduced in any form without the prior permission in writing of BIS. This does not preclude the free use, in the course of implementing the standard, of necessary details, such as symbols and sizes, type or grade designations. Review of Indian Standards Amendments are issued to standards as the need arises on the basis of comments. This Indian Standard has been developed from Dot: Title Page Foreword 1. Apparatus Table 1 5. Influence of Test Conditions 7. Interpretation of Results Table 2 Annex A a:

Chapter 2 : Non Destructive and In-situ Tests for RCC structures | Avantech Engineering Consortium Pvt. I

If there is a crack.1 This standard covers the object. pulse velocity method is a convenient technique for investigating structural concrete. the latter being more suitable for the lower part of the frequency range Indian Standard NON-DESTRUCTIVETESTINGOFCONCRETE METHODS-OF TEST PART 1 ULTRASONIC 1 SCOPE The ultrasonic pulse is.

Part and EN Avantech Engineering has considerable experience of conducting the CAPO tests on various infrastructure projects for health monitoring of bridges, buildings etc. Rebound Hammer Test Rebound Hammer test measures the surface hardness of concrete with approximate correlations to estimate the compressive strength of the structure. Although the intrinsic limitations of the test may result in large variations in the estimated strength, ease of conducting the test and low initial cost has made the test quite popular. Rebound Hammer tests are conducted in accordance with IS: Avantech Engineering Consortium has been undertaking health monitoring projects for power plants, real-estate developers, construction agencies etc. Core Tests Core tests involve taking the actual core samples from the structure using the diamond core cutting bits and subjecting the cores to compressive loading in the Compression Testing Machines, followed by the visual inspection. Core tests are conducted in conformance with the guidelines laid out in IS: Avantech Engineering has been undertaking testing of cores as a part of health assessment of existing buildings. Early Age Strength Estimation A reliable knowledge of Early Age Strength Development in Concrete can help in reducing the project duration, and the project cost by early and more efficient mobilization of construction resources like shuttering etc. Maturity Method Maturity Methods are based on the principal that the rate of hydration of cement is indicative of the early age strength development in concrete. Actual temperature history of the concrete is recorded by embedded probes, which is converted to estimate the current in-situ strength using the well established Maturity Functions. Thus computed velocity is an indicative of the quality of concrete and if the member is suffering from any structural flaw like honey-combing, voids etc. UPV tests are conducted according to IS: We have a wealth of experience of conducting the UPV test as a part of health assessment projects for power plants, fertilizer complexes and infrastructure projects to meet the project requirements. Impulse Response Test Impulse Response Test uses a low-strain impact to cause the structural member to vibrate in a bending mode and compute the amplitude of the response through the probe placed on the surface. The test system allows quick screening of structure for flaws like honeycombing, delaminations, voids etc. Avantech Engineering Consortium has carried out Impulse Response Test for screening of structural flaws in slabs in ware houses, deck slabs in buildings and bridges, airport aprons etc. Impact Echo Impulse Echo tests involve introduction of a stress pulse by a mechanical impact and studying the frequency response of the reflected waves. The dominant frequency in the frequency response is used to compute either the depth of the member or the possible depth of the flaw. Avantech Engineering Consortium has carried out Impact Echo tests to assess thickness of tunnel walls, crack depths and voids in tendons ducts in bridge girders. GPR allows the user to detect the structure for flaws like delaminations, voids, deterioration in the structure etc. Avantech Engineering offers world class GPR services for a wide range of applications with state of the art equipment and professionally trained engineers. Crack Depth Measurement The Crack Depth is calculated by using the principle of acoustic diffraction of ultrasound waves. The method uses a specially designed test instrument where the transducers are positioned on the surface in a line across the crack. The average depth of crack is calculated by measuring the transit time at different distances of transducers from the crack, viz at mm, mm and 20mm. Reinforcement Location and Corrosion Assessment Reinforcement Location by Ground Penetrating Radar GPR Ultra high frequency radars are an ideal system for locating and inspecting the reinforcement without damaging the existing structure. The system is a quick test method to examine the spacing, initiation of spalling and cover for the desired structural member. The test is the best solution to gather information for the multi-layer reinforcements. Cover Assessment Concrete cover provides the protection to the Reinforcement bars against corrosion. It thus becomes essential that there should always be a cover of suitable depth existing between the surface and first layer of reinforcement. Cover meter detects the cover depth using the pulse induction technique. Cover meter can also be used to estimate the depth, size and spacing between the reinforcement bars. Avantech Engineering Consortium has carried out tests to estimate the cover depth for various RCC structures as a part of health assessment for power and infrastructure projects. Half Cell Half Cell Potential Tests is used to estimate the likelihood of corrosion in the reinforcement bars. The test is used extensively for condition surveys of suspect RCC structures to identify areas with corrosion activity for further analysis to establish the cause of corrosion and estimate residual service life. Resistivity Tests Resistivity Tests are carried out to determine the resistance of structural concrete to the active corrosion. When the resistivity of the concrete is high, it is assumed that the probability of active and rapidly advancing corrosion is low and vice versa. Resistivity Test is a rapid test to ascertain the quality of concrete against rebar corrosion. Corrosion Rate Assessment Monitoring the corrosion activity and determining the rate of corrosion in the RCC structures is essential for the condition monitoring and estimating the service life of the structural member. Corrosion Rate is measured using GalvaPulse. GalvaPulse evaluates the corrosion rate of reinforcement by measuring Galvanic resistance using the Galvanostatic pulse technique. Carbonation Test The natural alkalinity in concrete provides a protective layer against corrosion. Carbon dioxide in air reacts with the Calcium salts, resulting in reduced pH, making the structure susceptible to corrosion. This reaction is termed as Carbonation. The depth of carbonation is determined using Phenolphthalein as an indicator. The test is a quick method to evaluate the cause of corrosion during corrosion surveys. A pull-out force is applied to the anchor using a specially designed adaptor and a counter pressure assembly. Design Load is applied to the anchor using a hydraulic pull machine and the pull-out strength of the anchor is determined. Analysis of the structure for these chemicals can provide a key information regarding the extent of corrosion and estimation of the structural life of the member.

Chapter 3 : Ultrasonic Pulse Velocity Method

fs~l(Part 1): Electronic Timing Device It shall be capable of measuring the time inter- val elapsing between the onset of a pulse gene-.

Chapter 4 : Is Code Part 1 (Ndt) - [PDF Document]

IS (Part 1): The shape and size of the concrete member do not influence the pulse velocity unless the least lateral dimension is less than a certain minimum value, for example the minimum lateral dimen- sion of about 80 mm for 50 kHz natural frequency of the transducer.