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Evaluation strength of Structure by UPV

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ABSTRCT: Ultrasonic pulse velocity is design to test to structure without causing any harm to structure. An ultrasonic pulse velocity (UPV) test is use to determine the quality of concrete structures with the help of velocity and time measurements. Hence this test was selected for project of Thermal power project (BSL)**.** Assessment was done at site and structure like column, slab, beams etc. were assessed and all procedure and precautions were followed as given in IS 516 (part5/sec1) 2018. It is well known that there are several factors which can influence the reading of ultrasonic velocity in concrete. Number of point was taken on such structure most relevant results can be observed. It was founded that various results which is reported, as per acceptance criteria based on IS.

I. INTRODUCTION

The ultrasonic pulse is generated by an electro acoustical transducer. When the pulse is induced into the concrete from a transducer, it undergoes multiple reflections at the boundaries the different material phases within the concrete. A complex system of stress waves is developed which includes longitudinal (compression), 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 dependent of the geometry of the material through which they pass and depends only on elastic properties, pulse velocity method is a convenient technique for investigating structural concrete.

The underlying principle of assessing the quality of concrete is that comparatively higher velocities are obtained when the quality of concrete in terms of density, homogeneity and uniformity is good. In case of poorer quality, lower velocities 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 discontinuity, thereby making the path length longer. Consequently, lower velocities are obtained. The actual pulse velocity obtained depends primarily upon the materials and mix proportions of concrete. Density and modulus of elasticity of aggregate also significantly affect the pulse velocity.

Objective

1. To understand the concept of UPV.
2. Assessment strength of structure by UPV.
3. Conducting case study on Thermal Power Project
4. Discussion and Suggestions for UPV testing.

II. CONCEPT OF ULTRSONIC PULSE VELOCITY

a) Equipments for Pulse velocity test

1. Electrical Pulse Generator

2.Transducers-One Pair-Piezoelectric and magneto-strictive types of transducers may 1 used, the latter being more suitable for the lower part of the frequency range

3. standard Calibration Bar-Two standard calibration bars, as per details shall be provided by the manufacturer of the apparatus for calibrating the apparatus

4 Amplifier

5 Electric Timing Device

b) Transducer arrangement

The receiving transducer detects the arrival of that component of the pulse, which arrives earliest. This is generally the leading edge of the longitudinal vibration. Although the direction in which the maximum energy is propagated is at right angles to the face of the transmitting transducer, it is possible to detect pulses, which have travelled through the concrete in some other direction. It is possible, therefore, to make measurements of pulse velocity by placing the two transducers on either:

i. opposite faces (direct transmission)
ii. adjacent faces (semi-direct transmission): or
iii. the same face (indirect or surface transmission).

These three arrangements are

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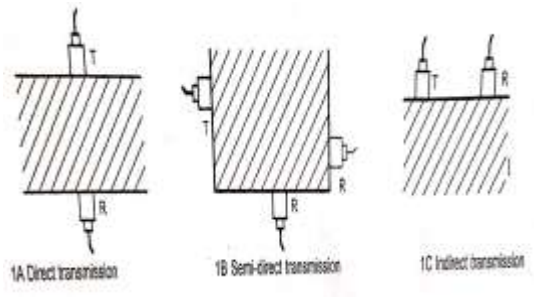

2.1 Surface Preparation

At the point of observation, the concrete shall be suitably prepared and any plaster or other coating shall be removed to expose the concrete surface. For this purpose, the use of carborundum stones or grinders may be adopted. However, care shall be taken to avoid any damage to concrete surface or concrete structure.

2.2 Ultrasonic Measurements

Place the two transducers on opposite faces (direct) transmission), or on adjacent faces (semi-direct transmission), or on the same face (indirect or surface transmission) Although the direction in which the maximum energy is propagated is at right angles to the face of the transmitting transducer, it is possible to detect pulses that have travelled through the concrete in some other direction Direct transmission method of ultrasonic pulse velocity measurements is the most efficient method and shall be adopted, if possible. However, sometimes, it may be necessary to greater than one quarter of its natural period. This is to place the transducers on opposite faces but not directly opposite each other Such arrangements shall be regarded as a semi-direct transmission

The third method for measurement of ultrasonic pulse velocity is the indirect transmission method.The indirect transmission arrangement is the least sensitive and shall be used when only one face of the concrete is accessible, or when the quality of the surface concrete relative to the overall quality is of interest.

Factors influencing pulse velocity measurements

There are various factors which influence pulse velocity measurements, such as,

a) surface condition and moisture content of concrete.
b) path length, shape and size of concrete member
c) Temperature of concrete
d) Stress to which the surface is subjected
e) Reinforcing bars.
f) Contact between the transducer and concrete
g) Cracks and voids.

In order to provide an accurate measurement of pulse velocity, it is necessary to take into account the various factors that influence the measurements

III. CASE STUDY

I did my first structural audit (SA) in year 2022 during starting of Masters Education; this was a Thermal power project (BSL). It was a great pleasure and learning for me to perform this audit; I had consulted several senior professors for this task. The faith and encouragement shown by staff of Thermal power project.I could understand that apart from the 'technical aspects' of civil/ structural engineering and construction there are two more strong aspects to SA – namely 'social/ emotional' and 'financial'. In recent years as many municipal corporations and government bodies have set up certain rules and regulations for SA there is fourth dimension added to the subject is statutory or legal. Thus (i) technical (ii) social, (iii) commercial and (iv) statutory (legal) aspects, are the four prominently known aspects till date, with more emphasis on 'technical' aspects. But let us remember that as the time progresses ahead the complexity of structural auditing will keep increasing and may lead to many more domains, dimensions added in future.

3.1 Steps to be followed for any Structural Audit:-

Whenever any client approaches a structural consultant for performing structural audit of his concrete structure then the consultant should collect the following information in advance.

3.2 Data Collection & Interaction with the Owners**:-**1. Complete address of structure, year of construction, documents like OC, CC, NOC, RERA etc. in place.

2. Ownership status – Govt./ Pvt./ disputed/ shared ownership etc. and the managing committee.

3 General background of the structure; previous records of audits and repairs.

4. Purpose of the audit – routine / for repairs / or for redevelopment.

5. Accessibility to the structure and various parts of it material used.

6. Emergency / Urgency of the audits.

7. Desired scope / extent of SA requested by the owner.

3.3 Competitive offer:-

1. Usually, the financial offer is extra report with recommendations, additional UPV services if necessary. As on date, more or less the rates are standardized in various metro cities.

2. Additional charges are applied if additional non-destructive testing is required.

3.4 Mandatory Tools:-

a. Writing pad

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b. High resolution Camera. Good quality Torch. 5m Measuring tape. Magnetic needle to decide North direction. (Modern smart mobile phones has all these facilities, together in various apps).
c. wires.
d. grease.
e. Personal Protective equipment
3.5 Tools As Per Need:-
a. UPV setup – Connecting wires to machine, concrete shall be suitably prepared and any plaster or other coating shall be removed to expose the concrete surface.
b. In big works. –A PPE kit consisting of goggles, glows, helmet, safety shoes, reflective jacket, safety belts and earplugs (if required) etc. is required.
c. In advance stage SA, a rebar locator machine, core cutter etc. may be required.

3.6 Report Writing and validity of Structural Audit Report: Writing a SA report is anart. The report should be concise yet elaborate! The report could be divided in three – (i) Data (ii) Observations (iii) Recommendations. First parts should start with the problem statement, purpose of the audit, brief background and the data available etc. In second part all the observations, , UPV readings, relevant photos etc. be presented. In part iii) of the SA report recommendations be presented. In recommendations if any specific brand of chemical or of selection with the owner/s as well as none favours any specific product/s or treatments, although the right of selection of any product solely depends on the owner/s. However in caseowner choses all together a different product/ treatment leading to paradigm shift/ departure from the recommendations of SA report then the validity of SA will get ceased off – partly or fully

3.7 Recommendations**:** Once the test on specimen is done, auditor comes to certain conclusion about the strength of concrete structure, correlation between damage pattern and accordingly can decide on the recommendations for no repire.Remember that the recommendations shall be purely based on the data and records and never on the owners insistence to write specific things in the report.

3.8 Concluding remarks
It is said that ‘Practice makes man perfect’, similarly by budding structural engineers they can associate with some seasoned consultant for first five to six years and do a regular practice of audits; then practice independently. In above paper author has given clear idea about various ‘dos’ and ‘don’ts’ along with a few case studies. If followed rigorously and further nurtured, then readers can gain expertise in the filled of Structural Audits. But after acquiring expertise do not forget to share the

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same to next generation and other fraternity members through papers / hands-on workshops internship programs etc.
The modern media, equipment and digital devices etc. are making the subject of SA more interesting yet intricate; it is a vast and live subject, so difficult to cover everything in merely eight to ten pages! Hope you liked whatever could be covered above. If you have any further queries / comments / suggestions / complements about this paper or the subject in general, then do share with us on the email ID provided at the end or with the editors.

3.9 General Information: A site namely, Thermal power project (BSL), has been selected for performing this case study Overall physical observation of the structures was done visually ,Now on various coulmns structures , ultrasonic pulse velocity test were performed. Ultimately, the readings for the structures were noted down separately. Readings to show the variation in the determined quality and strength of the structures.

Structural Audit of Thermal Power project, (BSL)

Location	:-	Thermal Power project, (BSL)
Type of Structure	:-	RCC.
Scope for Audit	:-	Racker Column of NDCT (Top, Centre, Bottom)

3.10 Principle of test:

A pulse of longitudinal vibrations is produced by an electro-acoustical transducer, which is held in contact with one surface of the concrete under test. When the pulse generated is transmitted into the concrete from the transducer using a liquid coupling material such as grease or cellulose paste, it undergoes multiple reflections at the boundaries of the different material phases within the concrete. A complex system of stress waves develops, which include both longitudinal and shear waves, and propagates through the concrete. The first waves to reach the receiving transducer are the longitudinal waves, which are converted into an electrical signal by a second transducer. Electronic timing circuits enable the transit time T of the pulse to be measured.

3.11 Test Procedure:

1. Before starting actual audit, the auditor may give a pep-talk to owners. The purpose and the brief procedure and the expected outcome may be briefed to the members to prepare their mind set.
2. Connecting the electrical wires to the UPV machine. Usually, audit can be started on rod firstly. The machine is connect to the device for the reading purpose. Then the concrete structure .
3. The concrete shall be suitably prepared and any plaster or other coating shall be removed to expose the concrete surface. For this purpose, the use of carbor undum stones or grinders may be adopted. However, care shall be taken to avoid any damage to concrete surface or concrete structure. For the purpose of testing the specimen shall be tested using ultrasonic measurement which can be done by following. Place the two transducers on opposite faces (direct) transmission), or on adjacent faces (semi-direct transmission), or on the same face (indirect or surface transmission) Although the direction in which the maximum energy is propagated is at right angles to the face of the transmitting transducer, it is possible to detect pulses that have travelled through the concrete in some other direction Direct transmission method of ultrasonic pulse velocity measurements is the most efficient method and shall be adopted, if possible. However, sometimes, it may be necessary to greater than one quarter of its natural period. This is to place the transducers on opposite faces but not directly opposite each other Such arrangements shall be regarded as a semi-direct transmission.
4. After the two opposite faced interact with ech other ultrasonic pulse velocity machine started to give reading on the electrical device which is connected the device. It give velocity.

Fig. a) Project plant

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Fig. b) Racker Column by NDCT

Fig. c) Column (Bottom position)

Readings:

Structural Audit of Bhusawal Thermal Power plant, Deepnagar (1 x 660 MW)

Sr No.	Location	Identification	UPV Velocity (Km/Sec)	Time (µs)
1	Column 24	Top	3.17	409.00
2		Centre	4.20	315.02
3		Bottom	3.73	347.03
4	Column 25	Top	4.01	323.00
5		Centre	4.01	312.00
6		Bottom	3.05	369.00
7	Column 26	Top	4.10	316.00
8		Centre	4.12	313.00
9		Bottom	4.01	316.00
10	Column 27	Top	4.12	315.00
11		Centre	4.15	312.00
12		Bottom	4.18	319.00
13	Column 28	Top	4.18	312.00
14		Centre	4.25	305.00
15		Bottom	4.17	312.00
16	Column 29	Top	4.02	307.00
17		Centre	4.22	308.00
18		Bottom	4.12	311.00
19	Column 30	Top	4.28	303.00
20		Centre	4.24	308.00
21		Bottom	4.21	303.00
Sr No.	**Location**	**Identification**	**UPV Velocity (Km/Sec)**	**Time (µs)**
22	Column 31	Top	4.24	304.00
23		Centre	4.14	313.00
24		Bottom	4.19	309.00
25	Column 32	Top	4.10	316.00
26		Centre	4.19	309.00
27		Bottom	4.19	310.00
28	Column 33	Top	4.08	318.00
29		Centre	4.02	304.00
30		Bottom	4.03	308.00

Acceptance Criteria:

Sr. No.	Average Value of Pulse Velocity No. by Cross Probing (km/s)	Concrete Quality Grading
1	above 4.40	Excellent
2	3.75 to 4.40	Good
3	3.00 to 3.75	Doubtful
4	Below 3.00	Poor

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IV. OBSERVATION AND DISSCUSSION

1. Low strength if found in any section is as reported as per acceptance criteria.
2. Column 30 has maximum velocity which is 4.28 km/s observed compared to other Column its concrete quality grading is good . During Audit.
3. The Bottom position of column 25 has minimum Velocity which is 3.05 km/s observed , its concrete quality grading is doubtful .
4. It is observed that no any column has poor concrete quality and most of column has good strength as per acceptance criteria. This structure has good strength.
5. 5. From data reading observed on the site , has good strength as per acceptance criteria from IS (IS 516 (Part 5/sec 1 2018).

V. CONCLUSION

1. It can be conclude that UPV can contribute to the success in control and quality deterioration of concrete structures
2. UPV can be used effectively for detection of cracks and flaws in hardened concrete.
3. Damage may result in a poorly adjusted reduction of service life of the structure. 4. assessing the potential durability of the concrete.
4. Present strength of structure is determined easily, without harming integrity of structure. 5. It is possible to determine concrete uniformity, to control its quality, to follow up the deterioration, to check the presence of internal flaws and voids using UPV.

Based on the study it is concluded that, following parameters must be taken into account while conducting the UPV of concrete structures:

a. The surface of the element to be tested should be smooth, dust free and moisture free.
b.Loose plaster or cover should be removed before conducting the test.
c. Calibration of the instrument should be done before every set of test particularly in ultrasonic pulse velocity meter.
d. UPV method is not adjusted to measure the structure strength, but it is useful to analyze the concrete properties and to determine its homogeneity
e. Transducers of UPV must be firm to the surface to ensure the accuracy of reading and should be placed away from embedded reinforcement as the pulse path get affected significantly.
6. Higher velocities indicate good quality and continuity of the material, while slower velocities may indicate concrete with many cracks or voids.
7. Evaluate dynamic modulus of elasticity of concrete

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