# PERIODIC ASSESSMENT AND LONG TERM DURABILITY CONSIDERATION OF CONCRETE ON FOUNDATION GALLERY OF DAM USING NON DESTRUCTIVE TEST METHOD

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**ABSTRACT:-** Interaction of concrete with persistent prevailing environmental condition will alter its material properties and cause deteriorations. There are various causes of deterioration in concrete structure such as improper construction practices, post construction expansion due to alkali aggregate reaction, corrosion of reinforcement, non homogeneity of concrete, development of cracks due to shrinkage/thermal stresses, aging etc.

Aging of concrete structures and their interactions with persistent prevailing environmental conditions will alter its material properties and cause deteriorations. In spite of maintaining the best quality control concrete may not behave as a homogeneous medium. Conducting any test in the modest way is the key factor for true assessment of the status of substratum. Diagnosis of the residual strength of concrete in in-situ condition using non-destructive tests provides useful information for adopting suitable preventive measures. Deteriorations in the concrete can be broadly imaged using ultrasonic pulse velocity technique. However, the results of ultrasonic pulse velocity depend on various factors. Such phenomena are very common in various elements of dam.

***Key words***- Concrete, Aging, Diagnostic tool, Ultrasonic, Non-Destructive.

## 1.0 INTRODUCTION

### 1.1 Importance and Need of Non-Destructive Testing:

It is often necessary to test concrete structures after the concrete has hardened to determine whether the structure is suitable for its designed use. Ideally such testing should be done without damaging the concrete. The tests available for testing concrete range from the completely non-destructive, where there is no damage to the concrete, through those where the concrete surface is slightly damaged, to partially destructive tests, such as core tests and pullout and pull off tests, where the surface has to be repaired after the test. The range of properties that can be assessed using non-destructive tests and partially destructive tests is quite large and includes such fundamental parameters as density, elastic modulus and strength as well as surface hardness and surface absorption, and reinforcement location, size and distance from the surface. In some cases it is also possible to check the quality of workmanship and structural integrity by the ability to detect voids, cracking and delamination.

Non-destructive testing can be applied to both old and new structures. For new structures, the principal applications are likely to be for quality control or the resolution of doubts about the quality of materials or construction. The testing of existing structures is usually related to an assessment of structural integrity or adequacy. In either case, if destructive testing alone is used, for instance, by removing cores for compression testing, the cost of coring and testing may only allow a relatively small number of tests to be carried out on a large structure which may be misleading. Non-destructive testing can be used in those situations as a preliminary to subsequent coring.

Cases of distress to structure under construction and in service have posed problem to engineers for investigation of such structures. Hence, need is felt to test the concrete in a structure in-situ by Non-destructive testing so as to evaluate its condition for taking appropriate remedial measures for rehabilitation/restoration. The various application of Non-destructive testing are assessment of overall quality/strength of concrete, diagnosis, categorization of distressed structures, ascertaining existing condition of concrete, checking of efficiency of repairs and for other time dependent studies. This paper mainly covers Non-destructive testing of concrete on foundation gallery of dam by Ultrasonic Pulse Velocity method.

## 2.0 TESTING PROGRAMME

The non-destructive tests using Portable Ultrasonic Non-destructive Digital Indicating Tester (PUNDIT) by Ultrasonic Pulse Velocity method were carried out on the concrete faces in the foundation gallery of the dam.

The tests were conducted by indirect method of pulse transmission. The whole upstream face of the gallery was identified for UPV test locations for carrying out the test. Test location points in 3 rows in the form a grid spaced at 40 cm horizontally and 40 cm vertically were created so that UPV tests could be carried out at each of these locations to assess the quality of in-situ concrete within the grid which is further extended to overall quality of the entire upstream wall of the gallery.

## 3.0 ULTRASONIC PULSE VELOCITY TEST

### 3.1 Basic Principles of Test

Pulses of longitudinal 'P' waves are produced by an electro-acoustical transducer which is held in contact with one surface of the concrete under test. After traversing a known path length L in the concrete, the pulse of vibrations is converted into an electrical signal by a second transducer and electronic circuits enable to determine the transit time T of the pulse to be measured.

The pulse velocity V is given by
$V = L / T$ for direct transmission of pulse velocity
Where L is the path length and T is the time

**Fig- 1: Ultrasonic Pulse Velocity Test Equipment (Proceq Model- PL 200)**

**Fig-2: Ultrasonic Pulse Velocity Test on Gallery of Dam**

### 3.2 Acceptance Criteria

Ultrasonic pulse velocity tests have been used on a wide scale for evaluation of relative quality of in-situ concrete. It is a qualitative and relative test and does not give the compressive strength of concrete unless prior calibration tests on concrete in question with the given set of materials are carried out. Generally, high pulse velocity readings in concrete are indicative of good quality.

Since, the ultrasonic pulse velocity readings in galleries are affected by vibrations in concrete generated due to high discharge in spillway through the gates, it is advised to carry out this test during lean period where there is either nil or very low discharge through spillway.

### 3.3 Velocity Criterion for Concrete Quality Grading as per IS: 13311 (Part I), 1992

| Pulse Velocity by cross probing, km/sec | Concrete quality grading |
|---|---|
| Above 4.5 | Excellent |
| 3.5 to 4.5 | Good |
| 3.0 to 3.5 | Medium |
| Below 3.0 | Doubtful |

## 4.0 DISCUSSION OF TEST RESULTS

### 4.1 Ultrasonic Pulse Velocity Test on Top Horizontal Row of Gallery

The Ultrasonic pulse velocity tests were conducted by indirect method on upstream face of foundation gallery at 250 test points with 40 cm horizontal path length. It is observed that ***out of 250 locations that were tested***, ***185 (74%) test locations indicate that concrete quality fall under good category***, 60 (24%) test locations fall under medium category and the remaining 5 (2%) test locations fall under doubtful category. ***Overall quality of concrete is good.***

### 4.2 Ultrasonic Pulse Velocity Test on Middle Horizontal Row of Gallery

The Ultrasonic pulse velocity tests were conducted by indirect method on upstream face of foundation gallery at 247 test points with 40 cm horizontal path length. It is observed that **out of 247 locations that were tested, 10 (4.04%)** ***test locations indicate that concrete quality fall under excellent category, 187 (75.70%) locations fall under good category,*** 46 (18.62%) test locations fall under medium category and the remaining 4 (1.62%) test locations fall under doubtful category. ***Overall quality of concrete is good.***

### 4.3 Ultrasonic Pulse Velocity Test on Bottom Horizontal Row of Gallery

The Ultrasonic pulse velocity tests were conducted by indirect method on upstream face of foundation gallery at 246 test points with 40 cm horizontal path length. It is observed that **out of 246 locations that were tested, 12 (4.87%)** ***test locations indicate that concrete quality fall under excellent category, 183 (74.39%) locations fall under good category,*** 48 (19.51%) test locations fall under medium category and the remaining 3 (1.22%) test locations fall under doubtful category. ***Overall quality of concrete is good.***

### 4.4 Ultrasonic Pulse Velocity Test on vertical grid points between Top and Middle Row of Gallery

The Ultrasonic pulse velocity tests were conducted by indirect method on upstream face of foundation gallery at 249 test points with 40 cm vertical path length. It is observed that ***out of 249 locations that were tested, 8 (3.21%) test locations indicate that concrete quality fall under excellent category, 178 (71.48%) locations fall under good category,*** 58 (23.29%) test locations fall under medium category and the remaining 5 (2%) test locations fall under doubtful category. ***Overall quality of concrete is good.***

### 4.5 Ultrasonic Pulse Velocity Test on vertical grid points between Middle and Bottom Row of Gallery

The Ultrasonic pulse velocity tests were conducted by indirect method on upstream face of foundation gallery at 248 test points with 40 cm vertical path length. It is observed that ***out of 248 locations that were tested, 11 (4.43%) test locations indicate that concrete quality fall under excellent category, 174 (70.16%) test locations indicate that concrete quality fall under good category*** and the remaining 60 (24.19%) test locations fall under medium category and the remaining 3 (1.2%) test locations fall under doubtful category. ***Overall quality of concrete is good.***

## 5.0 CONCLUSION AND RECOMMENDATION

The pulse velocity results were obtained for dam foundation gallery for assessment of in-situ quality of concrete. Test locations (1240) were scanned using UPV test methods and ***only a few test locations (20)<10%*** were categorized under doubtful category. In case of doubtful quality of concrete, additional tests shall have to be carried out to confirm the extent of deterioration the concrete has undergone according to IS: 13311 (Part I), 1992.

Based on the summary of the UPV test results, overall quality of in-situ concrete of the entire upstream wall of the gallery was categorised under **Good.** If the NDT test results too indicate doubtful quality in those areas where continuous leaching takes place, it is suggested to extract a few cores from selective locations and determine their compressive strength to decide further course of action.

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