International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 12 Issue 04, April-2023

Evaluation of the in-Situ Strength of Overhead Reservoirs in Amritsar City using Non-Destructive Tests

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***Abstract*:- Overhead Reservoir tanks are used mainly for the purpose of storing water and distributing it further to the local areas and factory, industry, etc. these tanks are mainly placed over the head that is built on a certain height. And as time passes by these tanks gets old and deteriorated due to chemical attacks so to check the strength and quality of this tanks Non-destructive testing methods are conducted which is of great scientific and practical importance.**

Non-destructive methods are getting more attention during past years because of its reduction in time and labour consumption and also provides with accurate results. Mainly two tests are conducted in this project, Ultrasonic Pulse Velocity and Cut and Pull Out test to check the quality, strength and integrity of the structures.

A total of 60 Ultrasonic pulse tests and 5 Cut and Pull Out tests were performed for twelve Overhead Reservoirs each in Amritsar city. After completing the tests results from Ultrasonic Pulse test showed that overall quality of the concrete is good and medium in structure, however at some location, quality was doubtful and the Cut and Pull Out test (CAPO) values showed that strength of the concrete is satisfactory and the accuracy of determining compressive strength by the Cut and Pull Out test related to the core compressive strength is 18.2% in average

keywords*: *Non-destructive, Overhead Reservoirs, CAPO-TEST, Ultrasonic Pulse Velocity

INTRODUCTION

Non-Destructive testing is the process of calculating materials without harming the concrete or the structure. This test can be used in both old and new structures, the NDT methods have received growing attention during recent years, especially during the need for quality characterization of damaged construction made of concrete or reservoir tanks. As NDT methods help in reduction of time consumption, a possibility of testing concrete strength in structures where cores cannot be drilled and requires less testing equipment which is less expensive as compared to cores which cannot be drilled. NDT method is preferred nowadays mostly because of its distinct advantage over the compression tests. The main advantage of this test is to avoid concrete damage or the performance of building structure components, their usage is simple and quick. This method has proved to be of real importance in all construction serving the purpose of testing and as an effective tool for inspection of concrete quality in concrete structures. The main objective of this test is to obtain compressive strength and other in-situ properties from existing tanks and structures. As this test was performed in Amritsar, Punjab, the concept of smart city is to provide improved personal satisfaction to the residents and make their lives more secure than ever. The safety concerns for the citizens cannot be confirmed without safe structures. Total of twelve overhead reservoirs were tested to check their quality, strength and integrity. The residents of this place have been facing a serious water crisis for the past few decades, as the underground water is leading to the contamination and degradation of the environment in that area, so the canal-based water project has been long term demand. The main objective of this project is to benefit the residents of the city for 30 years.

The 24x7 canal based water supply would be provided as an alternative to the groundwater and 560 tube-wells that fetch groundwater to meet the requirement of the society. So the construction of water-treatment plant is going rapidly in Vallah region and will be completed by 2024. More than 50 overhead reservoirs will be constructed in public places, some of the old reservoirs will be repaired. Since they have assured the possibility of water with no contamination so there would be no requirement for water purifiers. Mainly in this project we are dealing or comparing two Non-destructive test methods in an overhead reservoir tanks which is located in Amritsar. Tank mainly refers to the storage of water which is capable of storing large volume of water for drinking, washing and other purposes.

The water is initially stored in the tank and then distributed to the living communities, so overhead reservoir tanks are those tanks that are placed over the head that is built on a certain height, they may be built of any material but mostly nowadays concrete material is used, as this material is the safest method. Then tanks has a storage capacity of about 2500litres, they are easy to install and do not require lot of plumbing. Main reason for placing the tanks at a height is to enable the flow of water under gravity to the point where they are needed.

The tank is casted with the tank shell, this shell mainly holds the desired volume of water. So the sufficient concrete and steel reinforcements are needed to satisfy limit state serviceability of the tank shell, plus the size of column and beam with proper reinforcement is required to serve or make the support of tank or to make the tank stand. The design of OHSR also follow the same rule as reinforced concrete structures, with the main focus made to the crack width of the tank shell in order to ensure the

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water tightness of the structures, in general the life expectancy of the reservoir tanks are more than 30 years, as these type of tanks have high durability

METHODS

Ultrasonic Pulse Velocity:

Ultrasonic Pulse Velocity is done generally to check the quality of the concrete by determining the velocity of the ultrasonic pulses passing through the concrete structure. This test is performed as per IS 1311 Part-1 to know the inside behaviour of concrete. In this test ultrasonic pulse velocity meter is used with two probes to transmit and receive the signals.

Firstly some grease are applied over the transducers to remove some air voids then placed directly over the UPV machine. Then the pulses are generated from transmitter to receiver. The pulse gets counted by the meter, and as per IS code we get the quality of the concrete, this test gives information about cracks, voids, homogeneity inside the member.

[V = L/T] m/s

Quality of the concrete UPV (m/s)	**Quality of the concrete for**
Above 4500	Excellent
3500-4500	Good
3000-3500	Medium
Below 3000	Doubtful

Cut and Pull Out Test (CAPO)

The Cut and Pull Out test allows performing pull-out test on existing structures without the need of pre-installed inserts. The surface at the test location is ground using a tool. Firstly we will ground the surface location by a tool and that tool will be diamond-studded core bit.

So we will make a hole by a tool and that hole is 18.4 mm hole perpendicular to the surface. A slot is inserted into the hole to a diameter of 25 mm and at a depth of 25mm. A split ring is expanded in the slot and pulled out using a pull machine reacting against counter pressure ring. The concrete in between the expanded ring and the counter pressure ring is in a compression. So the pull-out force F is directly related to compressive strength.

RESULTS

CAPO-TEST RESULTS

Average compressive strength values of 12 Overhead Reservoirs in column through Cut and Pull-Out tests:

Sr. No.	No. of OHSRs (In Column)	Pull-Out Force (KN)	Compressive Strength (N/mm^2)	Average Compressive Strength (N/mm^2)
1.	17	13.08	16.04	28.09
2.	18	18.64	23.72	
3.	19	26.5	34.86	
4.	20	17.92	22.5	
5.	21	16.2	20.24	
6.	22	27.4	35.76	
7.	23	33.62	44.58	
8.	24	23.52	30.6	
9.	25	19.22	24.5	
10.	26	38.36	51.68	
11.	27	12.06	14.58	
12.	28	14.64	18.08	

Accuracy of determining the compressive strength by the CAPO- TEST related to core compressive strength:

$\alpha(CT) = 100\% (f_{cm.\,cub}(CT) – f_{cm.\,cub}(cr)) / f_{cm.\,cub}(cr)$

$f_{cm.\,cub}(CT)$: Mean cube compressive strength determined by CAPO-TEST (N/mm^2)

$f_{cm.\,cub}(cr)$: Mean cube compressive strength determined by testing of cores (N/mm^2)

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FOR OHSR-17
$f_{cm.\ cub}$ (cr) = 13.61 N/mm^2
$f_{cm.\ cub}$ (CT) = 16.04 N/mm^2
α(CT) = 15.15%

FOR OHSR-18
$f_{cm.\ cub}$ (cr) = 23.53 N/mm^2
$f_{cm.\ cub}$ (CT) = 23.72 N/mm^2
α(CT) = 0.81%

FOR OHSR-19
$f_{cm.\ cub}$ (cr) = 31.76 N/mm^2
$f_{cm.\ cub}$ (CT) = 34.86 N/mm^2
α(CT) = 9.8 N/mm^2

FOR OHSR-20
$f_{cm.\ cub}$ (cr) = 23.9 N/mm^2
$f_{cm.}$ cub (CT) = 22.7 N/mm^2
α(CT) = -5.0%

FOR OHSR-21
$f_{cm.\ cub}$ (cr) = 16.81 N/mm^2
$f_{cm.\ cub}$ (CT) = 20.24 N/mm^2
α(CT) = 20.4%

FOR OHSR-22
$f_{cm.\ cub}$ (cr) = 33.6 N/mm^2
$f_{cm.\ cub}$ (CT) = 35.76 N/mm^2
α(CT) = 6.4%

FOR OHSR-23
$f_{cm.\ cub}$ (cr) = 23.7 N/mm^2
$f_{cm.\ cub}$ (CT) = 44.58 N/mm^2
α(CT) = 87.6%

FOR OHSR-24
$f_{cm.\ cub}$ (cr) = 25.32 N/mm^2
$f_{cm.\ cub}$ (CT) = 30.6 N/mm^2
α(CT) = 20.86%

FOR OHSR-25
$f_{cm.\ cub}$(cr) = 22.26 N/mm^2
$f_{cm.\ cub}$(CT) = 24.5 N/mm^2
α(CT) = 10.1%

FOR OHSR-26
$f_{cm.\ cub}$ (cr) = 30.04 N/mm^2
$f_{cm.\ cub}$ (CT) = 51.68 N/mm^2
α(CT) = 72.03%

FOR OHSR-27
$f_{cm.\ cub}$(cr) = 14 N/mm^2

$f_{cm.\ cub}$(CT) = 14.58 N/mm^2
α(CT) = 4.14%

FOR OHSR- 28
$f_{cm.\ cub}$ (cr) = 23.66 N/mm^2

$f_{cm.\ cub}$ (CT) = 18.08 N/mm^2
α(CT) = -23.59%

OHSR N0.	Cores from structure tested in lab		CAPO-Test on structure	
	(N/mm^2)	Average of	(N/mm^2)	α(CT)
17.	13.61	3	16.04	15.2%
18.	23.5	3	23.7	0.8%
19.	31.8	3	34.9	9.8%
20.	23.9	2	22.7	-5.0%
21.	16.8	3	20.24	20.4%
22.	33.6	3	35.8	6.4%
23.	23.8	3	44.6	87.6%
24.	25.3	3	30.6	20.9%
25.	22.7	3	24.5	10.1%
26.	30.04	3	51.7	72.03%
27.	14	3	14.6	4.14%
28.	23.7	3	18.08	-23.6%
Average	23.6		28.1	+18.2%

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CONCLUSION

A detailed methodology in conducting the evaluation of the in-situ strength and quality in OHSRs in Ultrasonic testing was done on columns and beams of twelve Overhead Reservoirs for assessing the quality of the concrete. Mostly the quality of the concrete was medium in structure and in some cases the quality was doubtful and good.

The Cut and Pull Out test was mainly performed on the columns of the Overhead Reservoirs and it was found out that in most cases the strength of the concrete was satisfactory and in some cases it was not satisfactory.

The average accuracy on the compressive strength estimated by CAPO-TEST is 18.2% compared to core compressive strength.

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