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Condition Assessment of Concrete in the 2 PSC Girders of the Pipe Conveyor Bridge of 2 X 660 MW Udangudi Super Critical Thermal Power Project at Thiruchendur

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Abstract— *M/s ITD Cementation India Ltd, Thiruchendur, intended to assess the condition of concrete in the Prestressed Concrete (PSC) Girders of the Pipe Conveyor Bridge of 2 X 660 MW Udangudi Super Critical Thermal Power Project at Thiruchendur. A consultancy project proposal on 'Condition Assessment of Concrete in the PSC Girders of the Pipe Conveyor Bridge of 2 X 660 MW Udangudi Super Critical Thermal Power Project at Thiruchendur' was submitted by M/s Hitech Concrete Solutions Chennai Pvt Ltd, Chennai. M/s ITD Cementation India Ltd, Chennai confirmed the scope of work and entrusted the work to M/s Hitech Concrete Solutions Chennai Pvt Ltd, Chennai. The site investigation to assess the condition of concrete in the PSC Girders of the Pipe Conveyor Bridge of 2 X 660 MW Udangudi Super Critical Thermal Power Project at Thiruchendur was carried out by M/s Hitech Concrete Solutions Chennai Pvt Ltd, Chennai on 17-09-2019. This report outlines the details of the site investigation carried out to assess the quality of concrete, analysis of data obtained during the site investigation and the findings on the quality of concrete in the structure.*

I. INTRODUCTION

A conveyor bridge is a piece of mining equipment used in strip mining for the removal of overburden and for dumping it on the inner spoil bank of the open-cut mine. It is used together with multibucket excavators, frequently bucket chain excavators, that remove the overburden which is moved to the bridge by connecting conveyors. Conveyor bridges are used in working horizontally layered deposits with soft overburden rock in areas where mean annual temperatures are above freezing. They are frequently used in lignite mining.

In general, when a PSC (prestressed concrete) girder is manufactured, the lower portion of a girder is prestressed to endure load generated during a construction process, such as slabbing or packing. The present invention relates to a construction method for simple bridges or continuous bridges using prestressed concrete girder (PSC girder) and precast slabs (PSC slabs). The PSC girder, where prestress is applied to the lower portion of the center of the girder by the first tense, is spanned between piers, and the second tense is performed during the PSC slabs are put on the PSC girders, and hence, the present invention can construct bridges of low clearance and long span by preventing a loss of prestress due to load of the slabs and relieving excessive compression force generated on the upper edge portion of the center of the girder during the construction of the bridge.

II. SCOPE AND OBJECTIVE OF THE WORK

The scope of work in the present investigation is to assess the condition of concrete in the PSC Girders of the Pipe Conveyor Bridge of 2 X 660 MW Udangudi Super Critical Thermal Power Project at Thiruchendur using Rebound Hammer Test and Ultrasonic Pulse Velocity (UPV) tests - 2 PSC Girders.

III. DESCRIPTION OF THE STRUCTURE

The Girders tested were Prestressed Concrete (PSC) I Girders of the Pipe Conveyor Bridge of 2 X 660 MW Udangudi Super Critical Thermal Power Project at Thiruchendur. Prestressed Concrete (PSC) I Girders were 33.3 m long and 1.90 m deep. Photo 1 shows a general view of the PSC Girders. Fig. 1 give the layout of the PSC Girder of the Pipe Conveyor Bridge.

Fig. 1. View of the PSC Girders of Pipe Conveyor Bridge of 2 X 660 MW Udangudi Super Critical Thermal Power Project at Thiruchendur

IV. INVESTIGATION AT SITE

A. Choice of Test Method

The following test methods were employed to assess the quality of concrete in the PSC Girders of the Pipe Conveyor Bridge of 2 X 660 MW Udangudi Super Critical Thermal

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Power Project, Thiruchendur: Rebound Hammer Test and Ultrasonic Pulse Velocity Test

Rebound Hammer Test

The testing of concrete by rebound hammer method (also known as surface hardness test) is generally considered as a useful preliminary or complimentary method to other tests to assess the quality of near surface layer of the concrete. These tests will reveal whether any delamination has taken place due to corrosion initiation inside the structural member. In such cases, the energy will get dissipated in the area around the rebar due to corrosion and result in very low rebound hammer number. Hardness measurements provide information on the quality of only the near surface layer (about 30 mm to 90 mm thickness) of the concrete. Rebound hammer test requires smooth and non-oily surface.

The rebound hammer, which was used in this investigation, was of standard and reliable type, purchased from M/s Proceq SA, Switzerland, i.e., the type 'N' hammer, having an impact energy of 2.2 Nm. Rebound hammer tests were conducted in the selected location of the PSC Girders of the Pipe Conveyor Bridge of Udangudi Project at Thiruchendur, as per IS: 13311 (Part II) - 1992 [1]. The Rebound hammer test was conducted in the presence of the Engineers of M/s ITD Cementation India Ltd. The girders that were tested as well as the test locations was chosen in consultation with the Engineers of M/s ITD Cementation India Ltd. Since there are no available standards for assessing the near surface characteristics of concrete though rebound numbers, the following guidelines have been framed based on the experience gained over a period of 3 decades at SERC, Chennai:

TABLE 1. Rebound hammer number

Average Rebound Number	Quality of Concrete
>40	Very Good
30 to 40	Good
20 to 30	Satisfactory
<20	Poor Concrete

TABLE 2. Summary of the Rebound Hammer test Results

Sl. No	Identification	No. of Points	Rebound Hammer Value		
			Mini mum	Maxi mum	Aver age
1	Girder G23R/5	30	36	44	40
2	Girder G23R/6	26	34	40	37

B. Ultrasonic Pulse Velocity Test

In-situ testing is a specialised job requiring reliable test methods and instruments. For assessment of quality of in-situ concrete, a few testing methods and instruments are available and they could be categorized as non-destructive test methods and partially destructive test methods. As the primary objective of the investigation was to assess the condition of the in-situ concrete, the ultrasonic pulse velocity test method, which is a non- destructive test method, was chosen and adopted. This technique measures the velocity of the ultrasonic pulse of a particular frequency (54 KHz or 24 KHz for concrete) through the concrete medium.This method consists, basically, of measuring the transit time of ultrasonic pulse transmitted through the concrete medium and calculating the pulse velocity by dividing the path length by time of transit [2]. The pulse velocity measurements can be used to establish the following characteristics of the concrete structure.

Fig. 2. Photo 2 shows a view of the Rebound hammer test in progress in a PSC Girder.

i. homogeneity
ii. the presence of cracks, voids, and other imperfections
iii. changes in the structure of the concrete which occur with time
iv. the quality of the concrete in relation to the standard requirements
v. the quality of one element of concrete in relation to another
vi. the values of elastic moduli of concrete.

There are three possible ways of measuring pulse velocity, namely, direct transmission (cross probing), semi-direct transmission and indirect or surface transmission. The direct transmission method is generally preferred, since the maximum energy of the pulse is being directed at the receiving transducer and this gives maximum sensitivity. However, in many situations two opposite faces of the structural member may not be accessible for measurements or the path lengths may be too large. In such cases, the semi direct and indirect measurements are resorted. In the case of indirect method of measurement, the transmitting and receiving transducers are placed on the same face of the concrete member. In the case of semi direct measurement, the transducers are placed on the adjacent face of the concrete elements. Grid lines were marked at a spacing of 300 mm in both the directions of the selected PSC Girders. The area around the grid points was smeared with grease, so that a smooth- plain concrete surface was available for holding the transducer against the surface. Grease applied at the grid point provided an acoustic coupling medium between the concrete surface and the transducer. The transit time of ultrasonic pulse was read from the digital indicator of the PUNDIT (Portable Ultrasonic Non-destructive Digital Indicating Tester, manufactured by PROCEQ). When large voids/pores are present in the concrete member along the path of the

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ultrasonic pulse, the ultrasonic wave would get scattered and the pulse may not reach the receiving transducer. In such cases, readings on the PUNDIT would be unstable. In the present investigation, direct (Photo 3) method of measurement was adopted for the PSC Girders. The PSC Girders and the test locations were identified by M/s ITD Cementation India Ltd.

Fig. 3. View of the Upv Test In Progress In A Psc Girder By Direct Method Of Measurement

C. *Guidelines for Analysis of Test Results*

The general guidelines of Indian Standards IS: 13311 – 1992 - Part I [3] for assessing the quality of concrete based on pulse velocity values of concrete are as follows:

TABLE 3. Shows the summary of the UPV test results for the PSC Girders.

Sl. No.	Indicative quality	UPV readings in km/s.
1	Excellent	Greater than 4.50 km/s.
2	Good	Between 3.50 & 4.50 km/s.
3	Medium	Between 3.0 & 3.50 km/s.
4	Doubtful	Lesser than 3.00 km/s.

TABLE 4. Summary of the UPV test Results

Sl. No	Identification	No. of Points	UPV Value in km/s		
			Minimum	Maxi mum	Average
1	Girder G23R/5	30	4.38	4.72	4.55
2	Girder G23R/6	26	4.20	4.60	4.44

V. Evaluation of the Test Results

Repair done and NDT after repair shall be part along with revision in prestressing force. The results of the Rebound Hammer test and Ultrasonic Pulse Velocity Test conducted in the PSC Girders of the Pipe Conveyor Bridge are discussed in the following sections.

A. *Rebound Hammer Test*

It is found from Table 1 that the average Rebound Hammer values in the selected locations of the PSC Girders G23R/5 & G23R/6 of the Pipe Conveyor Bridge are 37 and 40 respectively, indicating that the quality of concrete in the near surface portion is “Good”.

B. *Ultrasonic Pulse Velocity Test*

It is found from Table 2 that the average UPV value in the selected locations of the Girder G23R/5 of the Pipe Conveyor Bridge are above 4.5 km/s indicating that the integrity of concrete can be considered as ‘Excellent’ as per the guidelines of IS: 13311 (Part I)- 1992.It is also found from Table 2 that the average UPV value in the selected locations of the Girder G23R/6 of the Pipe Conveyor Bridge are between 3.5 km/s and 4.5 km/s indicating that the integrity of concrete can be considered as ‘Good’ as per the guidelines of IS: 13311 (Part I)- 1992.

VI. Conclusion

Based on the results of the Non-Destructive Tests carried out on the PSC Girders of the Pipe Conveyor Bridge of 2 X 660 MW Udangudi Super Critical Thermal Power Project, Thiruchendur, the following conclusions are drawn:

- The average Rebound Hammer values in the selected locations of the PSC Girders G23R/5 & G23R/6 of the Pipe Conveyor Bridge are 37 and 40 respectively, indicating that the quality of concrete in the near surface portion is “Good”.
- The average UPV value in the selected locations of the Girder G23R/5 of the Pipe Conveyor Bridge are above 4.5 km/s indicating that the integrity of concrete can be considered as ‘Excellent’ as per the guidelines of IS: 13311 (Part I)- 1992.
- The average UPV value in the selected locations of the Girder G23R/6 of the Pipe Conveyor Bridge are between 3.5 km/s and 4.5 km/s indicating that the integrity of concrete can be considered as ‘Good’ as per the guidelines of IS: 13311 (Part I)- 1992.

Appendix A

TABLE A1 Rebound Hammer Values of the PSC Girder G23R/5

Location 1			
RH	1	2	3
A	42	40	42
B	44	42	40

Location 2		
RH	1	2
A	42	42
B	38	38

Location 3		
RH	1	2
A	38	39
B	38	42

Location 4		
RH	1	2
A	42	40
B	42	42

Location 5		
RH	1	2
A	44	40
B	42	38

Location 6		
RH	1	2
A	40	38
B	42	40

Location 7		
RH	1	2
A	38	42
B	38	36

TABLE A2 Rebound Hammer Values of the PSC Girder G23R/6

Location 1		
RH	1	2
A	34	34
B	36	38
C	38	34

Location 2		
RH	1	2
A	38	34
B	38	40

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Location 3		
RH	1	2
A	36	40
B	40	38

Location 4		
RH	1	2
A	36	40
B	38	38

Location 5		
RH	1	2
A	38	40
B	36	40

Location 6		
RH	1	2
A	38	38
B	38	36

TABLE A3 UPV Values of the PSC Girder G23R/5

Location 1			
UPV	1	2	3
A	4.50	4.63	4.56
B	4.52	4.51	4.60

Location 2		
UPV	1	2
A	4.42	4.58
B	4.38	4.45

Location 3		
UPV	1	2
A	4.45	4.55
B	4.42	4.55

Location 4		
UPV	1	2
A	4.51	4.55
B	4.51	4.52

Location 5		
UPV	1	2
A	4.62	4.55
B	4.48	4.48

Location 6		
UPV	1	2
A	4.72	4.70
B	4.60	4.60

Location 7		
UPV	1	2
A	4.65	4.67
B	4.60	4.60

TABLE A4 UPV Values of the PSC Girder G23R/6

Location 1		
UPV	1	2
A	4.54	4.38
B	4.48	4.44
C	4.39	4.37

Location 2		
UPV	1	2
A	4.28	4.58
B	4.2	4.29

Location 3		
UPV	1	2
A	4.48	4.48
B	4.52	4.48

Location 4		
UPV	1	2
A	4.43	4.45
B	4.43	4.55

Location 5		
UPV	1	2
A	4.29	4.38
B	4.48	4.48

Location 6		
UPV	1	2
A	4.49	4.49
B	4.60	4.51

Appendix B

Sl.No	Girder ID	Date of Casting	Strength at ages			
			5 / 6 days	7days	21days	28days
			CC	CC	CC	CC
1	G23L/1	27-Jun-19	41.73	46.40	51.13	57.14
2	G23R/1	02-Jul-19	44.47	47.59	53.23	56.30
3	G23R/2	06-Jul-19	42.50	46.34	52.27	56.87
4	G23L/2	09-Jul-19	44.68	46.33	52.80	56.38
5	G23L/3	13-Jul-19	41.63	44.77	52.74	55.75
6	G23L/4	16-Jul-19	43.14	45.85	52.01	57.25
7	G23R/3	20-Jul-19	41.25	45.98	53.52	57.36
8	G23L/5	23-Jul-19	44.15	47.40	52.40	57.02
9	G23L/6	27-Jul-19	41.72	46.37	53.22	55.97
10	G23R/4	30-Jul-19	44.80	47.14	53.62	57.53
11	G23R/5	03-Aug-19	42.92	46.65	53.84	57.22
12	G23R/6	06-Aug-19	---	45.08	53.33	55.35
13	G23L/7	10-Aug-19	42.79	47.60	53.73	55.94
14	G23R/7	14-Aug-19	40.31	46.59	52.86	56.13
15	G23R/8	11-Sep-19				

CC - Using Curing Compound application

6 days strength
Damaged Girder

Fig. B1 Cube strength FOR G23

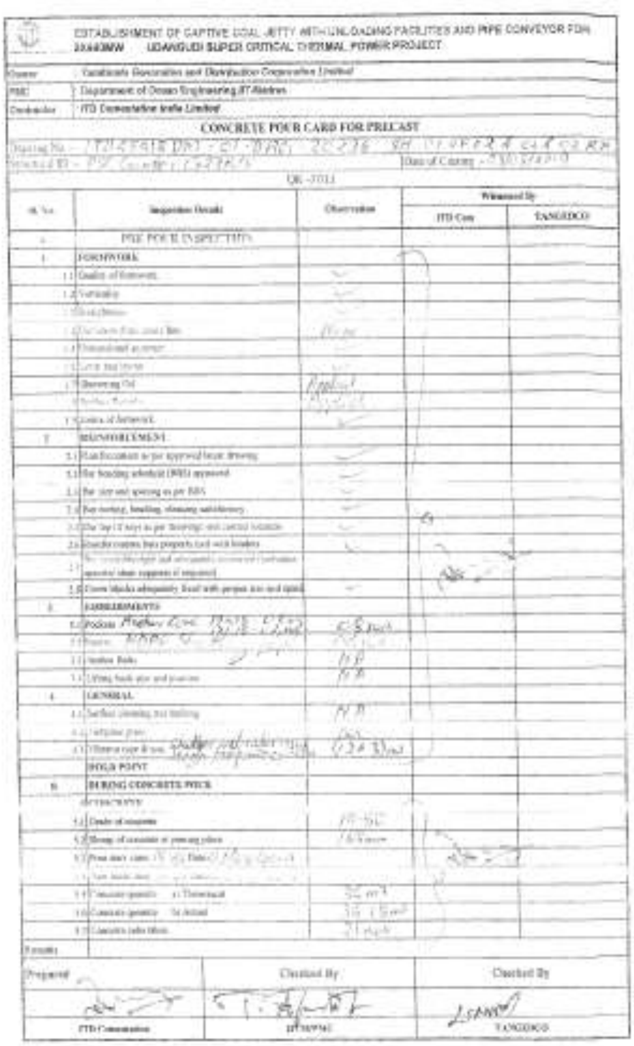

Fig. B2.1 Pour Card and Stressing Report G23R5

Fig. B2.2 Pour Card and Stressing Report G23R5

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Fig. B2.3 Pour Card and Stressing Report G23R5

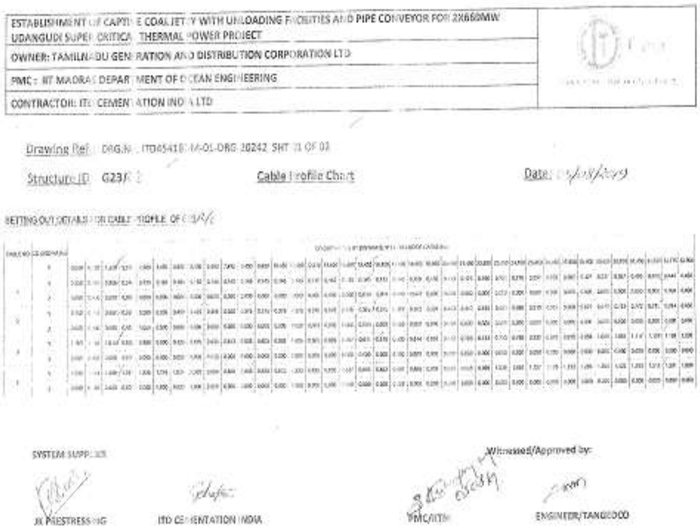

Fig. B2.4 Pour Card and Stressing Report G23R5

Fig. B3.1 Pour Card and Stressing Report G23R6

Fig. B3.2 Pour Card and Stressing Report G23R6

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Fig. B3.1 Jack Efficiency Report

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CALIBRATION CERTIFICATE FOR PRESSURE GAUGE

(Maximum Validity One Year from the date of issue)

OBSERVATIONS

Pressure on Dead Weight Tester in Kg/cm²	Observed Reading in Kg / cm² Gauge No. 185032	Gauge No. 185012
0	0	0
50	48	46
100	98	98
150	140	148
200	196	199
250	250	250
300	298	300
350	350	358
400	400	400
450	450	450
500	500	500
550	550	550
600	600	600

Fig. B3.2 Jack Efficiency Report

ACKNOWLEDGMENT

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REFERENCES

[1] IS: 13311 (Part II): 1992, "Non-destructive Testing of Concrete - Methods of Test",
[2] Bureau of Indian Standards.
[3] Bungey J.H., "The Testing of Concrete in Structures", Surrey University Press, London, 1982.
[4] IS: 13311 (Part I): 1992, "Non-destructive Testing of Concrete -Methods of Test",