

INSPECTION REPORT

FOR

**Health Survey of Existing Structure at
Ammonia Plant**

**Of
IFFCO, Paradeep
Orissa**



**INDIAN FARMERS FERTILISER COOPERATIVE
LTD, PARADEEP, ORISSA**

March - 2013



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March 21, 2013.

Health survey of the existing plant structures at IFFCO
Paradeep Unit.

INSPECTION REPORT
For
Condition Assessment
For
All structures in Ammonia plant
At
Utility and offsites plant
Paradeep, Orissa.

**1. AMMONIA CONTROL ROOM
AND
ELECTRIAL SUB-STATION**

History / Background of the structure:

The said structures i.e. “**Ammonia control room and Electrical sub station (OFFSITES AND UTILITY PLANT)**” of Indian Farmers Fertilizer Cooperative Ltd are located inside the plant premises at Paradeep Unit, Orissa - 754142.

- Ammonia control room and Electrical sub-station is functioning for almost over last 12 years, as reported. The structure was commissioned in 1998; as reported.
- Control Room and Electrical sub- station are the RCC structures; combined to each other. Control Room covered with RCC slab whereas Electrical sub – station is covered with G.I. pre-coated sheets along with its supporting steel framing system as seen in the photograph below.



Observations:-

South side external observations:-

- This area reveal distresses like leakage / seepage marks & moss growth due to damaged/missing rain water pipes, localized spalling of cover concrete thereby exposed reinforcement at the soffit of RCC chajja etc.



East side external observations:-

- This are reveal with distresses like vegetation growth, moss growth due to leakage/seepage, discoloration of paint and weathered surfaces etc.



West side external observations:-

- Damaged and broken RCC beam and chajja noted on West side due to new opening arrangements made, as per requirement. However, the area left without any treatment is a cause of concern. Also, Separation crack noted at the junction of RCC and masonry wall.



North side external observations:-

- Separation crack noted between the projected slab and parapet wall, discoloration of paint, localized exposed reinforcement and delamination of cover concrete noted at the soffit of projected slab as shown in the photograph below.



Internal Observations:-

Control room-

- Separation crack noted between RCC beam and masonry wall. Also noted diagonal cracks on wall and unfinished cut-out made to masonry wall for passing cable line. Slab area inspection could not be possible due to false ceiling.



INFERENCE OF N.D.T. RESULTS

In order to have adequate assessment of the pathological condition of the structure i.e. series of health parameters, series of NDT investigations are carried out. These include number of ultrasonic pulse velocity readings, half cell potentiometer test for corrosion potential, number of concrete chemical analysis, Carbonation, Cover meter and steel thickness test have been carried out. All the NDT findings are enclosed herewith.

1. *Ultrasonic Pulse Velocity Test* :- (IS 13311 - Part I)

This instrument works on the principle of passing high frequency sound waves through the body of the concrete & measuring the time taken. Distance of path length divided by the time taken provides velocity of the waves through the concrete member being tested.

Depending on the velocity, the quality of concrete as regards homogeneity can be judged. Lower velocity (less than 3 Km / sec) indicates some defects like honey combing, cracks, voids, rebounding etc. at the location of test.

The concrete surface is thoroughly cleaned & dried. The instrument is calibrated before taking readings. Coupling medium such as grease is applied to the probes, and reading is taken for the pulse velocity at the location. Appropriate correction factors are applied, wherever desired, for the presence of steel.

The USPV readings around 3 Km/sec and above indicate fair quality concrete whereas readings below 2 Km / sec indicate localized weakness at that particular zone.

As per IS, velocity below 3.00 Km / sec indicates 'Doubtful' quality concrete, velocity between 3.00 to 3.50 Km / sec indicates 'Medium' quality concrete and velocity above 3.50 Km / sec indicates 'Good' quality

concrete. And velocity 4.50 Km / sec indicate 'Excellent' quality concrete. From the above parameters we can judge the quality of concrete.

Details of Testing:

- The tests were conducted at total 9 locations.
- Maximum reading obtained as 5.34 km/sec at Column F2.
- Minimum reading obtained as 4.23 km/sec at Column f1.
- Average reading obtained as 4.88 km/sec, which indicates good quality of concrete.

Conclusion:

The test results indicate good quality concrete at most of the locations.

Please refer the test results attached herewith for details.

2. *Schmidt Rebound Hammer (IS 13311 Part II)*

Total 16 impact readings were taken at each location and average of middle ten was calculated after discarding the top three and bottom three readings. In this manner, total no. of points was tested on the selected concrete members.

The probable accuracy of prediction of concrete strength by the rebound hammer is + 25% as per IS code 13311(part II)

Details of Testing:

- The tests were conducted a 3 locations.
- The average of all the readings is 320.00 Kg/ Sq.cm.

Please refer the test results attached herewith for details.

3. *Cover meter investigations.*

This test indicates the cover of concrete over the reinforcement. In this case the cover is without the plaster.

Details of Testing:

- The tests were conducted at total 3 locations.
- Several readings of cover meter are in the range of 51 mm to 63mm.
- Clear cover does not indicate depth beyond 63 mm where test has carried out.
- The average cover of concrete reveals as 57.00 mm.

Conclusion:

- The test results confirm sufficient cover of concrete provided to the reinforcement at many locations.

Please refer the test results attached herewith for details.

Internal Observations:-

Electrical sub-station of panel room-

- All external openings are closed with masonry and also noted cracks in the closed area.



- As a matter of critical observation; deflection noted in the King post truss and roof purlins at some locations. Also, corrosion, scaling and pitting noted in the steel members of roof system.





- Separation crack noted in between the RCC and masonry wall at some locations.



- Unfinished plaster noted on the brick masonry wall on West and North side wall as shown in the photographs below.



RECOMMENDATIONS:

R.C.C. Members -

Corrosion related damages (in the RCC members) shall be rectified with the use of 'Polymer Modified Mortar' as per standard methodology as follows -

➤ 1. Cracks due to corrosion of steel reinforcement in RCC members

- Expose the cracked / spalled elements completely. Use long sharp chisels of about 16-20 mm diameter and hammers upto 2 lbs weight. Remove the complete corrosion of reinforcement with wire brushes (preferably mechanical type). Remove all the loose and damaged concrete particles till sound concrete of uniform texture is visible. Apply rust removers like 'Rusticide SS' or equivalent to the reinforcement to remove the traces of rust. Clean the reinforcement once again with the wire brush. Wash the complete concrete surface including the reinforcement to remove the traces of rust remover. Apply a coat of rust passivator like 'Polyalk Fixoprime and cement' or equivalent as per the recommendations of the manufacturers. The concrete surface treated for corrosion shall be patch repaired with Polymer Modified Mortar like 'Polyalk EP' or any other equivalent as per the manufacturer's recommendations.

➤ Exposed steel reinforcement

- Follow methodology to treat exposed reinforcement as per recommendation mentioned in corrosion cracks in R.C.C members with replacement of snapped steel with new steel

reinforcement of similar diameter, as per requirement as per existing design.

➤ **Hollow sound in RCC member**

- Break open the loose and damaged concrete, till the uniform and solid stage of concrete is witnessed.
- Give Polymer Mortar Treatment to this area as per recommendation mentioned for crack due to corrosion of reinforcement in R.C.C members.
- Grout the weak concrete areas with cement and non shrink additives or with low viscous epoxy.

➤ **Honey Combing / Cracks:-**

- These areas shall be grouted with cement grouting with addition of non shrinking additives.
- Aluminum / PVC multiperforated nipples may be used to carry out the injection operation.
- The pressure of 1.00 to 1.5 kg per sq cm may be applied for grouting.
- Care should be taken to remove trapped air inside the crack / honey combing areas to avoid back pressure.

➤ **Spalling of Concrete: -**

- This area shall be rectified by the process as explained earlier i.e. in recommendation no.1

➤ **Grout the area with low viscous epoxy injections of reputed manufacturers, as per specification, for cracks and weak concrete areas to make the area itself watertight.**

➤ **Separation cracks**

- Open the separation cracks with 'V' groove up to 15mm to 20mm depth.
- Clean the 'V' groove surface with water.
- Then apply the polymer mortar with metal embedded on it.
- This metal embedded mortar should be covered with proper chicken wire mesh with over lapping of 6 inch over brick work / Block work and 6 inch overlap to the R.C.C member (beam / Column).
- Apply the plaster according to the manufacturer's specification.

➤ **Moss Growth**

- Wherever the moss growth has been observed check that area for any hollow sound in the plaster.
- Remove and redo the damaged plaster and protect the surface with good quality paint.

➤ **Vegetation Growth**

- Cut the vegetation by its root.
- Treat the root area with "weedycide" as per the manufacturer's specification.
- Treat surrounding area as per requirement with normal procedures.

• **Structural Steel Members -**

- Localized replacement of the deteriorated steel elements as also further strengthening has to be done and need to be followed for the proposed rehabilitation work. However, the said strengthening work shall be done according to the design.

- Localized replacement of the steel elements of truss system which noted deflected; shall be done according to the design.
- Most of the distresses related to the inadequate connection details need be re-done with providing ideal connection details as can be best designed with improved specifications.
- Few General distresses like Existing corrosion of the steel members shall be removed as per standard method and all the Structural Steel members shall be treated with application of 3 coats of 'SUNPUGUARD' (a high quality Anti corrosive two component Polyurethane coating) or equivalent as per Manufacturer's recommendations. Proper surface preparation of all Structural Steel members shall be done before application of SUNPUGUARD or equivalent, as per manufacturer's recommendations.

- This is the broad assessment of the structural health at this stage.

C.Y.Chandanshive

Mahendra Barde

J. C. Kadam

Project Manager

Sr. Associate

Technical Director

2. AIR COMPRESSOR HOUSE (AMMONIA PLANT)

History / Background of the structure:

- The structure under reference i.e. Air Compressor is steel framed structure consisting Steel Columns, Steel Beams suitably rest on RCC foundations and covered with GI pre-coated sheet roof supported by suitable steel framing system.
- A. C sheet cladding has been liberally provided in the elevation treatment.
- Height of structure is approximately 13.5 meter.



Observations:-

- A.C sheets at cladding noted damaged / broken and noted holes on North side elevation.



- Severe corrosion, scaling noted in base plates & foundation nut bolts of steel columns at many locations.





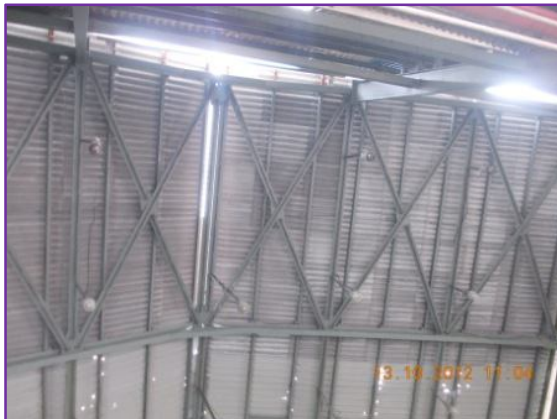
- Inadequate connections in the form of small cleats provided as also corrosion in the steel elements of connections etc. noted as shown in the photograph below.



- Corrosion noted in all the steel elements like columns, cross bracings, side gusset plates, central gusset plates and steel beams etc.



- Light corrosion and pitting noted in the steel elements of roof system like purlins, trusses, cross bracings etc. Also noted nut bolts missing in cross bracings and damaged pre coated sheets in the roofing system.



INFERENCE OF N.D.T. RESULTS

In order to have adequate assessment of the pathological condition of the structure i.e. series of health parameters, series of NDT investigations are carried out. These include number of ultrasonic pulse velocity readings, half cell potentiometer test for corrosion potential, number of concrete chemical analysis, Carbonation, Cover meter and steel thickness test have been carried out. All the NDT findings are enclosed herewith.

1. Steel Thickness Gauge:

This test is performed to acquire the thickness of the Structural steel members, as per actual.

Sr.	Locations	Member	Standard	Thickness Obtained	% Reduction
No.	-	-	Thickness	(mm)	
	<u>Ammonia Plant</u>	-			
	<u>Ammonia Compressor House</u>				
	<u>Column</u>				
1	Column A1 (200)	ISMB	5.70	5.90	-
2	Column A2 (200)	ISMB	5.70	4.90	14.04
3	Column A3 (200)	ISMB	5.70	4.60	19.30
4	Column A4 (200)	ISMB	5.70	5.00	12.28
5	Column A5 (200)	ISMB	5.70	4.90	14.04
6	Column A6 (200)	ISMB	5.70	5.20	8.77
7	Column B6 (450)	ISMB	9.40	8.90	5.32
8	Column C6 (450)	ISMB	9.40	9.40	0.00
9	Column D6 (200)	ISMB	5.70	4.90	14.04
10	Column D5 (200)	ISMB	5.70	5.80	-
11	Column D4 (200)	ISMB	5.70	5.90	-
12	Column D3 (200)	ISMB	5.70	5.80	-
13	Column D2 (200)	ISMB	5.70	6.20	-
14	Column D1 (200)	ISMB	5.70	5.80	-
15	Column C1 (450)	ISMB	9.40	9.50	-
	<u>Cross Bracing</u>				
16	Cross Bracing (60x60x8) A6	ISA	8.00	7.40	7.50
17	Cross Bracing (60x60x8) D6	ISA	8.00	7.40	7.50
	<u>Gusset Plate</u>				
18	Gusset Plate(8) A1	GP	8.00	6.40	20.00

19	Gusset Plate(8) A2	GP	8.00	6.90	13.75
20	Gusset Plate(8) A3	GP	8.00	6.00	25.00
21	Gusset Plate(8) A4	GP	8.00	7.70	3.75
22	Gusset Plate(8) A5	GP	8.00	8.00	0.00
23	Gusset Plate(8) A6	GP	8.00	8.10	-
24	Gusset Plate(12) B6	GP	12.00	10.20	15.00
25	Gusset Plate(8) C6	GP	8.00	6.60	17.50
26	Gusset Plate(8) D6	GP	8.00	4.60	42.50
27	Gusset Plate(8) D5	GP	8.00	6.00	25.00
28	Gusset Plate(8) D4	GP	8.00	8.00	0.00
29	Gusset Plate(8) D3	GP	8.00	6.10	23.75
30	Gusset Plate(8) D2	GP	8.00	7.20	10.00
31	Gusset Plate(8) D1	GP	8.00	7.80	2.50
32	Gusset Plate(16) C1	GP	16.00	9.40	41.25
The percentage of reduction in thickness of web in ISMBC varies from 5.32% to 19.30% with respect to the original thickness.					
The percentage of reduction in thickness of gusset plate varies from 2.50% to 42.50% with respect to the original thickness.					
The percentage of reduction in thickness of ISA varies from 0% to 7.50% with respect to the original thickness.					

2. Ultrasonic Pulse Velocity Test :- (IS 13311 - Part I)

This instrument works on the principle of passing high frequency sound waves through the body of the concrete & measuring the time taken. Distance of path length divided by the time taken provides velocity of the waves through the concrete member being tested.

Depending on the velocity, the quality of concrete as regards homogeneity can be judged. Lower velocity (less than 3 Km / sec) indicates some defects like honey combing, cracks, voids, rebounding etc. at the location of test.

The concrete surface is thoroughly cleaned & dried. The instrument is calibrated before taking readings. Coupling medium such as grease is

applied to the probes, and reading is taken for the pulse velocity at the location. Appropriate correction factors are applied, wherever desired, for the presence of steel.

The USPV readings around 3 Km/sec and above indicate fair quality concrete whereas readings below 2 Km / sec indicate localized weakness at that particular zone.

As per IS, velocity below 3.00 Km / sec indicates 'Doubtful' quality concrete, velocity between 3.00 to 3.50 Km / sec indicates 'Medium' quality concrete and velocity above 3.50 Km / sec indicates 'Good' quality concrete. And velocity 4.50 Km / sec indicate 'Excellent' quality concrete. From the above parameters we can judge the quality of concrete.

Details of Testing:

- The tests were conducted at total 7 locations.
- Maximum reading obtained as 4.58 km/sec at column B6.
- Minimum reading obtained as 4.01 km/sec at pedestal A3.
- Average reading obtained as 4.29 km/sec, which indicates good quality of concrete.

Conclusion:

The test results indicate good quality concrete at most of the locations.

Please refer the test results attached herewith for details.

3. Schmidt Rebound Hammer (IS 13311 Part II)

Total 16 impact readings were taken at each location and average of middle ten was calculated after discarding the top three and bottom three readings. In this manner, total no. of points was tested on the selected concrete members.

The probable accuracy of prediction of concrete strength by the rebound hammer is + 25% as per IS code 13311(part II)

Details of Testing:

- The tests were conducted at 7 locations.
 - The average of all the readings is 435.71 Kg/ Sq.cm.
- Please refer the test results attached herewith for details.

4. Cover meter investigations.

This test indicates the cover of concrete over the reinforcement. In this case the cover is without the plaster.

Details of Testing:

- The tests were conducted at total 4 locations.
- Several readings of cover meter are in the range of 47 mm to 53 mm.
- Clear cover does not indicate depth beyond 53 mm where test has carried out.
- The average cover of concrete reveals as 48.50 mm.

Conclusion:

- The test results confirm sufficient cover of concrete provided to the reinforcement at many locations.

Please refer the test results attached herewith for details.

RECOMMENDATIONS:

- Localized replacement of the deteriorated steel elements as also further strengthening has to be done and need to be followed for the proposed rehabilitation work. However, the said strengthening work shall be done according to the design.
- The gap between concrete and top finishing layer (in RCC pedestals) shall be finished with suitable grouting as per existing system/method.
- Most of the distresses related to the inadequate connection details need be re-done with providing ideal connection details as can be best designed with improved specifications.
- Few General distresses like Existing corrosion of the steel members shall be removed as per standard method and all the Structural Steel members shall be treated with application of 3 coats of 'SUNPUGUARD' (a high quality Anti corrosive two component Polyurethane coating) or equivalent as per Manufacturer's recommendations. Proper surface preparation of all Structural Steel members shall be done before application of SUNPUGUARD or equivalent, as per manufacturer's recommendations.
- Damaged sheets at roof & cladding shall be removed; locally; and replaced with similar type of materials.
- This is the broad assessment of the structural health at this stage.

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Technical Director

3. AMMONIA PIPE RACK

Observations:-

- Cracks noted on top finishing layer of RCC pedestals. Also, corrosion, scaling and pitting noted in the steel elements (of connection system) like nut bolts, base plate, and gusset plates etc. at many locations. Corrosion also noted in the main steel members like columns, beams, cross bracings and tie beams etc. Please refer typical photographs below.





- Inadequate connections in the form of cleat angles missing in one side noted at every connection. Please refer typical photographs below.



- Deflection noted in the steel column no-14 at a location as seen in the photograph below. This might be the original construction deficiency however the area needs monitoring for further development; if any.



- Severe corrosion, scaling noted on base plate, foundation nut bolts, bottom section of steel column etc. Also, stiffener plate noted bent at the area connected with cross bracing as shown in the photograph below.



INFERENCE OF N.D.T. RESULTS

In order to have adequate assessment of the pathological condition of the structure i.e. series of health parameters, series of NDT investigations are carried out. These include number of ultrasonic pulse velocity readings; Cover meter and steel thickness test have been carried out. All the NDT findings are enclosed herewith.

1. Steel Thickness Gauge:

This test is performed to acquire the thickness of the Structural steel members, as per actual.

Sr.	Locations	Member	Standard	Thickness Obtained	% Reduction
No.	-	-	Thickness	(mm)	
	<u>Ammonia Plant</u>	-			
	<u>Pipe Rack Near Compressor House</u>				
	<u>Columns</u>				
1	Column A1 (250)	ISMB	6.90	6.60	4.35
2	Column A2 (250)	ISMB	6.90	6.50	5.80
3	Column A3 (250)	ISMB	6.90	5.90	14.49
4	Column A4 (250)	ISMB	6.90	5.60	18.84
5	Column A5 (250)	ISMB	6.90	7.00	-
6	Column B1 (250)	ISMB	6.90	7.00	-
7	Column B2 (250)	ISMB	6.90	6.80	1.45
8	Column B3 (250)	ISMB	6.90	6.30	8.70
9	Column B4 (250)	ISMB	6.90	6.20	10.14
10	Column B5 (250)	ISMB	6.90	6.50	5.80
11	Column A6 (250)	ISMB	6.90	7.00	-
12	Column A2 (250)	ISMB	6.90	7.50	-
13	Column B7 (300)	ISMB	7.50	7.50	0.00
14	Column A9 (300)	ISMB	7.50	7.60	-
15	Column B9 (300)	ISMB	7.50	7.50	0.00
16	Column A11 (300)	ISMB	7.50	7.80	-
17	Column B11 (300)	ISMB	7.50	7.90	-
18	Column A13 (300)	ISMB	7.50	7.40	1.33

19	Column B13 (300)	ISMB	7.50	7.80	-
20	Column A16 (300)	ISMB	7.50	7.50	0.00
21	Column B16 (300)	ISMB	7.50	7.60	-
22	Column A19 (350)	ISMB	8.10	8.20	-
23	Column B19 (350)	ISMB	8.10	7.80	3.70
24	Column A24 (350)	ISMB	8.10	7.80	3.70
25	Column B25 (350)	ISMB	8.10	8.20	-
	<u>Cross Bracing</u>				
26	Cross Bracing (60x60x6) A1	ISA	6.00	5.50	8.33
27	Cross Bracing (60x60x6) A2	ISA	6.00	6.00	0.00
28	Cross Bracing (60x60x6) A3	ISA	6.00	6.20	-
29	Cross Bracing (60x60x6) A4	ISA	6.00	5.80	3.33
30	Cross Bracing (60x60x6) A5	ISA	6.00	No Reading	-
31	Cross Bracing (60x60x6) B1	ISA	6.00	5.40	10.00
32	Cross Bracing (60x60x6) B2	ISA	6.00	No Reading	-
33	Cross Bracing (60x60x6) B3	ISA	6.00	4.10	31.67
34	Cross Bracing (60x60x6) B4	ISA	6.00	5.50	8.33
35	Cross Bracing (60x60x6) B5	ISA	6.00	4.80	20.00
36	Cross Bracing (60x60x6) A6	ISA	6.00	6.10	-
37	Cross Bracing (60x60x6) A2	ISA	6.00	6.10	-
38	Cross Bracing (75x75x8) B7	ISA	8.00	8.30	-
	<u>Gusset Plate</u>				
39	Gusset Plate (12mm) A1	GP	12.00	10.50	12.50
40	Gusset Plate (12mm) A2	GP	12.00	5.90	50.83
41	Gusset Plate (12mm) A3	GP	12.00	10.20	15.00
42	Gusset Plate (16mm) A4	GP	12.00	12.20	-
43	Gusset Plate (16mm) A5	GP	12.00	No Reading	
44	Gusset Plate (12mm) B1	GP	12.00	10.10	15.83
45	Gusset Plate (12mm) B2	GP	12.00	12.20	-
46	Gusset Plate (12mm) B3	GP	12.00	11.70	2.50
47	Gusset Plate (12mm) B4	GP	12.00	11.80	1.67
48	Gusset Plate (12mm) B5	GP	12.00	11.50	4.17
49	Gusset Plate (12mm) A6	GP	12.00	10.00	16.67
50	Gusset Plate (12mm) A2	GP	12.00	10.00	16.67
51	Gusset Plate (12mm) B7	GP	12.00	10.30	14.17
52	Gusset Plate (12mm) A9	GP	12.00	10.00	16.67
53	Gusset Plate (12mm) B9	GP	12.00	10.30	14.17
54	Gusset Plate (12mm) A11	GP	12.00	10.20	15.00
55	Gusset Plate (12mm) B11	GP	12.00	8.00	33.33
56	Gusset Plate (12mm) A13	GP	12.00	10.50	12.50

57	Gusset Plate (12mm) B13	GP	12.00	10.30	14.17
58	Gusset Plate (12mm) A16	GP	12.00	10.50	12.50
59	Gusset Plate (12mm) B16	GP	12.00	10.80	10.00
60	Gusset Plate (12mm) A19	GP	12.00	10.70	10.83
61	Gusset Plate (12mm) B19	GP	12.00	11.80	1.67
62	Gusset Plate (12mm) A24	GP	12.00	11.10	7.50
63	Gusset Plate (12mm) B25	GP	12.00	12.10	-
The percentage of reduction in thickness of web in ISMB varies from 1.33% to 18.84% with respect to the original thickness.					
The percentage of reduction in thickness of gusset plate varies from 1.67% to 50.83% with respect to the original thickness.					
The percentage of reduction in thickness of ISA varies from 3.33% to 31.67% with respect to the original thickness.					

2. Ultrasonic Pulse Velocity Test :- (IS 13311 - Part I)

This instrument works on the principle of passing high frequency sound waves through the body of the concrete & measuring the time taken. Distance of path length divided by the time taken provides velocity of the waves through the concrete member being tested.

Depending on the velocity, the quality of concrete as regards homogeneity can be judged. Lower velocity (less than 3 Km / sec) indicates some defects like honey combing, cracks, voids, rebounding etc. at the location of test.

The concrete surface is thoroughly cleaned & dried. The instrument is calibrated before taking readings. Coupling medium such as grease is applied to the probes, and reading is taken for the pulse velocity at the location. Appropriate correction factors are applied, wherever desired, for the presence of steel.

The USPV readings around 3 Km/sec and above indicate fair quality concrete whereas readings below 2 Km / sec indicate localized weakness at that particular zone.

As per IS, velocity below 3.00 Km / sec indicates 'Doubtful' quality concrete, velocity between 3.00 to 3.50 Km / sec indicates 'Medium' quality concrete and velocity above 3.50 Km / sec indicates 'Good' quality concrete. And velocity 4.50 Km / sec indicate 'Excellent' quality concrete. From the above parameters we can judge the quality of concrete.

Details of Testing:

- The tests were conducted at total 17 locations.
- Maximum reading obtained as 5.08 km/sec at pedestal no. A9.
- Minimum reading obtained as 3.64 km/sec at Pedestal no. 18.
- Average reading obtained as 4.59 km/sec, which indicates good quality of concrete.

Conclusion:

The test results indicate good quality concrete at most of the locations.

Please refer the test results attached herewith for details.

3. *Schmidt Rebound Hammer (IS 13311 Part II)*

Total 16 impact readings were taken at each location and average of middle ten was calculated after discarding the top three and bottom three readings. In this manner, total no. of points was tested on the selected concrete members.

The probable accuracy of prediction of concrete strength by the rebound hammer is + 25% as per IS code 13311(part II)

Details of Testing:

- The tests were conducted at 10 locations.
 - The average of all the readings is 600.00 Kg/ Sq.cm.
- Please refer the test results attached herewith for details.

4. *Cover meter investigations.*

This test indicates the cover of concrete over the reinforcement. In this case the cover is without the plaster.

Details of Testing:

- The tests were conducted at total 5 locations.
- Several readings of cover meter are in the range of 32 mm to 40 mm.
- Clear cover does not indicate depth beyond 40 mm where test has carried out.
- The average cover of concrete reveals as 36 mm.

Conclusion:

- The test results confirm sufficient cover of concrete provided to the reinforcement at many locations.

Please refer the test results attached herewith for details.

Ammonia condensate structure-

- Structural steel elements of this structure noted with corrosion at some locations. However, severe corrosion and scaling noted on base plate, foundation nut bolts at almost all locations. Please refer typical photographs below.



INFERENCE OF N.D.T. RESULTS

In order to have adequate assessment of the pathological condition of the structure i.e. series of health parameters, series of NDT investigations are carried out. These include number of ultrasonic pulse velocity readings, half cell potentiometer test for corrosion potential, number of concrete chemical analysis, Carbonation, Cover meter and steel thickness test have been carried out. All the NDT findings are enclosed herewith.

1. Steel Thickness Gauge:

This test is performed to acquire the thickness of the Structural steel members, as per actual.

Sr. No.	Locations	Member	Standard Thickness	Thickness Obtained (mm)	% Reduction
	<u>Ammonia Plant</u>	-			
	<u>Condensate Structure Near Compressor House</u>	-			
	<u>Column</u>				
1	Column C4 (300)	ISMB	7.50	7.80	-
2	Column C3 (300)	ISMB	7.50	7.90	-
3	Column C2 (300)	ISMB	7.50	7.80	-
4	Column C1 (300)	ISMB	7.50	7.40	1.33
5	Column B1 (300)	ISMB	7.50	7.40	1.33
6	Column A1 (300)	ISMB	7.50	7.80	-
7	Column A2 (400)	ISMB	8.90	9.00	-
8	Column A3 (400)	ISMB	8.90	9.00	-
9	Column A4 (300)	ISMB	7.50	7.60	-
10	Column B4 (300)	ISMB	7.50	7.90	-
11	Column B3 (400)	ISMB	8.90	7.50	15.73
12	Column B2 (400)	ISMB	8.90	9.10	-
	<u>Cross Bracing</u>				
13	Cross Bracing (60x60x8) C3	ISA	8.00	5.60	30.00
14	Cross Bracing (60x60x8) C2	ISA	8.00	5.70	28.75
15	Cross Bracing (60x60x8) B2	ISA	8.00	7.80	2.50

16	Cross Bracing B1-B3 (60x60x8)	ISA	8.00	6.60	17.50
	Gusset Plate				
17	Gusset Plate (12) C4	GP	12.00	10.20	15.00
18	Gusset Plate (12) C3	GP	12.00	12.80	-
19	Gusset Plate (12) C2	GP	12.00	11.60	3.33
20	Gusset Plate (12) C1	GP	12.00	10.50	12.50
21	Gusset Plate (12) B1	GP	12.00	10.60	11.67
22	Gusset Plate (12) A1	GP	12.00	9.90	17.50
23	Gusset Plate (12) A2	GP	12.00	No Reading	
24	Gusset Plate (12) A3	GP	12.00	9.10	24.17
25	Gusset Plate (12) A4	GP	12.00	9.60	20.00
26	Gusset Plate (12) B4	GP	12.00	10.50	12.50
27	Gusset Plate (12) B3	GP	12.00	11.00	8.33
28	Gusset Plate (12) B2	GP	12.00	10.60	11.67
The percentage of reduction in thickness of ISMB varies from 1.33% to 15.73% with respect to the original thickness.					
The percentage of reduction in thickness of ISA varies from 2.50% to 30.00% with respect to the original thickness.					
The percentage of reduction in thickness of gusset plate varies from 3.33% to 24.17% with respect to the original thickness.					

PIPE RACK BETWEEN TWO AMMONIA TANKS

OBSERVATIONS:-

- Severe corrosion noted in the steel elements like base plate, foundation nut bolts, central gusset plate and cross bracings etc.



- Inadequate connections in the form of cleat angles missing in one side noted at every connection. Please refer typical photographs below.



- Vegetation growth noted at junction of the steel column and RCC pedestal as seen in the photographs below.



- Severe corrosion and scaling noted on the longitudinal and horizontal members of steel beams as seen in the photographs below.



- Corrosion, pitting and scaling noted on the steel members supporting staircase and M.S grating as seen in the photographs below.



RECOMMENDATIONS:

- Localized replacement of the deteriorated steel elements as also further strengthening has to be done and need to be followed for the proposed rehabilitation work. However, the said strengthening work shall be done according to the design.
- Deflection noted in the steel column at a location might be the original construction deficiency however the area needs monitoring for further development; if any.
- The gap between concrete and top finishing layer (in RCC pedestals) shall be finished with suitable grouting as per existing system/method.
- Most of the distresses related to the inadequate connection details need be re-done with providing ideal connection details as can be best designed with improved specifications.
- Few General distresses like Existing corrosion of the steel members shall be removed as per standard method and all the Structural Steel members shall be treated with application of 3 coats of 'SUNPUGUARD' (a high quality Anti corrosive two component Polyurethane coating) or equivalent as per Manufacturer's recommendations. Proper surface preparation of all Structural Steel members shall be done before application of SUNPUGUARD or equivalent, as per manufacturer's recommendations.
- This is the broad assessment of the structural health at this stage.

C.Y.Chandanshive

Mahendra Barde

J. C. Kadam

Project Manager

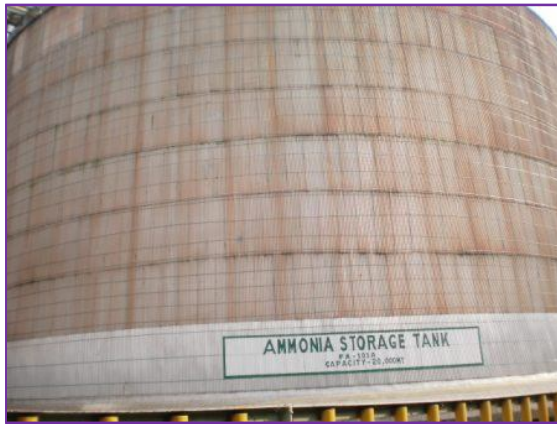
Sr. Associate

Technical Director

4. STAIRCASES OF THE AMMONIA STORAGE TANKS

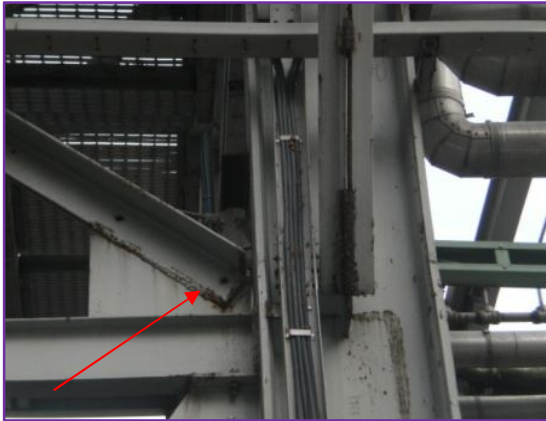
Observations:-

- The staircase near the above said tank reveal distresses like corrosion in all the steel elements like columns, beams, cross – bracings, stringer beams, base plates, gusset plates, foundation nut – bolts etc; inadequate connections in the form of missing cleat angles, missing nut – bolts as also insufficient welding done etc. Please refer typical photographs below.
- [Ammonia tank - 20000 MT \(FA.101A\)-](#)



- Moss growth noted on the RCC pedestal, also corrosion and pitting on vertical steel column noted as shown photographs below.





Scaling and pitting on steel members

Ammonia tank - 10000 MT (FA.101C)-



Corrosion, scaling and pitting



Corrosion, scaling and pitting on weld connection and steel members



Crack on top layer of RCC pedestal / Nut bolt missing and insufficient welding

Ammonia tank - 20000 MT (FA.101B)-

- Staircase seems painted recently hence all the visible distresses are covered.



INFERENCE OF N.D.T. RESULTS

In order to have adequate assessment of the pathological condition of the structure i.e. series of health parameters, series of NDT investigations are carried out. These include number of steel thickness test have been carried out. All the NDT findings are enclosed herewith.

1. Steel Thickness Gauge:

This test is performed to acquire the thickness of the Structural steel members, as per actual.

Sr. No.	Locations	Member	Standard Thickness	Thickness Obtained (mm)	% Reduction
	<u>Ammonia Plant</u>	-			
	<u>Ammonia Tank No.1</u>	-			
	<u>Staircase Ground Floor</u>				
	<u>Columns</u>				
1	Column A1 (400)	ISMB	8.90	8.90	0.00
2	Column A2 (400)	ISMB	8.90	9.00	-
3	Column B1 (400)	ISMB	8.90	9.00	-
4	Column B1 (400)	ISMB	8.90	9.00	-
5	Tie Beam A1-B1 (200)	ISMB	5.70	5.60	1.75
	<u>First Floor</u>				
6	Column A1 (400)	ISMB	8.90	9.10	-
7	Column A2 (400)	ISMB	8.90	8.80	1.12
8	Column B1 (400)	ISMB	8.90	8.90	0.00
9	Column B1 (400)	ISMB	8.90	8.90	0.00
10	Tie Beam A3-B2 (200)	ISMB	5.70	5.90	-
11	Staircase Beam at 1st Flight(250)	ISMC	7.10	5.80	18.31
12	Staircase Beam at 3rd Flight (250)	ISMC	7.10	7.20	-
The percentage of reduction in thickness of web in ISMB varies from 1.12% to 1.75% with respect to the original thickness.					
The percentage of reduction in thickness of web in ISMC varies from 0% to 18.31% with respect to the original thickness.					

	<u>Ammonia Tank No.2</u>				
	<u>Staircase Ground Floor</u>				
13	Column A1 (400)	ISMB	8.90	9.10	-
14	Column A2 (400)	ISMB	8.90	9.10	-
15	Column B1 (400)	ISMB	8.90	9.00	-
16	Column B1 (400)	ISMB	8.90	9.00	-
17	Tie Beam A1-B1 (200)	ISMB	5.70	5.80	-
18	Staircase Beam at 1st Flight (300)	ISMC	7.60	7.80	-
	<u>First Floor</u>				
19	Column A1 (400)	ISMB	8.90	9.00	-
20	Column A2 (400)	ISMB	8.90	9.10	-
21	Column B1 (400)	ISMB	8.90	9.10	-
22	Column B1 (400)	ISMB	8.90	9.10	-
23	Tie Beam A2-B2 (200)	ISMB	5.70	5.80	-
24	Staircase Beam at 3rd Flight (300)	ISMC	7.60	7.80	-
	<u>Ammonia Tank No.3</u>				
	<u>Staircase Ground Floor</u>				
25	Column A1 (450)	ISMB	9.40	9.60	-
26	Column B1 (450)	ISMB	9.40	9.50	-
27	Column A2 (450)	ISMB	9.40	9.50	-
28	Column B2 (450)	ISMB	9.40	9.40	0.00
29	Stranger Beam (200)	ISMC	6.10	6.20	-
	<u>First Floor</u>				
30	Column A1 (450)	ISMB	9.40	9.50	-
31	Column B1 (450)	ISMB	9.40	9.20	2.13
32	Column A2 (450)	ISMB	9.40	9.50	-
33	Column B2 (450)	ISMB	9.40	9.50	-
34	Stranger Beam (250)	ISMC	7.10	6.90	2.82
The percentage of reduction in thickness of web in ISMB varies from 0% to 2.13% with respect to the original thickness.					
The percentage of reduction in thickness of web in ISMC varies from 0% to 2.82% with respect to the original thickness.					

RECOMMENDATIONS:

- Localized replacement of the deteriorated steel elements as also further strengthening has to be done and need to be followed for the proposed rehabilitation work. However, the said strengthening work shall be done according to the design.
- The gap between concrete and top finishing layer (in RCC pedestals) shall be finished with suitable grouting as per existing system/method.
- Most of the distresses related to the inadequate connection details need be re-done with providing ideal connection details as can be best designed with improved specifications.
- Few General distresses like Existing corrosion of the steel members shall be removed as per standard method and all the Structural Steel members shall be treated with application of 3 coats of 'SUNPUGUARD' (a high quality Anti corrosive two component Polyurethane coating) or equivalent as per Manufacturer's recommendations. Proper surface preparation of all Structural Steel members shall be done before application of SUNPUGUARD or equivalent, as per manufacturer's recommendations.
- This is the broad assessment of the structural health at this stage.

C.Y.Chandanshive

Mahendra Barde

J. C. Kadam

Project Manager

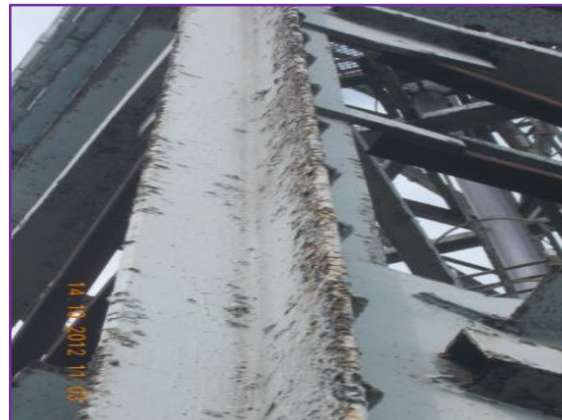
Sr. Associate

Technical Director

5. FLARE STACK STRUCTURE

Observations:-

- The main members of steel framing system i.e. steel columns, tie beams, cross bracings etc. noted with corrosion, scaling and pitting at many locations as shown in the photographs below.





- Nut bolts missing noted on cross bracings and horizontal members at many locations as shown in the typical photographs below.



- Structural framing system noted updated in the form of removal of damaged cross bracings and replaced with new member, at some locations as shown in the typical photographs below.



- Vegetation growth, moss growth and crack on top finishing layer noted in the RCC pedestals. Also scaling and pitting on base plate, side gusset plate and vertical steel members noted as shown in the photographs below.





Crack on top layer

INFERENCE OF N.D.T. RESULTS

In order to have adequate assessment of the pathological condition of the structure i.e. series of health parameters, series of NDT investigations are carried out. These include number of ultrasonic pulse velocity readings, Cover meter and steel thickness test have been carried out. All the NDT findings are enclosed herewith.

1. Steel Thickness Gauge:

This test is performed to acquire the thickness of the Structural steel members, as per actual.

Sr. No.	Locations	Member	Standard Thickness	Thickness Obtained (mm)	% Reduction
	<u>Ammonia Plant</u>	-			
	<u>Ammonia Flare Stack</u>	-			
	<u>Columns</u>				
	<u>Column C3</u>				
1	Vertical Member (150x150x12)	ISA	12.00	10.30	14.17
2	Cross Bracing C3-C4 (150x150x12)	ISA	12.00	9.70	19.17
3	Cross Bracing C3-C1 (150x150x12)	ISA	12.00	10.20	15.00
4	Gusset Plate (20mm)	GP	20.00	19.30	3.50
5	Junction of G P & Cross bracing(20+150x150x12)	ISA	12.00	21.80	-
6	Base Plate (30mm)	MS Plate	30.00	28.20	6.00
	<u>Column C1</u>				
7	Vertical Member (150x150x12)	ISA	12.00	11.80	1.67
8	Cross Bracing C1-C2 (150x150x12)	ISA	12.00	9.20	23.33
9	Cross Bracing C1-C3 (150x150x12)	ISA	12.00	9.80	18.33
10	Gusset Plate (20mm)	GP	20.00	13.80	31.00
11	Junction of G P & Cross bracing(20+150x150x12)	ISA	12.00	13.40	-
12	Base Plate (30mm)	MS Plate	30.00	No Reading	-

Column C4					
13	Vertical Member (150x150x18)	ISA	18.00	17.80	1.11
14	Cross Bracing C4-C3 (150x150x18)	ISA	18.00	12.80	28.89
15	Cross Bracing C4-C2 (150x150x18)	ISA	18.00	13.70	23.89
16	Gusset Plate (20mm)	GP	20.00	19.80	1.00
17	Junction of G P (20+150x150x12)	ISA	12.00	11.80	1.67
18	Base Plate (30mm)	MS Plate	30.00	25.80	14.00
Column C2					
19	Vertical Member (150x150x18)	ISA	18.00	15.90	11.67
20	Cross Bracing (150x150x18)	ISA	18.00	11.30	37.22
21	Cross Bracing (150x150x18)	ISA	18.00	14.50	19.44
22	Gusset Plate (20mm)	GP	20.00	19.80	1.00
23	Junction of G P (20+150x150x12)	ISA	12.00	10.80	10.00
24	Base Plate (30mm)	MS Plate	30.00	26.10	13.00
The percentage of reduction in thickness of ISA varies from 1.11% to 37.22% with respect to the original thickness.					
The percentage of reduction in thickness of gusset plate varies from 1.00% to 31.00% with respect to the original thickness.					
The percentage of reduction in thickness of base plate varies from 6.00% to 14.00% with respect to the original thickness.					

2. Ultrasonic Pulse Velocity Test :- (IS 13311 - Part I)

This instrument works on the principle of passing high frequency sound waves through the body of the concrete & measuring the time taken. Distance of path length divided by the time taken provides velocity of the waves through the concrete member being tested.

Depending on the velocity, the quality of concrete as regards homogeneity can be judged. Lower velocity (less than 3 Km / sec) indicates some defects like honey combing, cracks, voids, rebounding etc. at the location of test.

The concrete surface is thoroughly cleaned & dried. The instrument is calibrated before taking readings. Coupling medium such as grease is applied to the probes, and reading is taken for the pulse velocity at the location. Appropriate correction factors are applied, wherever desired, for the presence of steel.

The USPV readings around 3 Km/sec and above indicate fair quality concrete whereas readings below 2 Km / sec indicate localized weakness at that particular zone.

As per IS, velocity below 3.00 Km / sec indicates 'Doubtful' quality concrete, velocity between 3.00 to 3.50 Km / sec indicates 'Medium' quality concrete and velocity above 3.50 Km / sec indicates 'Good' quality concrete. And velocity 4.50 Km / sec indicate 'Excellent' quality concrete. From the above parameters we can judge the quality of concrete.

Details of Testing:

- The tests were conducted at total 4 locations.
- Maximum reading obtained as 4.86 km/sec at Pedestal C2.
- Minimum reading obtained as 4.01 km/sec at pedestal C4.
- Average reading obtained as 4.48 km/sec, which indicates good quality of concrete.

Conclusion:

The test results indicate good quality concrete at most of the locations.

Please refer the test results attached herewith for details.

3. Schmidt Rebound Hammer (IS 13311 Part II)

Total 16 impact readings were taken at each location and average of middle ten was calculated after discarding the top three and bottom three readings. In this manner, total no. of points was tested on the selected concrete members.

The probable accuracy of prediction of concrete strength by the rebound hammer is + 25% as per IS code 13311(part II)

Details of Testing:

- The tests were conducted at 4 locations.
 - The average of all the readings is 400.00 Kg/ Sq.cm.
- Please refer the test results attached herewith for details.

4. Cover meter investigations.

This test indicates the cover of concrete over the reinforcement. In this case the cover is without the plaster.

Details of Testing:

- The tests were conducted at total 4 locations.
- Several readings of cover meter are in the range of 55 mm to 64mm.
- Clear cover does not indicate depth beyond 64 mm where test has carried out.
- The average cover of concrete reveals as 59.50 mm.

Conclusion:

- The test results confirm sufficient cover of concrete provided to the reinforcement at many locations.

Please refer the test results attached herewith for details.

Recommendations / Conclusion:-

- Localized replacement of the deteriorated steel elements as also further strengthening has to be done and need to be followed for the proposed rehabilitation work. However, the said strengthening work shall be done according to the design.
- The gap between concrete and top finishing layer (in RCC pedestals) shall be finished with suitable grouting as per existing system/method.
- Most of the distresses related to the inadequate connection details need be re-done with providing ideal connection details as can be best designed with improved specifications.
- Few General distresses like Existing corrosion of the steel members shall be removed as per standard method and all the Structural Steel members shall be treated with application of 3 coats of 'SUNPUGUARD' (a high quality Anti corrosive two component Polyurethane coating) or equivalent as per Manufacturer's recommendations. Proper surface preparation of all Structural Steel members shall be done before application of SUNPUGUARD or equivalent, as per manufacturer's recommendations.
- This is the broad assessment of the structural health at this stage.

C.Y.Chandanshive

Mahendra Barde

J. C. Kadam

Project Manager

Sr. Associate

Technical Director

6. FLARE STACK PIPE RACK STRUCTURE

Observations:-

- Severe corrosion, scaling and pitting noted in the base plate, stiffener plate and steel column at some locations as shown in the photographs below.



- Weld joint opened out noted on the cross bracings at few locations due to severe corrosion and scaling as shown in the photographs below.



- Corrosion noted in the steel elements like longitudinal, horizontal, vertical members of the supporting system of pipes at many locations as shown in the typical photographs below.



- Inadequate connections noted in the form of longitudinal members did not reached to steel columns properly as seen in the typical photograph below.



- RCC pedestals provided to support the steel framing system of pipe rack noted with distresses like exposed reinforcement (actually it is original construction defect i.e. reinforcement laid without sufficient cover of concrete), localized bulging of cover concrete & cracks due to corrosion of reinforcement, moss growth and cracks in the top finishing layer etc. as shown in the photographs below.





INFERENCE OF N.D.T. RESULTS

In order to have adequate assessment of the pathological condition of the structure i.e. series of health parameters, series of NDT investigations are carried out. These include number of ultrasonic pulse velocity readings; Cover meter and steel thickness test have been carried out. All the NDT findings are enclosed herewith.

1. Steel Thickness Gauge:

This test is performed to acquire the thickness of the Structural steel members, as per actual.

Sr.	Locations	Member	Standard	Thickness Obtained	% Reduction
No.	-	-	Thickness	(mm)	
	<u>Ammonia Plant</u>	-			
	<u>Piper rack Near Flare Stack</u>	-			
	<u>Columns</u>				
1	Column A2 (350)	ISMB	8.10	6.80	16.05
2	Column B3 (350)	ISMB	8.10	6.90	14.81
3	Column A5 (350)	ISMB	8.10	5.50	32.10
4	Column B5 (350)	ISMB	8.10	7.20	11.11
5	Column A7 (250)	ISMB	6.90	6.90	0.00
6	Column B7 (250)	ISMB	6.90	7.00	-
7	Column A6 (250)	ISMB	6.90	7.20	-
8	Column A7 (250)	ISMB	6.90	5.50	20.29
9	Column A9 (250)	ISMB	6.90	7.20	-
10	Column B9 (250)	ISMB	6.90	7.10	-
11	Column A11 (250)	ISMB	6.90	7.10	-
12	Column B11 (250)	ISMB	6.90	7.20	-
13	Column A13 (250)	ISMB	6.90	7.20	-
14	Column B13 (250)	ISMB	6.90	7.30	-
15	Column A15 (250)	ISMB	6.90	6.90	0.00
16	Column B15 (250)	ISMB	6.90	6.50	5.80
17	Column A18 (250)	ISMB	6.90	6.90	0.00
18	Column B18 (250)	ISMB	6.90	7.00	-

19	Column A19 (250)	ISMB	6.90	6.80	1.45
20	Column B19 (250)	ISMB	6.90	7.00	-
21	Column A21 (250)	ISMB	6.90	7.00	-
22	Column B21 (250)	ISMB	6.90	6.80	1.45
23	Column A20 (250)	ISMB	6.90	7.40	-
24	Column B20 (250)	ISMB	6.90	7.00	-
25	Column A22 (250)	ISMB	6.90	6.90	0.00
26	Column B22 (250)	ISMB	6.90	7.10	-
	Cross Bracing				
27	Cross Bracing (75x75x8) A2	ISA	8.00	7.30	8.75
28	Cross Bracing (705x75x8) A5	ISA	8.00	7.50	6.25
29	Cross Bracing (150) B7	ISMC	5.00	5.00	0.00
30	Bracing (65x65x8) A19	ISA	8.00	5.60	30.00
31	Bracing (65x65x8) B22	ISA	8.00	7.80	2.50
The percentage of reduction in thickness of ISMB varies from 1.45% to 32.10% with respect to the original thickness.					
The percentage of reduction in thickness of ISA varies from 2.50% to 8.75% with respect to the original thickness.					

2. Ultrasonic Pulse Velocity Test :- (IS 13311 - Part I)

This instrument works on the principle of passing high frequency sound waves through the body of the concrete & measuring the time taken. Distance of path length divided by the time taken provides velocity of the waves through the concrete member being tested.

Depending on the velocity, the quality of concrete as regards homogeneity can be judged. Lower velocity (less than 3 Km / sec) indicates some defects like honey combing, cracks, voids, rebounding etc. at the location of test.

The concrete surface is thoroughly cleaned & dried. The instrument is calibrated before taking readings. Coupling medium such as grease is applied to the probes, and reading is taken for the pulse velocity at the location. Appropriate correction factors are applied, wherever desired, for the presence of steel.

The USPV readings around 3 Km/sec and above indicate fair quality concrete whereas readings below 2 Km / sec indicate localized weakness at that particular zone.

As per IS, velocity below 3.00 Km / sec indicates 'Doubtful' quality concrete, velocity between 3.00 to 3.50 Km / sec indicates 'Medium' quality concrete and velocity above 3.50 Km / sec indicates 'Good' quality concrete. And velocity 4.50 Km / sec indicate 'Excellent' quality concrete. From the above parameters we can judge the quality of concrete.

Details of Testing:

- The tests were conducted at total 10 locations.
- Maximum reading obtained as 4.68 km/sec at Pedestal A9.
- Minimum reading obtained as 4.25 km/sec at pedestal A6.
- Average reading obtained as 4.44 km/sec, which indicates good quality of concrete.

Conclusion:

The test results indicate good quality concrete at most of the locations.

Please refer the test results attached herewith for details.

3. *Schmidt Rebound Hammer (IS 13311 Part II)*

Total 16 impact readings were taken at each location and average of middle ten was calculated after discarding the top three and bottom three readings. In this manner, total no. of points was tested on the selected concrete members.

The probable accuracy of prediction of concrete strength by the rebound hammer is + 25% as per IS code 13311(part II)

Details of Testing:

- The tests were conducted at 10 locations.
 - The average of all the readings is 439.00 Kg/ Sq.cm.
- Please refer the test results attached herewith for details.

4. *Cover meter investigations.*

This test indicates the cover of concrete over the reinforcement. In this case the cover is without the plaster.

Details of Testing:

- The tests were conducted at total 10 locations.
- Several readings of cover meter are in the range of 49 mm to 67mm.
- Clear cover does not indicate depth beyond 67 mm where test has carried out.
- The average cover of concrete reveals as 58.00 mm.

Conclusion:

- The test results confirm sufficient cover of concrete provided to the reinforcement at many locations.

Please refer the test results attached herewith for details.

Recommendations / Conclusion:-

R.C.C. Members -

Corrosion related damages (in the RCC members) shall be rectified with the use of 'Polymer Modified Mortar' as per standard methodology as follows -

➤ 1. Cracks due to corrosion of steel reinforcement in RCC members

- Expose the cracked / spalled elements completely. Use long sharp chisels of about 16-20 mm diameter and hammers upto 2 lbs weight. Remove the complete corrosion of reinforcement with wire brushes (preferably mechanical type). Remove all the loose and damaged concrete particles till sound concrete of uniform texture is visible. Apply rust removers like 'Rusticide SS' or equivalent to the reinforcement to remove the traces of rust. Clean the reinforcement once again with the wire brush. Wash the complete concrete surface including the reinforcement to remove the traces of rust remover. Apply a coat of rust passivator like 'Polyalk Fixoprime and cement' or equivalent as per the recommendations of the manufacturers. The concrete surface treated for corrosion shall be patch repaired with Polymer Modified Mortar like 'Polyalk EP' or any other equivalent as per the manufacturer's recommendations.

➤ Exposed steel reinforcement

- Follow methodology to treat exposed reinforcement as per recommendation mentioned in corrosion cracks in R.C.C members with replacement of snapped steel with new steel

reinforcement of similar diameter, as per requirement as per existing design.

➤ **Hollow sound in RCC member**

- Break open the loose and damaged concrete, till the uniform and solid stage of concrete is witnessed.
- Give Polymer Mortar Treatment to this area as per recommendation mentioned for crack due to corrosion of reinforcement in R.C.C members.
- Grout the weak concrete areas with cement and non shrink additives or with low viscous epoxy.

➤ **Honey Combing / Cracks:-**

- These areas shall be grouted with cement grouting with addition of non shrinking additives.
- Aluminum / PVC multiperforated nipples may be used to carry out the injection operation.
- The pressure of 1.00 to 1.5 kg per sq cm may be applied for grouting.
- Care should be taken to remove trapped air inside the crack / honey combing areas to avoid back pressure.

➤ **Spalling of Concrete: -**

- This area shall be rectified by the process as explained earlier i.e. in recommendation no.1

➤ **Moss Growth**

- Wherever the moss growth has been observed check that area for any hollow sound in the plaster.
- Remove and redo the damaged plaster and protect the surface with good quality paint.

➤ **Vegetation Growth**

- Cut the vegetation by its root.
- Treat the root area with “weedycide” as per the manufacturer’s specification.
- Treat surrounding area as per requirement with normal procedures.

➤ The gap between concrete and top finishing layer (in RCC pedestals) shall be finished with suitable grouting as per existing system/method.

➤ **Grout the area with low viscous epoxy injections of reputed manufacturers, as per specification, for cracks and weak concrete areas to make the area itself watertight.**

• **Structural Steel Members -**

➤ Localized replacement of the deteriorated steel elements as also further strengthening has to be done and need to be followed for the proposed rehabilitation work. However, the said strengthening work shall be done according to the design.

➤ Most of the distresses related to the inadequate connection details need be re-done with providing ideal connection details as can be best designed with improved specifications.

➤ Few General distresses like Existing corrosion of the steel members shall be removed as per standard method and all the Structural Steel members shall be treated with application of 3 coats of 'SUNPUGUARD' (a high quality Anti corrosive two component Polyurethane coating) or equivalent as per Manufacturer's recommendations. Proper surface preparation of all Structural Steel members shall be done before application of SUNPUGUARD or equivalent, as per manufacturer's recommendations.

➤ This is the broad assessment of the structural health at this stage.

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**7. AMMONIA COOLING TOWER
AND
STEEL STRUCTURES**

Observations:-

- Moss growth on entire structure, vegetation growth, crack / gap between RCC wall and slab noted as seen the photographs below. Also, note corrosion in the steel elements of staircase.



Moss growth and corrosion in steel elements of staircase



Moss growth, vegetation growth and crack/gap between RCC wall & slab

- Bulging of concrete noted at some locations especially at the construction joints/subsequent concrete pours as seen in the photographs below.



- RCC abutments /columns noted physically cut as seen in the photographs below so as to accommodate process pipe.



- Water logging noted on top level of cooling tower also moss growth, vegetation growth and fungus noted at surrounding pump foundation as shown in the photographs below.



- Severe corrosion, scaling and pitting noted in the steel elements of staircase as shown in the photographs below.



INFERENCE OF N.D.T. RESULTS for AMMONIA COOLING TOWER:

In order to have adequate assessment of the pathological condition of the structure i.e. series of health parameters, series of NDT investigations are carried out. These include number of ultrasonic pulse velocity readings, Cover meter test have been carried out. All the NDT findings are enclosed herewith.

1. Steel Thickness Gauge:

This test is performed to acquire the thickness of the Structural steel members, as per actual.

Sr.	Locations	Member	Standard	Thickness Obtained	% Reduction
No.	-	-	Thickness	(mm)	
	<u>Ammonia Plant</u>	-			
	<u>Ammonia Cooling Tower</u>	-			
	<u>Staircase on West Side</u>				
1	Staircase Beam 1(250)	ISMC	7.10	6.80	4.23
2	Staircase Beam 2(250)	ISMC	7.10	7.10	0.00
	<u>Staircase on North Side</u>				
3	Staircase Beam 1(250)	ISMC	7.10	6.40	9.86
4	Staircase Beam 2(250)	ISMC	7.10	6.90	2.82

The percentage of reduction in thickness of ISMC varies from 2.82% to 9.86% with respect to the original thickness.

2. Ultrasonic Pulse Velocity Test :- (IS 13311 - Part I)

This instrument works on the principle of passing high frequency sound waves through the body of the concrete & measuring the time taken. Distance of path length divided by the time taken provides velocity of the waves through the concrete member being tested.

Depending on the velocity, the quality of concrete as regards homogeneity can be judged. Lower velocity (less than 3 Km / sec) indicates some defects like honey combing, cracks, voids, rebounding etc. at the location of test.

The concrete surface is thoroughly cleaned & dried. The instrument is calibrated before taking readings. Coupling medium such as grease is applied to the probes, and reading is taken for the pulse velocity at the location. Appropriate correction factors are applied, wherever desired, for the presence of steel.

The USPV readings around 3 Km/sec and above indicate fair quality concrete whereas readings below 2 Km / sec indicate localized weakness at that particular zone.

As per IS, velocity below 3.00 Km / sec indicates 'Doubtful' quality concrete, velocity between 3.00 to 3.50 Km / sec indicates 'Medium' quality concrete and velocity above 3.50 Km / sec indicates 'Good' quality concrete. And velocity 4.50 Km / sec indicate 'Excellent' quality concrete. From the above parameters we can judge the quality of concrete.

Details of Testing:

- The tests were conducted at total 60 locations.
- Maximum reading obtained as 5.65 km/sec at north side.
- Minimum reading obtained as 2.90 km/sec at east side.
- Average reading obtained as 3.84 km/sec, which indicates good quality of concrete.

Conclusion:

The test results indicate good quality concrete at most of the locations.

Please refer the test results attached herewith for details.

3. *Schmidt Rebound Hammer (IS 13311 Part II)*

Total 16 impact readings were taken at each location and average of middle ten was calculated after discarding the top three and bottom three readings. In this manner, total no. of points was tested on the selected concrete members.

The probable accuracy of prediction of concrete strength by the rebound hammer is + 25% as per IS code 13311(part II)

Details of Testing:

- The tests were conducted at 20 locations.
- The average of all the readings is 506.83 Kg/ Sq.cm.

Please refer the test results attached herewith for details.

4. Cover meter investigations.

This test indicates the cover of concrete over the reinforcement. In this case the cover is without the plaster.

Details of Testing:

- The tests were conducted at total 14 locations.
- Several readings of cover meter are in the range of 54 mm to 64mm.
- Clear cover does not indicate depth beyond 64 mm where test has carried out.
- The average cover of concrete reveals as 58 mm.

Conclusion:

- The test results confirm sufficient cover of concrete provided to the reinforcement at many locations.

Please refer the test results attached herewith for details.

STEEL STRUCTURES-

AIR RECEIVER TANK-

- Severe corrosion, scaling and pitting noted on the structural steel column, base plate and foundation nut bolts of air receiver tank near the ammonia cooling tower. Also, two vertical columns directly rest on steel plate without any fixtures as shown in the photographs below.



Severe corrosion and scaling on base plate and nut bolts / vertical steel column directly rest on steel plate.

PIPE RACK-

- Severe corrosion, scaling and pitting noted on the structural steel column, base plate; horizontal and vertical steel members etc. as shown in the photographs below.



STEEL STRUCTURE NEAR THE AIR RECEIVER TANK-

- Structure seems recently painted hence visible distresses are covered.



INFERENCE OF N.D.T. RESULTS

In order to have adequate assessment of the pathological condition of the structure i.e. series of health parameters, series of NDT investigations are carried out. These include number of steel thickness test have been carried out. All the NDT findings are enclosed herewith.

1. Steel Thickness Gauge:

This test is performed to acquire the thickness of the Structural steel members, as per actual.

Sr.	Locations	Member	Standard	Thickness Obtained	% Reduction
No.	-	-	Thickness	(mm)	
	<u>Ammonia Plant</u>	-			
	<u>Ammonia Shed Near Cooling Tower</u>	-			
	<u>Columns</u>				
1	Column A1 (250)	ISMB	6.90	7.30	-
2	Column A2 (250)	ISMB	6.90	7.50	-
3	Column A3 (250)	ISMB	6.90	7.60	-
4	Column B1 (250)	ISMB	6.90	7.00	-
5	Column B2 (250)	ISMB	6.90	7.40	-
6	Column B3 (250)	ISMB	6.90	7.30	-

Recommendations / Conclusion:-

R.C.C. Members -

Corrosion related damages (in the RCC members) shall be rectified with the use of 'Polymer Modified Mortar' as per standard methodology as follows -

➤ 1. Cracks due to corrosion of steel reinforcement in RCC members

- Expose the cracked / spalled elements completely. Use long sharp chisels of about 16-20 mm diameter and hammers upto 2 lbs weight. Remove the complete corrosion of reinforcement with wire brushes (preferably mechanical type). Remove all the loose and damaged concrete particles till sound concrete of uniform texture is visible. Apply rust removers like 'Rusticide SS' or equivalent to the reinforcement to remove the traces of rust. Clean the reinforcement once again with the wire brush. Wash the complete concrete surface including the reinforcement to remove the traces of rust remover. Apply a coat of rust passivator like 'Polyalk Fixoprime and cement' or equivalent as per the recommendations of the manufacturers. The concrete surface treated for corrosion shall be patch repaired with Polymer Modified Mortar like 'Polyalk EP' or any other equivalent as per the manufacturer's recommendations.

➤ Exposed steel reinforcement

- Follow methodology to treat exposed reinforcement as per recommendation mentioned in corrosion cracks in R.C.C members with replacement of snapped steel with new steel

reinforcement of similar diameter, as per requirement as per existing design.

➤ **Hollow sound in RCC member**

- Break open the loose and damaged concrete, till the uniform and solid stage of concrete is witnessed.
- Give Polymer Mortar Treatment to this area as per recommendation mentioned for crack due to corrosion of reinforcement in R.C.C members.
- Grout the weak concrete areas with cement and non shrink additives or with low viscous epoxy.

➤ **Honey Combing / Cracks:-**

- These areas shall be grouted with cement grouting with addition of non shrinking additives.
- Aluminum / PVC multiperforated nipples may be used to carry out the injection operation.
- The pressure of 1.00 to 1.5 kg per sq cm may be applied for grouting.
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