INSPECTION REPORT

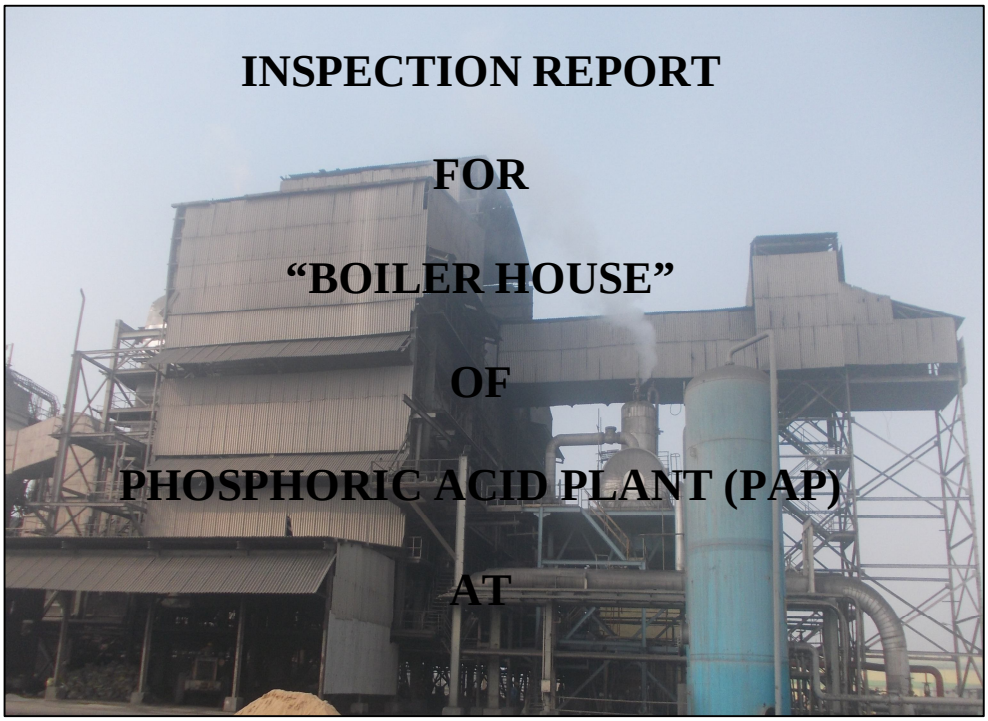
FOR

"BOILER HOUSE"

OF

PHOSPHORIC ACID PLANT (PAP)

AT



INDIAN FARMERS FERTILISER COOPERATIVE LTD, PARADEEP, ORISSA

March– 2013

STRUCTWEL DESIGNERS & CONSULTANTS PVT. LTD.

Structwel, Plot No. 15, Sector 24,
Off Sion Panvel Highway, Turbhe,
Navi Mumbai – 400 705.

Tel. : 91-22-2784 10 10 (7 Lines) Fax : 91-22-2784 10 07
Email : structwel@vsnl.net Web :http://www.structwel.com

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IFFCO/ SDCPL /2013/2731

25nd March 2013.

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

INSPECTION REPORT

For

Condition Assessment

For

"BOILER HOUSE"

Of

A F B C BOILER PLANT

At

Paradeep, Orissa.

History / Background of the structure:

1. The structure under reference i.e. “BOILER HOUSE” situated in AFBC boiler plant at Indian Farmers Fertilizers Cooperative Ltd. (IFFCO) Paradeep, Orissa.
2. The structure consists of Steel Columns and Steel Beams having steel plate and M.S. gratings platforms at desired levels as per requirement.
3. The entire height of the structure is 33.68 m subdivided in ground + 5 floor levels i.e. 3.35, 3.60, 6.65, 7.90, 9.05, 12.15, 14.75, 18.00 and 33.68m level, respectively, as per requirement. Besides, Tie beams have also been provided as per requirement.
4. All steel Columns rest on R.C.C. foundations connected with base plates & anchor bolts. However, the said steel Columns are further encased with R.C.C. for the area above the said foundations.

5. East and west side structures are in the form of shade used to store raw material. Columns of the shade have been constructed with new RCC pedestals. Some steel columns noted bent due to hit of vehicles.

Observations:-

Structural Audit is an important technical requirement for any structure and has series of parameters to be adequately investigated and assuredly complied with.

During this exercise the structure was inspected thoroughly on several occasions by us to record, verify, and study the modifications/additions made if any, to observe distresses, level of malfunctioning and corrosion levels in structural steel members.

In the period of last approximately 12 years of its existence, various defects developed in the said structures, mainly as follows –

General Observations:

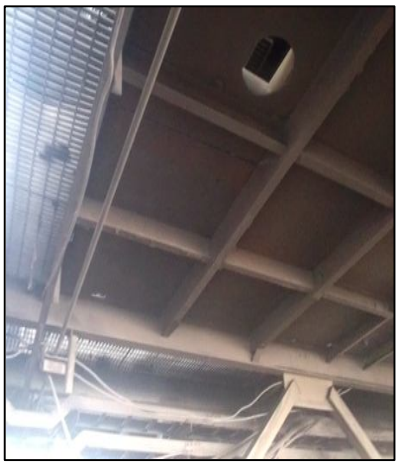
- The foundation are encased with RCC pedestal; noted with honey combing and deposition of raw material

  Please refer photograph below.

At Ground floor

- Structural platform noted with minor to severe corrosion, also noted localized missing of welding and cleat angle. Holes were made in the platform as per the process requirement.

  Please refer photograph below.



At 3.35 level

- Severe corrosion noted at localized area.

  Please refer typical photographs below.

At 3.35 and 3.60 level

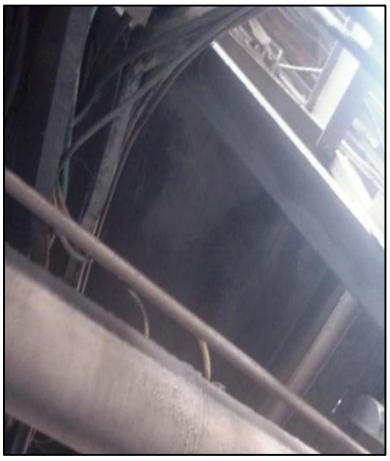
- M.S bracings have been provided at ground level as per requirement.

  Please refer typical photographs below.

At 3.35 level

- Severe corrosion scaling, rusting and peeling/delamination of protective paint noted in structural framing system.

  Please refer photograph below.



- Severe corrosion scaling, rusting and peeling/delamination of protective paint noted gusset plate and structural system. Also noted localized missing of cleat and seat angle.

  Please refer photograph below.

At 7.90 level

- Existing structural framing system noted with severe corrosion in ms platform and localized missing of seat and cleat angles.

  Please refer photograph below.

At 9.05 level

- Inadequate connection of main beam and secondary beams.

  Please refer photograph below.

At 9.05 level

- M S plate provided to cover the passage noted with severs scaling, rusting, peeling of existing paint.

  Please refer photograph below.

At 12.15 level

- As a matter of critical observation; upheaval noted in M S grating platform/walkway.

  Please refer photograph below.

At 14.75 level

- Damaged cladding at top level noted with severe corrosion and peeling of paint.

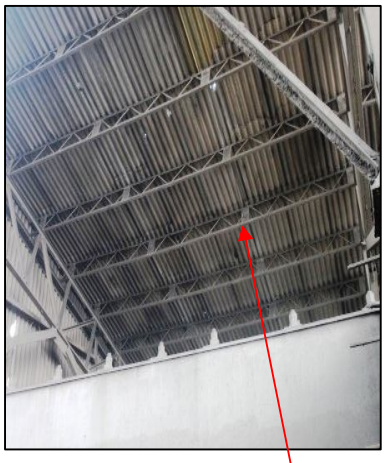
  Please refer photograph below.

At 33.68 level

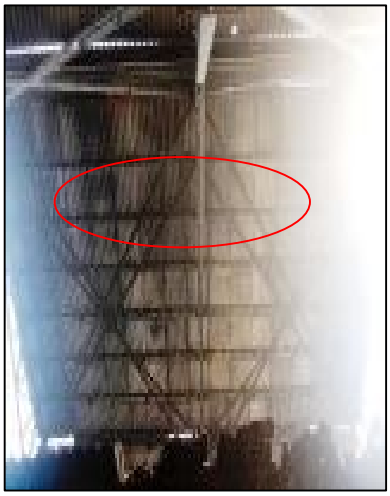
At 33.68 level

- Roofing structural supporting members noted with severe corrosion and bent at some location.

  Please refer photograph below.



At 33.68 level



Roofing level

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 mainly include number of Steel thickness tests which have been carried out for checking the actual thickness of steel members.

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.

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
	AFBC Boiler Plant				
	AFBC Boiler Building				
	Column				
1	Column A1 (350)	ISMB	8.10	8.10	0.00
2	Column B1 (350)	ISMB	8.10	8.20	-
3	Column C1 (350)	ISMB	8.10	8.20	-
4	Column A2 (400)	ISMC	8.60	8.00	6.98
5	Column A3 (400)	ISMC	8.60	8.30	3.49
6	Column A6 (400)	ISMC	8.60	8.60	0.00
7	Column A7 (400)	ISMC	8.60	8.60	0.00
8	Column A8 (400)	ISMC	8.60	8.70	-
9	Column A9 (400)	ISMC	8.60	8.80	-
10	Column B9 (350)	ISMC	8.10	7.80	3.70

11	Column C9 (350)	ISMC	8.10	8.10	0.00
12	Column D9 (350)	ISMC	8.10	8.40	-
13	Column D6 (600) W	ISMB	12.00	8.40	30.00
14	Column D6 (600) F	ISMB	12.00	12.00	0.00
15	Cross Bracing A2-A3 (150)	ISMC	5.40	5.00	7.41
The percentage of reduction in the thickness of cross bracing varies from 3.49 to 7.41% with respect to the original thickness.					
	First Floor				
16	Column A8 (400)	ISMC	8.60	8.60	0.00
17	Column A7 (400)	ISMC	8.60	8.50	1.16
18	Column A6 (400)	ISMC	8.60	8.90	-
19	Column A5 (400)	ISMC	8.60	8.50	1.16
20	Column A4 (600)	ISMB	12.00	12.00	0.00
21	Column B4 (600)	ISMB	12.00	11.60	3.33
22	Column B5 (600)	ISMB	12.00	11.00	8.33
23	Column B3 (600)	ISMB	12.00	11.40	5.00
24	Column B2 (400)	ISMC	8.60	8.50	1.16
25	Column A1 (350)	ISMB	8.10	8.20	-
	Second Floor				
25	Column A1 (350)	ISMB	8.10	8.2	-
26	Column A2 (400)	ISMC	8.60	8.30	3.49
27	Column B2 (750)	ISMC	15.00	13.20	12.00
28	Column C2 (650)	ISMC	14.00	10.50	25.00
29	Column A3 (400)	ISMC	8.60	8.70	-
30	Column C3 (400)	ISMC	8.60	8.80	-
	Third Floor				
30	Column A4 (400)	ISMC	8.60	8.7	-
31	Column B3 (650)	ISMC	14.00	12.80	8.57
32	Column A7 (400)	ISMC	8.60	8.8	-
33	Column B7 (650)	ISMC	14.00	12.30	12.14
34	Column C7 (650)	ISMC	14.00	12.3	12.14
35	Column A8 (400)	ISMC	8.60	8.80	-
36	Column A9 (350)	ISMB	8.10	8.2	-
37	Column B8 (650)	ISMC	14.00	12.20	12.86
38	Column C8 (650)	ISMC	14.00	10.3	26.43
39	Column C9 (350)	ISMB	8.10	6.60	18.52
40	Column C7 (650)	ISMC	14.00	12.60	10.00
	Fourth Floor				
41	Column D7 (350)	ISMB	8.10	8.2	-
42	Column C7 (650)	ISMC	14.00	10.00	28.57
43	Column A7 (400)	ISMC	8.60	8.00	6.98
44	Column D8 (650)	ISMC	14.00	3.00	78.57
45	Column D8 (350)	ISMB	8.10	8.30	-
	Fifth Floor				
46	Column A7 (400)	ISMC	8.60	8.7	-

47	Column B7 (650)	ISMC	14.00	12	14.29
48	Column C7 (650)	ISMC	14.00	12.4	11.43
49	Column A9 (350)	ISMB	8.10	8.3	-
50	Column A3 (400)	ISMC	8.60	8.1	5.81
51	Column A2 (400)	ISMC	8.60	8.5	1.16
52	Column A1 (350)	ISMB	8.10	8.3	-
53	Column B3 (650)	ISMC	14.00	12.6	10.00
54	Column B2 (650)	ISMC	14.00	12.7	9.29

The percentage of reduction in the thickness of columns varies from 3.49% to 78.57% 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 8 locations on R.C.C pedestal
- Maximum reading obtained as 4.61 km/sec at pedestal no. A1.
- Minimum reading obtained as 1.76 km/sec at pedestal no. B8.
- Average reading obtained as 3.46 km/sec, which indicates medium quality of concrete.

Conclusion:

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

Please refer the test results attached herewith for details.

3. Half Cell Potentiometer (ASTMC- 876-80)

Half Cell Potentiometer works on the principle of measuring milli-voltage in the circuit of reinforcement & cover concrete using copper sulphate half cell.

This test measures corrosion potential of the embedded steel in concrete with half cell (Cu/CuSo4). This method essentially consists of measurement of the absolute potential at the concrete surface with reference to an electrode. It is necessary to have direct electrical connections to the embedded steel. The measured absolute potential with reference to the referred electrode is considered to be the best criterion for assessing the corrosion status of the embedded steel rods. The test is fairly indicative of corrosion response at present and of the future.

The negative terminal of the voltmeter is connected directly to a protruding end of embedded steel by means of a “crocodile clamp”. The digital handheld operated mile-voltmeter will show the potential measurements.

The following precautions are taken:-

The protruding embedded steel bar must be cleaned with an abrasive paper before making electrical connection to ensure low electrical contact resistance.

The concrete surface shall be cleaned thoroughly with a soft wire brush to remove the adhering calcium carbonated layers, which cause high electrical resistance during the potential measurement. This is essential preparatory requirement and has been ensured all along, before actual testing.

The concrete surface to be subjected to test shall be kept wet uniformly before the commencement of potential measurement.

The readings more negative than -350 mV indicate high probability of Active corrosion. More positive than -200 mV indicate high probability of no corrosion. Readings between -200 mV to -350 mV indicate uncertainty of corrosion and positive readings indicate probability of insufficient moisture in concrete. The existence of corrosion in steel is further confirmed by high percentage of chloride and less pH value obtained by other methods of testing. Such series of corroborative testing techniques are evolved to reach at most reliable findings.

Details of Testing:

- The tests were conducted at 01 location.

Conclusion:

- The test result indicates high probability of active corrosion at one representative location where test have been conducted.

Please refer the test results attached herewith for details.

4. 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 ll)

Details of Testing:

- The tests were conducted at 8 locations.
- The average of all the readings is 314.38 Kg/ Sq.cm.

Please refer the test results attached herewith for details.

5. 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.
- **S**everal readings of cover meter are in the range of 88 mm to 101 mm.
- Clear cover does not indicate depth beyond 101 mm where test has carried out.
- The average cover of concrete reveals as 94.5 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.

6. Carbonation Test **(Ref BS 1881 Part 201: 1986).**

This test is carried out to measure the depth of concrete from the external face up to which it has undergone carbonation.

The test requires core samples of 25 mm or 50 mm diameter to be taken out for a depth of about 80 to 100 mm. higher diameter cores taken can also be used for this test. The core sample is sprayed by 2% phenolphthalein solution starting from the exposed or external surface of concrete. If sprayed concrete turns pink, it is considered as non-carbonated. The depth of carbonation is measured in millimeters as the depth from the external face of concrete to the point beyond which the phenolphthalein sprayed concrete turns pink in color. If the core of concrete is not available the test can be performed by suitably exposing the concrete by cutting or breaking by chisel and performing the test on this freshly exposed surface as described above.

Details of Testing:

- The tests were conducted at total 2 locations on RCC pedestal.
- For pedestal, readings of carbonation depth are noted up to 47 mm depth.

Conclusion:

- Comparing to the average clear cover of concrete to reinforcement for R.C.C. Columns, as revealed through cover Meter test i.e. 94.50 mm, the Carbonation test results confirms that the cover of concrete has carbonated up to 47 mm at representative locations where test has carried out. A carbonation test result at slab confirms that the cover of concrete has carbonated.

Please refer the test results attached herewith for details.

7. Chemical Analysis: (pH, Cl, SO3) ***(Ref: IS 456-2000)***

This test indicates chloride content in concrete indicating the extent of corrosion of steel and pH value. If it is low, it indicates acidic nature.

Low sulphate content shows that there may not be any effect on strength of concrete.

High chloride content in cover concrete indicates possibility of corrosion in reinforcement bars.

The higher percentage of chlorides & sulphates indicates deterioration of concrete and possibility of its disintegration.

The limits of chlorides as Cl and sulphate as SO3 in concrete are as per IS 456 - 1978 Appendix A.

The tests for chloride and sulphate were carried out throughout the length of the core to ascertain the extent of ingress.

Details of testing:

- The tests conducted on total 01 samples collected by core extraction.
- Average of pH value is 9.78

Conclusion:

- Average pH of Concrete is dropped to 9.78 as compared to fresh concrete i.e. 13. This is alarming as alkaline barrier in the cover concrete turning acidic, hence care need to be taken for protection of the concrete.
- The chloride content is higher than the permissible limits in almost all the representative locations where test has been carried out. That means probability of active corrosion in the reinforcement bars which can be confirmed with the readings of Half Cell Potentiometer test.
- The sulphate content is within the permissible limits at most of the representative locations where test has been carried out.

Please refer the test results attached herewith for details.

Recommendations / Conclusion:-

In light of the observed defects; following remedial measures are recommended to carry out for efficient improvement in the serviceable life span of the structures; under reference.

R.C.C. Members -

Corrosion related damages (in the RCC members) shall be rectified with the use of 'Polymer Modified Mortar'.

➢ ***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.

- **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 (in RCC pedestals) 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.