INSPECTION REPORT

For

Health Survey of Structures

Of

Ammonia Plant

At

IFFCO, Paradeep

Orissa

INDIAN FARMERS FERTILISER COOPERATIVE LTD, PARADEEP, ORISSA

March - 2013

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IFFCO/ SDCPL /2013/2720

March 25, 2013.

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

INSPECTION REPORT

For

Condition Assessment

For

Ammonia Plants structures

At

Utility and offisites plant

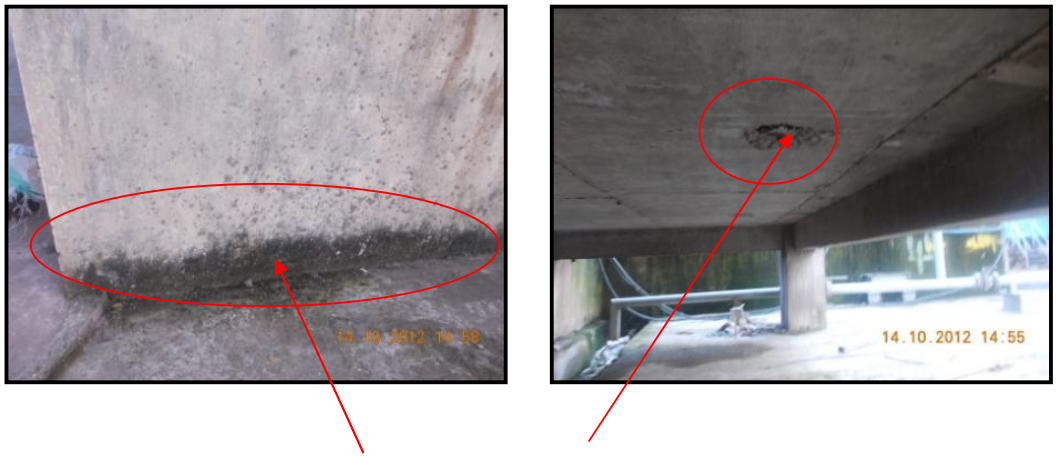
Of

Paradeep, Orissa.

1. PUMP FOUNDATION & STORE ROOM ETC. AT AMMONIA END STATION

Observations:-

- RCC slab provided to support Pump area framing system above noted with distresses like segregation & honey combing at subsequent concrete pours, localized spalling of concrete thereby exposed reinforcement at the soffit of the slab etc. as seen in the typical photographs below.



Segregation and spalling of concrete noted.

Cracks at the subsequent concrete pours & segregation noted .

R.C.C Pedestal:-

- R.C.C. encasement done at bottom part of vertical support members noted with cracks at top finishing layer and moss growth. Please refer typical photographs below.

Seepage, moss growth & cracks at top finishing layer of pedestal.

Structural Elements of framing system:-

- Structural elements of the framing system i.e. steel columns, side gusset plate at various connections etc. noted with localized corrosion, scaling and peeling / delamination of existing paint etc. Please refer photograph below.

Corrosion and peeling of paint noted on the column.

- Inadequate fixing & finishing of steel column with RCC pedestal noted as shown in the photograph below.

Store Room:-

- Store Room is a RCC framed structure as seen in the photograph below noted with distresses like cracks & hollow sound in plaster, discoloration and weathered surfaces etc.

2. ELECTRICAL SUB-STATION / NEW R.C.C STRUCTURE

History / background:-

- This is a RCC framed structure as seen in the photographs attached herewith; seem a new structure. Ground floor area used for cable alignment. The structure has one RCC staircase provided.

Observations:-

- This structure noted with distresses like damaged RCC chajja, weathered surface, leakage / seepage marks & delamination of cover concrete at staircase area and cracks in external plaster 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, 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 18 locations.
- Maximum reading obtained as 2.98 km/sec at column B2.
- Minimum reading obtained as 2.56 km/sec at column B1.
- Average reading obtained as 2.85 km/sec, which indicates doubtful quality of concrete.

Conclusion:

The test results indicate doubtful 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 ll)

Details of Testing:

- The tests were conducted at 5 locations.
- The average of all the readings is 476.00Kg/ 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 5 locations.
- **S**everal readings of cover meter are in the range of 40 mm to 48 mm.
- Clear cover does not indicate depth beyond 48 mm where test has carried out.
- The average cover of concrete reveals as 44 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.

3. SULPHRIC ACID TANK (S.A.P)

AND

PHOSPHARIC ACID TANK (P.A.P)

SAP Tank Observations:-

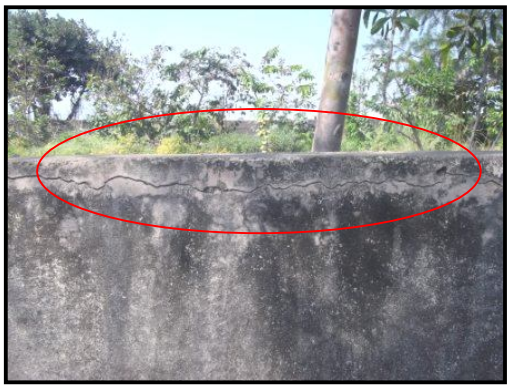
R.C.C Tank Foundation:-

- RCC foundation noted with distresses like delamination of acid proof tiles, erosion in tile joints, localized vegetation growth and localized exposed reinforcement at the area where drain system exits. Please refer below photographs.

R.C.C Dyke wall:-

- R.C.C Dyke walls provided to enclose the peripheral area for the tanks.

  The said dyke walls noted with wide spread cracks on top at many locations as shown in the typical photograph below.



Cracks noted on the R.C.C dyke wall.

- Through & wide spread vertical crack noted on dyke wall on West side. Also, weathered surfaces and disalignment noted as shown in the typical photographs below.

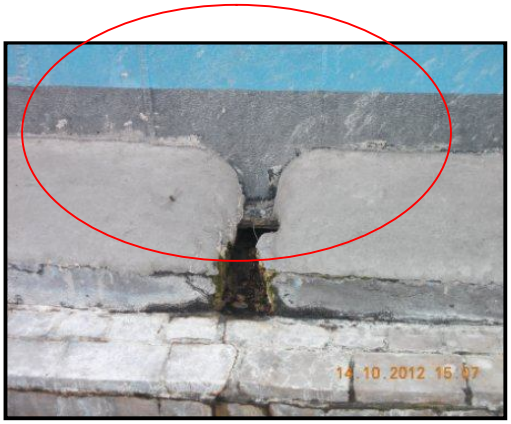
Flooring:-

- C.C flooring done inside the area of tanks premises; noted with distresses like cracks/gaps & vegetation growth at constructions joints, holes and improper slopes etc. as shown in the typical photographs below.

PAP Tank Observations:-

R.C.C Tank Foundation:-

- RCC foundation noted with distresses like delamination of acid proof tiles, erosion in tile joints and localized exposed reinforcement at the area where drain system exits. Please refer below photographs.
- Repairs work was in progress at rear side of tank area; has been noted at the time of detailed inspection.



R.C.C Dyke wall:-

- R.C.C Dyke walls provided to enclose the peripheral area for the tanks; noted with distresses like untreated Expansion joints/expansion joints noted without filling material, localized through & wide spread vertical cracks and weathered surfaces etc. Please refer typical photographs below.

- Disalignment noted in the common RCC dyke wall between the two tanks; under reference.

Flooring:-

- C.C flooring done inside the area of tanks premises; noted with distresses like cracks/gaps & vegetation growth at constructions joints, holes and improper slopes etc. as shown in the typical photographs below.

INFERENCE OF N.D.T. RESULTS AT AMMONIA SAP and PAP Tanks DYKE wall:

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 and Cover meter 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:

East side RCC wall

- The tests were conducted at total 4 locations.
- Maximum reading obtained as 4.04 km/sec.
- Minimum reading obtained as 2.89 km/sec.
- Average reading obtained as 3.625 km/sec, which indicates good quality of concrete.

South side RCC wall

- The tests were conducted at total 4 locations.
- Maximum reading obtained as 4.05 km/sec.
- Minimum reading obtained as 3.27 km/sec
- Average reading obtained as 3.612 km/sec, which indicates good quality of concrete.

West side RCC wall

- The tests were conducted at total 4 locations.
- Maximum reading obtained as 4.05 km/sec.
- Minimum reading obtained as 2.89 km/sec Average reading obtained as 3.60 km/sec, which indicates good quality of concrete.

North side RCC wall

- The tests were conducted at total 4 locations.
- Maximum reading obtained as 4.58 km/sec.
- Minimum reading obtained as 3.59 km/sec

  Average reading obtained as 4.127 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 ll)

Details of Testing:

North side wall:-

- The tests were conducted at 4 locations.
- The average of all the readings is 293.75 Kg/ Sq.cm.

Please refer the test results attached herewith for details.

South side wall:-

- The tests were conducted at 4 locations.
- The average of all the readings is 342.50 Kg/ Sq.cm.

Please refer the test results attached herewith for details.

West side wall:-

- The tests were conducted at 4 locations.
- The average of all the readings is 333.75 Kg/ Sq.cm.

Please refer the test results attached herewith for details.

East side wall:-

- The tests were conducted at 4 locations.
- The average of all the readings is 350.00 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:

East side wall:-

- The tests were conducted at total 1 location.
- Several readings of cover meter are in the range of 48 mm to 49 mm.
- Clear cover does not indicate depth beyond 49 mm where test has carried out.
- The average cover of concrete reveals as 48.50 mm.

West side wall:-

- The tests were conducted at total 1 location.
- Several readings of cover meter are in the range of 45 mm to 48 mm.
- Clear cover does not indicate depth beyond 48.00 mm where test has carried out.
- The average cover of concrete reveals as 46.50 mm.

South side wall:-

- The tests were conducted at total 1 location.
- Several readings of cover meter are in the range of 46 mm to 48 mm.
- Clear cover does not indicate depth beyond 48.00 mm where test has carried out.
- The average cover of concrete reveals as 47.00 mm.

North side wall:-

- The tests were conducted at total 1 location.
- Several readings of cover meter are in the range of 46 mm to 48 mm.
- Clear cover does not indicate depth beyond 48.00 mm where test has carried out.
- The average cover of concrete reveals as 47.00 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.

4. OSBL PIPE RACK

History / Background of the structure:

- The structure under reference i.e. “OSBL PIPE RACK” situated in Offsites and Utility plant at Indian Farmers Fertilizers Cooperative Ltd. (IFFCO) Paradeep unit, Orissa.
- The said structure i.e. OSBL PIPE RACK starts from AFBC boiler and continues till the end of the Ammonia plant. All plants pipe racks support system are liberally connected to the said OSBL pipe rack. All vertical steel members suitably rest on RCC pedestal/foundation. Various tie levels are provided at desired levels as per requirement and elevated structures are constructed at cross roads.

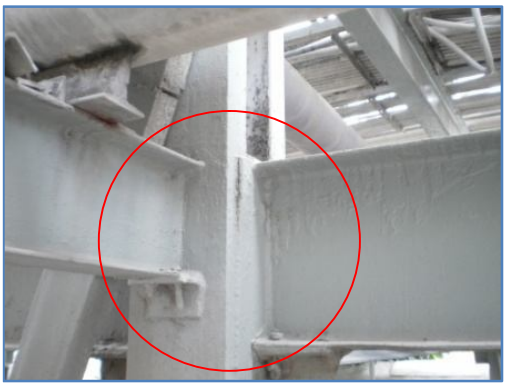
OSBL Pipe structure starts from AFBC boiler to DM Plant & continues till the end of Ammonia plant.

Observations:-

OSBL PIPE RACK START FROM AFBC BOILER TO D.M PLANT:-

- Deteriorated condition of steel elements due to severe corrosion noted at many locations near the AFBC boiler house as shown in the typical photographs below.

- Inadequate connections in the form of cleat angle missing on one side noted at many locations in the entire framing system as shown in the typical photographs below.



- Localized missing of nut bolts noted at many locations on longitudinal members, horizontal members and cross bracing as shown in the typical photographs below.

- Foundation nut bolts, base plate, side gusset plate and bottom section of the steel column noted with scaling, corrosion and pitting etc. Also RCC pedestal edges are damaged at many locations. Please refer typical photographs below.

- Steel columns noted with severe corrosion might be due to the continuous presence of water around as shown in the typical photograph below.

- Framing system of cantilever brackets noted with weld joints opened out due to severe corrosion and scaling at many locations as shown typical photographs below.

- Steel elements of connections noted with corrosion. Please refer typical photographs below.

- Vertical members as seen in the photographs below noted with deflection in the alignment; might be due to the original construction deficiency. Also noted tack welding done instead of full welding. Localized missing of nut bolts at every connection also noted. Please refer typical photographs below.

- Localized missing of longitudinal members noted as shown in the typical photograph below.

- Moss growth noted on the RCC pedestals at some locations. Also sever corrosion and scaling on vertical members & side gusset plates noted as shown in the typical photographs below.

Severe corrosion and scaling

Elevated area (at road crossings) Observations-

- Structural steel framing system of elevated pipe rack support system noted with localized corrosion in longitudinal members, horizontal members, cross bracings, nut bolts, vertical members, localized missing of nut bolts & cross bracings, peeling of existing paint etc. Please refer photographs below.

Corrosion and scaling

Nut bolts missing on cross bracings

Cross bracing missing

Cut/slotted cross bracing

Corrosion, scaling and cut/slotted cross bracing

Inadequately welded connections

Severe corrosion

OSBL START FROM D.M PLANT TO AMMONIA PLANT

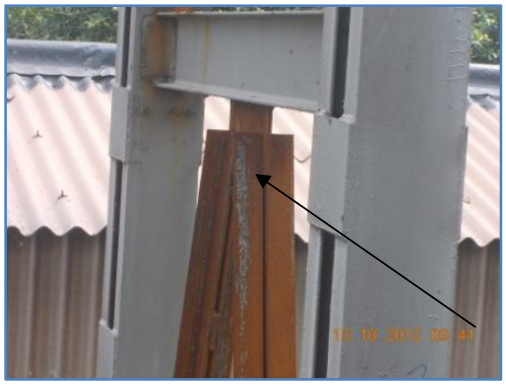
- Honey combing, moss growth, gap between base plate and RCC pedestal, corrosion and scaling on base plate, side gusset plate and foundation nut bolts and vegetation growth noted as shown in the typical photographs below.

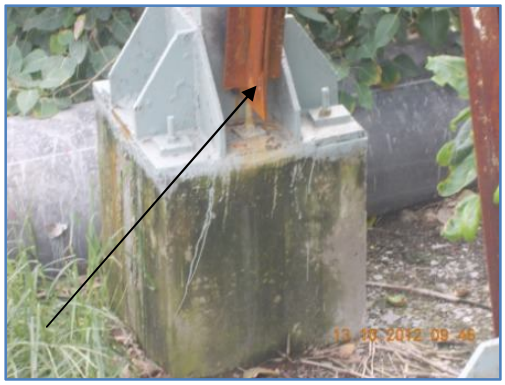
Scaling, corrosion on base plate and gusset plate also vegetation growth and honey combing

- Localized exposed reinforcement (actually it is original construction deficiency i.e. reinforcement laid without sufficient cover concrete), delamination of cover concrete of RCC pedestals etc. noted at many locations as shown in the photographs below.

- Vertical members of the framing system noted with corrosion & pitting at many locations at many locations as shown in the typical photographs below.

- Few structural elements noted without protective paints as shown in the typical photographs below.

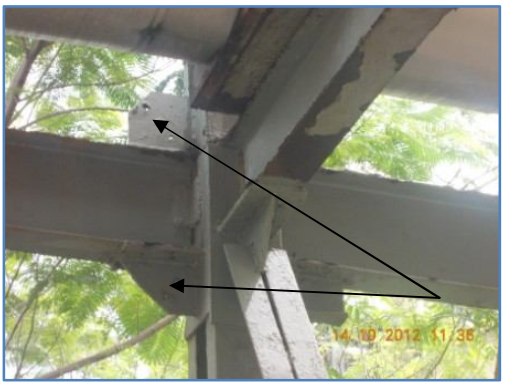




- Severe corrosion, scaling, pitting and peeling of paint noted on vertical steel member, side gusset plate, seat and cleat angle of longitudinal and horizontal steel members at some locations as shown in the typical photographs below.

- Vegetation growth, moss growth and localized nut bolt missing noted at some locations as shown in the typical photographs below.

- Localized missing/slotted cross bracings as also weld connections opened out noted at some locations as shown in the typical photographs below.



- Scaling, corrosion on nut bolts, gusset plates and also in weld connections noted at many locations as shown in the photographs below.

- Inspection of the few areas especially area of OSBL from Ammonia cooling tower to end of the SAP and PAP steel tanks could not be possible; locally; due to unavailability of proper access and profuse vegetation as seen 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 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
	OFF SITE & UTILITES	-			
	OSBL Pipe Rack from D.M plant to Ammonia plant				
	Column				
1	Column A1(200)	MC	6.10	6.2	-
2	Column B1(200)	MC	6.10	5.6	8.20
3	Column A6 (200)	MC	6.10	6.2	-
4	Column B6 (200)	MC	6.10	6.2	-
5	Column A11 (200)	MC	6.10	6.1	0.00
6	Column B11 (200)	MC	6.10	5.2	14.75
7	Column A16 (200)	MC	6.10	5.1	16.39
8	Column B16 (200)	MC	6.10	6.3	-
9	Column A21 (200)	MC	6.10	6.3	-
10	Column B21 (200)	MC	6.10	6.2	-
11	Column A26 (200)	MC	6.10	6.2	-
12	Column B26 (200)	MC	6.10	6.2	-
13	Column A31 (200)	MC	6.10	5.7	6.56
14	Column B31 (200)	MC	6.10	5.9	3.28
15	Column A36 (200)	MC	6.10	6.5	-
16	Column B36 (200)	MC	6.10	6.1	0.00
17	Column A41 (200)	MC	6.10	5.7	6.56
18	Column B41 (200)	MC	6.10	6.2	-
19	Column A46 (200)	MC	6.10	5.4	11.48
20	Column B46 (200)	MC	6.10	5.9	3.28
21	Column A51 (200)	MC	6.10	5.1	16.39

22	Column B51 (200)	MC	6.10	6.3	-
23	Column A56 (200)	MC	6.10	6.1	-
24	Column B56 (200)	MC	6.10	5.8	4.92
25	Column A61 (200)	MC	6.10	6.2	-
26	Column B61 (200)	MC	6.10	6.3	-
27	Column A66 (200)	MC	6.10	6.2	-
28	Column B66 (200)	MC	6.10	6.3	-
29	Column A71 (200)	MC	6.10	5.1	16.39
30	Column B71 (200)	MC	6.10	6.3	-
31	Column A76 (200)	MC	6.10	6.3	-
32	Column B76 (200)	MC	6.10	6.2	-
33	Column A81 (200)	MC	6.10	6.1	0.00
34	Column B81 (200)	MC	6.10	6.2	-
35	Column A86 (200)	MC	6.10	6.3	-
36	Column B86 (200)	MC	6.10	6.3	-
37	Column A91 (200)	MC	6.10	6.3	-
38	Column B91 (200)	MC	6.10	6.3	-
39	Column A96 (200)	MC	6.10	6.3	-
40	Column B96 (200)	MC	6.10	6.3	-
41	Column A101 (200)	MC	6.10	5.4	11.48
42	Column B101 (200)	MC	6.10	5.0	18.03
43	Column A106 (200)	MC	6.10	5.3	13.11
44	Column B106 (200)	MC	6.10	5.2	14.75
45	Column A111 (200)	MC	6.10	5.9	3.28
46	Column B111 (200)	MC	6.10	5.4	11.48
47	Column A116 (200)	MC	6.10	6.3	-
48	Column B116 (200)	MC	6.10	6.3	-
49	Column A121 (200)	MC	6.10	5.7	6.56
50	Column B121 (200)	MC	6.10	5.9	3.28
51	Column A126 (200)	MC	6.10	6.3	-
52	Column B126 (200)	MC	6.10	6.3	-
53	Column A131 (200)	MC	6.10	5.9	3.28
54	Column B131 (200)	MC	6.10	6.3	-
55	Column A136 (200)	MC	6.10	5.5	9.84
56	Column B136 (200)	MC	6.10	6.3	-
57	Column A141 (200)	MC	6.10	6.1	0.00
58	Column B141 (200)	MC	6.10	6.3	-
59	Column A146 (200)	MC	6.10	6.3	-
60	Column B146 (200)	MC	6.10	6.3	-
61	Column A151 (200)	MC	6.10	6.3	-
62	Column B151 (200)	MC	6.10	6.3	-
63	Column A156 (200)	MC	6.10	6.3	-

64	Column B156 (200)	MC	6.10	6.2	-
65	Column A161 (200)	MC	6.10	6.3	-
66	Column B161 (200)	MC	6.10	6.3	-
67	Column A166 (200)	MC	6.10	6.3	-
68	Column B166 (200)	MC	6.10	6.3	-
69	Column A171 (200)	MC	6.10	6.2	-
70	Column B171 (200)	MC	6.10	6.1	-
71	Column A176 (200)	MC	6.10	6.2	-
72	Column B176 (200)	MC	6.10	5.7	6.56
73	Column A181 (200)	MC	6.10	5.5	9.84
74	Column B181 (200)	MC	6.10	6.2	-
75	Column A186 (200)	MC	6.10	6.3	-
76	Column B186 (200)	MC	6.10	6.2	-
77	Column A191 (200)	MC	6.10	6.3	-
78	Column B191 (200)	MC	6.10	6.2	-
79	Column A196 (200)	MC	6.10	5.9	3.28
80	Column B196 (200)	MC	6.10	6.2	-
81	Column A201 (200)	MC	6.10	6.3	-
82	Column B201 (200)	MC	6.10	6.0	1.64
83	Column A206 (200)	MC	6.10	5.1	16.39
84	Column B206 (200)	MC	6.10	6.2	-
85	Column A211 (200)	MC	6.10	6.3	-
86	Column B211 (200)	MC	6.10	5.9	3.28
87	Column A216 (200)	MC	6.10	5.7	6.56
88	Column B216 (200)	MC	6.10	6.2	-
89	Column A221 (200)	MC	6.10	6.5	-
90	Column B221 (200)	MC	6.10	6.2	-
91	Column A226 (200)	MC	6.10	6.3	-
92	Column B226 (200)	MC	6.10	6.1	0.00
93	Column A240 (200)	MC	6.10	6.2	-
94	Column B240 (200)	MC	6.10	5.7	6.56
95	Column A241 (200)	MC	6.10	6.3	-
96	Column B241 (200)	MC	6.10	6.3	-
97	Column A242 (200)	MC	6.10	6.2	-
98	Column B242 (200)	MC	6.10	6.2	-
99	Column A243 (200)	MC	6.10	6.2	-
100	Column B243 (200)	MC	6.10	6.2	-
101	Column A244 (200)	MC	6.10	6.3	-
102	Column B244 (200)	MC	6.10	6.2	-
103	Column A245 (200)	MC	6.10	6.5	-
104	Column B245 (200)	MC	6.10	6.3	-
105	Column A246 (200)	MC	6.10	6.3	-

106	Column B246 (200)	MC	6.10	6.0	1.64
107	Column A247 (200)	MC	6.10	5.1	16.39
108	Column B247 (200)	MC	6.10	5.2	14.75
109	Column A248 (200)	MC	6.10	7.9	-
110	Column B248 (200)	MC	6.10	5.4	11.48
111	Column A249 (200)	MC	6.10	6.0	1.64
112	Column B249 (200)	MC	6.10	5.5	9.84
113	Column A250 (200)	MC	6.10	5.4	11.48
114	Column B250 (200)	MC	6.10	5.9	3.28
115	Column A251 (200)	MC	6.10	6.2	-
116	Column B251 (200)	MC	6.10	4.9	19.67
117	Column A252 (200)	MC	6.10	7.2	-
118	Column B252 (200)	MC	6.10	7.0	-
119	Column A253 (200)	MC	6.10	5.4	11.48
120	Column B253 (200)	MC	6.10	6.3	-
121	Column A254 (200)	MC	6.10	6.3	-
122	Column B254 (200)	MC	6.10	5.4	11.48
123	Column A256 (200)	MC	6.10	5.1	16.39
124	Column B256 (200)	MC	6.10	4.9	19.67
125	Column A257 (200)	MC	6.10	5.6	8.20
126	Column B257 (200)	MC	6.10	5.5	9.84
127	Column A258 (200)	MC	6.10	6.2	-
128	Column B258 (200)	MC	6.10	6.3	-
129	Column A259 (200)	MC	6.10	6.3	-
130	Column B259 (200)	MC	6.10	6.2	-
131	Column A260 (200)	MC	6.10	5.6	8.20
132	Column B260 (200)	MC	6.10	4.2	31.15
Note: - The percentage of reduction in thickness of ISMC varies from 1.64% to 31.15% with respect to the original thickness.					
	Cross Bracing				
133	Cross Bracing (75 x 75 x 10) A1	ISA	10.0	8.5	15.00
134	Cross Bracing (75 x 75 x 10) B6	ISA	10.0	9.9	1.00
135	Cross Bracing (75 x 75 x 10) A11	ISA	10.0	9.7	3.00
136	Cross Bracing (75 x 75 x 10) B16	ISA	10.0	10.0	0.00
137	Cross Bracing (75 x 75 x 10) A21	ISA	10.0	9.7	3.00
138	Cross Bracing (75 x 75 x 10) B26	ISA	10.0	9.6	4.00
139	Cross Bracing (75 x 75 x 10) A31	ISA	10.0	8.9	11.00
140	Cross Bracing (75 x 75 x 10) B36	ISA	10.0	8.9	11.00
141	Cross Bracing (75 x 75 x 10) A41	ISA	10.0	9.2	8.00
142	Cross Bracing (75 x 75 x 10) B46	ISA	10.0	9.1	9.00
143	Cross Bracing (75 x 75 x 10) A51	ISA	10.0	8.5	15.00
144	Cross Bracing (75 x 75 x 10) B56	ISA	10.0	8.4	16.00

145	Cross Bracing (75 x 75 x 10) A61	ISA	10.0	7.6	24.00
146	Cross Bracing (75 x 75 x 10) B66	ISA	10.0	8.2	18.00
147	Cross Bracing (75 x 75 x 10) A71	ISA	10.0	9.1	9.00
148	Cross Bracing (75 x 75 x 10) B76	ISA	10.0	8.7	13.00
149	Cross Bracing (75 x 75 x 10) A81	ISA	10.0	8.9	11.00
150	Cross Bracing (75 x 75 x 10) B86	ISA	10.0	9.9	1.00
151	Cross Bracing (75 x 75 x 10) A91	ISA	10.0	9.5	5.00
152	Cross Bracing (75 x 75 x 10) B96	ISA	10.0	9.1	9.00
153	Cross Bracing (75 x 75 x 10) A101	ISA	10.0	9.0	10.00
154	Cross Bracing (75 x 75 x 10) B106	ISA	10.0	8.9	11.00
155	Cross Bracing (75 x 75 x 10) A111	ISA	10.0	8.5	15.00
156	Cross Bracing (75 x 75 x 10) B116	ISA	10.0	9.5	5.00
157	Cross Bracing (75 x 75 x 10) A121	ISA	10.0	8.9	11.00
158	Cross Bracing (75 x 75 x 10) B126	ISA	10.0	9.5	5.00
159	Cross Bracing (75 x 75 x 10) A131	ISA	10.0	8.5	15.00
160	Cross Bracing (75 x 75 x 10) B136	ISA	10.0	8.3	17.00
161	Cross Bracing (75 x 75 x 10) A141	ISA	10.0	8.9	11.00
162	Cross Bracing (75 x 75 x 10) B146	ISA	10.0	8.9	11.00
163	Cross Bracing (75 x 75 x 10) A151	ISA	10.0	8.5	15.00
164	Cross Bracing (75 x 75 x 10) B156	ISA	10.0	8.3	17.00
165	Cross Bracing (75 x 75 x 10) A161	ISA	10.0	8.7	13.00
166	Cross Bracing (75 x 75 x 10) B166	ISA	10.0	9.5	5.00
167	Cross Bracing (75 x 75 x 10) A171	ISA	10.0	8.8	12.00
168	Cross Bracing (75 x 75 x 10) B176	ISA	10.0	8.2	18.00
169	Cross Bracing (75 x 75 x 10) A181	ISA	10.0	8.6	14.00
170	Cross Bracing (75 x 75 x 10) B186	ISA	10.0	10.7	-
171	Cross Bracing (75 x 75 x 10) A191	ISA	10.0	9.7	3.00
172	Cross Bracing (75 x 75 x 10) B196	ISA	10.0	9.2	8.00

173	Cross Bracing (75 x 75 x 10) A201	ISA	10.0	8.7	13.00
174	Cross Bracing (75 x 75 x 10) B206	ISA	10.0	8.5	15.00
175	Cross Bracing (75 x 75 x 10) A211	ISA	10.0	9.5	5.00
176	Cross Bracing (75 x 75 x 10) B216	ISA	10.0	9.5	5.00
177	Cross Bracing (75 x 75 x 10) A221	ISA	10.0	9.5	5.00
178	Cross Bracing (75 x 75 x 10) B226	ISA	10.0	8.4	16.00
179	Cross Bracing (75 x 75 x 10) A240	ISA	10.0	8.2	18.00
180	Cross Bracing (75 x 75 x 10) B241	ISA	10.0	9.1	9.00
181	Cross Bracing (75 x 75 x 10) A242	ISA	10.0	9.0	10.00
182	Cross Bracing (75 x 75 x 10) B243	ISA	10.0	8.7	13.00
183	Cross Bracing (75 x 75 x 10) A244	ISA	10.0	9.2	8.00
184	Cross Bracing (75 x 75 x 10) B245	ISA	10.0	10.7	-
185	Cross Bracing (75 x 75 x 10) A246	ISA	10.0	7.9	21.00
186	Cross Bracing (75 x 75 x 10) B247	ISA	10.0	7.9	21.00
187	Cross Bracing (75 x 75 x 10) A248	ISA	10.0	8.0	20.00
188	Cross Bracing (75 x 75 x 10) B249	ISA	10.0	8.0	20.00
189	Cross Bracing (75 x 75 x 10) A250	ISA	10.0	7.5	25.00
190	Cross Bracing (75 x 75 x 10) B251	ISA	10.0	7.9	21.00
191	Cross Bracing (75 x 75 x 10) A252	ISA	10.0	7.7	23.00
192	Cross Bracing (75 x 75 x 10) B253	ISA	10.0	6.1	39.00
193	Cross Bracing (75 x 75 x 10) A254	ISA	10.0	7.1	29.00
194	Cross Bracing (75 x 75 x 10) B255	ISA	10.0	7.0	30.00
195	Cross Bracing (75 x 75 x 10) A256	ISA	10.0	6.9	31.00
196	Cross Bracing (75 x 75 x 10) B257	ISA	10.0	6.5	35.00
197	Cross Bracing (75 x 75 x 10)	ISA	10.0	8.2	18.00

	A258				
198	Cross Bracing (75 x 75 x 10) B259	ISA	10.0	5.7	43.00
199	Cross Bracing (75 x 75 x 10) A260	ISA	10.0	6.8	32.00
Note:- The percentage of reduction in thickness of cross bracings varies from 1.00% to 43.00% with respect to the original thickness.					
	Gusset plate				
200	Gusset plate (12mm) A1	GP	12.0	11.5	4.17
201	Gusset plate (12mm) B6	GP	12.0	10.9	9.17
202	Gusset plate (12mm) A11	GP	12.0	12.0	0.00
203	Gusset plate (12mm) B16	GP	12.0	10.7	10.83
204	Gusset plate (12mm) A21	GP	12.0	10.2	15.00
205	Gusset plate (12mm) B26	GP	12.0	11.7	2.50
206	Gusset plate (12mm) A31	GP	12.0	11.1	7.50
207	Gusset plate (12mm) B36	GP	12.0	11.9	0.83
208	Gusset plate (12mm) A41	GP	12.0	11.6	3.33
209	Gusset plate (12mm) B46	GP	12.0	10.9	9.17
210	Gusset plate (12mm) A51	GP	12.0	10.7	10.83
211	Gusset plate (12mm) B56	GP	12.0	11.5	4.17
212	Gusset plate (12mm) A61	GP	12.0	11.4	5.00
213	Gusset plate (12mm) B66	GP	12.0	10.3	14.17
214	Gusset plate (12mm) A71	GP	12.0	11.5	4.17
215	Gusset plate (12mm) B76	GP	12.0	12.0	0.00
216	Gusset plate (12mm) A81	GP	12.0	11.9	0.83
217	Gusset plate (12mm) B86	GP	12.0	10.6	11.67
218	Gusset plate (12mm) A91	GP	12.0	10.9	9.17
219	Gusset plate (12mm) B96	GP	12.0	10.7	10.83
220	Gusset plate (12mm) A101	GP	12.0	11.1	7.50
221	Gusset plate (12mm) B106	GP	12.0	11.8	1.67
222	Gusset plate (12mm) A111	GP	12.0	11.2	6.67
223	Gusset plate (12mm) B116	GP	12.0	12.0	0.00
224	Gusset plate (12mm) A121	GP	12.0	11.2	6.67
225	Gusset plate (12mm) B126	GP	12.0	11.7	2.50
226	Gusset plate (12mm) A131	GP	12.0	11.0	8.33
227	Gusset plate (12mm) B136	GP	12.0	10.8	10.00
228	Gusset plate (12mm) A141	GP	12.0	10.4	13.33
229	Gusset plate (12mm) B146	GP	12.0	10.6	11.67
230	Gusset plate (12mm) A151	GP	12.0	11.2	6.67
231	Gusset plate (12mm) B156	GP	12.0	10.9	9.17
232	Gusset plate (12mm) A161	GP	12.0	11.8	1.67
233	Gusset plate (12mm) B166	GP	12.0	10.8	10.00
234	Gusset plate (12mm) A171	GP	12.0	11.7	2.50

235	Gusset plate (12mm) B176	GP	12.0	10.6	11.67
236	Gusset plate (12mm) A181	GP	12.0	10.2	15.00
237	Gusset plate (12mm) B186	GP	12.0	10.9	9.17
238	Gusset plate (12mm) A191	GP	12.0	10.2	15.00
239	Gusset plate (12mm) B196	GP	12.0	11.5	4.17
240	Gusset plate (12mm) A201	GP	12.0	11.9	0.83
241	Gusset plate (12mm) B206	GP	12.0	10.5	12.50
242	Gusset plate (12mm) A211	GP	12.0	12.0	0.00
243	Gusset plate (12mm) B216	GP	12.0	10.9	9.17
244	Gusset plate (12mm) A221	GP	12.0	9.8	18.33
245	Gusset plate (12mm) B226	GP	12.0	11.4	5.00
246	Gusset plate (12mm) A240	GP	12.0	10.2	15.00
247	Gusset plate (12mm) B241	GP	12.0	10.8	10.00
248	Gusset plate (12mm) A242	GP	12.0	10.2	15.00
249	Gusset plate (12mm) B243	GP	12.0	11.1	7.50
250	Gusset plate (12mm) A244	GP	12.0	11.2	6.67
251	Gusset plate (12mm) B245	GP	12.0	10.2	15.00
252	Gusset plate (12mm) A246	GP	12.0	11.9	0.83
253	Gusset plate (12mm) B247	GP	12.0	10.8	10.00
254	Gusset plate (12mm) A248	GP	12.0	10.6	11.67
255	Gusset plate (12mm) B249	GP	12.0	9.9	17.50
256	Gusset plate (12mm) A250	GP	12.0	10.2	15.00
257	Gusset plate (12mm) B251	GP	12.0	11.1	7.50
258	Gusset plate (12mm) A252	GP	12.0	10.2	15.00
259	Gusset plate (12mm) B253	GP	12.0	10.3	14.17
260	Gusset plate (12mm) A254	GP	12.0	10.7	10.83
261	Gusset plate (12mm) B255	GP	12.0	6.8	43.33
262	Gusset plate (12mm) A256	GP	12.0	10.9	9.17
263	Gusset plate (12mm) B257	GP	12.0	10.1	15.83
264	Gusset plate (12mm) A258	GP	12.0	10.5	12.50
265	Gusset plate (12mm) B259	GP	12.0	10.6	11.67
266	Gusset plate (12mm) A260	GP	12.0	10.1	15.83

The percentage of reduction in thickness of gusset plate varies from 0.83% to 43.33% with respect to the original thickness.

COMMON RECOMMENDATIONS

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' 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.

- **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 Dyke walls / RCC tanks etc) 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.

- 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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