Detail Project Report

on

Condition Assessment of UCO Bank Building

CONTENT

1.0 ABOUT THE BUILDING

The United Commercial Bank (UCO) has one of its commercial building for their operational purpose located at the Thambu Chetty Street, Mannady, Chennai. The building consist of Ground + six floors coming under greater Chennai Corporation. The building is of rectangular in orientation with plot size of 122 ft. North & 115 ft. South and 95 ft. East & 92 ft. West. The type of construction is RCC framed structure. The building was constructed around 1970 and the current age of the building is of 54 years. The RCC open footing type of foundation has been adopted with brick walls as infills. The total plinth area was estimated as 45,065 sq.ft., from ground to sixth floor + seventh floor (headroom + lift room) with the floor height of 10 feet.

2.0 OBJECTIVE OF THE WORK

To perform the health assessment of the building based on visual inspection, field test and Laboratory test.

3.0 OBERVATIONS FROM VISUAL INSPECTION

The visual investigations were carried out at UCO Building at Chennai. Based on visual inspection following observations were made:

- Several cracks were observed at structural members and walls due to the dampness.
- Reinforcement has been corroded in most of the column and lintel beam sections which shows the need to check the depth of corrosion activity in the R.C.C members.
- The ventilators provided at toilets were not in good conditions due to which the rainwater enters inside the toilet areas which causes dampness.
- The exterior facade of the Building shows signs of the cracks and distress on the RCC elements.
- The distress in lintel beam and corrosions in reinforcement were observed at all floors especially at restrooms.
- Several Cracks were observed at sixth floor cantilever portions and at balcony through which the water enters the structural members and exterior walls which leads to excessive distress column members.
- Damage in the pressed tiles and the substrate at terrace has been observed hence the tiles has to be removed and proper weather proofing has to be done.

4.0 TESTS CONDUCTED FOR CONDITION ASSESSMENT OF THE BUILDING

The following test were conducted at site and laboratory for the health assessment of the building,

- Ultrasonic Pulse Velocity (UPV) Test
- Schmidt Rebound Hammer Test
- Carbonation test
- pH test
- Compressive strength test of concrete core samples

4.1 Ultrasonic Pulse Velocity Test

As the primary objective of the investigation was to assess the condition of in-situ concrete, the ultrasonic pulse velocity test method, which is a non-destructive test method was chosen and adopted. This technique measures the velocity of the ultrasonic pulses of a particular frequency (54 KHz or 24 KHz for concrete) through the concrete medium. The method consists, basically, of measuring the timing of ultrasonic pulses transmitted through the concrete medium and calculating the pulse velocity by dividing the path length by time.

There are three possible ways of measuring pulse velocity, namely

I. Direct transmission
II. Semi-direct transmission
III. Indirect or surface transmission

The direct transmission method is generally preferred, since the maximum energy of the pulse is being directed at the receiving transducer and this gives maximum sensitivity.

The pulse velocity measured in reinforced concrete in the vicinity of reinforcing bars is usually higher than in plain concrete of the same composition. This is because, the pulse velocity in steel is 1.2 to 1.9 times the velocity in plain concrete and under certain conditions, the first pulse to arrive at the receiving transducer travels partly in concrete and partly in steel. Wherever possible, measurements were taken in such a way that the steel does not lie directly in the path of the pulse. Correction factors were applied, for measurements which were taken in the proximity of reinforcing bars.

The area around the grid points was smeared with gel/grease, so that a smooth-plain concrete surface was available for holding the transducer against the surface. Grease/gel was applied at the grid point provided an acoustic coupling medium between the concrete surface and the transducer. The transit time of ultrasonic pulse was read from the digital indicator of the Ultrasonic Pulse Velocity Tester manufactured by Proceq, Switzerland. Since the readings were taken in surface transmission method necessary correction factors have been applied as per Indian standards.

To assess the condition of concrete in the various structural elements, non-destructive testing was carried out by employing Ultrasonic Pulse Velocity method as per IS: 516 (Part 5/Sec 1)-2018. The UPV test values on the surfaces of critical members located at various floors [Figs. 7(a), 8(b) and 10] are given in Table 2. As already indicated, the primary objective of this investigation was to assess the concrete integrity at critical regions. In order to achieve this objective, it was considered necessary to take the pulse velocity measurements on a number of points which are close to each other so that adequate data will be available to make a reliable assessment. For this purpose, the tested area was divided into well-defined grid points. The size of the grid was taken 20 cm x 20 cm.

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Guidelines for Analysis of Results of UPV Test

The values of velocity in m/sec are indicated at the respective grid points of the structural elements given in the drawings. As per IS: 516 (Part 5/Sec 1). the general guidelines for assessing the quality, based on Ultrasonic Pulse Velocity (UPV) values of concrete are as follows:-

Average value of Pulse Velocity above 4400 m/s	**- Excellent**
Average value of Pulse Velocity ranges from 3750 m/s to 4400 m/s	**- Good**
Average value of Pulse Velocity less ranges from 3000 m/s to 3750 m/s	**- Doubtful**
Average value of Pulse Velocity less than 3000 m/s	**- Poor**

The general guidelines, which are adopted for interpreting the pulse velocity values in this investigation, are as follows:

- Points having average pulse velocity values more than 3750 m/s are to be considered as good and it could be reasonably inferred that voids and/or loss of integrity of serious nature would not, in general, exist.
- The UPV value of 3750 m/s and above could be considered as acceptable, as evidence of good quality concrete.

4.2 Schmidt Rebound Hammer Test

The testing of Reinforced Cement Concrete members of the building by rebound hammer method (also known as surface hardness test) is generally considered as a complimentary test to other tests to assess the quality of surface layer of the concrete. Hardness measurements provide information on the quality of only the surface layer (about 30 mm to 90 mm thickness) of the concrete. Rebound hammer test requires smooth and non-oily surface. The rebound hammer, which was used in this investigation, was of standard and reliable type, purchased from M/s. Proceq SA, Switzerland, i.e., the type 'N' hammer, and having impact energy of 2.207 Nm with a measuring range of 10 to 70 MPa.

To assess the condition of concrete in the various structural elements, non-destructive testing was carried out by employing Rebound Hammer Testing method as per IS: 516 [Part 5/Sec 4]-2020. The rebound hammer test values on the surfaces of critical members located at various floors [Figs. 7(b), 8(a) and 11] are given in Table 3. The tests were conducted on same grid point which was marked for UPV test.

4.3 Core test

The compressive strength of the existing members at the critical regions was estimated using compression testing machine. The core samples were collected as per IS516 (Part 4):2018 and the testing was conducted in the laboratory. The Profoscope Rebar Locator was used to check the rebar locations [Fig. 5] and grid lines were drawn. The core drilling positions were marked after identifying the location of reinforcements [Fig. 9(b)] and core drilling was carried out at various locations. Fig. 3 to fig 6 indicate the process of core drilling at various locations of critical members. A total number of 9 samples were collected from the critical regions. The size of the samples were 75 mm diameter and 150 m length. The samples were packed neatly and brought to the lab for further testing. Grinding surfaces of cylindrical sample were done to remove sharp edges and a coat of gypsum was applied over the top and bottom of cylinder. The samples were tested in compressive testing machine and the strength was evaluated using the formula as follows.

The compressive strength of specimen = Load taken at failure/Cross-sectional area of cylindrical specimen

4.4. Carbonation test

Carbonation is a process in which carbon dioxide from the atmosphere diffuses through the porous cover concrete and may reduce the pH to 8 or 9, at which the passivating/oxide film is no longer stable. Carbonation process involves the following two stages: First, the atmospheric carbon dioxide (CO_2) reacts with water in the concrete pores to form carbonic acid (H_2CO_3). This is followed by reaction of the carbonic acid with calcium hydroxide [$Ca(OH)_2$] to form calcium carbonate ($CaCO_3$). This process leads to cause a reduction in the pH value of the pore solution from 12.5 to 13.5 to around 8 to 9, which causes depassivation of protective layer of the reinforcement bars and initiates their corrosion.

The test shall be performed on freshly exposed concrete surface as per IS516 (Part 2 / Sec 4)-2021. This may be either freshly broken surface of concrete or extracted concrete core sample which may preferably be split and the test may be conducted on the split face. If facility for splitting is not available, then the core may be surface dried and sealed to prevent further carbonation. After breaking [Fig. 18], the concrete surface shall immediately be cleared of any dust or loose particles.

The freshly exposed concrete surface prepared shall be sprayed with a fine mist of phenolphthalein indicator solution [Fig. 16 and 17]. Care shall be taken to avoid the formation of flow channels on the test surface. The measurements shall be conducted soon after the colour has stabilized [Fig. 19]. The demarcation between the region, which turns into magenta (dark pink color) and the region showing no change in colour will indicate the carbonation front. The carbonation depth [Fig. 19 (b)] shall be measured on the exposed face. When the carbonation front runs as a straight line parallel to the surface, the depth of carbonation d_k is determined. When the carbonation front runs not a straight line, a graphical average d_k and the maximum depth $d_{k\,max}$ should be recorded.

4.5 pH Test

The pH test was conducted on the samples collected from the site. The pH test was carried out as per ASTM C25-99. The experimental set up and the sample preparation are shown in Figure 13 and Figure 14 respectively. The testing process is given in Figure 15 and the results are shown in Table 5.

5.0 DESCRIPTION OF SAMPLINGS

The concrete cores were taken at different location based on the vulnerability identified by the visual assessment. Nine concrete core (Figs. 1-6) samples were taken at columns and beams. The description of sampling and its location were given in Table 1.

Table 1. Description of Samplings

S.No	Sampling Number	Location
1	C1	Terrace outside facing corner column
2	C2	Terrace outside facing corner column
3	C3	Sixth floor balcony column facing inside
4	C4	Sixth floor column near staircase
5	C5	Fifth floor column near staircase
6	C6	Middle column at Parking area
7	C7	Entrance column at Parking area
8	B1	Fifth floor beam near staircase
9	B2	Beam at Parking area

* C – Column and B- Beam

Figure.1 Concrete core samples

Figure.2 Location of C1 and C2

Figure.3 Core drilling at C1 and C2 locations

(a)

(b)

(c)

Figure.4 Core drilling at (a) C3 (b) C4 and (c) C5 & B1

Figure.5 Locating rebar at C6 location using profoscope

(a)

(b)

Figure.6 Core drilling at (a) C7 (b) B2

6.0 RESULTS AND DISCUSSION

6.1 Non-destructive technique test conducted at site

As mentioned in the section 4.1 & 4.2, the NDT test like UPV and Rebound hammer test were conducted at site at critical location based on visual inspection. The UPV and rebound hammer test conducted at C7 location is shown in Fig. 7. The UPV and rebound hammer test conducted at C3 location is shown in Fig. 8. The plastering were removed by chipping off the top layer of the concrete member and surface were prepared for future test as shown in Fig. 9. The UPV and rebound hammer test conducted at C1 & C1' locations is shown in Fig. 10 & 11. The tested values for shown in Table 2 & 3.

Table 2. Ultrasonic Pulse Velocity (UPV) Values

Tested location	Velocity (m/s)						Mean Velocity (m/s)
C1	4176	3836	3779	4232	3887	3508	3855
	4153	3624	3580	4003	3636		
C1'	4295	3620	4034	3635			3896
C2	4204	4046	3655	3262	4492		3931
C9	4414	4110	4130	3747	3650	4317	4073
	4143					`	

Table 3. Rebound hammer Values

Tested location	Rebound number						Mean number	Compressive strength (N/mm^2)
C1	46.5	40	35	54	36	38	44	40
	44	52	51.5	44.5				
C1'	44.5	53.5	48.5	34	53.5	46.5	46	44
	42							
C2	48.5	58	58	51	54		54	58
C9	52	51	60	55	53	50	53	56
	55	53	52					

NOTE: On thorough examining the concrete cores (Fig. 1), the coarse aggregate presence is predominant when compared to fine aggregates. Due to the above fact the rebound hammer hits the aggregates and the rebound number is excessively in higher side based on which the conclusion cannot be made and it can be considered as additional result only.

(a) (b)

Figure.7 (a) UPV test and (b) Rebound hammer test at location C7

(a) (b)

Figure.8 (a) Rebound hammer test and (b) UPV test at location C3

(a) (b)

Figure.9 (a) Reinforcement grid marking and (b) Surface preparation for NDT test at location C1 & C1

(a) (b)

Figure.10 UPV test at location C1 & C1

(a) (b)

Figure.11 Rebound hammer test at location C1 & C1

6.2 Test conducted in Laboratory

For the collected samples various tests like Carbonation test, compressive strength test, chloride test and pH test were done in laboratory (Table 4).

Table 4. Matric of lab test

S.NO	SAMPLING NUMBER	CARBONATION 'AVERAGE DEPTH' (mm)	COMPRESSIVE STRENGTH (kN)	CHLROIDE	pH
1	C1	-	✔	✔	✔
2	C2	✔	-	-	-
3	C3	✔	✔	-	-
4	C4	-	✔	✔	✔
5	C5	-	✔		
6	C6	✔	✔	-	-
7	C7	-	✔	✔	✔
8	B1	-	✔	✔	✔
9	B2	-	✔	✔	✔

* Y – Test conducted for that sampling

The concrete core samples were test for compressive strength using compression testing machine (CTM) as shown in Fig. 12 (a). At constant loading rate the concrete core were tested [Fig. 12 (b) to 12(i)] and the final load capacity were tabulated [Table 5]. The exterior column sample C1 shows lesser compressive strength when compared with other tested samples. This may be due to the impact of carbonation. The compressive strength of each tested samples were found by dividing with the area of cylinder and the resulted values were converted with respect to cube compressive strength.

(a)

(b)

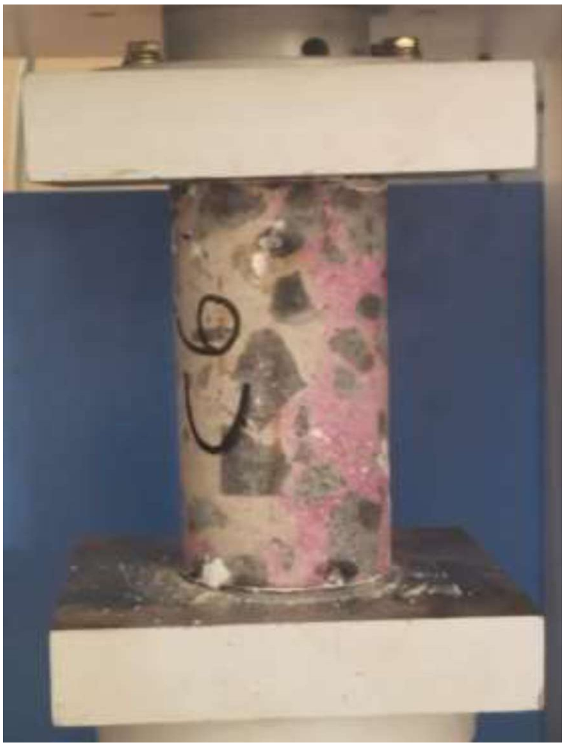
(c)

(d)

(e)

(f)

(g)



(h)

(i)

Figure.12 (a) to (i) Compression test of Concrete core samples using CTM

As mentioned in section 4.5, the pH of the concrete were found for each concrete samples shown in Table 4. The experimental set up for pH test is shown in Fig. 13. The samples prepared were shown in Fig. 14 and testing of samples is shown in Fig. 15. The pH values shows that the concrete retains its alkalinity to a greater extent [Table 5].

Figure.13 pH experimental setup at lab

(a)

(b)

Figure.14 (a) and (b) Sample preparation for pH testing at lab

(a) (b)

Figure.15 (a) and (b) pH testing of samples at lab

The exterior column concrete core C2 & balcony column concrete core C3 were tested for carbonation at site (Fig. 16 & 17). The depth were measure at site for both samples. For furthur confirmation, the carbonation test was carried out in the laboratory by breaking the concrete core samples into two haves by means of split tensile test (Fig. 18). Since the sample were broken into several perices, a small pieces from the surface side were taken and tested for carbonation. The depth of carbonaiton were measure using scale as shown in Fig. 19. The avergae depth of carbonation for sample C2, C3 & C6 were found to be 22 mm, 12 mm and 9 mm respectively [Table 5].

Figure 16. Carbonation test conducted at site for C2 sample

Figure 17. Carbonation test conducted at site for C3 sample

Figure.18 Split tensile testing of core cut sample for carbonation test

(a)

(b)

Figure.19 (a) Concrete sample taken for carbonation test from split test (b) Mean carbonation depth of C2 sample measured at lab

Various test like carbonation, chloride, compressive strength and pH were conducted in laboratory. The results obtained were tabulated (Table 5).

Table 5. Lab test results for each samplings

S.NO	SAMPLING NUMBER	CARBONATION 'AVERAGE DEPTH' (mm)	COMPRESSIVE STRENGTH (N/mm^2)	pH
1	C1	-	15	11.35
2	C2	22	-	-
3	C3	12	30	-
4	C4	-	35	12.44
5	C5	-	18	
6	C6	9	33	-
7	C7	-	33	12.43
8	B1	-	22	12.04
9	B2	-	24	12.48

[*]**Note:** The result shows the durability of concrete on the tested locations only.

Based on ultrasonic pulse velocity test, the integrity of the concrete at tested locations were in good conditions (Table 2) as the mean velocity is higher than 3750 m/sec. Carbonation at terrace corner column which was fully exposed to the outside environment (C2) has significant impact of carbonation with average depth of 22 mm. The other tested samples like C3 and C6 has least impact of carbonation which was due to partial exposure to outside environment. Each concrete core samples were tested in compression testing machine (CTM) based on which the compressive strength of each specimen was found. The least and average strength was found to be 15 N/mm^2 and 26 N/mm^2 respectively. The least strength

were found at location C1 which shows attack of carbonation and slight lesser pH value.
The pH test shows that the concrete retains its alkalinity at most of the tested samples which were not exposed to environment completely. The alkalinity of the concrete core sample at location C1 slightly decreases which was due to the impact of carbonation, as the mentioned tested samples were fully exposed to the environment (Table 5).

7.0 CONCLUSIONS

- Due to stagnant water at terrace slab causes corrosion of reinforcement which leads to spalling of concrete.
- The seepage of water from terrace slab to the below floors has been observed which play a crucial role in affecting the buildings' stability.
- From the ultrasonic pulse velocity and rebound hammer test, it was concluded that the integrity of the concrete is in good condition.
- The cover concrete on the exterior concrete surface which was exposed fully to the environment got affected by carbonation to a significant extent.
- The pH test shows that the alkalinity of the concrete was not affected much though a slight variation in pH level has been observed when compared with exterior RC members to the interior members.
- The compressive strength shows that the concrete attains the average strength of 20 N/mm^2, which ensures that the concrete strength has been retained to greater extent.
- From the field and laboratory test, it was confirmed that the durability of concrete is in good condition but it needs to maintain periodically.

As at several places the spalling of concrete in columns and lintel beams, corrosion of reinforcement, and dampness at walls were observed, it was concluded that the retrofitting has to be done to prevent future damages of the building.

Note:

- Merely adhering to the recommendation does not satisfy the requirement as the quality of retrofitting work is depends on the contractor who undertakes the work.
- The stability analysis of the building has not been done and the above conclusions/recommendation has no role to ensure the structural stability.
- The results were made based on the tested locations only.

8.0 REOMMENDATIONS

Based on the visual inception, lab and field test, the following recommendation were suggested,

Terrace

- Remove the existing pressed tiles till the parent concrete.
- Surface preparation including removal of dust, loose mortar, dirt, laitance, etc.,
- Cracks shall be treated by chasing cracks to a "V" groove and filled with polymer repair material.

Grouting:

- Drill 18mm diameter holes at 1m Centre to Centre for a depth of 100mm all-round the slab and fixing PVC pipes of 18mm diameter using quick setting cement. Grout the points so fixed with cement added with shrinkage compensating admixture Cebex 100 at the rate of 150 grams. per bag of cement using hand operated grouting machine and grout the points completely, etc.,
- Corner coving is properly done with application of single component PU water Proofing system followed by coving in CM 1:4 by admixing SBR polymer @ 200 ml per bag of cement and non-shrink grout additive @ 150 grams per bag of cement and finish with a neat fillet all around.
- Application of PU Water Proofing system in 2 coats to ensure the coating has been taken up to 300 mm at the parapet wall and terminate the coating properly.
- Laying of Protection Screed Concrete by admixing SBR @ 300 ml per bag of cement by fixing button marks with the proper gradient.
- Fixing of Good quality of pressed Tiles in CM 1:4 by admixing SBR @ 100 ml per bag of cement followed by grouting of all the Joints neatly.

Sunshades:

- Dismantling the RC sunshade using heavy duty chipping machine.
- The corroded reinforcement shall be cut and handed over to the client and if the reinforcement is in good condition, the same shall be used.
- Mark the position of holes to be drilled for anchoring the rebar into the slab. As per the site requirement.
- Drill 12mm diameter holes in the marked places using rotary hammer drilling

machine of reputed make to a depth of 100mm into the slab.

- Clean the holes neatly and wash the same with water.
- Allow it to dry and make sure that no fine dust particles are present in the holes.
- Mix the Lok fix polyester resin using a spatula and push the same into the holes with a proper tool so that the bottom most point of the hole receives the material.
- The filling is to be done for a minimum portion of 1/3rd of the hole depth. Now insert the rebar which needs to be anchored for the provision of main reinforcement, gently and finish the surface of the around the rebar area using the same material which comes out of the hole excessively.
- Cut the required diameter bars as main reinforcement - 10mm diameter bars used as main reinforcement to the required length with proper development length and tie them as per the requirement. Also, the required 8mm diameter bars shall be used as distributors.
- Installation of Sacrificial Anodes XPI
- Prior to installation of the Galvashield XPI units, check the continuity of the steel reinforcement.
- Any loss of continuity will require additional electrical connections or restoration of continuity by effective means.
- Select a location for the Galvashield XPI as close as practical to the edge of the repair zone. Galvashield XPI units should be positioned around/along the repair boundary.

**Note:*

- In addition to standard substrate preparation, the Galvashield XPI anode(s) shall be thoroughly pre-soaked in clean water for a minimum of 10 minutes and a maximum of 20 minutes, prior to the application of the repair mortar.
- Tighten tie wires using Galvashield Fixing Tool so that no free movement is possible, thus ensuring good electrical continuity.
- Application of Anti-Corrosive Coating:
- Clean the rebar using the rust remover if there exists any rust, otherwise clean the rebar free of foreign material. Mix the base and hardener of the zinc rich epoxy resin mechanically using a slow speed heavy duty drilling machine fitted with mixing paddle.
- Apply the mixed materials to the cleaned rebar and allow it to dry completely.

- Providing slurry tight form work including strutting, propping, etc., which should not deform or leak , the same shall be fabricated in position using 12mm thick commercial plywood as per the required line and length at all different floor levels as per the standard specification complete.,
- Form work should be rigid to prevent loss of concrete at all stages & appropriate to the methods of placing & compacting as per standard specification. It should be made of suitable material.
- The form work should be coated with shutter release agent prior to fixing.
- The mixing and placing of machine mixed M 20 grade of concrete for sunshade for an average thickness of 100mm. Care shall be taken to ensure proper compaction and placing of the concrete ensuring a neat finish.

Reinforced Concrete Columns & Beams:

- Remove the spalled cover concrete, loose plaster, etc., with mild chiseling, if required mild breaker, etc., completely.
- Remove the rust, dust, dirt completely using a wire brush and clean the surface thoroughly.
- Provision of 2mm welded mesh with proper anchoring to the existing main reinforcement and into the RCC member.
- Installation of Sacrificial Anodes XPI
- Prior to installation of the Galvashield XPI units, check the continuity of the steel reinforcement.
- Any loss of continuity will require additional electrical connections or restoration of continuity by effective means.
- Select a location for the Galvashield XPI as close as practical to the edge of the repair zone. Galvashield XPI units should be positioned around/along the repair boundary.
- In addition to standard substrate preparation, the Galvashield XPI anode(s) shall be thoroughly pre-soaked in clean water for a minimum of 10 minutes and a maximum of 20 minutes, prior to the application of the repair mortar.
- Tighten tie wires using Galvashield Fixing Tool so that no free movement is possible, thus ensuring good electrical continuity.
- Application of Zinc Primer over the existing reinforcement and the new re-bars

provided on the RCC member.

- Preparation of Polymer modified patch repair mortar in CM 1:4 by addition of Nitobond SBR/equivalent @ 300 ml per bag of cement.
- Preparing the Polymer Bonding Slurry with Nitobond AR/SBR before the application of Polymer modified patch repair mortar.
- Application of PMM (Polymer modified Mortar) over the well-prepared substrate by pushing the mortar tightly into the crevices and the pockets to ensure the mortar properly packed etc.
- Finish the surface with proper levels and float with sponge to ensure proper finish.
- Cure the surface normally.

Fenders:

- All the dilapidated and distressed fenders should be knocked off and all the edges and surfaces should be properly treated by removing the loose concrete, mortar, etc.,
- Application of Polymer modified repair mortar with proper polymer bonding agent and all the edges and surfaces to be finished neatly.

Wall Cracks:

- Chase the crack to a "V" Groove with a disc cutter to the alignment.
- Remove the dust, dirt, laitance, etc., completely.
- Application of Polymer, expansive, non-shrink crack filler with a neat putty blade and finish off neatly.

Protective Coating for RCC members:

- Surface Preparation includes removal of dust, dirt, laitance, etc.,
- Treatment of Cracks if any by chasing to a "V" Groove and filled with non-shrink, expansive polymer material.
- Application of Protective coating system Nippon weather bond Advanced with first coat as primer application by soft bristle brush.
- The topcoats should be applied to the right angle to the previous coat and finish off neatly.

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