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STRUCTURAL HEALTH MONITORING OF A CONCRETE STRUCTURESIN GAUTAM BUDDHA UNIVERSITY

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ABSTRACT

A reinforced concrete structure constructs a combination of concrete and steel bars. Structures are constructed by using different grade of concrete and steel bars. Its durability depends on various factors viz. workability, water-cement ratio, cover distance, temperature etc. Strength of concrete structures against these adverse conditions is goes to reducing with passage of time. When these factors increase which causing corrosion of reinforcement, spalling of concrete and reduce the durability of the structures. This phenomenon starts in any concrete structures so vigilant periodic health monitoring approach becomes mandatory. The suitable methods adopted will depend on the observed degree of deterioration. This paper describes an experimental study to diagnose degree of corrosion and status of concrete on reinforced concrete water tank and parapet wall in Gautam Buddha University by using Half-Cell Potentiometer and Portable Ultrasound Non-destructive Digital Indicator Tester (PUNDIT).

KEYWORDS: Corrosion, Steel bars, Half-Cell Potentiometer, Ultrasound Non-destructive Digital Indicator Tester

INTRODUCTION

Water tank and parapet walls made up of concrete which are reinforced with the steel bars. Presence ofvoids cracks in concrete and corrosion of steel bars is the principle causeof the degradation of the structure. Half-Cell potentiometer test is used to evaluate the corrosion activity of reinforcement, its extent and severity. Ultrasound non-destructive digital indicator tester test is use to evaluate the concrete quality. These tests are carried out on water tank slab, its side walls and near parapet walls. White efflorescence had been seen on water tank slab and small cracks on the side wall (Fig. 1.1).

METHODS ADOPTED

Half – Cell Electrical Potential Method to Measure Corrosion of Reinforcement in Concrete (ASTM C 876-91)

The half-cell potential (HCP) test assesses the condition of the steel embedded in concrete with regard to corrosion activity. In this method, the electrical potential difference between the upper steel rebars and a standard portable reference electrode in contact with the concrete surface is measured. The half cell is usually Copper/ Copper Sulphate or Silver/ Silver Chloride cell but other combinations are used. The concrete functions as an electrolyte and the risk of corrosion of reinforcement in immediate region of the test location may be related empirically to the measured potential difference. The typical layout of the equipment is shown Fig. 2.1.It consist a rigid tube composed of dielectric material that is non-reactive with copper or copper sulphate, a porous wooden or plastic plug that remains wet by capillary action, and a copper rod that is immersed within the tube in a saturated solution of copper sulphate. The solution is prepared using reagent grade copper sulphate dissolved to saturation in distilled or deionized water. An electrical junction device is used to provide a low electrical resistance liquid bridge between the surface and the half cell is normally a sponge. Electrical contact solution is made from normal house hold detergent.

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Fig. 1.1: White efflorescence on water tank slab and cracks on side wall

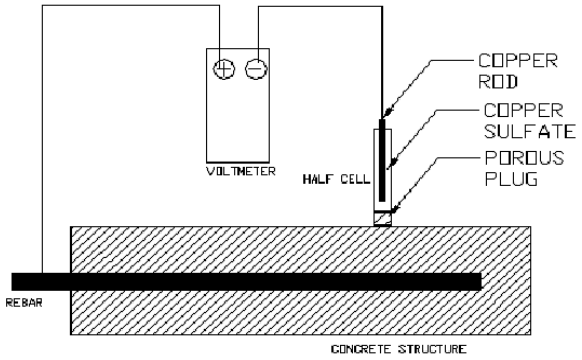

Fig. 2.1: Copper- Copper Sulphate Half- Cell

Measurements are made in either a grid or random pattern. The potential risks of corrosion based on potential difference readings are presented in Table I.

Table I: The potential risks of corrosion based on potential difference readings

Half cell potential (mV) reading	Percentage chance of active corrosion
less than -500mv	Visible evidence of Corrosion
-350 to -500 mv	90%
200 to -350 mv	50%
More than -200 mv	10%

Portable Ultrasound Non destructive Digital Indicator Tester (IS 13311 (Part 1) : 1992)

Through an indirect transmission mode, ultrasonic pulse velocitiesas illustrated in Fig. 2.2 were measured by acommercially available Portable Ultrasound Non destructive Digital Indicator Tester (PUNDIT) with an associated transducer pair. The nominal frequency of the transducers used for testing concrete sections is 54 kHz. The principle of ultrasonic pulse velocity measurement involves sending a wave pulse into concrete by an electro acoustical transducer and measuring the travel time for the pulse to propagate through the concrete. The pulse is generated by a transmitter and received by a similar type of receiver in contact with the other surface. In the experimental studies, the transmitter and receiver were placed at a distance of 0.5 m for each observation. As a result, the travelling length of the ultrasonic pulse was 0.5 m. The concrete surface must be prepared in advance for a proper acoustic coupling by applying grease. Light pressure is needed to ensure firm contact of the transducers against the concrete surface.

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Knowing the path length (L), the measured travel time between the transducers (T) can be used to calculate the pulse velocity (V) using the formula V = L/T.

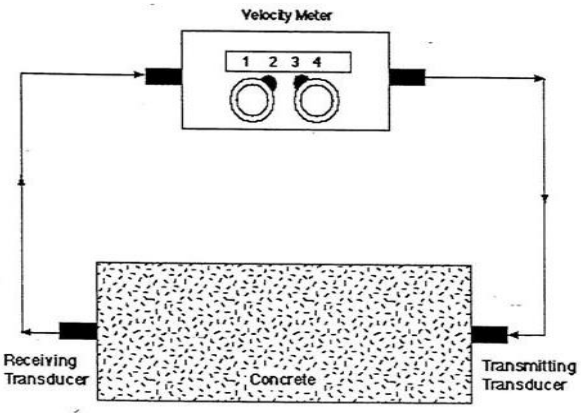

Figure 2.2: Ultrasonic pulse Velocity Testing

EQUIPMENT USED

Corrosion Monitoring Equipments

Following equipments were deployed for the corrosion monitoring of reinforcement in concrete (Fig. 3.1)

- Micro cover meter- R Meter MKIII
- Half Cell Surveyor- CORMAP II

Micro Cover Meter and Half Cell Surveyor

Fig. 3.1: Equipments used for corrosion investigation

The micro cover meter has been used to locate the rebar. The concrete surface was examined for the exposed rebar or got exposed to get a reference point. Surface was made wet and observation locations were marked on the surface.

The pre-activated Cu-CuSO4 Half Cell was used to take observation. The test results are categorized in 7 categories from A to G category in the typical map recorded on CORMAP II, their interpretation is given in Table II.

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Table II: Categories of Corrosion Activity

A = - 0.420, B = - 0.350	A & B – 90% chance corrosion is occurring in this area
C = - 0.280 , D = - 0.210	C & D – Corrosion activity over this area is uncertain
E = - 0.140, F = - 0.070 G=0.00	E –G – 90% chance that no corrosion activity is present over this area

Portable Ultrasound Non destructive Digital Indicator Tester (PUNDIT)
PUNDIT (Fig. 3.2) was used to observe the time of travel of ultrasonic wave between two fixed point at a distance of 50 cm apart. Waves are generated through one transducer and received by another transducer.

Pulse wave velocity is calculated by following relation. Based on the pulse wave velocity the status of concrete is categorized in four categories (Table III)

Velocity = Distance/Time

Fig. 3.2: Portable Ultrasound Non destructive Digital Indicator Tester Equipment (PUNDIT)

Table-III: Showing the Status of Concrete based on Pulse Wave Velocity

Pulse Wave Velocity in Km/sec	Status of Concrete
Below 3	Doubtful
3 to 3.5	Medium
3.5 to 4.5	Good
Above 4.5	Excellent

TEST LOCATIONS

The corrosion monitoring and pulse wave tests were carried out at selected locations at chatrapatishahuji hostel water tank and parapet wall near tank in gautambuddha university. Detailed locations of the selected area and grid patterns are given in table IV.

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Table IV: Details of locations for corrosion monitoring and pulse wave tests

SR. No.	LOCATIONS	GRID PATTERN
1.	ChatrapatiShahuji Hostel Water Tank Slab (length=13 feet, width= 9 feet, 7 inch)	11'x11'(column x row)
2.	Water tank wall view facing girls hostel (length= 13 feet, height= 6 feet, 6 inch)	11'x5'(column x row)
3.	Water tank wall view facing roof (length= 13 feet, height= 6 feet, 6 inch)	11'x5'(column x row)
4.	Parapet inner wall near tank ChatrapatiShahuji hostel (length= 10 feet, height= 2 feet)	9'x2'(column x row)
5.	Parapet outer wall near tank ChatrapatiShahuji hostel (length= 9 feet, height= 3 feet)	8'x3'(column x row)

OBSERVATIONS

The investigation work of corrosion monitoring and pulse wave velocity test carried out at certain fixed locations (Table IV). The observed values for the tests done on water tank and parapet walls. Pulse Wave Velocity testresults presented in Fig. 6.1-6.5in the form of contour map and Half-Cell potentiometer test results presented in Fig.6.6-6.10 in the form of scatter graphand pie chart

RESULTS AND DISCUSSION

Portable Ultrasound Non destructive Digital Indicator Tester (PUNDIT) Results

ChatrapatiShahuji Hostel Water Tank Slab

The first grid point of each row was located at a right corner of the water tank slab. The horizontal and vertical grid distance between two points is 30c.m. and 25c.m. respectively. The results shows that concrete in a good qualityand test results are presented in Fig. 6.1

Water tank wall view facing girls hostel

The first grid point of each row was located at a right corner of the water tank wall. Grid distance is 30c.m. horizontally and vertically both side. The results shows that concrete in a good quality and test results are presented in Fig. 6.2

Water tank wall view facing roof

The first grid point of each row was located at a right corner of the water tank wall. Grid distance is 30c.m. horizontally and vertically both side. The results shows that concrete in a good quality and test results are presented in Fig. 6.3.

Parapet inner wallnear tank ChatrapatiShahuji hostel

The first grid point of each row was located at a right corner of the parapet wall. Horizontal grid distance is 30c.m. and 25c.m. vertically. The results shows that concrete in a doubtful quality and test results are presented in Fig. 6.4

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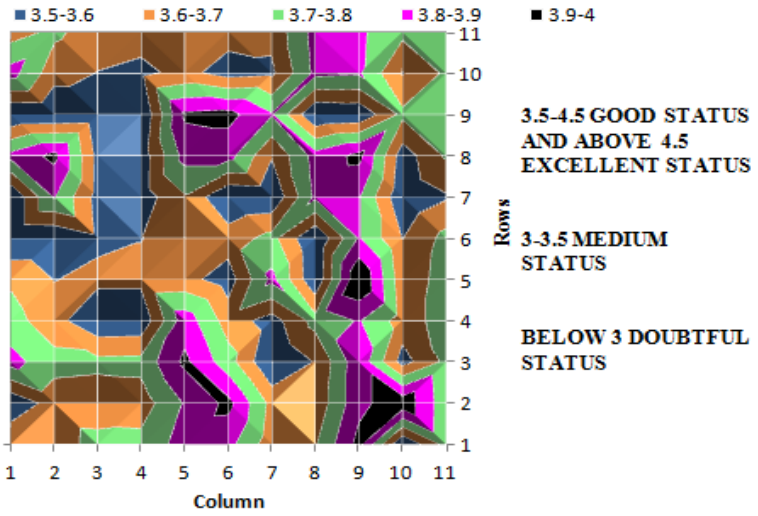

Fig. 6.1: Status of Concrete quality based on Pulse Wave Velocity Test

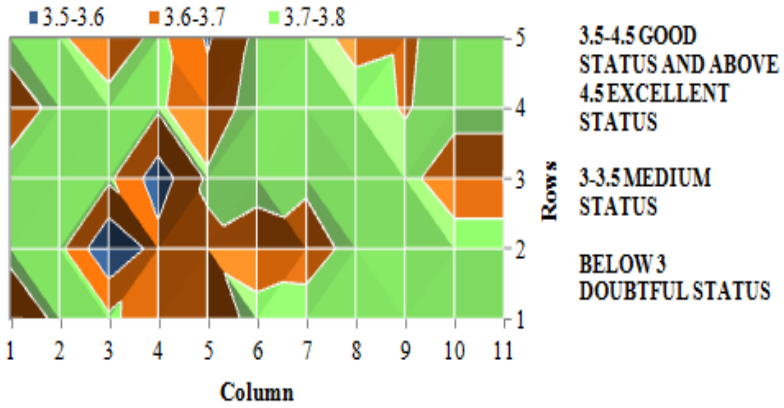

Fig. 6.2: Status of Concrete quality based on Pulse Wave Velocity Test

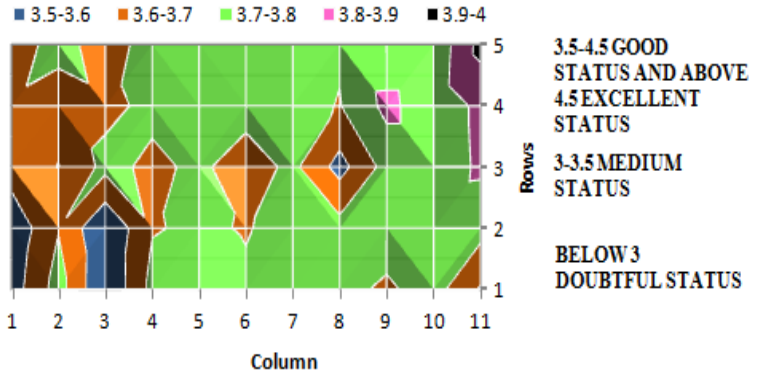

Fig. 6.3: Status of Concrete quality based on Pulse Wave Velocity Test

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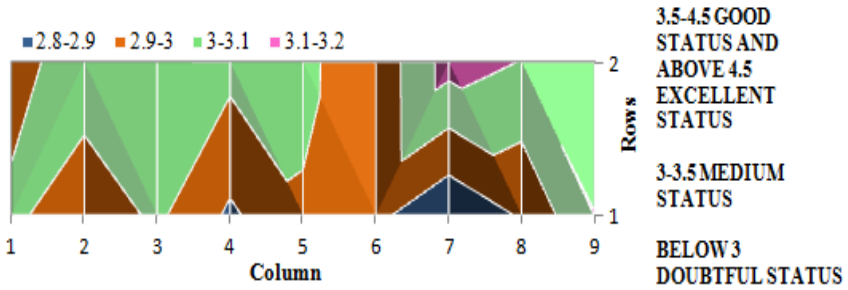

Fig. 6.4: Status of Concrete quality based on Pulse Wave Velocity Test

Parapet outer wallnear tank ChatrapatiShahuji hostel

The first grid point of each row was located at a right corner of the parapet wall. Horizontal grid distance is 30c.m. and 25c.m. vertically. The results shows that concrete in a doubtful and medium quality and test results are presented in Fig. 6.5

Half-Cell Potential Test Results

ChatrapatiShahuji Hostel Water Tank Slab

8% scanned area fall under categories 'A'&'B', depicting , 90% chance of corrosion is occurring in this area whereas 24% area fall under categories 'C'&'D' showing uncertain corrosion activity. 68% area (15% in 'E' and 16% in 'F' categories) falls in area which are indicatives of no noticeable corrosion activity in the scanned area of the slab (Fig. 6.6).

Water tank wall view facing girls hostel

11% scanned area fall under categories 'A'&'B', depicting , 90% chance of corrosion is occurring in this area

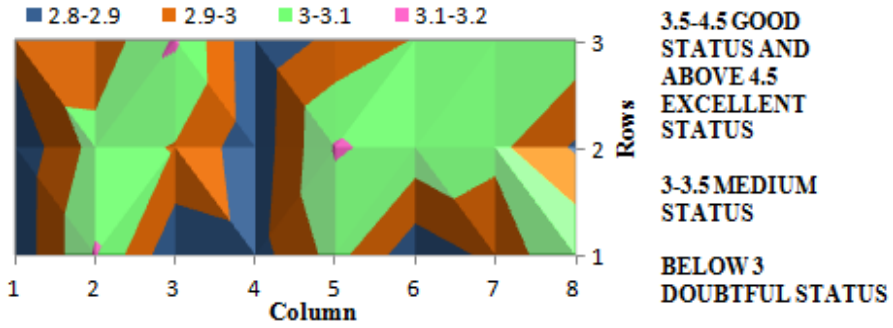

Fig. 6.5: Status of Concrete quality based on Pulse Wave Velocity Test

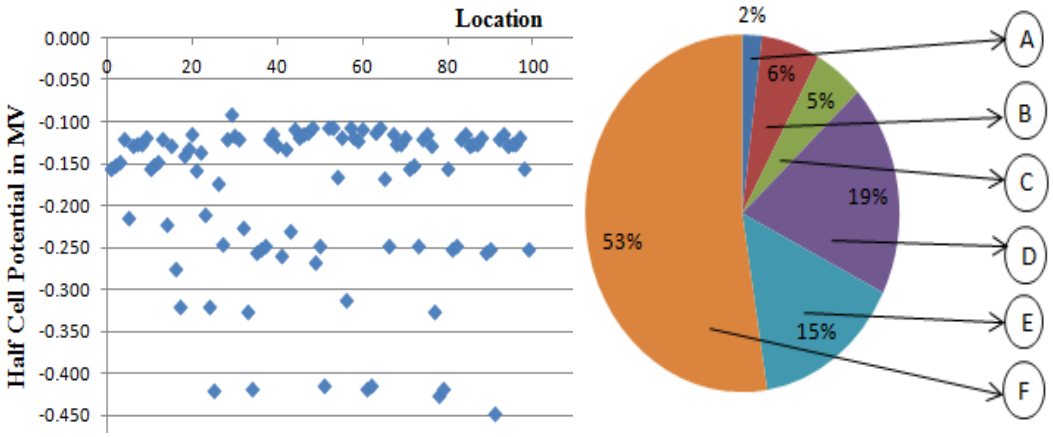

Fig 6.6 Scatter graphshowing corrosion status and pie chart of scanned area

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whereas 33% area fall under categories 'C'&'D' showing uncertain corrosion activity. 56% area (29% in 'E'and 27% in 'F' categories) falls in area which are indicatives of no noticeable corrosion activity in the scanned area of the wall (Fig. 6.7).

Water tank wall view facing roof

Only 2% scanned area fall under categories'B', depicting , 90% chance of corrosion is occurring in this area whereas 55% area fall under categories 'C'&'D' showing uncertain corrosion activity. 43% in 'E' falls in area which is indicatives of no noticeable corrosion activity in the scanned area of the wall (Fig. 6.8).

Parapet inner wallnear tank ChatrapatiShahuji hostel

Only 61% area falls under categories 'C' &'D' showing uncertain corrosion activity. 39% area (17% in 'E' and 22% in 'F' categories) falls in area which are indicatives of no noticeable corrosion activity in the scanned area of the wall (Fig. 6.9).

Parapet outer wallnear tank ChatrapatiShahuji hostel

100% area (50% in 'E' and 50% in 'F' categories) falls in area which are indicatives of no noticeable corrosion activity in the scanned area of the wall (Fig. 6.10).

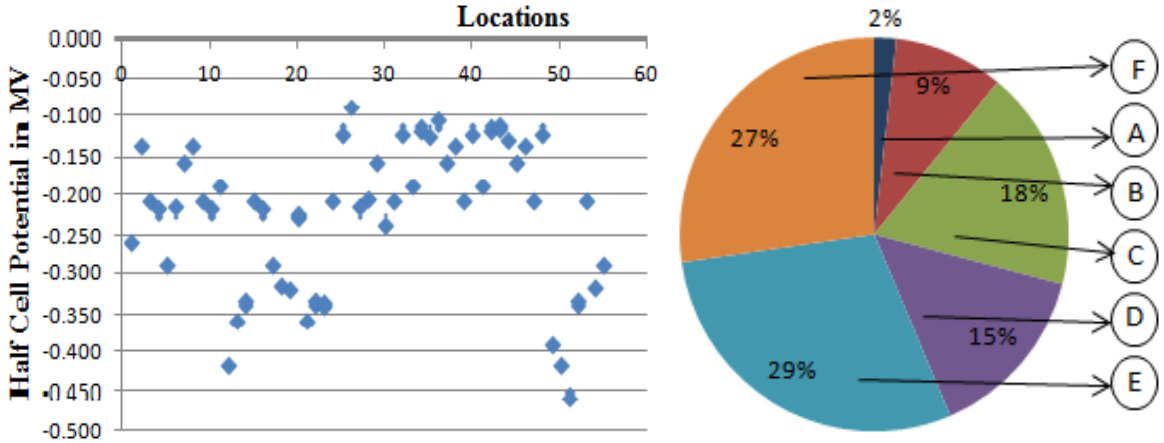

Fig 6.7 Scatter graphshowing corrosion status and pie chart of scanned area

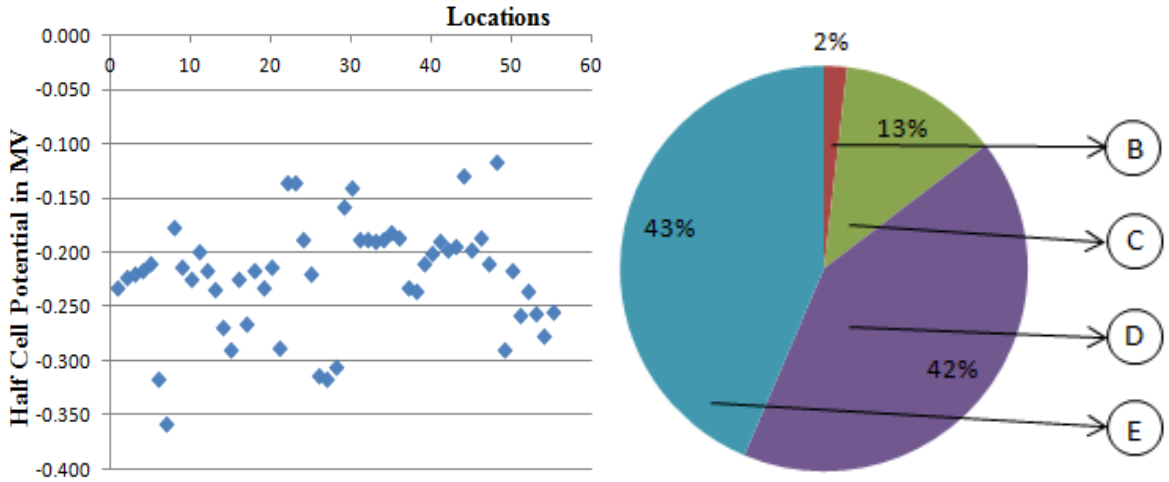

Fig 6.8 Scatter graphshowing corrosion status and pie chart of scanned area

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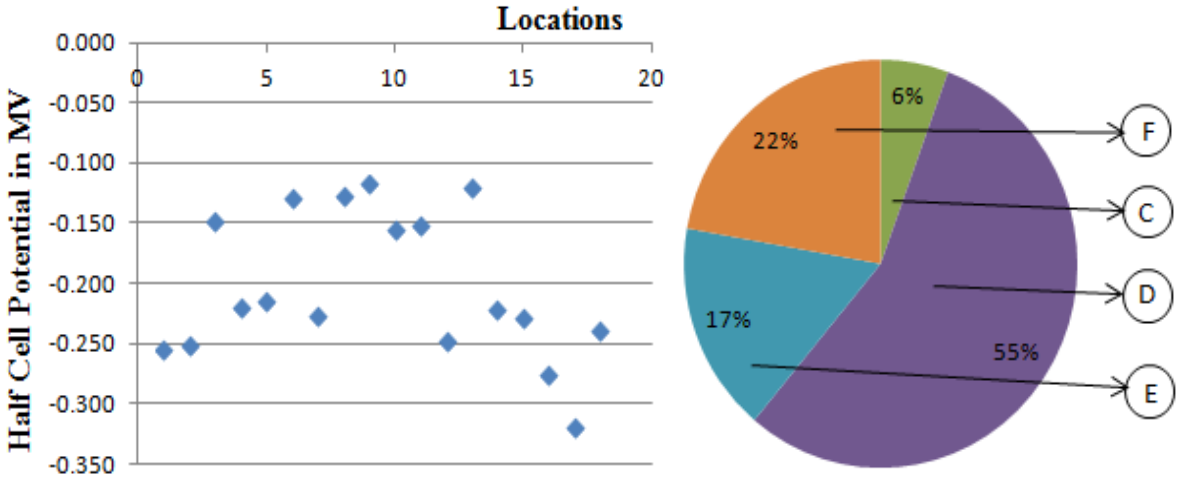

Fig 6.9 Scatter graphshowing corrosion status and pie chart of scanned area

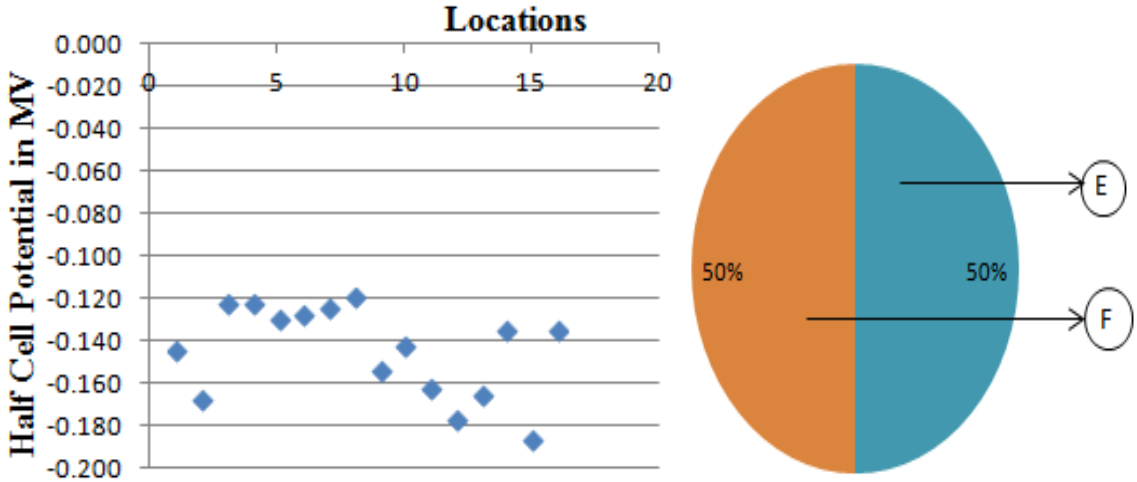

Fig 6.10 Scatter graphshowing corrosion status and pie chart of scanned area

CONCLUSION

- Pulse wave velocity test results shows the concrete quality of the water tank slab and the side wall are in a good status (above 3.5km/sec)but the concrete quality of the parapet walls are in doubtful and medium status (below 3 and 3-3.5km/sec)
- Half Cell Potential test results shows that
  - ➢ No corrosion activity shows in parapet outer wall
  - ➢ Corrosion activity has already initiated Parapet inner wall and water tank wall facing roof
  - ➢ High degree of corrosion presence in water tank slab and water tank wall facing girls hostel

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