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# Structural Assessments of Concrete Piers in A Barrage Project Using Portable Ultrasound Non-Destructive Digital Indicator Tester

GK Vijh[1], Pankaj Sharma[2], NV Mahure[3], SK Jain[4], Sameer Vyas[5], SL Gupta[6]

Scientist D, Concrete Division, CSMRS, Hauz Khas, New Delhi, India[1]
Scientist C, Concrete Chemistry Division, CSMRS, Hauz Khas, New Delhi, India[2]
Scientist D, Concrete Diagnostic Division, CSMRS, Hauz Khas, New Delhi, India[3]
Scientist B, Concrete Division, CSMRS, Hauz Khas, New Delhi, India[4]
Assistant Research Officer, Concrete Chemistry Division, CSMRS, Hauz Khas, New Delhi, India[5]
Scientist E/Group Head, Concrete Group, CSMRS, Hauz Khas, New Delhi, India[6]

**Abstract**: Functional life of any barrage project depends on functional stability of the concrete piers. The piers are constructed using concrete of different grades. Its durability is dependent on various factors viz. speed of running water, its aggressivity, temperatures fluctuations etc. The endurance capacity of these piers against these adverse conditions is goes on reducing with passage of time. Gradually permeability of concrete increases which causes leaching of binding materials thus weakening the structure. Once such a phenomenon is observed in any such structures a vigilant periodic monitoring approach becomes mandatory. The suitable remedial measure to be adopted will depend on the observed degree of deterioration. In this paper effort has been made to assess the status of concrete in the piers of a barrage project using Portable Ultrasound Non-destructive Digital Indicator Tester.

**Keywords**: Leaching, pier, Ultrasonic, Non-destructive, pulse velocity.

## I. INTRODUCTION

*A* In a barrage the endurance capacity of piers against adverse conditions such as speed of running water, its aggressivity, temperatures fluctuations etc goes on reducing with passage of time. The permeability of concrete gradually increases. causes leaching of binding materials thus weakening the structure (Fig. 1).

Fig. 1 Exposed reinforcement in piers due to spalling of cover

Once such a phenomenon is observed in any such structures a vigilant periodic monitoring approach becomes mandatory. The suitable remedial measure to be adopted will depend on the observed degree of deterioration. In this paper effort has been made to assess the status of concrete in the piers of a barrage project using Portable Ultrasound Non-destructive Digital Indicator Tester.

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***B*** *Literature Review*

The permeated water causes corrosion of reinforcement leading to weakening of structure [1]. Diagnosis of the residual strength of concrete and its constant monitoring will provide useful information for adopting suitable preventive measures [2]. Using non destructive tests in diagnosis of concrete is an efficient and versatile monitoring technique which can be safely applied in any field conditions [3]. Quality of concrete can be evaluated using ultrasonic pulse velocity technique which is a non destructive method of testing [4]. It uses the basic principle of determining time taken by an irrational pulse to travel a known distance through a concrete [5]. Ultrasonic pulse velocity of concrete is used to predict compressive strength [6, 7]. Pulse velocity is influenced by status of concrete [8, 9].

## II METHOD ADOPTED

***A*** *Ultrasound Non destructive Test*

Through an indirect transmission mode, as illustrated in Fig. 2, ultrasonic pulse velocities were measured by a commercially 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 traveling 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. 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.

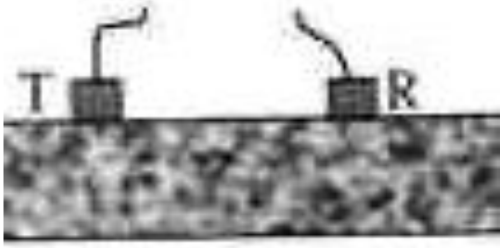


Figure 2: Indirect Transmission Modes (T: Transducer, R: Receiver)

## III EQUIPMENT USED

*Portable Ultrasound Non destructive Digital Indicator Tester (PUNDIT)*

PUNDIT (Fig. 3) was used to observe the time of travel of ultrasonic wave between two fixed point at a distance of 500 cm apart. Waves are generated through one transducer and received by another transducer.

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Fig.3. Portable Ultrasound Non destructive Digital Indicator Tester Equipment (PUNDIT)

Pulse wave velocity is calculated by following relation. Based on the pulse wave velocity the status of concrete is categorized in four categories (Table 1)

**Velocity = Distance/Time**

**Table-1: Showing the Status of Concrete based on Pulse Wave Velocity**

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

## IV TEST LOCATIONS

Detailed location of different piers and grid patterns are given in Table 2.

Table 2: Details of locations for corrosion monitoring

| Pier | Location |
|---|---|
| 1 | D/S RHS FACE, 3.2m from gate. |
| 2 | D/S RHS 2.3 m away from the pier tail top |
| 3 | D/S RHS FACE10 m away from the gate |
| 4 | D/S RHS FACE 19.5 m away from the gate |
| 5 | D/S LHS FACE 7 m away from the gate |
| 6 | D/S RHS FACE, 26.3 m away from the gate. |
| 7 | D/S RHS FACE13.7 m away from the gate |
| 8 | D/S RHS, 16 m away from the gate. |
| 9 | D/S RHS, 25.7 m away from the gate |

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## V OBSERVATIONS

Investigations were carried out at certain fixed locations selected on the basis of heavy leaching patches (Table 2). The observed values for the tests done at 9 piers are presented in fig. 4 – 12.

## VI RESULT AND DISCUSSION

Ultrasonic Pulse Velocity test was conducted on 9 piers on down-stream side of concrete faces at grid points formed on a grid of size 50 cm x 50 cm along 3 to 5 rows. The successive distance between the two points was kept as 50 cm. from each other on all the rows.

### *A Right face of Pier No.1 on Down-Stream side*

The first grid point of each row was located at a horizontal distance of about 3.2 m away from the gate. The vertical distance of the I$^{st}$,II$^{nd}$,III$^{rd}$,IV$^{th}$&V$^{th}$ rows were 5.0 m,5.5 m,6.0 m,7.8 m & 8.3 m respectively from top of the pier. The results are presented in the fig. 4. The pie chart clearly shows that 39% of the scanned area falls under doubtful region.

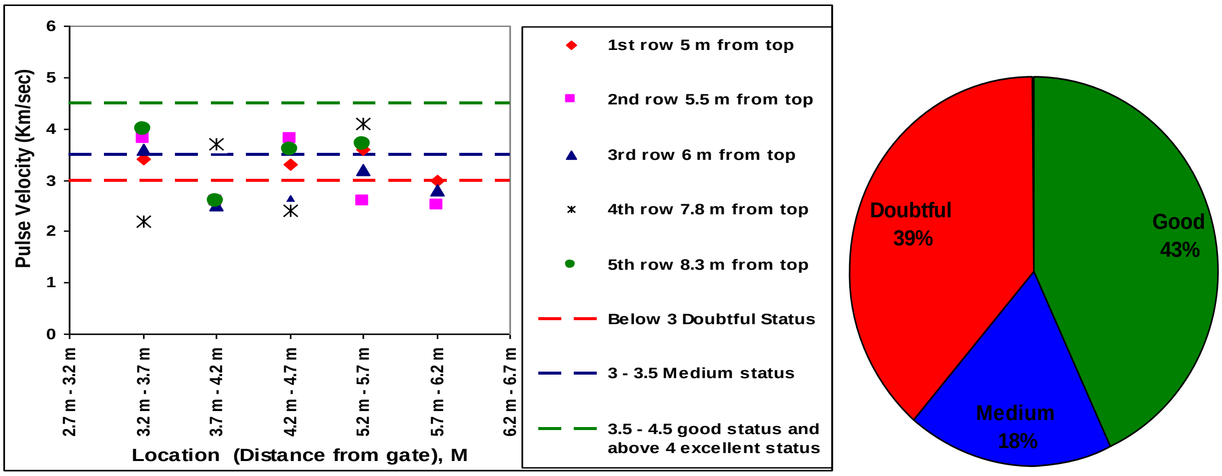


**Fig 4: Status of Concrete based on Pulse Wave Velocity Test**

### *B Right face of Pier No. 2 on Down-Stream side*

The first grid point of each row was located at a horizontal distance of about 2.3 m away from the pier tail top. The vertical distance of the I$^{st}$,II$^{nd}$ and III$^{rd}$ rows were 2.5 m, 3.0 m and 3.5 m respectively from top of the pier. The results are presented in the fig. 5. The pie chart clearly shows that 25% of the scanned area falls under doubtful region.

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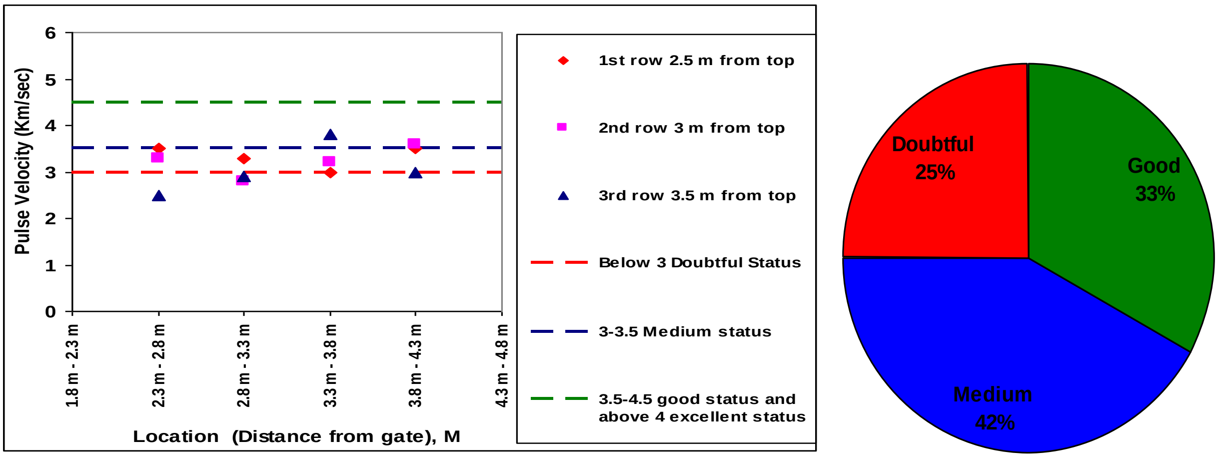


**Fig 5: Status of Concrete based on Pulse Wave Velocity Test**

***C*** *Right face of Pier No.3 on Down-Stream side*

The first grid point of each row was located at a horizontal distance of about 10 m away from the gate. The vertical distance of the I$^{st}$,II$^{nd}$ and III$^{rd}$ rows were 5.2 m,5.7 m and 6.05 m respectively from top of the pier. The results are presented in the fig. 6. The pie chart clearly shows that 25% of the scanned area falls under doubtful region

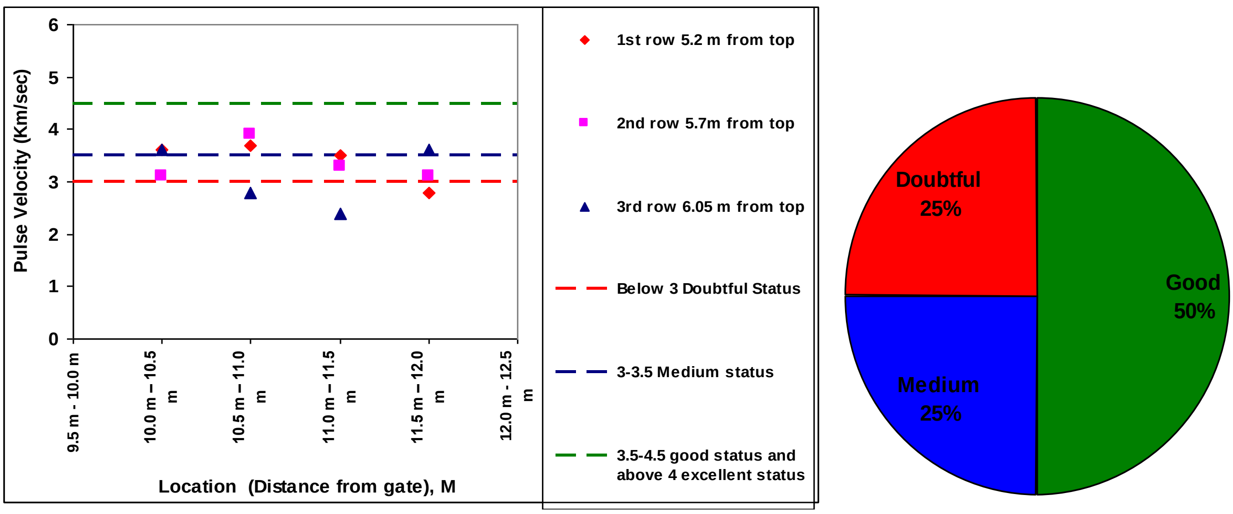


Fig 6: Status of Concrete based on Pulse Wave Velocity Test

***D*** *Right face of Pier No. 4 on Down-Stream side*

The first grid point of each row was located at a horizontal distance of about 19.5 m away from the gate. The vertical distance of the I$^{st}$,II$^{nd}$, IIIr$^{d}$&IV$^{th}$ rows were 5.0 m, 5.5 m, 6.0 m and7.8 m respectively from top of the pier. The results are presented in the fig. 7. The pie chart clearly shows that 25% of the scanned area falls under doubtful region

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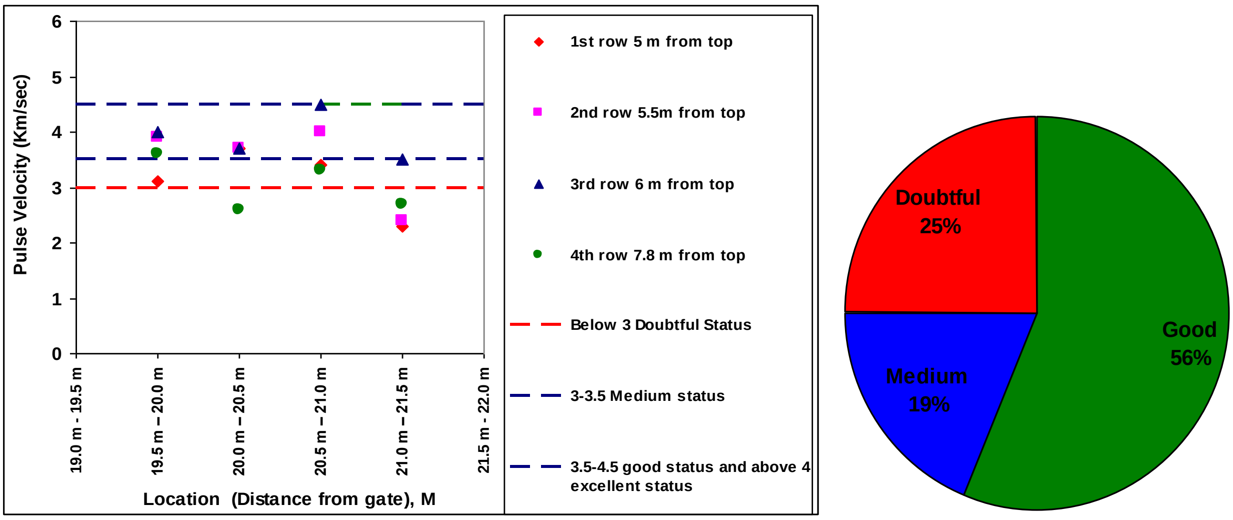


Fig 7: Status of Concrete based on Pulse Wave Velocity Test

***E*** *Left face of Pier No.5 on Down-Stream side*

The first grid point of each row was located at a horizontal distance of about 7 m away from the gate. The vertical distance of the I$^{st}$,II$^{nd}$ and III$^{rd}$ rows were 5.0 m,5.5 m and 6.0 m respectively from top of the pier. The results are presented in the fig. 8. The pie chart clearly shows that 17% of the scanned area falls under doubtful region

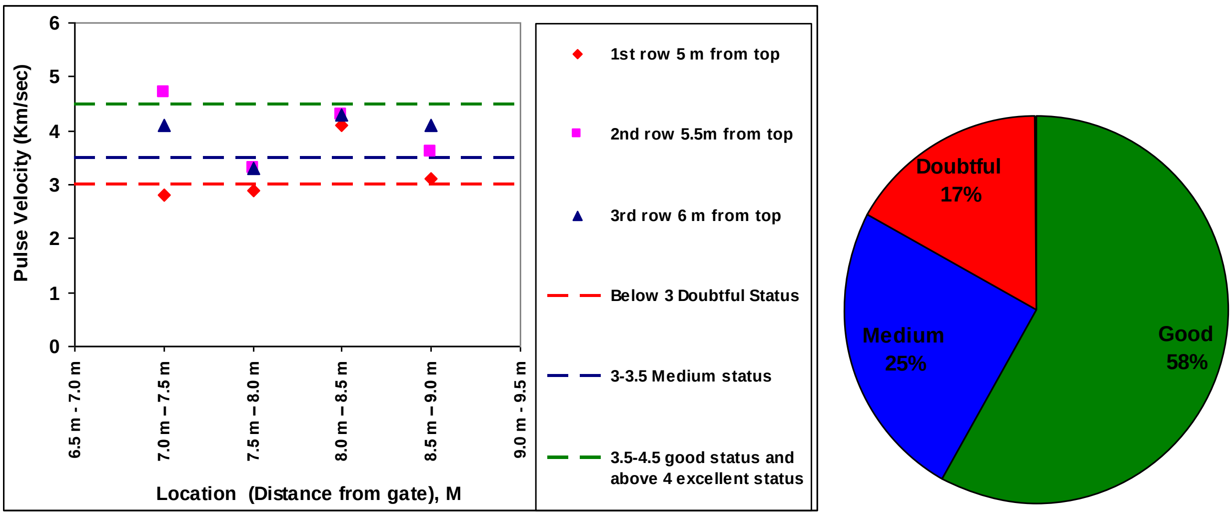


Fig 8: Status of Concrete based on Pulse Wave Velocity Test

***F*** *Right face of Pier No.6 on Down-Stream side*

The first grid point of each row was located at a horizontal distance of about 26.3 m away from the gate. The vertical distance of the I$^{st}$,II$^{nd}$, &III$^{rd}$ rows were 4.5 m,5.0 m and 5.5 m respectively from top of the pier. The results are presented in the fig. 9. The pie chart clearly shows that 25% of the scanned area falls under doubtful region.

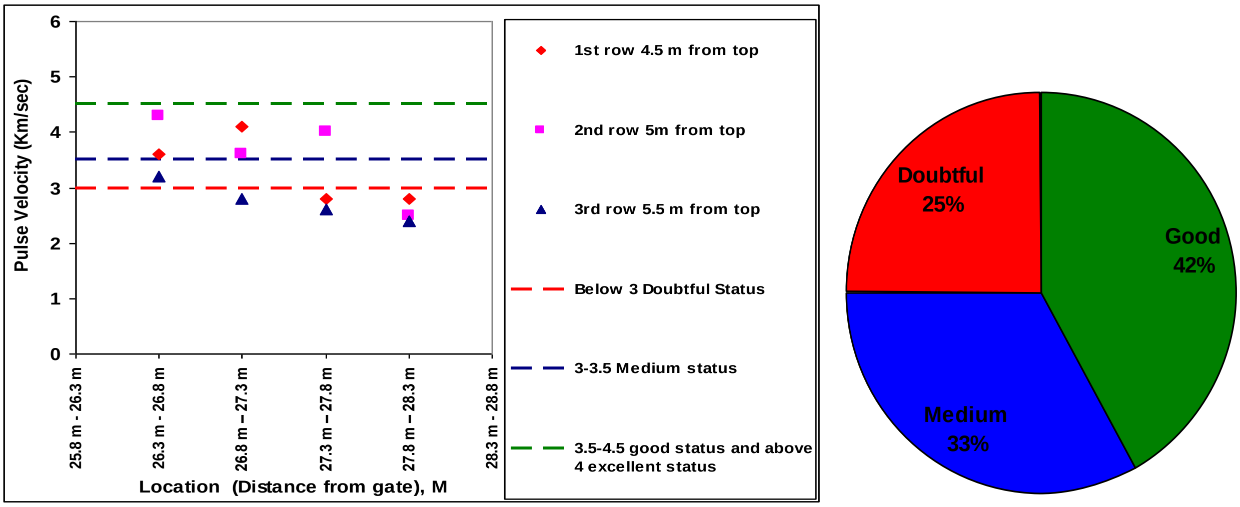


Fig 9: Status of Concrete based on Pulse Wave Velocity Test

***G*** *Right face of Pier No.7 on Down-Stream side*

The first grid point of each row was located at a horizontal distance of about 13.7 m away from the gate. The vertical distance of the I$^{st}$,II$^{nd}$, &III$^{rd}$ rows were 8.10 m,8.6 m and 9.2 m respectively from top of the pier. The results are presented in the fig. 10. The pie chart clearly shows that 7% of the scanned area falls under doubtful region

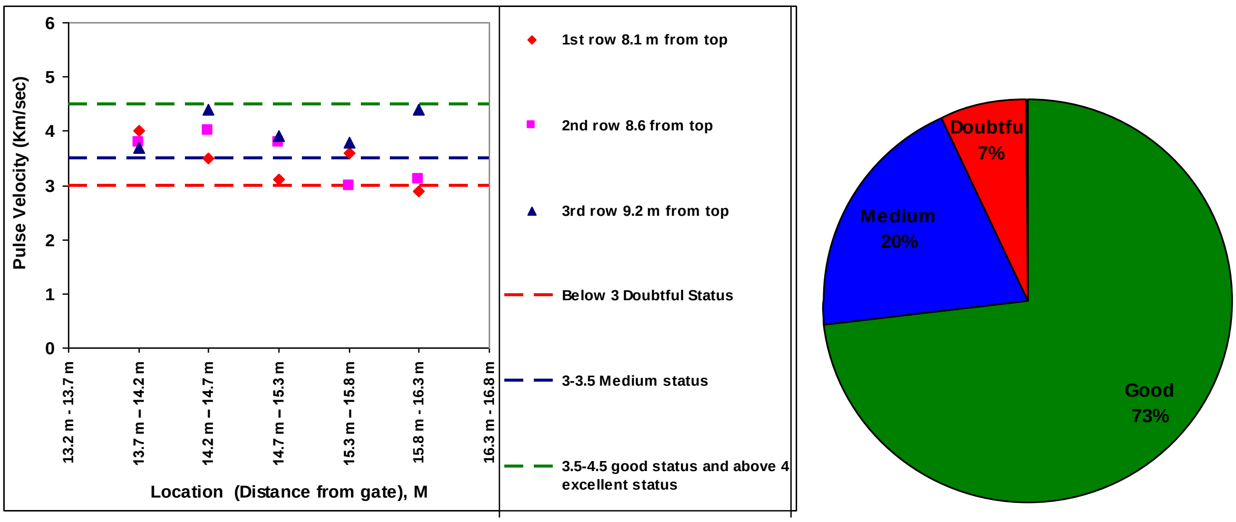


Fig 10: Status of Concrete based on Pulse Wave Velocity Test

***H*** *Right face of Pier No.8 on Down-Stream side*

The first grid point of each row was located at a horizontal distance of about 16 m away from the gate. The vertical distance of the I$^{st}$,II$^{nd}$ and III$^{rd}$ rows were 5.0m,5.5m and 6.0m respectively from top of the pier. The results are presented in the fig. 11. The pie chart clearly shows that 25% of the scanned area falls under doubtful region

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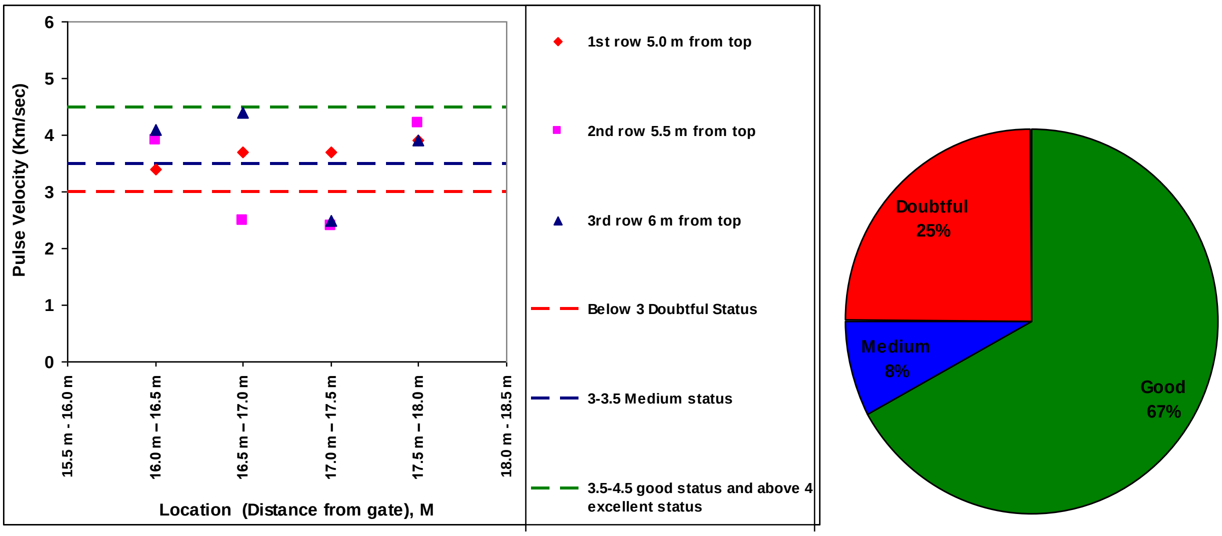


Fig 11: Status of Concrete based on Pulse Wave Velocity Test

***I*** *Right face of Pier No.9 on Down-Stream side*

The first grid point of each row was located at a horizontal distance of about 25.7 m away from the gate. The vertical distance of the Ist,IInd, &IIIrd rows were 5.0m,5.5m and 6.0m respectively from top of the pier. The results are presented in the fig. 12. The pie chart clearly shows that 33% of the scanned area falls under doubtful region

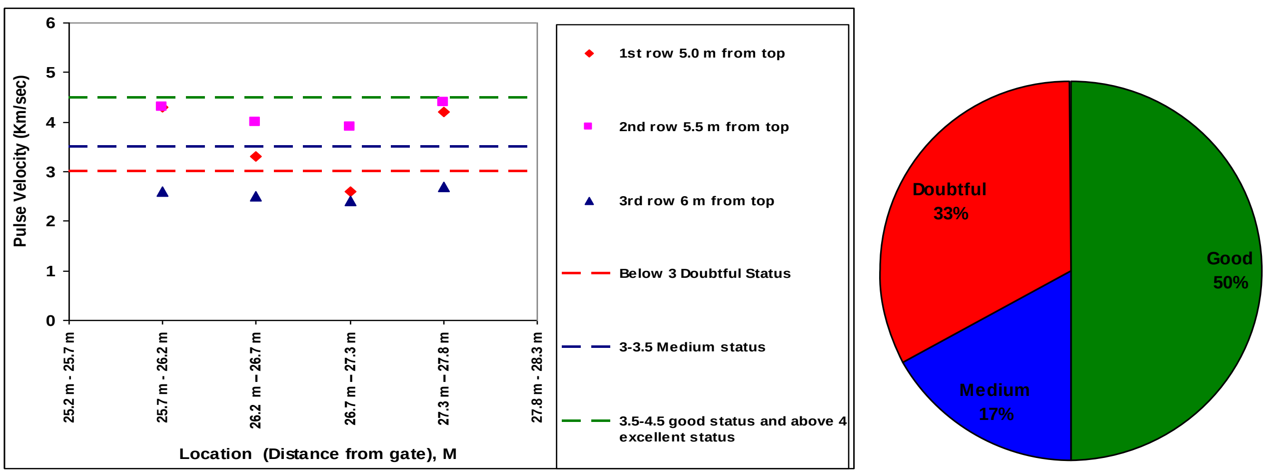


Fig 12: Status of Concrete based on Pulse Wave Velocity Test

## VII CONCLUSION

Based on pulse wave velocity test pier no 5 and 7 have 7% and 17% of the scanned area as doubtful status while in other piers 25% - 39% of the scanned area is categorized as doubtful i.e. the status of concrete is not good in this region.

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Further investigation to confirm the status of concrete is planned by extracting cores from these affected zones and testing these core samples in laboratory.

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