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International
Journal
Of Modern Engineering Research (IJMER)

Effect of Dimensional Variation of Test Section on Performance of Portable Ultrasound Non-Destructive Digital Indicator Tester in Assessment of Status of Concrete

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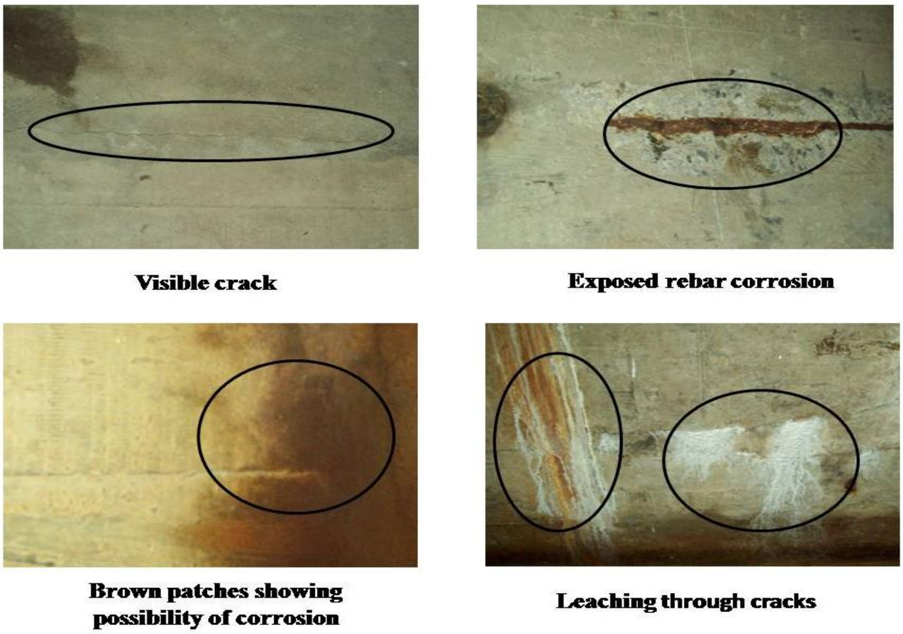
Abstract: *Aging of concrete structures and their interactions with persistent prevailing environmental conditions will alter its material properties and cause deteriorations. Inspite of maintaining the best quality control concrete may not behave as a homogeneous medium. Conducting any test in the modest way is the key factor for true assessment of the status of substratum. Diagnosis of the residual strength of concrete in insitu condition using non-destructive tests provides useful information for adopting suitable preventive measures. Deteriorations in the concrete can be broadly imaged using ultrasonic pulse velocity technique. However, the results of ultrasonic pulse velocity depend on various factors. To establish the effect of span length of test sections 16 tests were conducted at 4 different locations in the galleries of a hydroelectric project situated in the Himalayan region. This paper presents the findings of these tests which clearly emphasize the need of defining optimum length of test span for the best reflection of status of scanned area.*

Keywords: *Concrete, Test span, Ultrasonic, Non-destructive, Heterogeneous substratum.*

I. INTRODUCTION

Aging of concrete structures and their interactions with persistent prevailing environmental conditions will alter the material properties and cause deteriorations (fig.1).



Visible crack **Exposed rebar corrosion**

Brown patches showing possibility of corrosion **Leaching through cracks**

Figure 1: Deteriorations in concrete

In such situations instant diagnosis of problem in insitu conditions becomes mandatory. Diagnosis of the residual strength of concrete and its constant monitoring will provide useful information for adopting suitable preventive measures [4, 5, 9]. Selection of proper test method and applying it in modest way is the key factor to study the status of concrete. Using non-destructive tests (NDT) in diagnosis of defects in concrete is an efficient and versatile monitoring technique which can be safely applied in any field conditions [1, 8]. Quality of concrete can be evaluated using ultrasonic pulse velocity technique which is a NDT method of testing [2]. For assessing insitu deterioration indirect transmission of ultrasonic pulse velocity (UPV) is applied. In this method ultrasonic stress waves are propagated between two points located on the same surface. It uses the basic principle of determining time taken by an irrational pulse to travel a known distance through a concrete [3]. UPV is influenced by status of concrete [6, 7].

Inspite of best quality control concrete may not behave as a homogeneous medium so for any two sections UPV may or may not be the same. It may differ if the length of test section is altered. So in order image the correct condition of test section an optimum length of test section needs to be defined. To study this 16 tests were carried out at 4 different locations in the galleries of a hydroelectric project situated in the Himalayan region.

II. METHOD ADOPTED

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 in two different manners

1. At a distance of 0.3 m horizontally
2. At a distance of 0.9 m horizontally

As a result, the traveling length of the ultrasonic pulse was 0.3 m and 0.9m horizontally. The concrete surface was prepared in advance for a proper acoustic coupling by applying grease. Light pressure was applied 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.

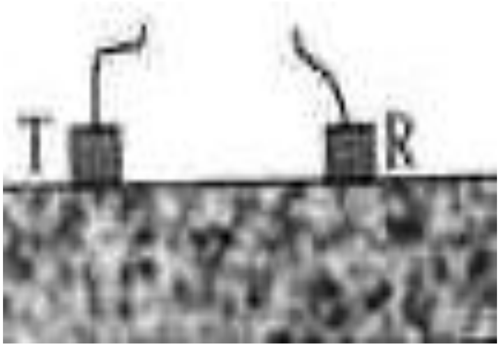


Figure 2: Indirect Transmission Mode (T: Transducer, R: Receiver)

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 specified distance. Waves are generated through one transducer and received by another transducer. Based on the UPV the status of concrete is assessed

Figure 3: Portable Ultrasound Non destructive Digital Indicator Tester Equipment (PUNDIT)

IV. Observations

Investigations were carried out at 4 locations selected on the basis of various visual defects (Table 1).

Table I: *Locations of Test Points*

Location	Face	Row	Number of observation points	Presentation of Observations
A	Upstream	Upper	50	Fig. 4
		Lower	50	Fig. 5
	Downstream	Upper	50	Fig. 6
		Lower	50	Fig. 7
B	Upstream	Upper	87	Fig. 8
		Lower	87	Fig. 9
	Downstream	Upper	87	Fig. 10
		Lower	87	Fig. 11
C	Upstream	Upper	143	Fig. 12
		Lower	143	Fig. 13
	Downstream	Upper	143	Fig. 14
		Lower	143	Fig. 15
D	Upstream	Upper	77	Fig. 16
		Lower	77	Fig. 17
	Downstream	Upper	77	Fig. 18
		Lower	77	Fig. 19

V. Result And Discussion

Location A

The results of Pulse Wave Velocity test conducted for 30cm and 90 cm categories for four rows are presented in Fig. 4a, 5a, 6a and 7a. Based on the test results it is observed that the UPV observed for a span of 30 cm is more than that observed for the span of 90 cm (Fig. 4b, 5b, 6b and 7b).

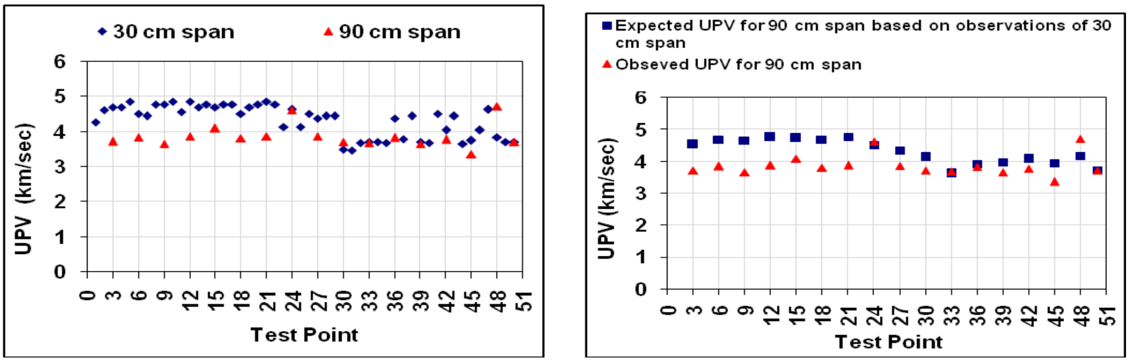


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Figure 4: UPV - upstream upper row

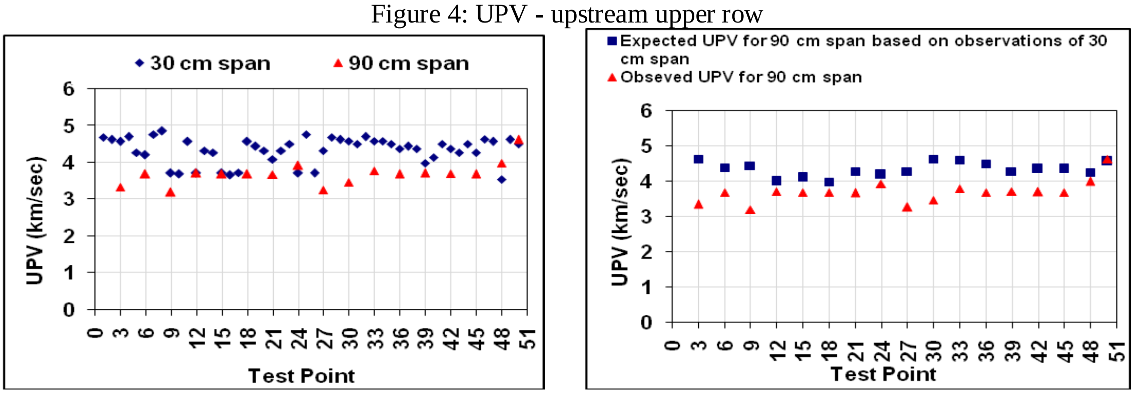

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Figure 5: UPV - upstream lower row

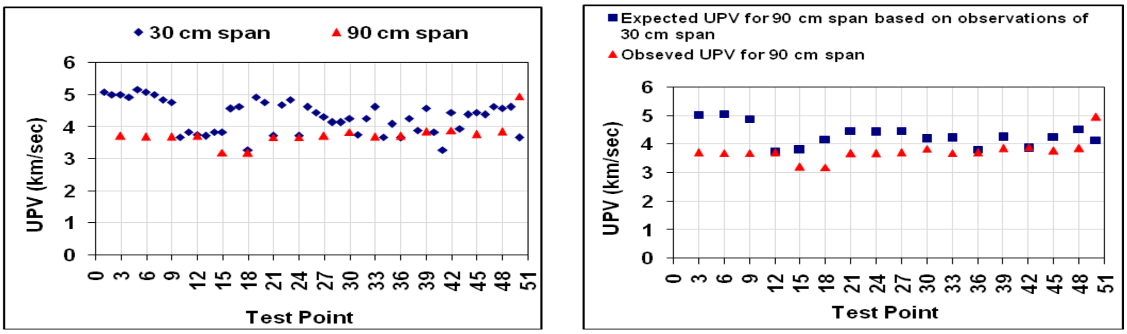

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Figure 6: UPV - downstream upper row

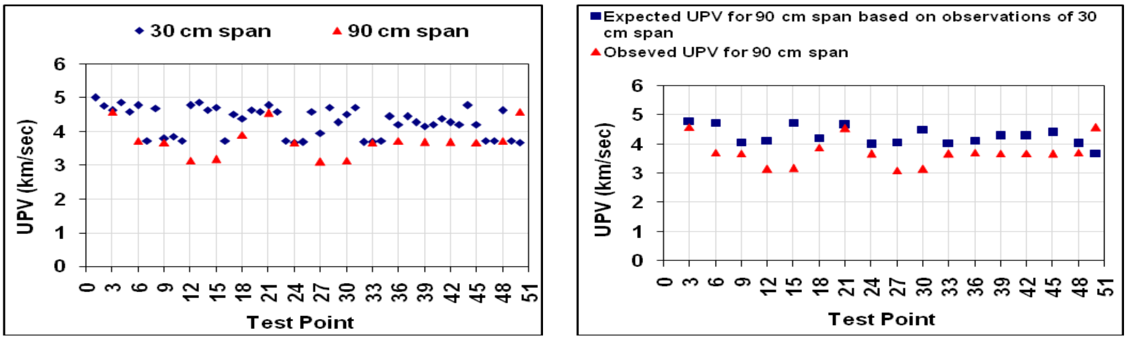

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Figure 7: UPV - downstream lower row

Location B

The results of Pulse Wave Velocity test conducted for 30cm and 90 cm categories for four rows are presented in Fig. 8a, 9a, 10a and 11a. Based on the test results it is observed that the UPV observed for a span of 30 cm is more than that observed for the span of 90 cm (Fig. 8b, 9b, 10b and 11b).

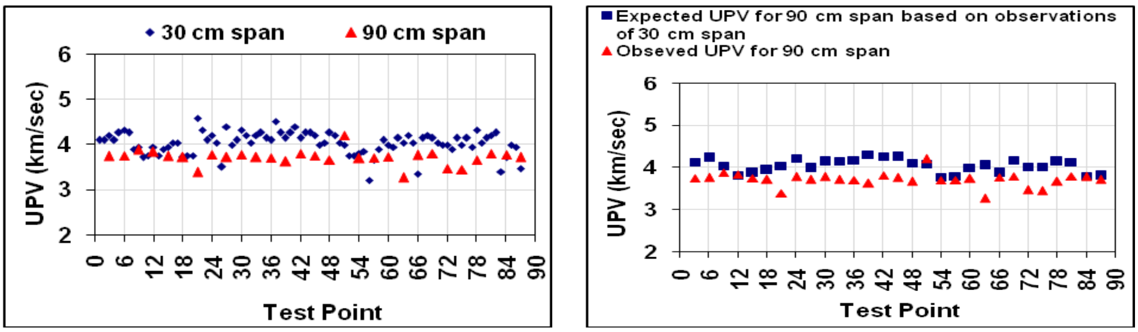

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Figure 8: UPV - upstream upper row

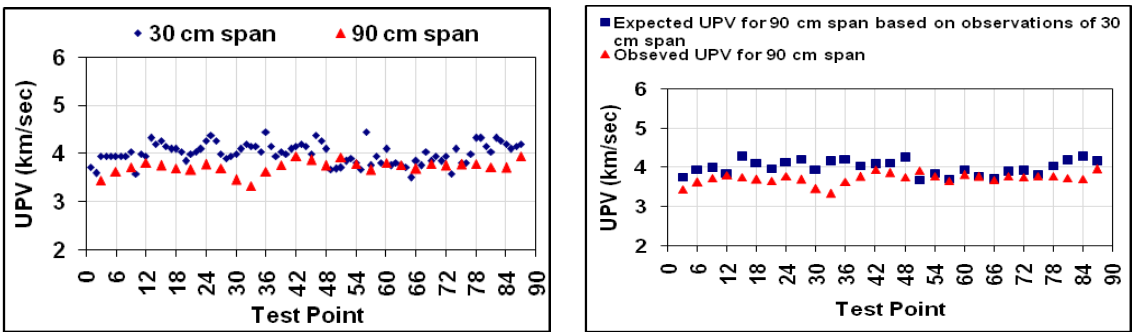

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Figure 9: UPV - upstream lower row

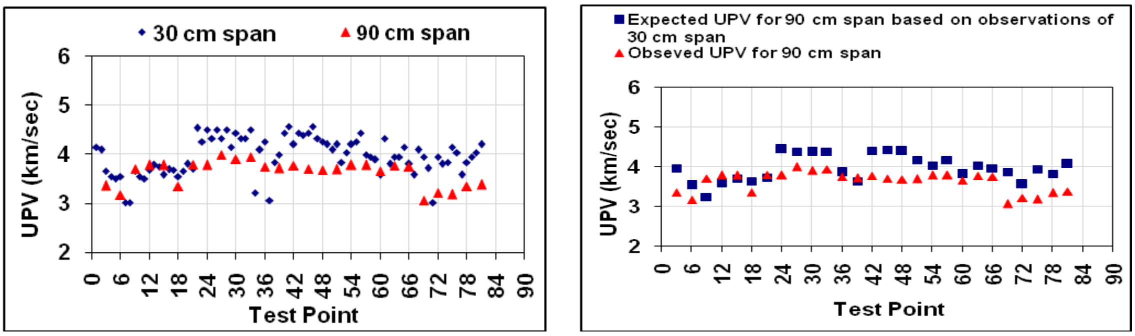

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Figure 10: UPV - downstream upper row

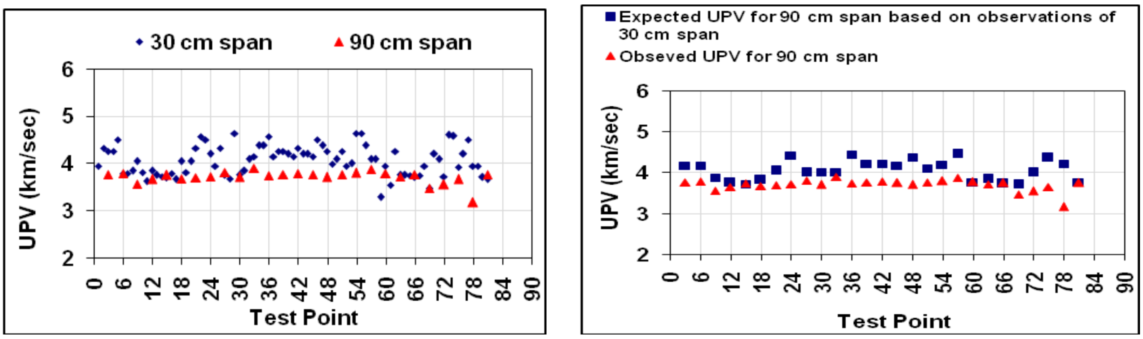

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Figure 11: UPV - downstream lower row

Location C

The results of Pulse Wave Velocity test conducted for 30cm and 90 cm categories for four rows are presented in Fig. 12a, 13a, 14a and 15a. Based on the test results it is observed that the UPV observed for a span of 30 cm is more than that observed for the span of 90 cm (Fig. 12b, 13b, 14b and 15b).

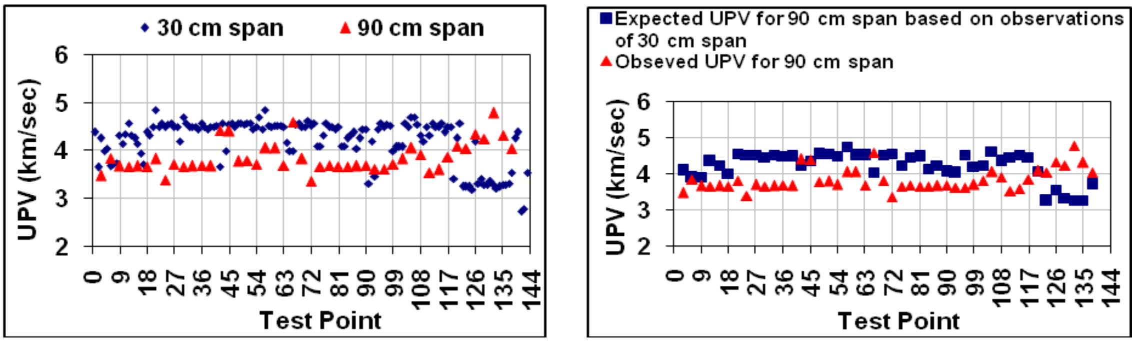

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Figure 12: UPV - upstream upper row

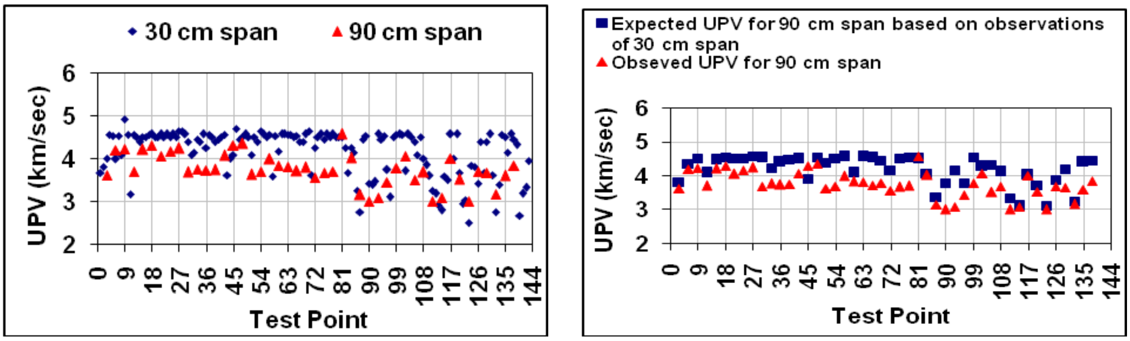

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Figure 13: UPV - upstream upper row

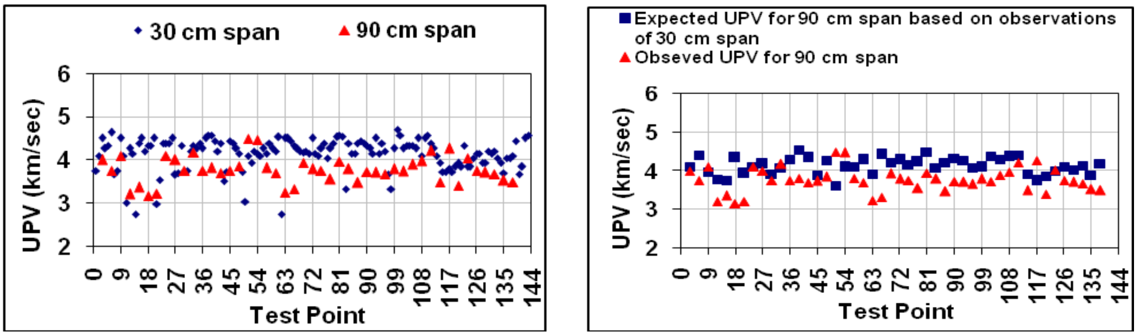

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Figure 14: UPV - upstream upper row

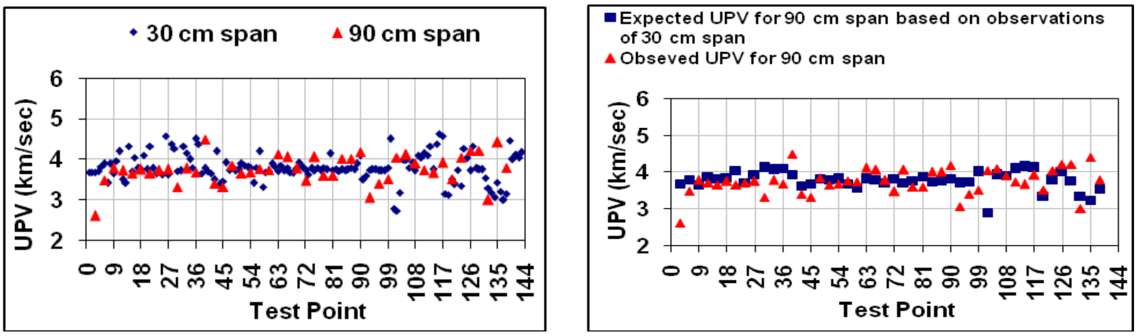

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Figure 15: UPV - upstream upper row

Location D

The results of Pulse Wave Velocity test conducted for 30cm and 90 cm categories for four rows are presented in Fig. 16a, 17a, 18a and 19a. Based on the test results it is observed that the UPV observed for a span of 30 cm is more than that observed for the span of 90 cm (Fig. 16b, 17b, 18b and 19b).

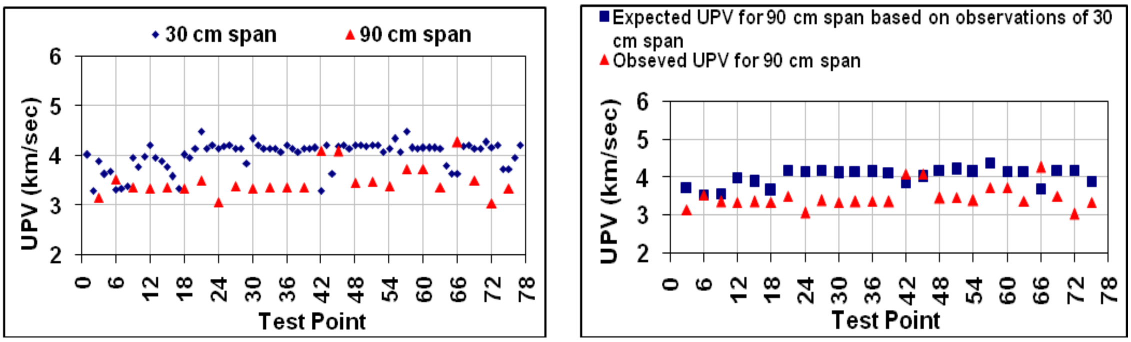

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Figure 16: UPV - upstream upper row

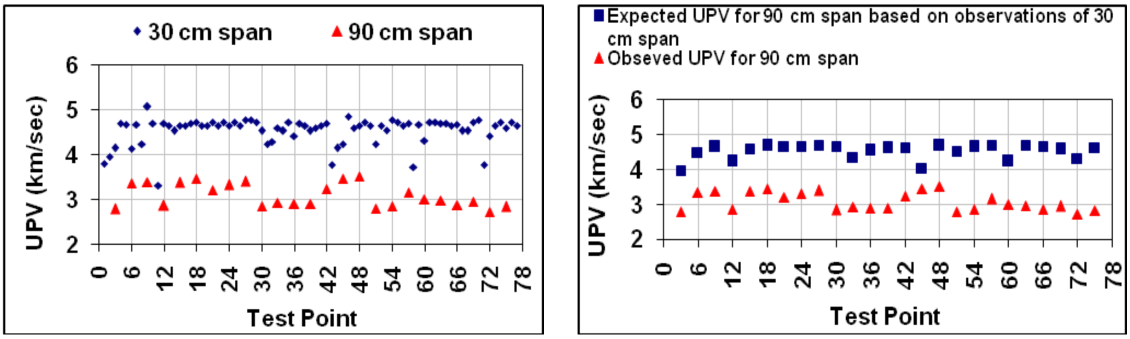

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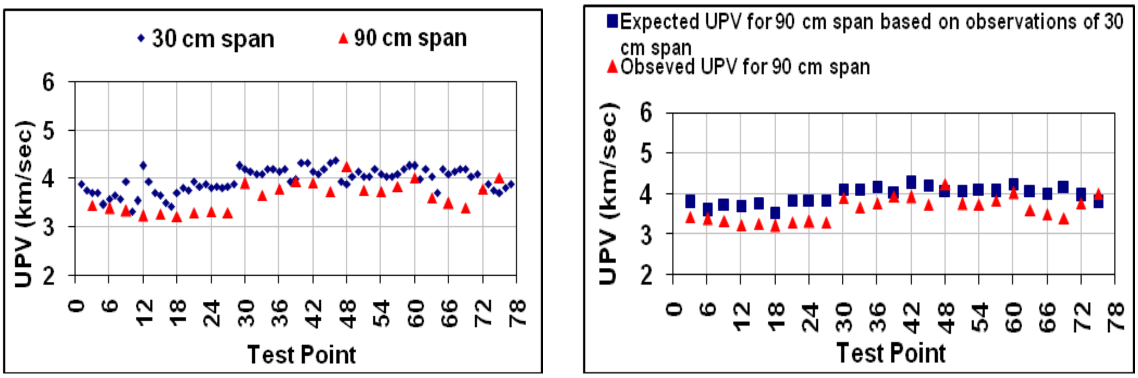
Figure 17: UPV - upstream lower row



a b

Figure 18: UPV - downstream upper row

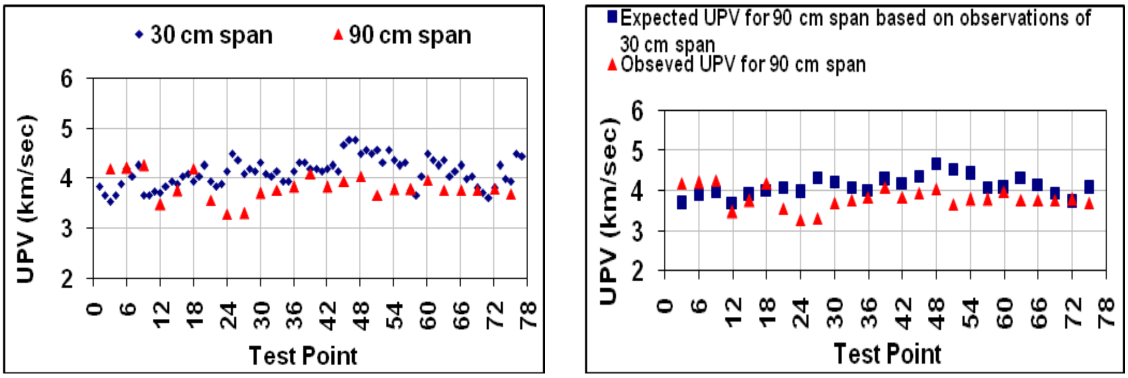


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Figure 19: UPV - downstream lower row

Since ultrasonic pulse velocity depends on status of concrete, it may not be the same for any two sections. The study clearly shows that the ultrasonic pulse velocity recorded for a span of 30 cm is more than that for 90 cm span. Assessment of the status of heterogeneous substratum through ultrasonic pulse velocity in a short span may not reflect true image as it might encounter a more dense short section or even a rebar.

VI. Conclusion

Conducting any test in the modest way is the key factor for true assessment of the status of substratum. Inspite of maintaining the best quality control concrete may not behave as a homogeneous medium. Diagnosis of the residual strength of concrete in insitu condition using non-destructive tests provides useful information for adopting suitable preventive measures. Deteriorations in the concrete can be broadly imaged using ultrasonic pulse velocity technique. However, the results of ultrasonic pulse velocity recorded for different span length of test sections can be different.

VII. Further Study

In order to define the optimum length of the test section for observing ultrasonic pulse velocity in a particular site condition, further study is continued to correlate the results of ultrasonic pulse velocity in insitu condition and ultrasonic pulse velocity observed in representative core samples extracted from the test section.

ACKNOWLEDGEMENT

The authors extend their sincere thanks to Director CSMRS for his constant inspiration. We also extend our sincere gratitude to all the authors whose publications provided us directional information from time to time.

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