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Application of NDT Apparatus for Possible Use as Structural Health Monitoring of Concrete Building in the Field

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OUTLINE

- INTRODUCTION
- METHODOLOGY
- RESULTS AND DISCUSSION
- CONCLUSION

Introduction

Background

- Errors in the process of construction work due to low-quality control
- Extreme load on the building caused by natural disasters such as earthquakes; and
- Insufficient data for evaluating purposes if the building function is to be improved.

Doubts arise about the ability of building's serviceability

→ a non-destructive test (NDT) on the existing building structure is required

Objective

This study is aimed to develop models for interpreting the residual strength of concrete structures in the field when the material quality and structural condition of the structure are questionable

METHODOLOGY

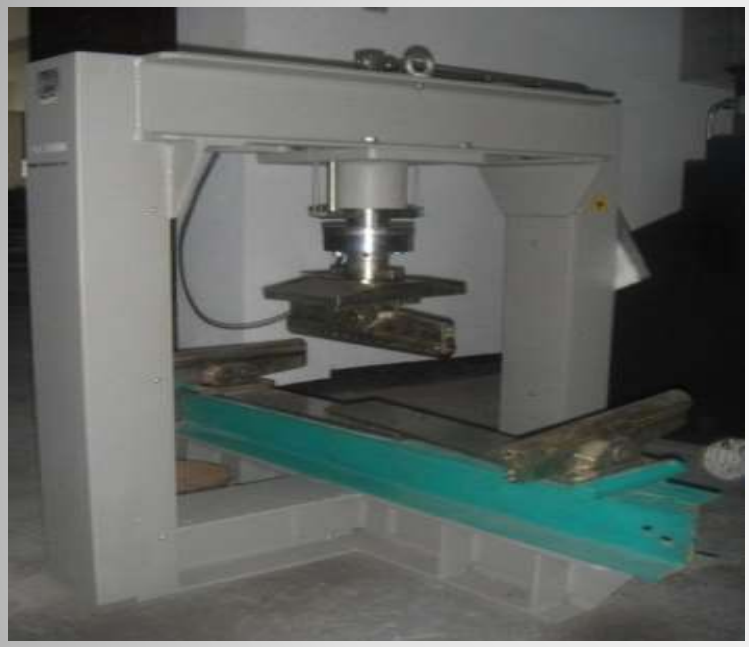
Apparatus used

1. Pundit plus

2. Schmidt Hummer

Apparatus used

3. Flexural test equipment



4. Compression test equipment

Material properties

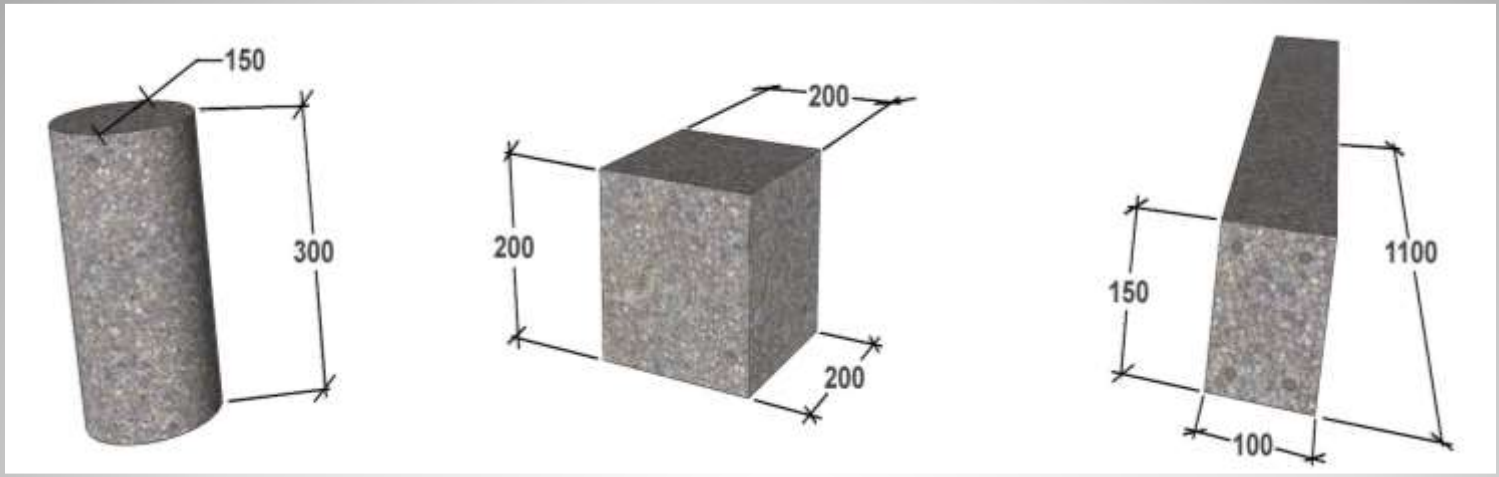
Description	Aggregates	
	Sand	Course aggregate
Unit weight (gr/cm³)	1341	1451
Bulk density (gr/cm³)	1.520	1.646
Fineness modulus	3.203	6.67
Mud content (%)	3.06	-
Specific gravity (SSD)	2.65	2.56

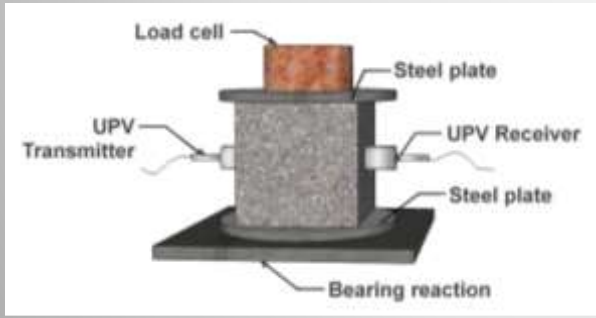
Concrete mix proportions

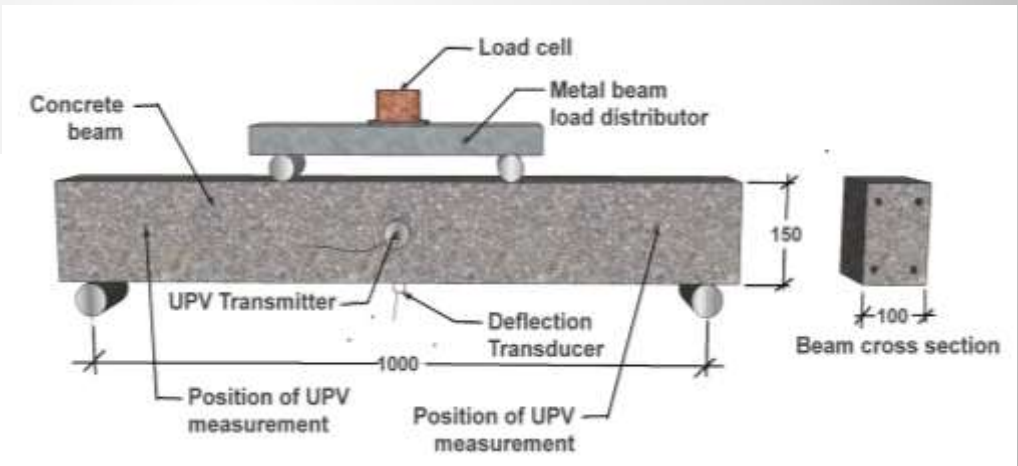
Description	Compressive strength (MPa)		
	25	35	45
Water to cement ratio	0.56	0.48	0.43
Cement (kg/m³)	360	427	466
Water (kg/m³)	205	205	205
Sand (kg/m³)	740	713	693
Gravel (kg/m³)	1110	1070	1040

Group	Designation*)	Specimen number	Objective
1	C-25	3	A preliminary test to develop the relationship between cylinder and cube specimen in terms of its mechanical properties
	C-35	3	
	C-45	3	
	Cu-25	3	
	Cu-35	3	
	Cu-45	3	
	Total 1	18 = (9 C and 9 Cu)	
2	Cu-25	3	Test UPV, Hammer, and DT
	Cu-35	3	
	Cu-45	3	
	Total 2	9	
3	B-25	3	Real structure component representation
	B-35	3	
	B-45	3	
	Total 3	9	

Test specimens and schedule





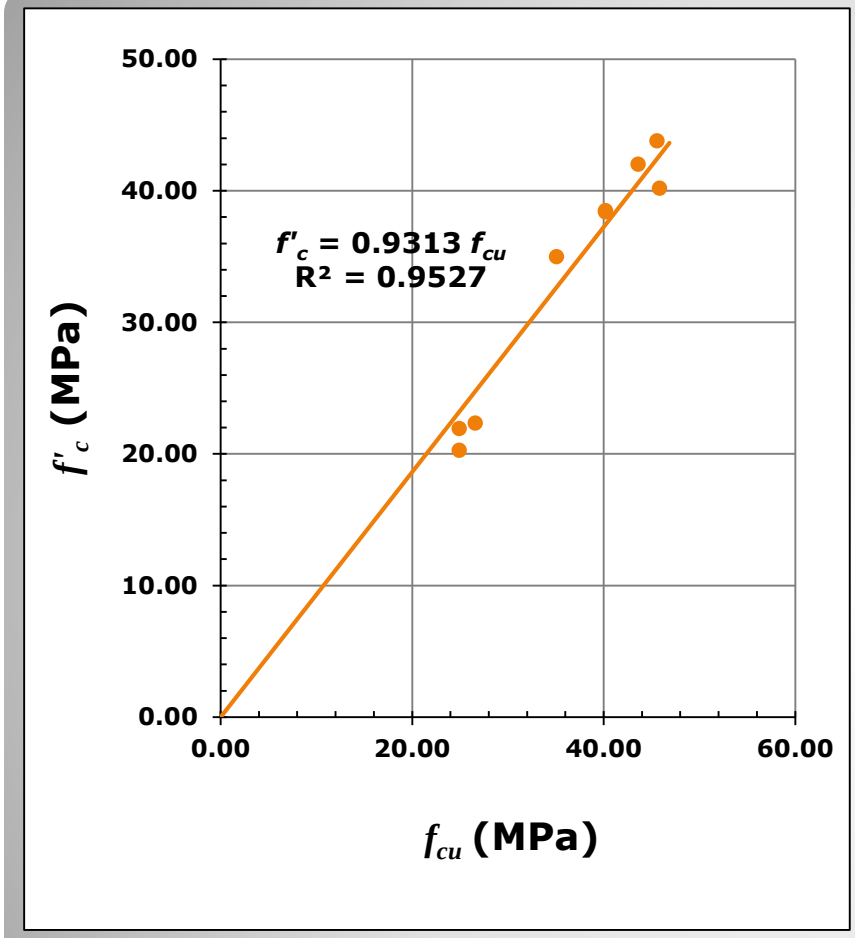


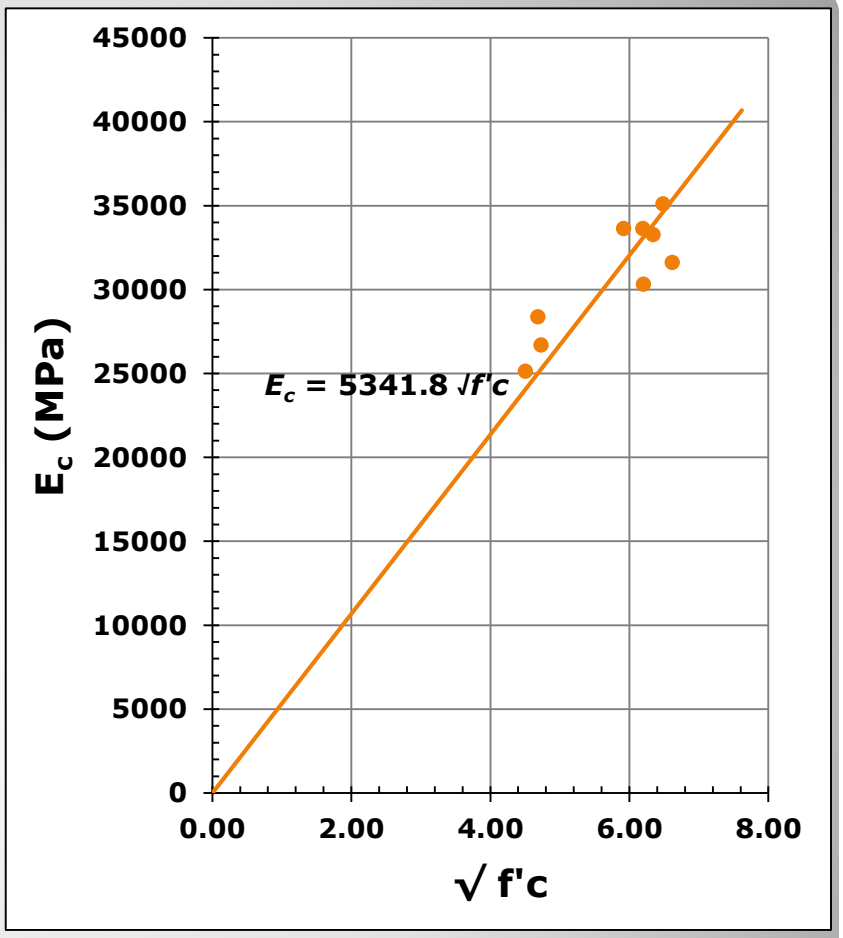
Details of specimens and testing

Testing activities

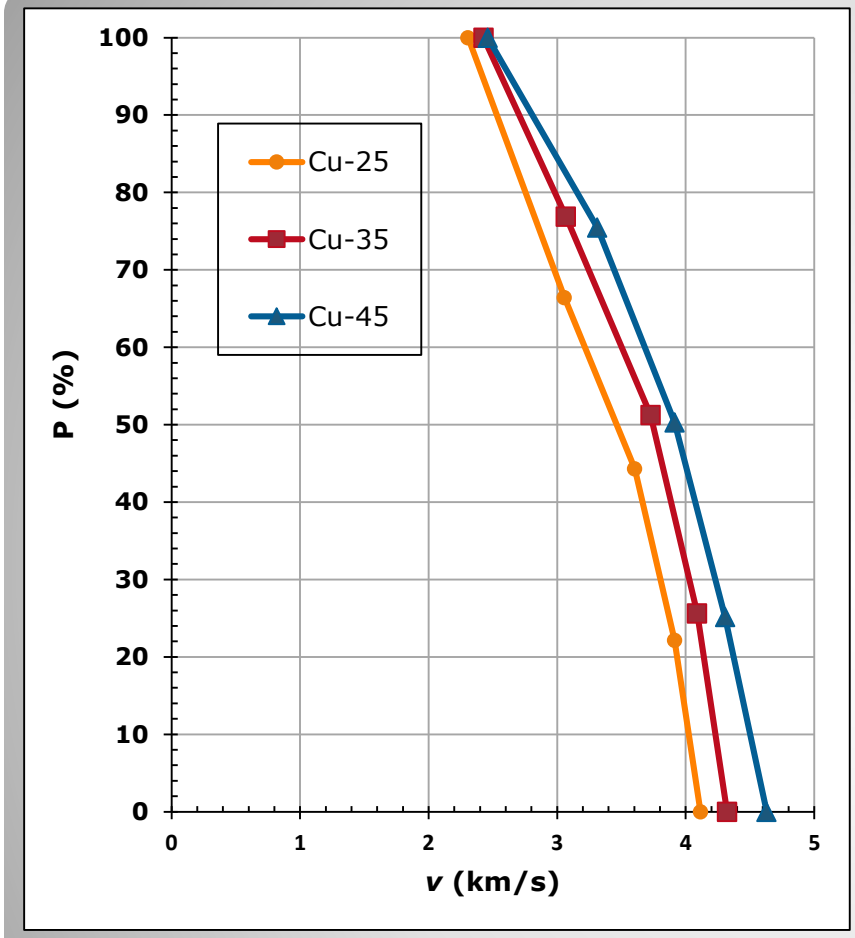
Testing activities (Structure representation)

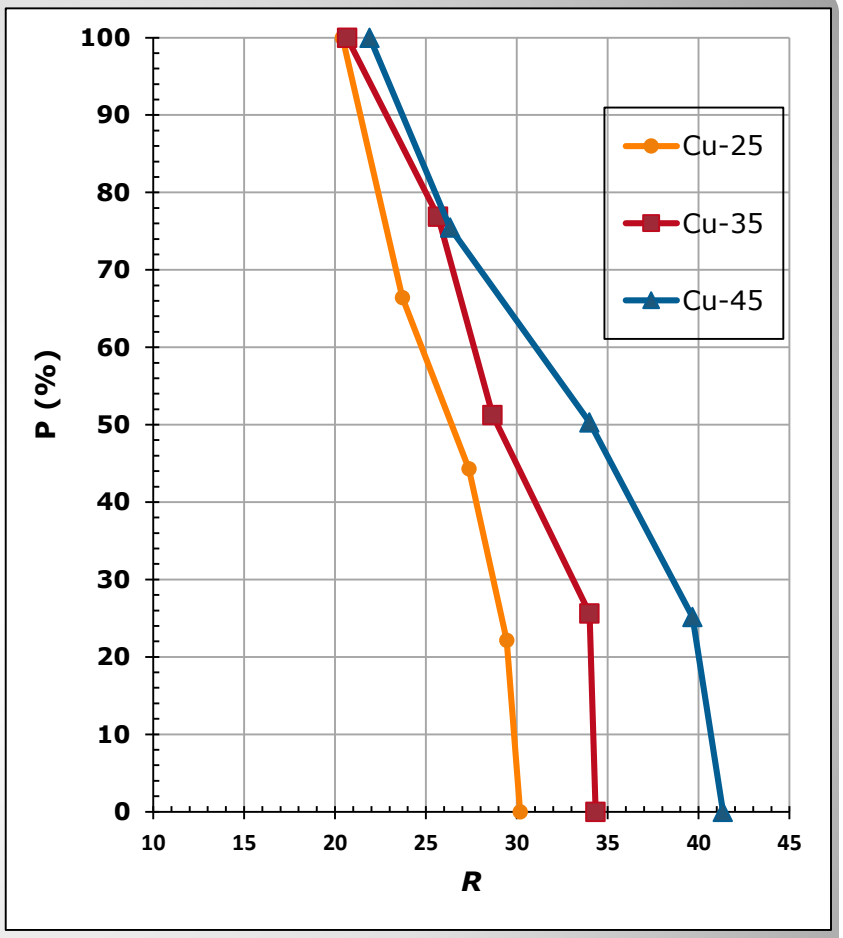
RESULTS AND DISCUSSION



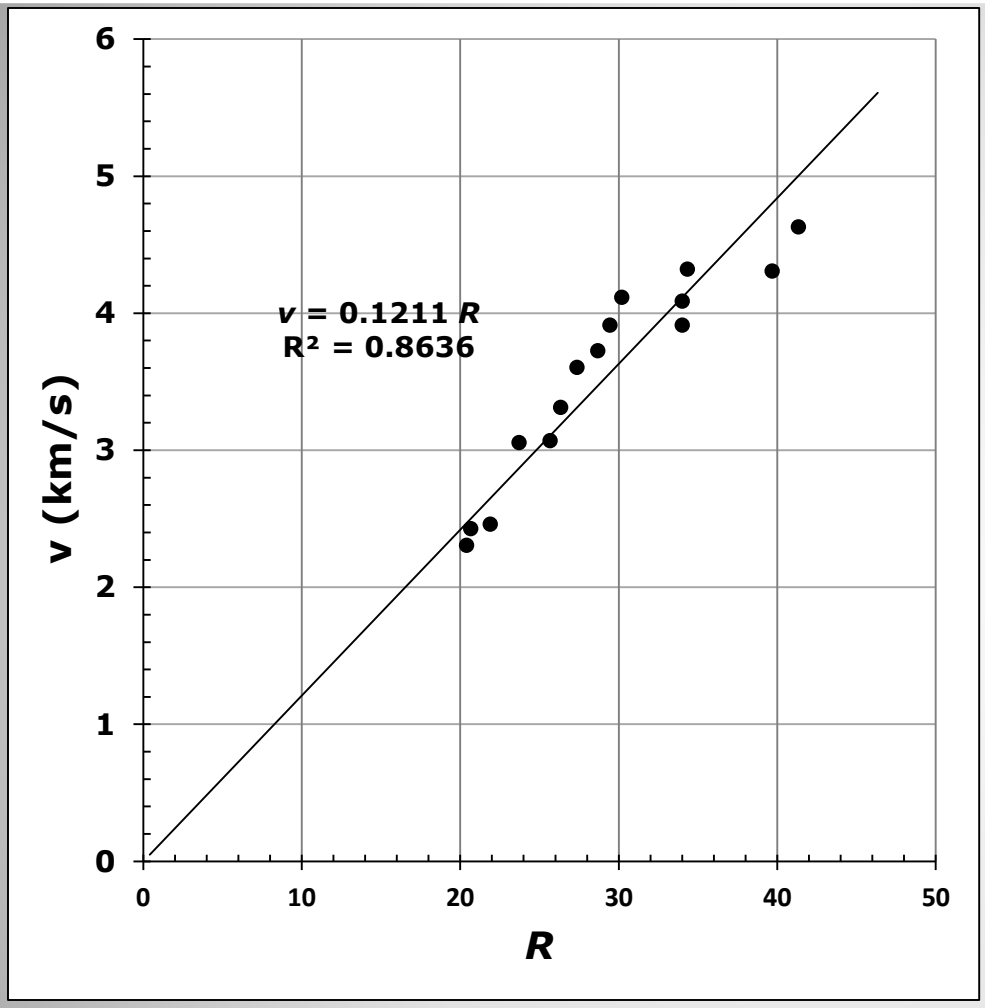


Compressive strength and elastic modulus





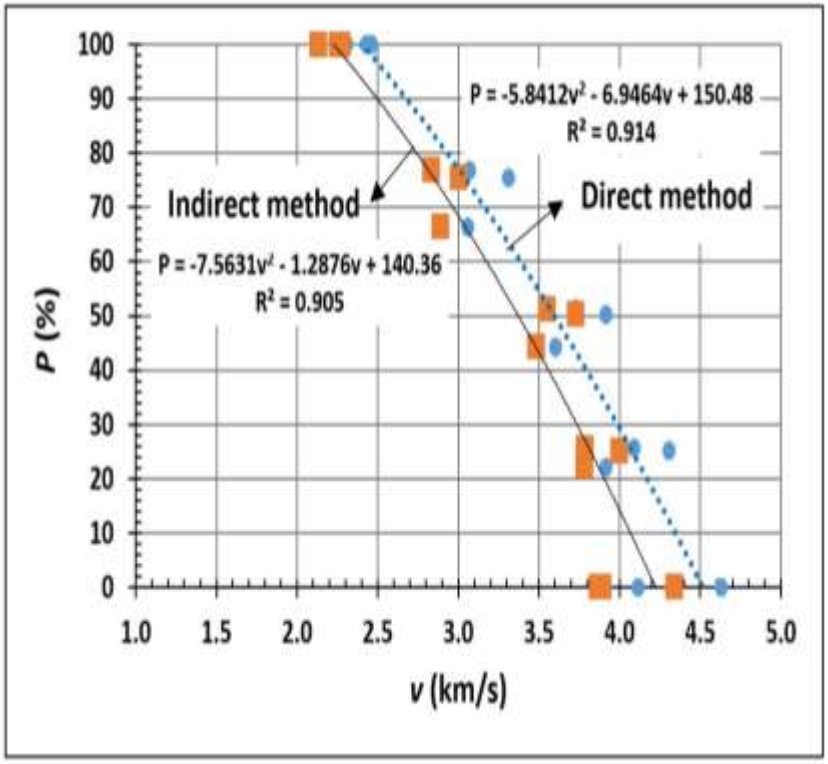
UPV and Rebound number

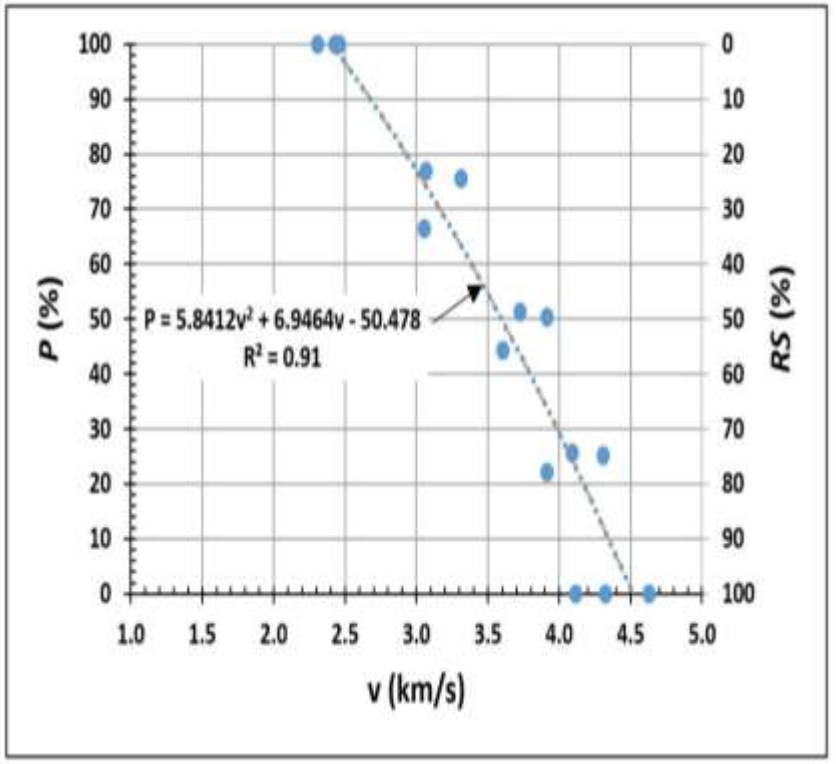


- **Linear relationship**
- **v = 0.1211 R**

V – R relationship

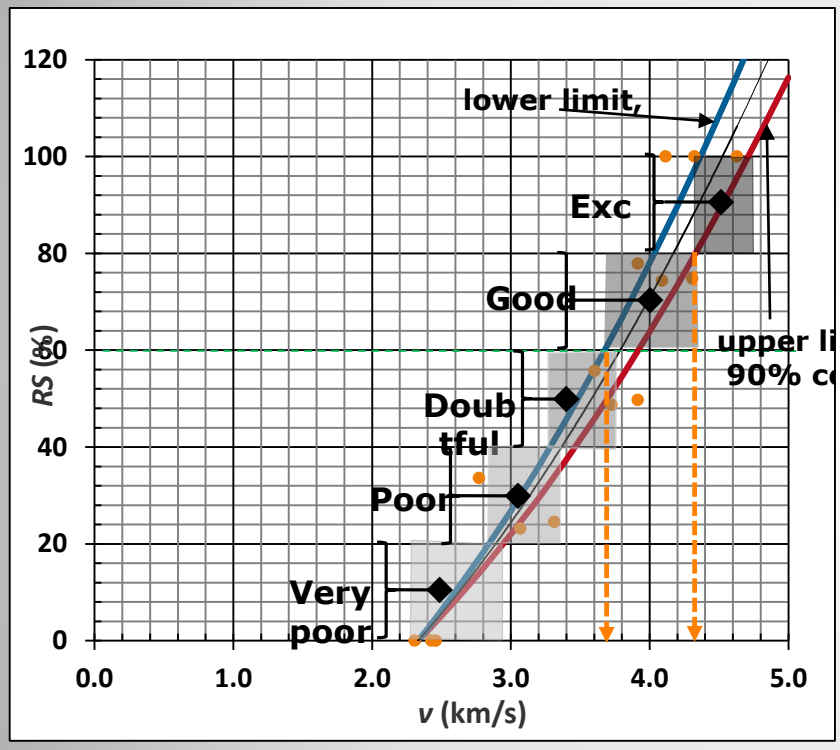
Percentage load acting against *v*: different scanning method (left); direct method showing residual strength (right)



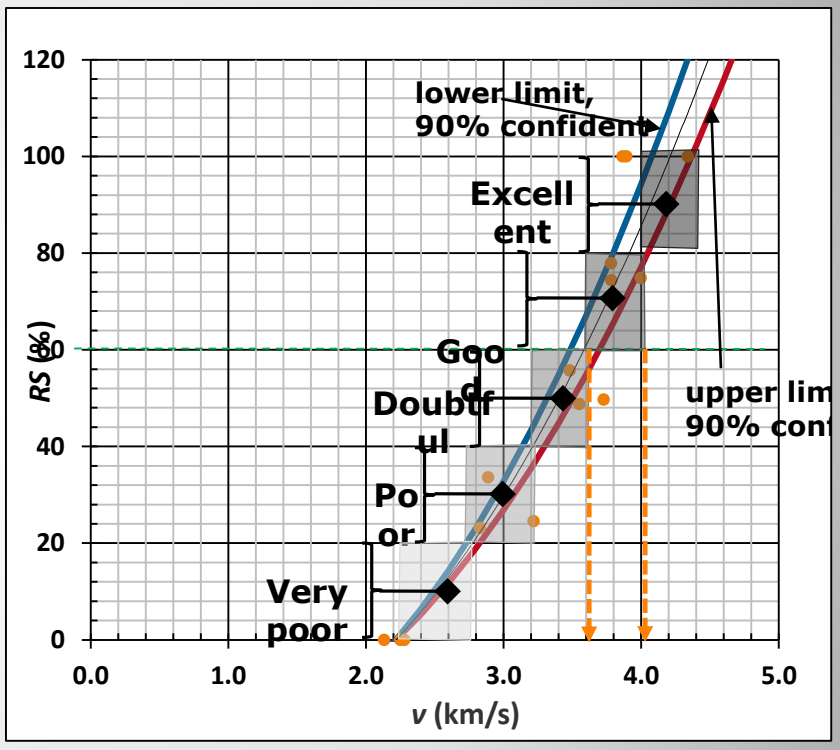


P-v and RS-v relationsip

Direct method



Indirect method



Residual strength and concrete classification

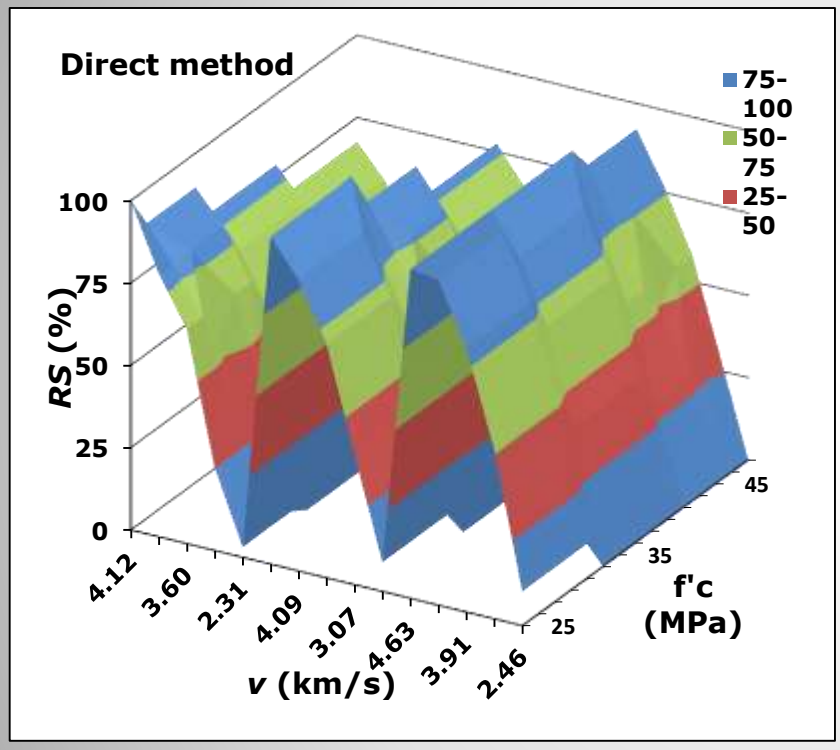
Concrete quality	Pulse velocity (km/s)*)		Pulse velocity (km/s)				Residual strength, *RS* (%)
			Direct method		Indirect method		
	v	range	v	range	v	range	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
excellent	> 4.5	~	> 4.4	~	> 4.2	~	> 80
good	3.5 – 4.5	1.0	3.7 – 4.4	0.7	3.6 – 4.1	0.5	60 - 80
doubtful	3.0 – 3.5	0.5	3.3 – 3.7	0.4	3.2 – 3.6	0.4	40 - 60
poor	2.0 – 3.0	1.0	2.9– 3.3	0.4	2.8 – 3.2	0.4	20 - 40
very poor	< 2.0	~	< 2.9	~	< 2.8	~	< 20

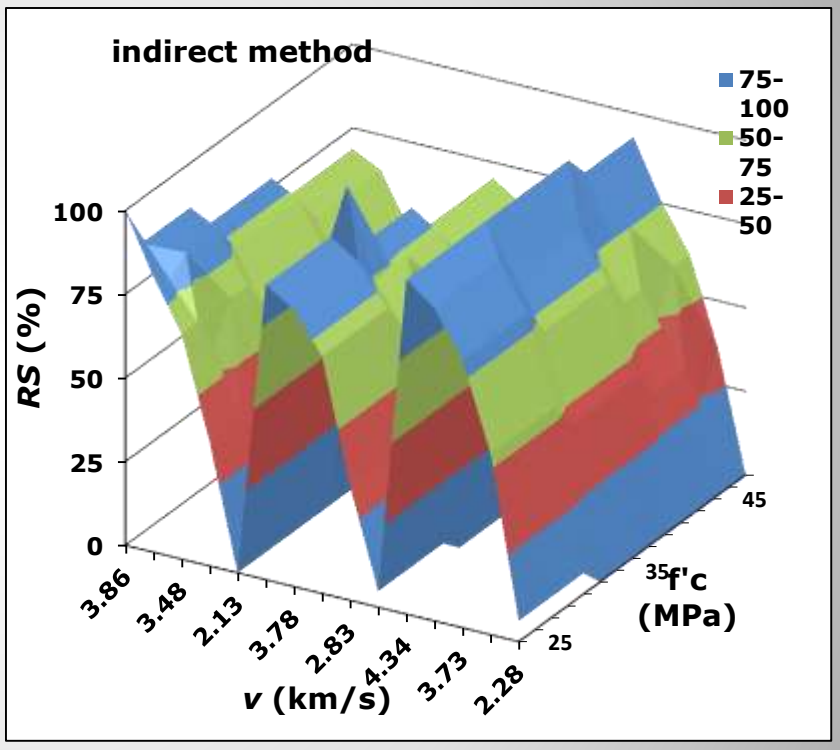
*) Reference [10]

Developing model: Concrete quality on the bases of pulse velocity

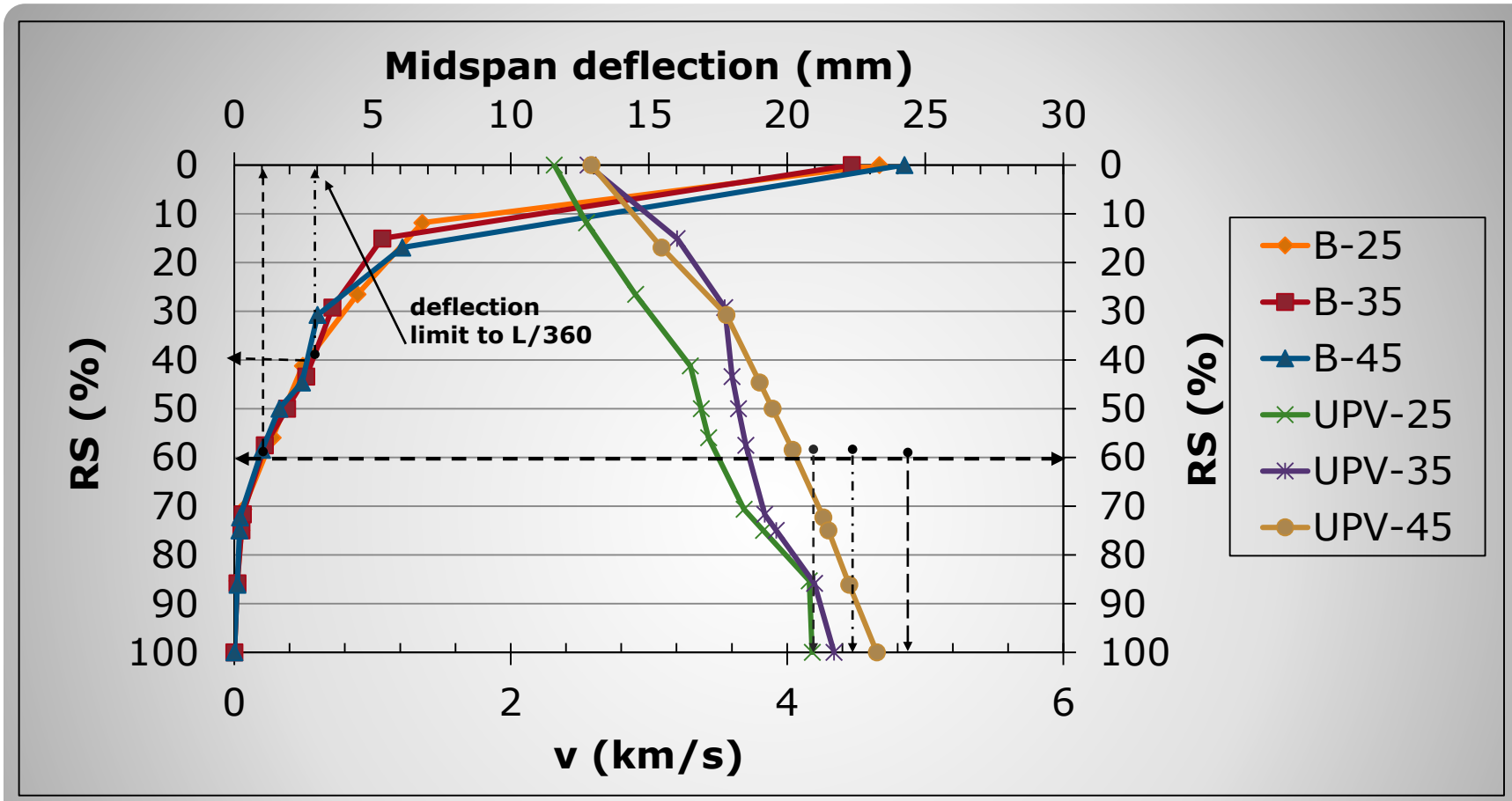
$RS = 47.82\ v_d - 1.1 f_c - 79.699$

$RS = 50.75\ v_i - 0.899 f_c - 86.975$





Developing model in 3D plot



Interpretation of beam condition (model validation)

Longitudinal pulse velocity (km/s)*)	Pulse velocity (km/s)		Concrete quality/ structure condition	Residual strength, *RS* (%)
	Compression test	Flexural test		
v	*v*	*v*		
(1)	(2)	(3)	(4)	(5)
> 4.5	**> 4.4**	**> 4.2**	**excellent**	**> 80**
3.5 – 4.5	**3.7 – 4.4**	**3.5 – 4.1**	**good**	**60 - 80**

*) Reference [10]

Comparison of structure condition on the bases of pulse velocity with a different approach

CONCLUSIONS

- The value of *v* is directly proportional to the load and inversely proportional to the residual strength.
- Concrete structures with a residual strength of more than 60% are considered healthy or in a structurally "good" condition.
- Also, the concrete structure is healthy when the *v* measured gives a value of 3.5 and above. This value is acceptable and lies within the *v* range of 3.5 – 4.5 given in the reference

Thank you