UNIVERSIDAD PRIVADA BOLIVIANA
Faculty of Civil Engineering

USE OF NON-DESTRUCTIVE TESTING IN THE DETERMINATION OF PREDICTIVE MODELS FOR THE ESTIMATION OF THE SECANT ELASTIC MODULUS AND COMPRESSIVE STRENGTH OF CONCRETE PRODUCED BY THE COMPANY SOBOCE S.A. IN THE METROPOLITAN REGION OF COCHABAMBA

Presented by: Andrés Ignacio Jaramillo Herrera

SELF - DESCRIPTION

- *Andrés Ignacio Jaramillo Herrera*
- *Tarija-Bolivia 1998 (24)*
- *UPB Research Student*
- *Technical Advisory Intern at SOBOCE.SA*
- *Goal: Master Degree in* **Structural Engineering**

POSITIVE

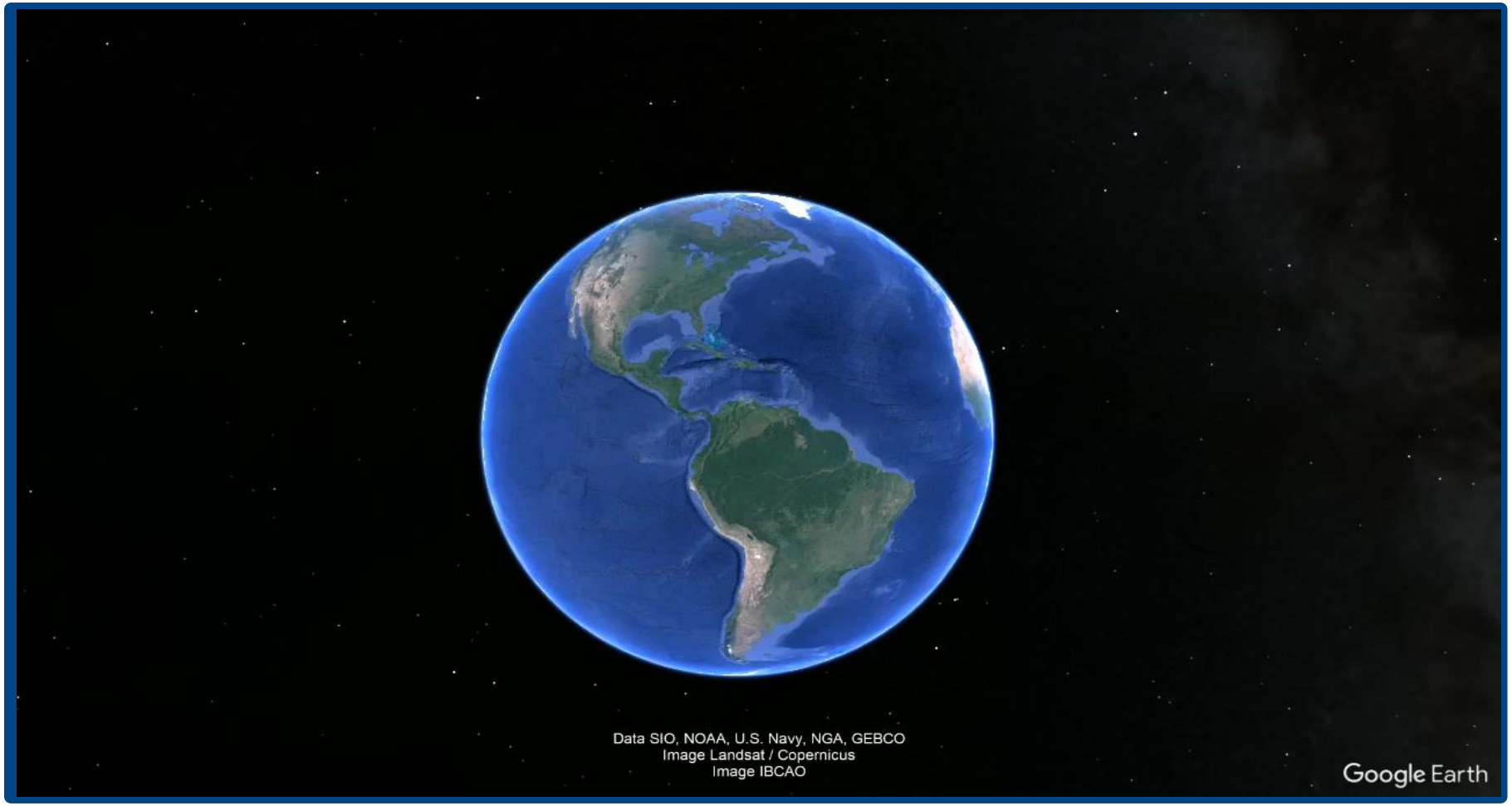
DISCIPLINED

CONFIDENT

HARDWORKING

FAIR

COCHABAMBA – BOLIVIA



REDIMIX – SOBOCE.SA

UNIVERSIDAD PRIVADA BOLIVIANA

GENERAL OBJECTIVE

"Determine regression models that help estimate the secant elastic modulus and compressive strength of concrete produced by the company SOBOCE.SA in the metropolitan region of Cochabamba, with stone aggregates from alluvial banks of the Parotani river and Viacha brand IP40 cement through the application of non-destructive testing methods in concrete"

ESPECIFIC OBJECTIVES

- Complete the phase of experimental tests on different types of concrete in the laboratories of the company SOBOCE.SA (Cochabamba) and at UNIVERSIDAD PRIVADA BOLIVIANA (Campus Julio León Prado).
- Determination of regression models through the collection and processing of data obtained from the compressive strength, elastic modulus, ultrasound wave velocity and sclerometer tests.
- Validation of regression models through the Comparison with Previous Equations

METHODOLOGY

- ❑ Identification of the variables to study: Compressive Strength, Ultrasonic Pulse Velocity, Rebound Index Hammer and Modulus of Elasticity
- ❑ Execution of 300 Compressive Strength tests, 300 Ultrasonic Pulse Velocity tests, 150 sclerometer test and 60 of modulus elasticity tests.
- ❑ Application of procedures as ASTM C-31, ASTM C-39, ASTM C-597, ASTM C-805 and ASTM C-469.
- ❑ Analysis of the effectivity of each model found.

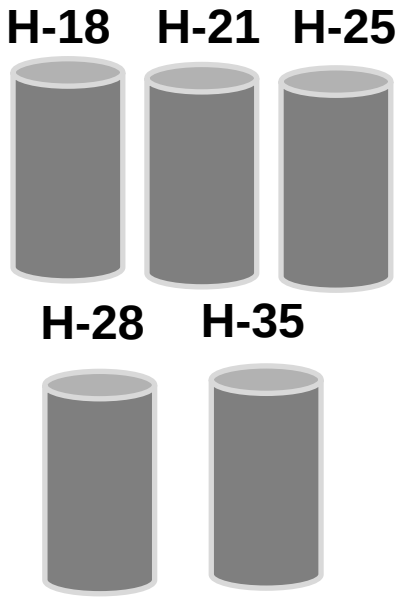
MEASUREMENT EQUIPMENT

- **Ultrasonic Tester Pundit PL-200 (PROCEQ)**

- **Sclerometer hardness Tester Silver Schmidt (PROCEQ)**

MEASUREMENT EQUIPMENT (MODULUS OF ELASTICTY)

TEST EXECUTION METHODOLOGY



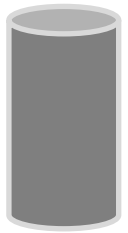
300 concrete cylinder 15x30 cm

- 3 days
- 7 days
- 14 days
- 28 days
- 56 days
- 90 days

TESTS

- ASTM 31
- ASTM 39
- ASTM 597
- ASTM 805
- ASTM 469

15x30 cm



60 concrete cylinder

- 3 days => 10
- 7 days => 10
- 14 days => 10
- 28 days => 10
- 56 days => 10
- 90 days => 10

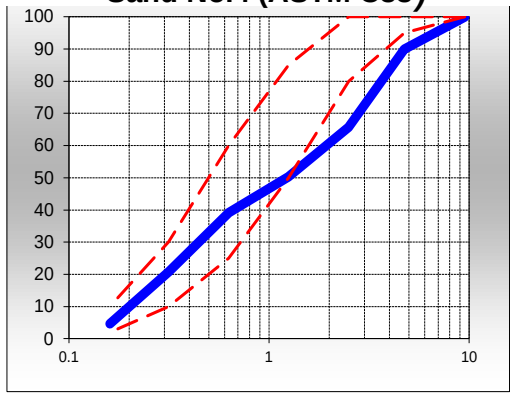
MATERIALS

MIX PROPORTION OF CONCRETE

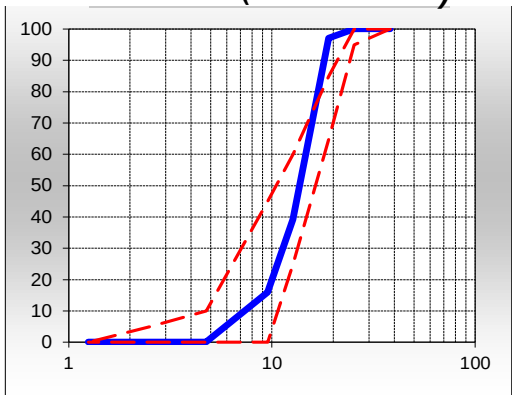
f'c (MPa)	Cement Viacha IP40 (Kg/m3)	Sand (Kg/m3)	Gravel 3/4" (Kg/m3)	Water (Kg/m3)	W/C
18	253	1210	710	193	0.76
21	280	1136	758	195	0.7
25	305	1085	786	195	0.64
28	328	1036	814	195	0.59
35	350	1190	773	178	0.51

GRANULOMETRIES CURVES

Sand No.4 (ASTM C33)



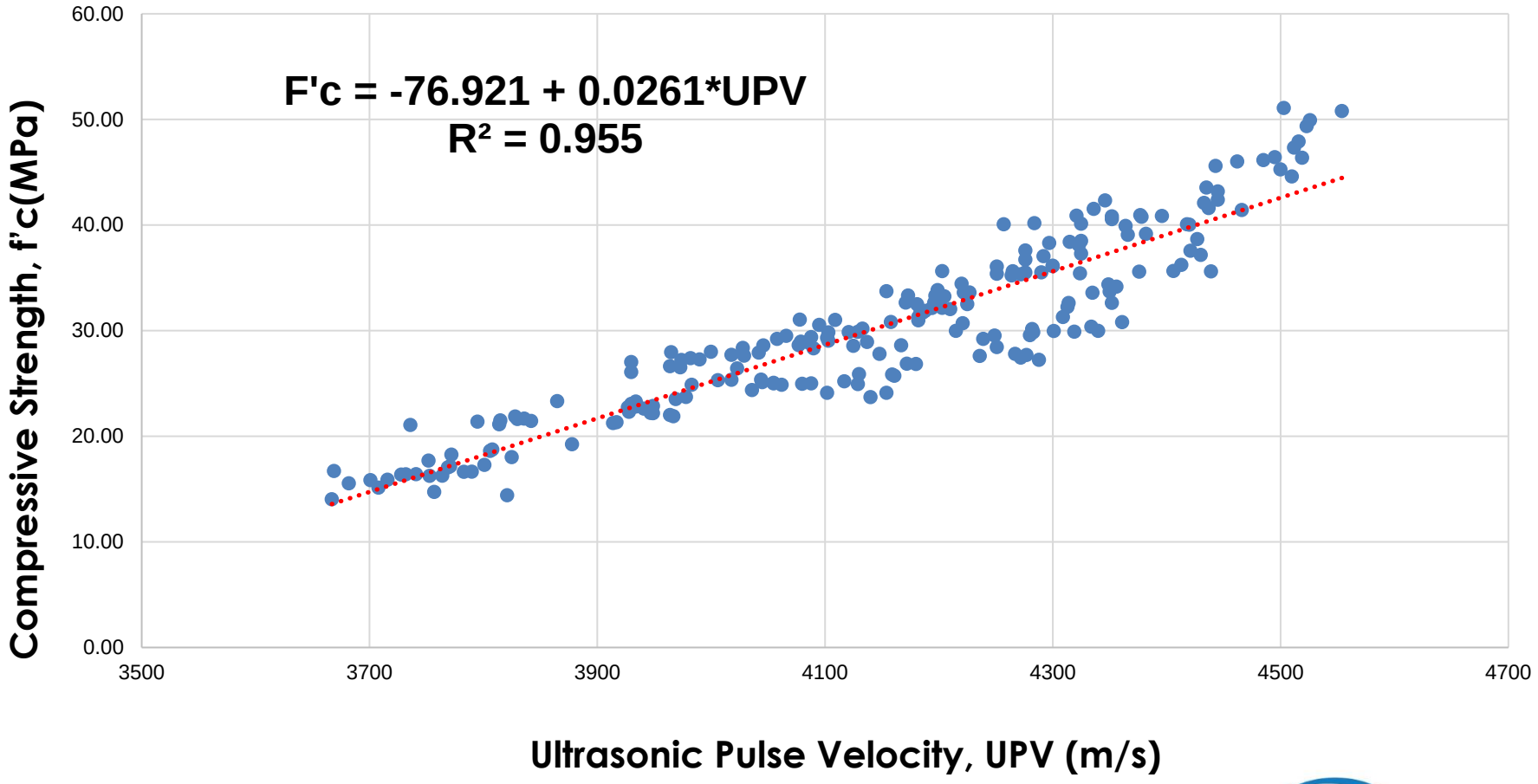
Gravel ¾" (ASTM C33-57)



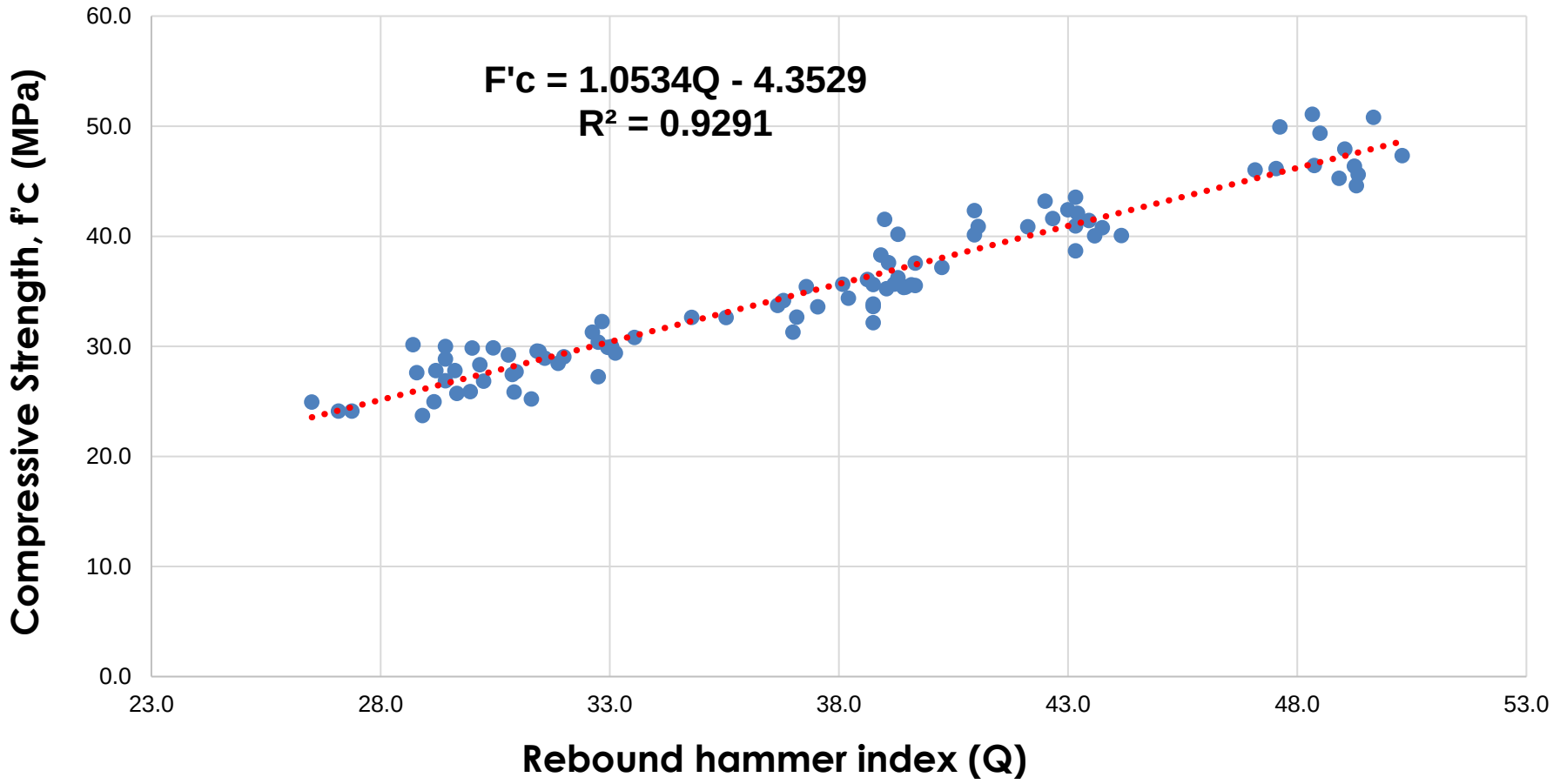
CHEMICHAL PROPERTIES OF CEMENT VIACHA

Content%	IP-40	ASTM C150
%SiO2	30.08	-
%Al2O3	5.95	-
%Fe2O3	2.76	-
%CaO	53.30	-
%MgO	2.32	Max% 6
%Mn2O3	0.12	-
%TiO2	0.18	-
%P2O5	0.12	-
%K2O	1.88	-
%Na2O	0.67	-
%SO3	2.00	Max% 3
%LOI	2.43	Max% 3

COMPRESSIVE STRENGTH VS ULTRASONIC PULSE VELOCITY



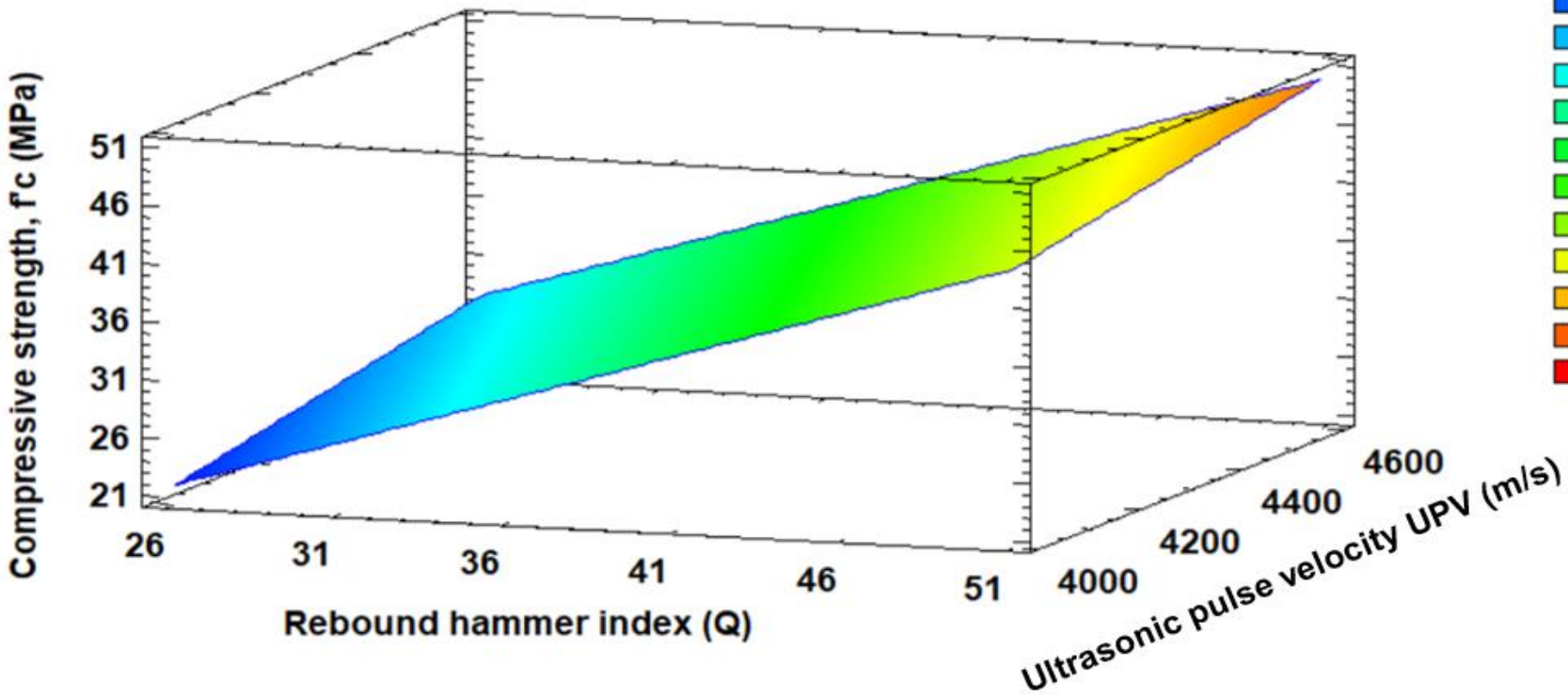
COMPRESSIVE STRENGTH VS REBOUND HAMMER INDEX



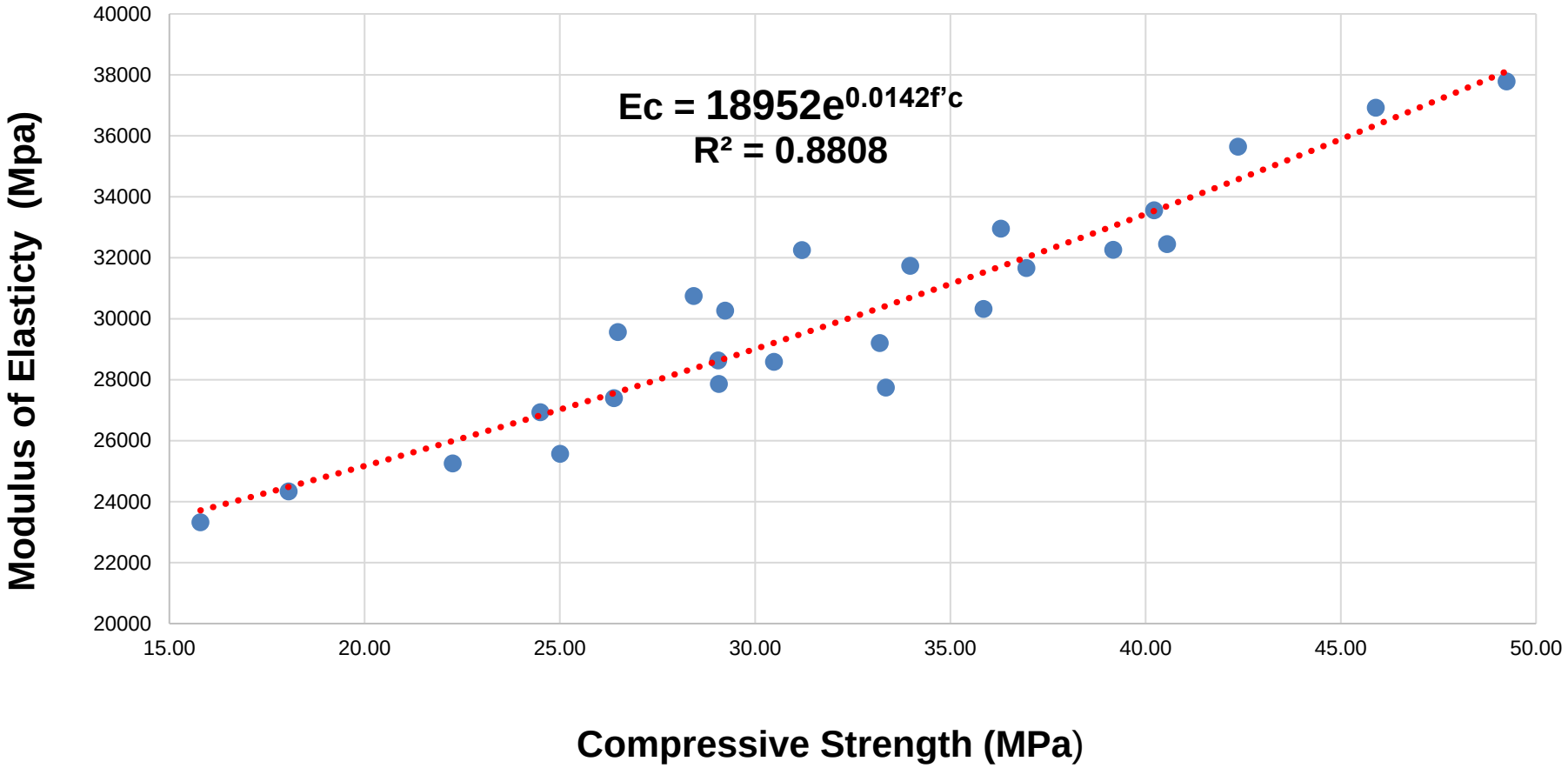
COMPRESSIVE STRENGTH VS ULTRASONIC PULSE VELOCITY VS REBOUND HAMMER INDEX

$F'c = -41.4416 + 0.890661*Q + 0.0100169*UPV$

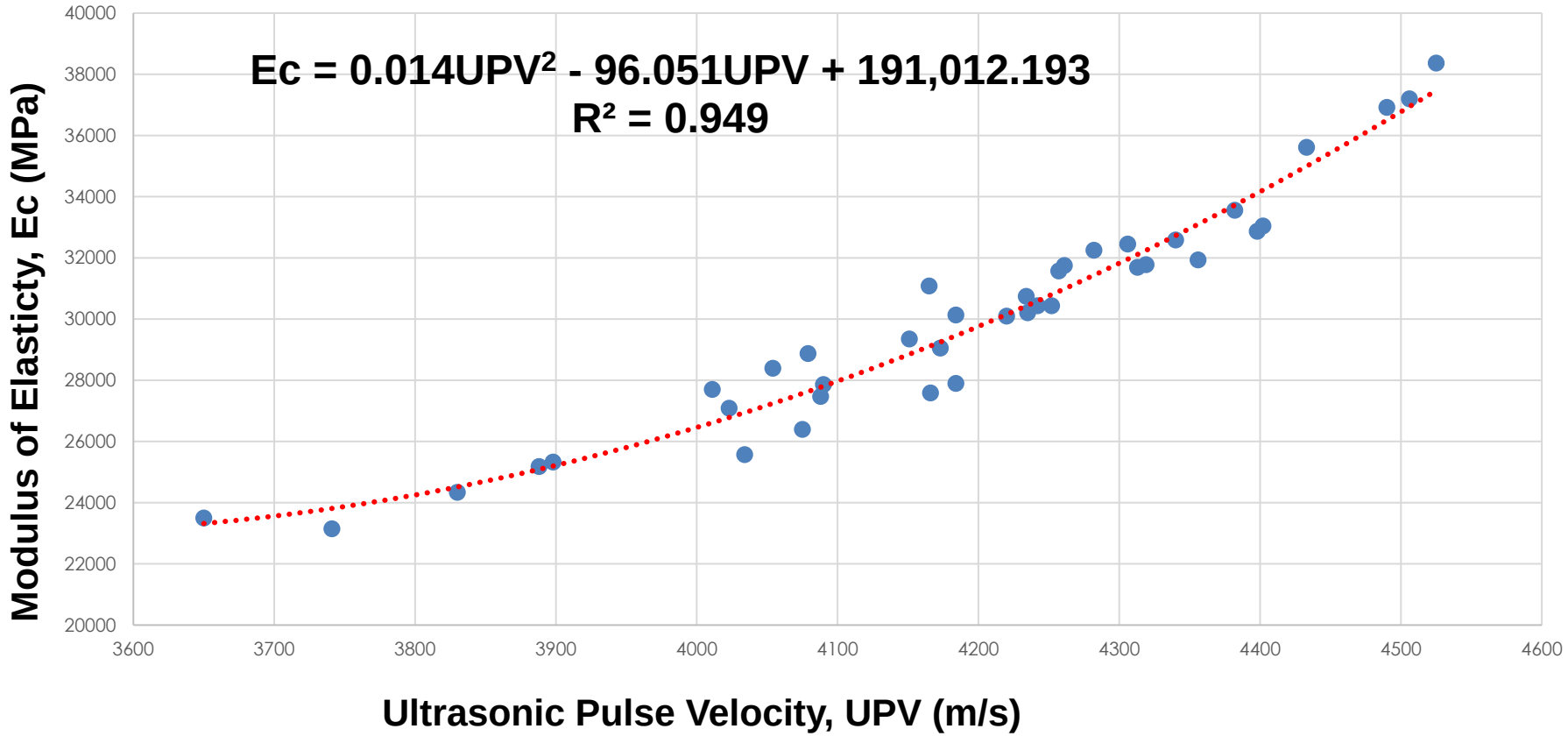
$R^2 = 0.9380$



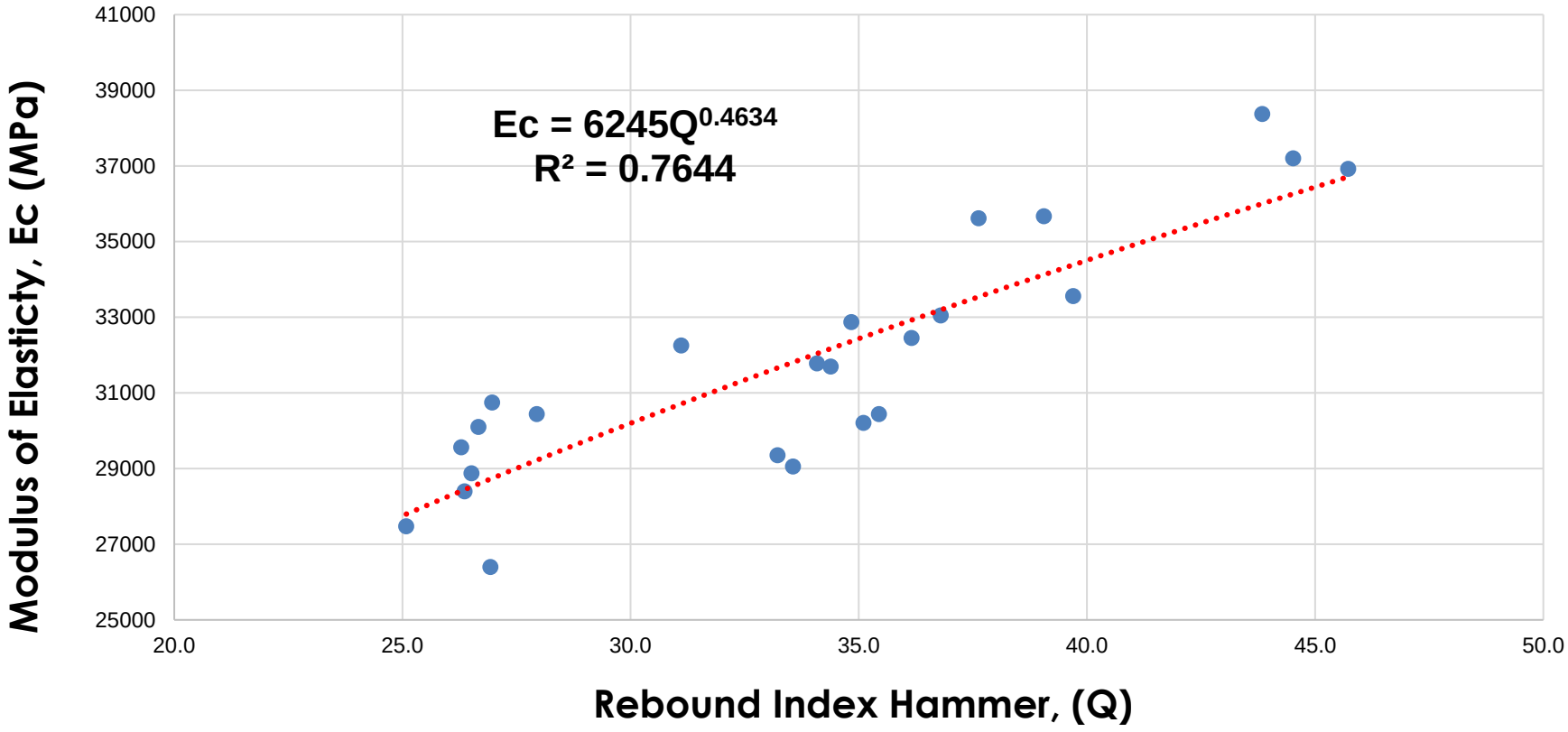
MODULUS OF ELASTICITY VS COMPRESSIVE STRENGTH



MODULUS OF ELASTICITY VS ULTRASONIC PULSE VELOCITY



MODULUS OF ELASTICITY VS REBOUND HAMMER INDEX



COMPARISON RESULTS OF COMPRESSIVE STRENGTH OF CONCRETE BY ULTRASONIC PULSE VELOCITY AND REBOUND HAMMER TEST

ULTRASONIC PULSE VELOCITY TEST

REFERENCES	TEST/PREDICTED	STANDAR DEVIATION	ROOT MEAN SQUARE	REGRESSION FORMULA (MPa)
Popovic	0.59	8.09	11.93	f'c= 0.0028e0.0021UPV
Architectural Institute of Japan (AIJ)	0.92	4.76	5.27	f'c = 21.5UPV – 62
Kim	0.95	11.11	4.61	f'c = 50.163UPV – 178.2
Raouf Ali	0.88	3.37	7.08	f'c=2.016e0.00061UPV
Turgut	0.97	4.69	4.66	f'c=1.146e0.00077UPV
Proposed Eq.	1.06	5.78	3.78	f'c=-76.921 + 0.0261UPV

REBOUND HAMMER TEST

REFERENCES	TEST/PREDICTED	ESTÁNDAR DEVIATION	ROOT MEAN SQUARE	REGRESSION FORMULA (MPa)
Atici	0.7	9.12	10.26	f'c = 3.34e0.058Q
Kim	1.52	7.57	17.7	f'c = 1.267Q+9.7868
Architectural Institute of Japan (AIJ)	1	4.36	3.24	f'c = 0.73Q+10
Kwon	0.99	15.47	8.75	f'c = 2.59Q - 51.5
Willetts	0.72	8.66	9.36	f'c = 0.00935*Q^2+0.8Q-12.06
PROCEQ (L)	0.5	7.15	17.23	f'c = 1.9368e0.0637Q
Proposed Eq.	1	6.96	1.91	f'c = 1.0534Q - 4.3529

COMPARISON RESULTS OF COMPRESSIVE STRENGTH OF CONCRETE BY COMBINED METHOD AND MODULUS OF ELASTICTY TEST

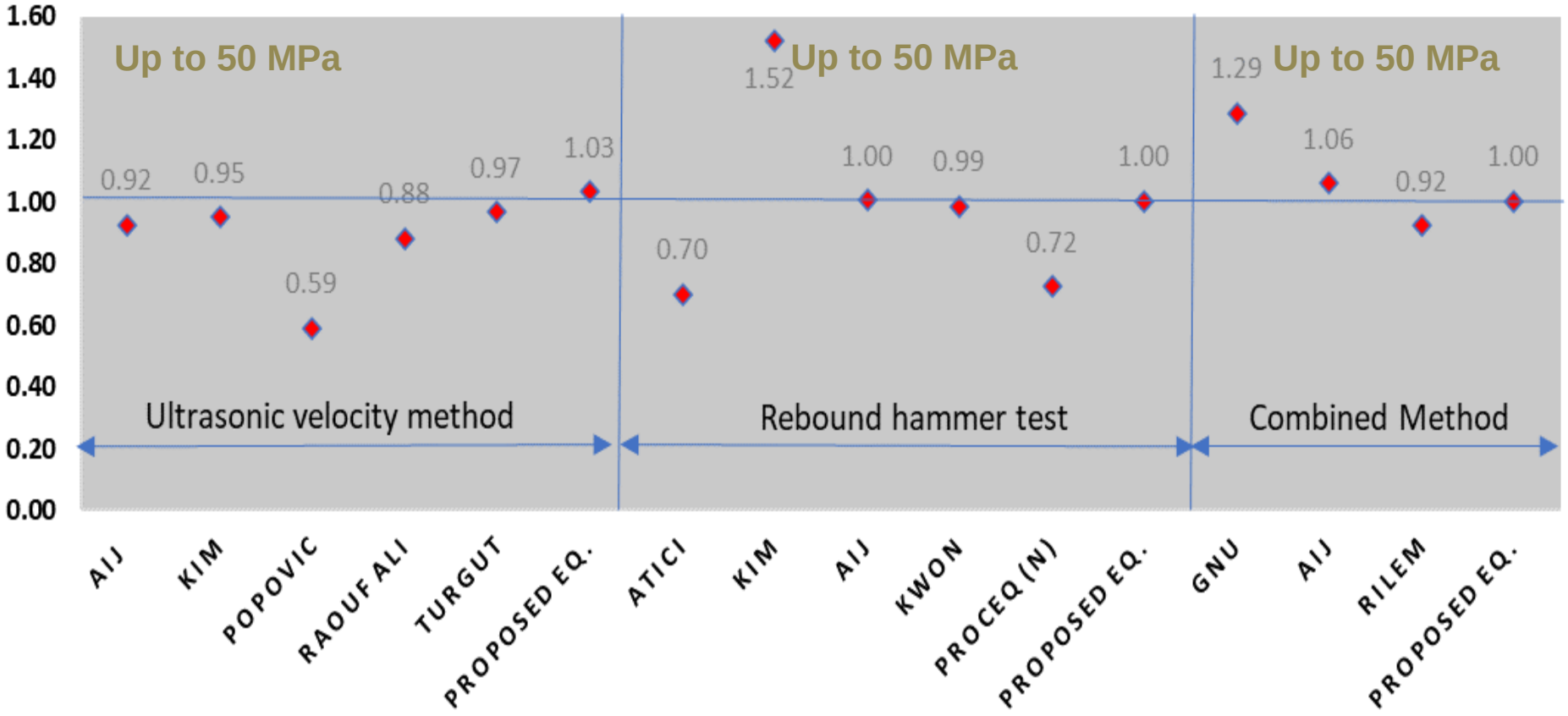
COMBINED METHOD

REFERENCES	TEST/PREDICTED	STANDAR DEVIATION	ROOT MEAN SQUARE	REGRESSION FORMULA (MPa)
Proposed Eq.	1	6.99	1.79	f'c = -41.442 + 0.891Q + 0.01UPV
Architectural Institute of Japan (AIJ)	1.06	8.51	3.33	f'c = 0.82Q+26.9UPV-109.4
RILEM	0.92	9.32	3.87	f'c= 10^(0.379VPU+0.0115Q-0.567)
Gyeongnam National University (GNU)	1.29	10.1	10.78	f'c = 23.37UPV+1.13Q-97.83

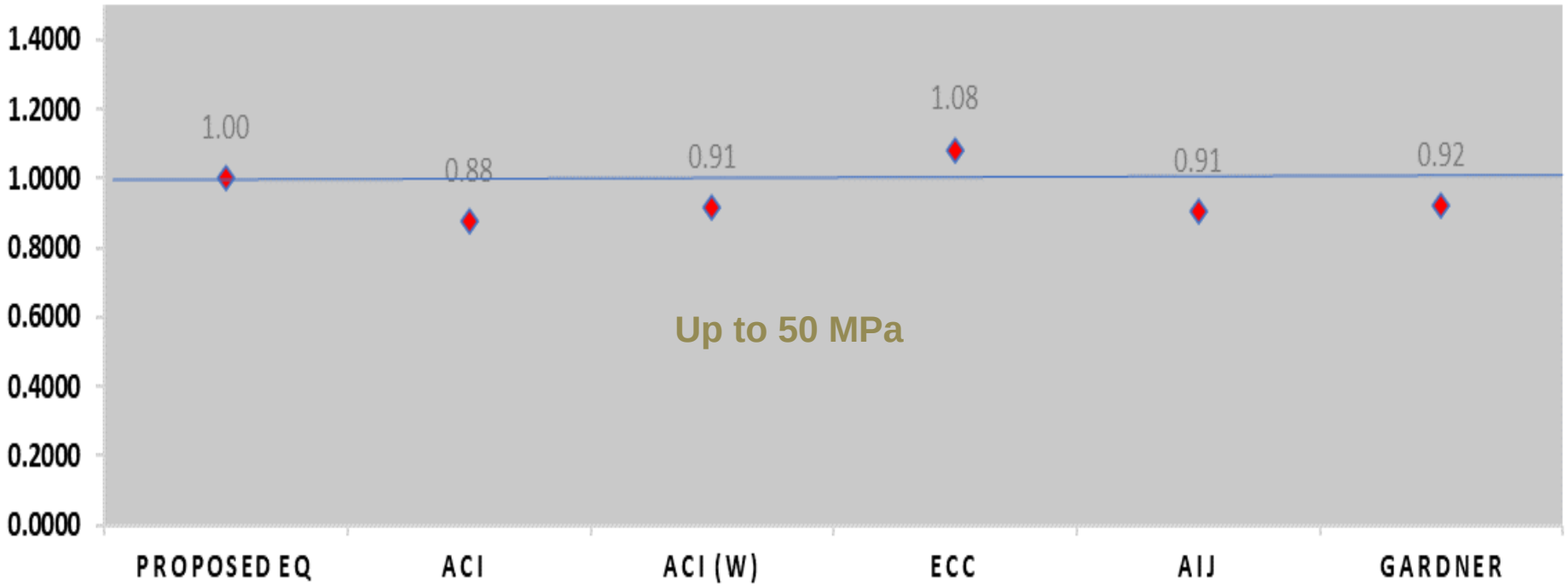
MODULUS OF ELASTICITY TEST

REFERENCES	TEST/PREDICTED	STANDAR DEVIATION	ROOT MEAN SQUARE	REGRESSION FORMULA (MPa)
Proposed Eq.	1.00	3528.1	1261.1	Ec = 18952e0.0142f'c
American concrete institute (ACI)	0.88	3472.3	3926.5	$Ec = 4700\sqrt{f'c}$
American concrete institute (ACI) (W)	0.91	3619.0	2903.5	$Ec = w_c^{1.5}(0.043) * \sqrt{f'c}$
European Concrete Committee (ECC)	1.08	2258.9	2875.2	$Ec = 9500(f'c + 8)^{\frac{1}{3}}$
Architectural Institute of Japan (AIJ)	0.91	3582.9	3148.9	$Ec = 21000 w_c^{1.5}\sqrt{f'c/20}$
Gardner	0.92	3176.8	2795.5	$Ec = 3500 + 4300\sqrt{f'c}$

AVERAGE STRENGTH RATIO FROM PREDICTED AND TESTED COMPRESSIVE STRENGTH

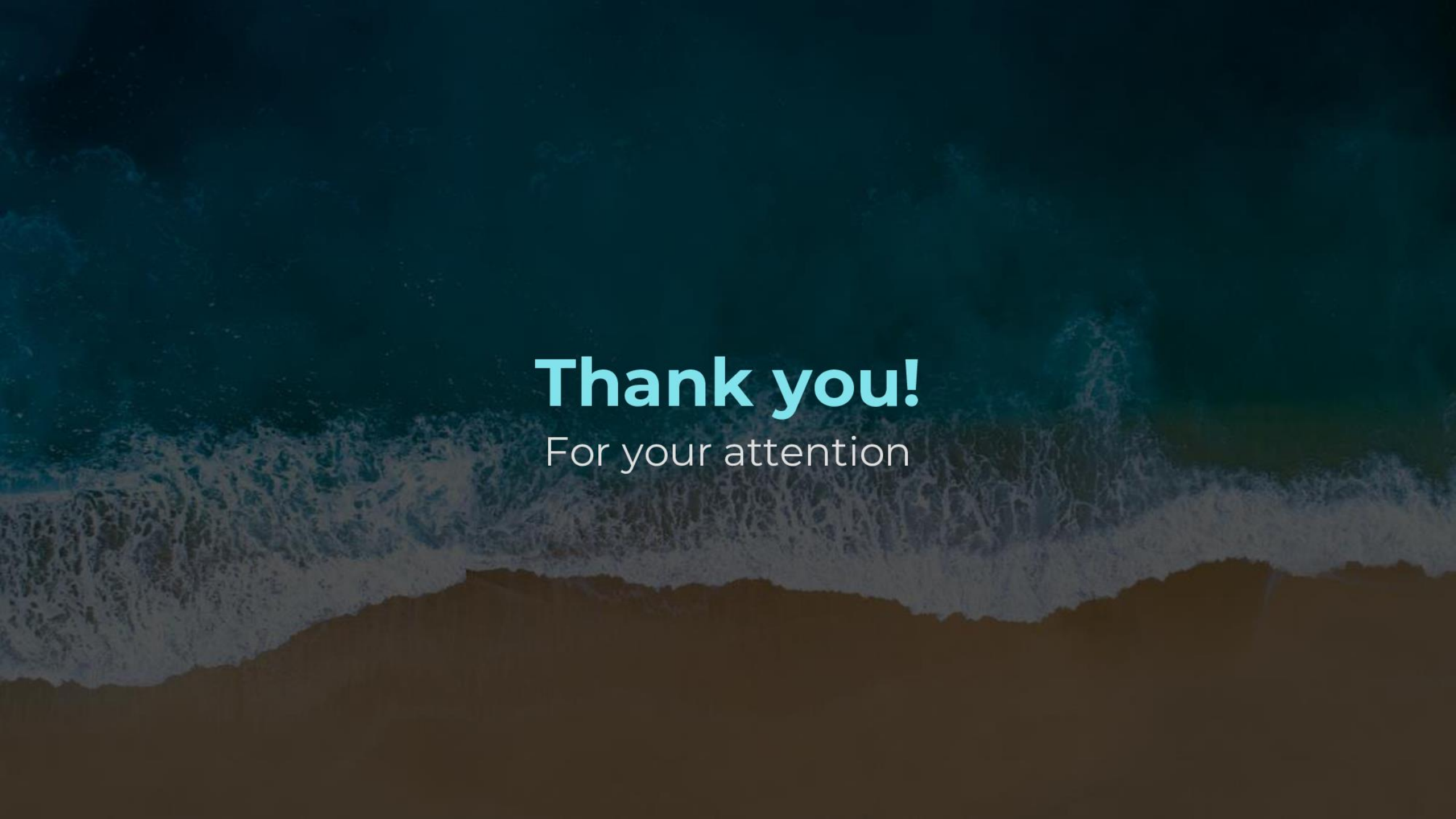


AVERAGE STRENGTH RATIO FROM PREDICTED AND TESTED MODULUS OF ELASTICITY TEST



CONCLUSIONS

- In this study, the proposed estimation equation that uses a dual regression approach in conjunction with rebound hammer tests and the ultrasonic pulse velocity method showed the highest accuracy and the lowest RMSE in predicting compressive strength.
- The quality of the concrete evaluated throughout the experimental process has a very good quality. This was deduced from the range of ultrasound wave speeds which is between 3800 to 4500 m/s.
- It was concluded that the difference between the values obtained by the models elaborated with respect to other estimation models is due to the composition of the cement, the characteristics of the aggregates used for the elaboration of the concrete and the model of the measurement equipment used.
- The models that predict compressive strength through the ultrasound pulse velocity and sclerometer rebound index present prediction efficiencies quite similar to those of the models presented by other authors in different parts of the world.


Thank you!
For your attention