



Evaluation of the use of piezoelectric transducers in determining the strength of concrete

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Introduction

Nowadays, concrete is the second most consuming material in construction structures. Due to the use of this product in the construction industry, concrete testing is a critical issue. By examining the patterns and behaviours of the energy waves, it is possible to find the degree of homogeneity and correlate it with compression strength of this material of structures. Piezoelectric transducers can demonstrate the hardness and uniformity of the sample by measuring how waves propagate.

Research aim

- Evaluate the use of piezoelectric transducers as a cheaper and faster way to test the strength of concrete.

Objectives

- ❖ Test how wave velocity changes in different concrete samples with different characteristics, in this case changing porosity and curing time;
- ❖ Find the relationship between concrete compression strength and how energy is propagated in the concrete mass
- ❖ Analyse the results obtained using this piezoelectric transducers compared to destructive tests.

Outline

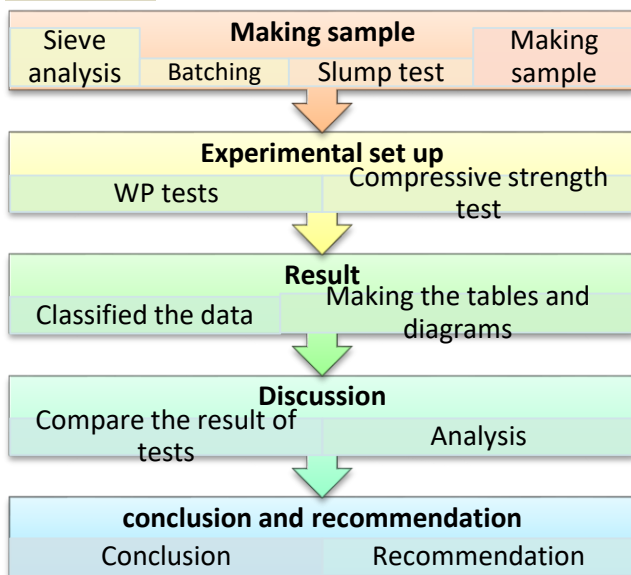


Figure 1: Details of process (Author)

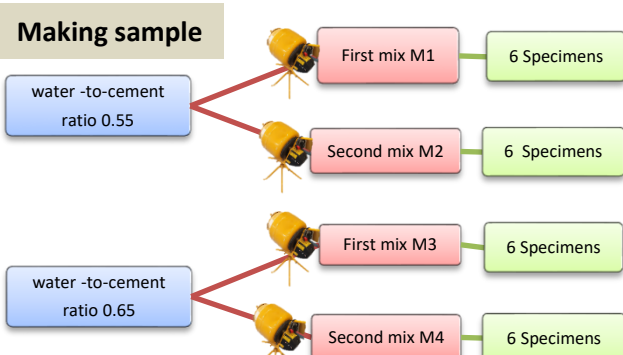


Figure 2: Diagram of amount and ratio of specimens (Author)

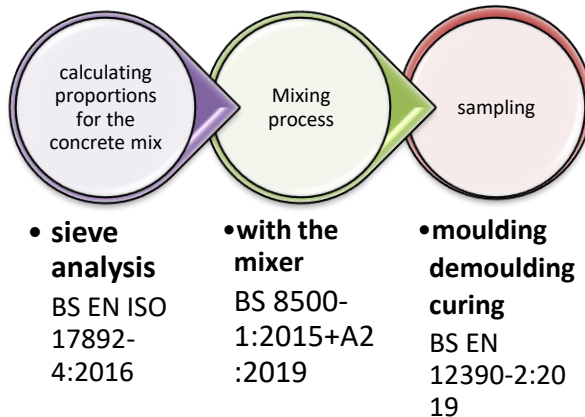


Figure 3: steps of making samples (Author)

Experiments set up

Two transducers were attached to the samples with a certain distance from together, and then the sample was hit with a hammer at a specific point. The velocity of the generated wave was calculated, and the strength of the samples predicted accordingly. There is not an exact standard for this unique design of the experiment. So it was tried to act on the base of the standard of the closest test. Which is **EN 12504-4:2004**.

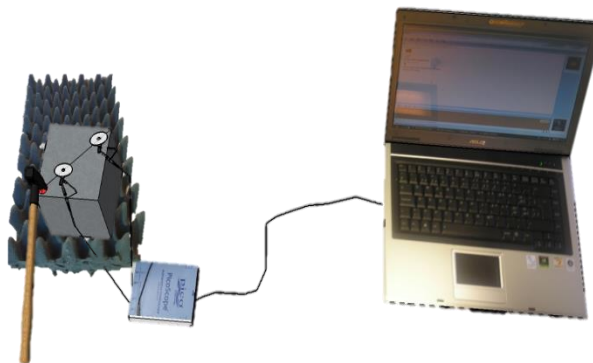


Figure 4: process of experiment (Author)

RESULTS

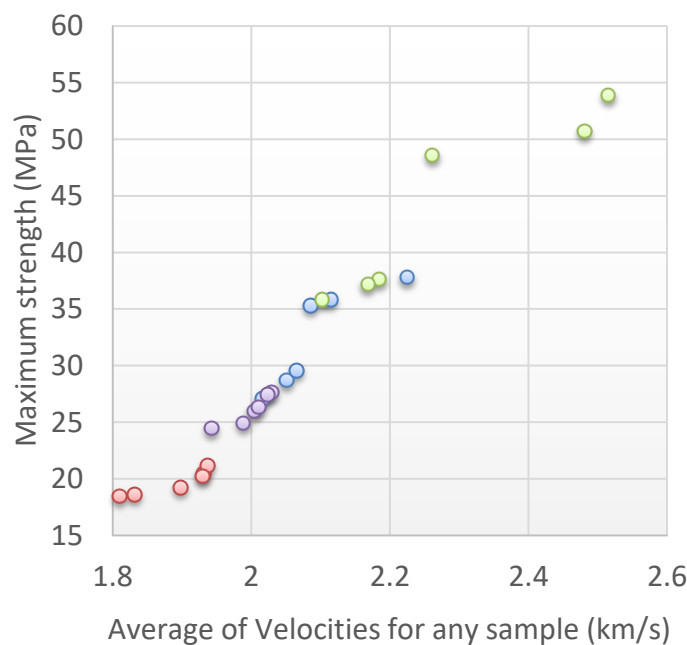


Figure 5: result of Wave propagation and compressive machine (Author)

Discussion

For analysing the results, a liner regression should be applied to establish a relation between the results. The F Statistic is shown the linear regression is a good idea for analysing the results of tests. And equation of regression line for mixes is as below:

Table 1: regression lines foe mixes in each stage (Author)

MIX	Equation for regression line
ratio 0.55 at the 7-day	$\bar{y} = -80.021 + 53.689\bar{x}$
ratio 0.65 at the 7-day	$\bar{y} = -14.619 + 18.153\bar{x}$
ratio 0.55 at the 28-day	$\bar{y} = -54.222 + 42.958\bar{x}$
ratio 0.65 at the 28-day	$\bar{y} = -48.173 + 37.150\bar{x}$

the Adjusted R2 is 0.969895. As rule of thumb for acceptable R2, there is a substantial relation between predicted the strengths by transducers and the recorded strength by the compressive machine. In this case, the Standard Error is 1.756091, which is perfectly acceptable.

Conclusion

regression analysis has shown a direct relationship between velocity and strength with a same direction. The transducers have shown a higher velocity by increasing the age of the samples as accurate as of the compressive machine. Regression analyse are shown that the low-porosity mix (ratio 0.55) has a higher velocity because its gradient of the regression line is steeper than the other mixes (ratio 0.65). Also it indicates the transducers recorded less time (higher velocity of waves) for more strength of concrete. The F Statistic is shown there is a substantial relation between predicted the strengths by transducers and the recorded strength by the compressive machine. Based on the results obtained, it can be claimed that the PZT proved their efficiency in measuring strength at different age and porosity.

Recommendation , further research

- It has suggested the test have should repeat in the 60-day stage.
- It is better to use a precision instrument to create an accurate force to apply to all samples.
- It is also possible to use three or four sensors instead of two sensors.

References

- Cook, P. Wheeler, C. Wright, J (2000) *Using statistics to understand the environment*. London: Routledge. Series: Routledge introductions to environment series. pp 10-50