Investigating the Role of Different Compounds in Concrete

Hayden O. Gunn '19 and Hugh O. Thurman III

Department of Physics, Hampden-Sydney College, Hampden-Sydney, VA 23943

ABSTRACT
In this summer's research, various concrete samples were made and tested using different techniques to measure the strength of the concrete sample. The Poisson ratio was calculated for each of the test as well as the elastic modulus.

INTRODUCTION
This s Concrete has been known for a long time to be extremely versatile and used in more things than many people even know. Concrete began being used a lot in the 1960's to replace expensive steel girders and steel decking in the tall high-rise buildings. Concrete is often used in residential driveways, house foundations, walls, as well as many other uses such as paving and curb & gutter applications. Sometimes pre-made molds used to create certain things like drainage pipes, big bridge pieces, and other items. Concrete is used more than any other manmade material in the world, and the second most consumed substance in the world, second only to water. The concrete industry has an approximated net worth of 37 billion dollars and has over 2 million employees.

The research project that was completed was in the field of civil engineering. It focused on concrete, more specifically, it focused on the different compounds we can add to concrete to increase its strength. These studies assessed how different substances can influence the strength and shape ability of concrete. Different additives could make the concrete stronger or weaker and we can use different instruments such as a strain gauge to measure the strength of the concrete. Studies have shown that there are some specific compounds when added to concrete significantly increase the strength of the concrete as a whole. However, a comprehensive analysis of the concrete shed light on what is needed to make concrete stronger and possibly cheaper than ever.

A strain gauge is a sensor that when you apply force to it has a varying resistance. So, a change in electrical resistance is caused by varying force, pressure, tension or weight. When we applied these varying forces to the object that contains the strain gauge, the becomes stressed causing the change in resistance. The strain gauge is one of the most important sensors used in electrical measurement and proved very important in my work. It is important to note that strain gauges can pick up contraction as well as expansion the only difference is the sign of the data reading. The strain gauge was used in a Wheatstone bridge circuit.

Concrete has many properties that make it very ideal for being in structures such as strength, malleable, and relatively cheap for how long it lasts. A maturity test is the most common test used in the field and in the lab to measure the strength of concrete once it is poured. The strength is strictly related to both temperature and age. Concrete's strength is obviously of utmost importance.

There are three different sound waves that are very important to my studies s-waves, p-waves, and Raleigh waves. S-waves are shear waves, which means that the motion of the medium is perpendicular to the direction of propagation of the wave. The energy is thus less easily transmitted through the medium, and S-waves are slower. P-waves are longitudinal waves which mean the vibrations are along the same direction as the direction of travel. The other kind of surface wave is the Rayleigh wave, named for John William Strutt, Lord Rayleigh, who mathematically predicted the existence of this kind of wave in 1885. A Rayleigh wave rolls along the sample just like a wave rolls across a lake or an ocean.

The hammer measures the rebound of a spring-loaded mass impacting against the surface of the sample. The test hammer will hit the concrete at a defined energy. Its rebound is dependent on the hardness of the concrete and is measured by the test equipment. Pulse echo method is a non-destructive testing technique that uses the propagation of ultrasonic waves in the object being tested. Using the time, it takes for pulse to go from one end of the object to the other determines the velocity of the wave. This velocity can be transformed into Poisson's ratio calculation.

Ball drop method, I first started with a ball being dropped from a distance with a ball dropper. This was done first to try and get repeatable data. Next, I read in a different paper that a ball pinned hammer was used with success. I then tried this method with success. The sound waves travel from the hammer hitting the top of the concrete, through the concrete to the transducer on the bottom of the concrete. The velocity is turned into a Poisson's ratio calculation.

Poisson's ratio is another very important aspect of measuring the strength of concrete. Poisson's ratio the ratio of the relative contraction strain (transverse, lateral or radial strain) normal to

the applied load to the relative extension strain (or axial strain) in the direction of the applied load.
Poisson's ratio can be expressed as:

$\mu = - \varepsilon_t / \varepsilon_l$

where μ = Poisson's ratio, ε_t = transverse strain (m/m, ft/ft), ε_l = longitudinal or axial strain (m/m, ft/ft)

The elastic modulus is defined as the change in stress with an applied strain. If there were two materials being used to make the same size object and one was made of concrete and the other made of rubber. If you apply the same load to both of them, the concrete since it has a larger elastic modulus, deflects less than the rubber. Elastic modulus is different than strength. Something with a higher elastic modulus can be weaker in tension strength.

$$V_p = \sqrt{\frac{E_d(1-v)}{\rho(1+v)(1-2v)}}$$

$$V_R = \frac{0.87+1.12v}{1+v} \sqrt{\frac{E_d}{2\rho(1+v)}}$$

V_R and V_p, are the velocity of the P-wave and the velocity of the Rayleigh wave.

ρ was the density of the sample

v was Poisson's ratio, and Ed is the elastic modulus.

$$E_d = (\frac{V_p}{V_r})^2 (0.7569 + 0.\ 4388\boldsymbol{v} - 2.64\boldsymbol{v}^2 - 2.5\boldsymbol{v}^3) = 1 + \boldsymbol{v} - \boldsymbol{v}^2 - \boldsymbol{v}^3$$

Where $\boldsymbol{v}$ is Poisson's ratio

E_d is the elastic modulus

$(\frac{V_p}{V_r})^2$ *V_R and V_p, are the velocity of the P-wave and the velocity of the Rayleigh wave.*

RESULTS

In order to test my methods, I used a known block of aluminum with a known Poisson ratio. A Poisson ratio of 0.38 was received and the know value of Al is 0.35. I then used the same methods on the concrete that has a known Poisson ratio of 0.1 to 0.25. I used three different primary samples: 68% aggregate 32% cement by weight, 60% cement 40% aggregate, and a 50/50 mix. Using the rebound hammer, I got a Poisson ratio of:

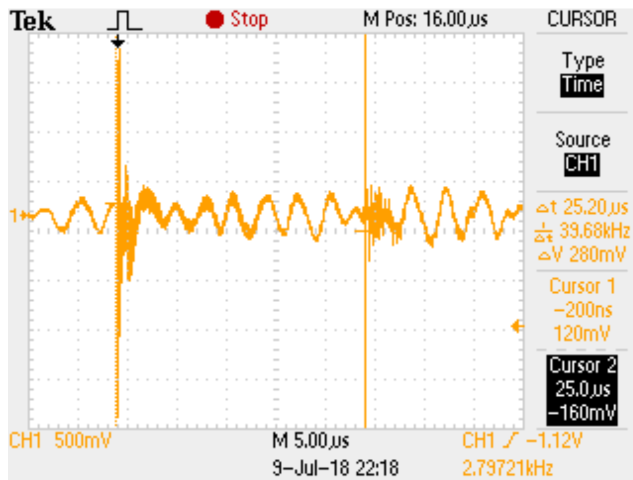
- Regular: 0.15
- 60/40: 0.23
- 50/50: 0.19

Using the hammer drop method I got a Poisson ratio of:

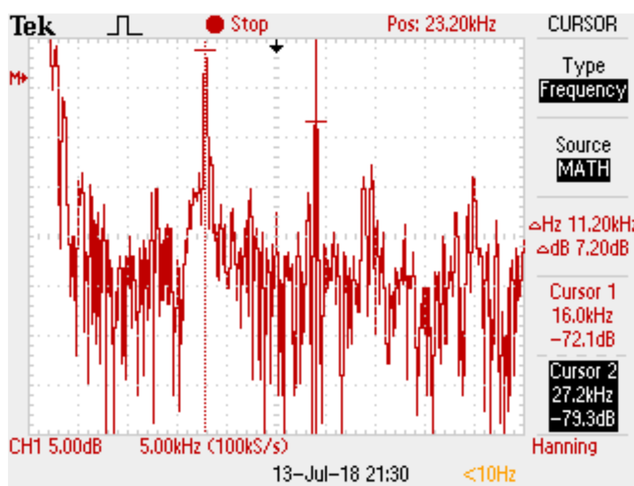
- Regular: 0.19
- 60/40: 0.21
- 50/50: 0.18

For Elastic Modulus:
• Aluminum: Known- 69GPa Calculated- 56
• Concrete Samples: Known- 17-30 MPa
• Regular- 11.3 MPa
• 60 cement/40 aggregate- 14.69 MPa
• 50/50- 12.94 Mpa

Above are the concrete samples.



Above is a photo of the pulse echo method.



Above is the ball drop method.

CONCLUSION

Results gains from the summer experiments will be used in future work. Fine tuning will need to occur to make the methods more consistent and get results that are more accurate. Research will be continued into the ensuing semesters and will be continually worked on. The results received from this work so far are very promising and show that the methods work and just finer tuning needs to occur to get great results that are repeatable.

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