KM22 Compressible Grout
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May 1, 2022

Compressible Grout for Geotechnical Applications

Photo by Steven Wright

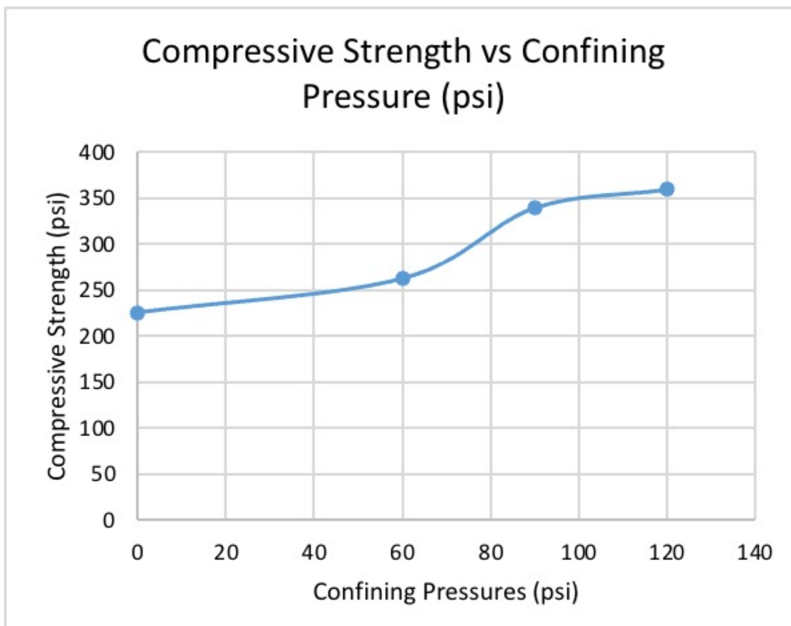
Traditionally, the annular space between a tunnel liner and the excavated rock has been filled with a neat cement and bentonite mixture. This mix will fill the inconsistent spaces between the excavated rock and the tunnel liner system. This is an excellent method when the tunnel is not subjected to loading due to seismic creep or additional compressive forces from stresses relived from the excavation. KM Materials has developed a material that can absorb these additional forces and rebound from any relaxation or deformations of the surrounding rock.

KM22 is the trade name for the patent pending compressible mix design from KM Materials. This mix has demonstrated rebounding capabilities when subjected to stresses and then having the stresses relieved.

Working with the Bureau of Reclamation, KM Materials had several tests run to determine the rebounding capabilities of the mix design. Initial tests were done for unconfined compressive strength, compression and shear wave velocities, and finally axial strain in a triaxial cell with the vertical strain relaxed at 5%, 7%, and 10% axial strain.

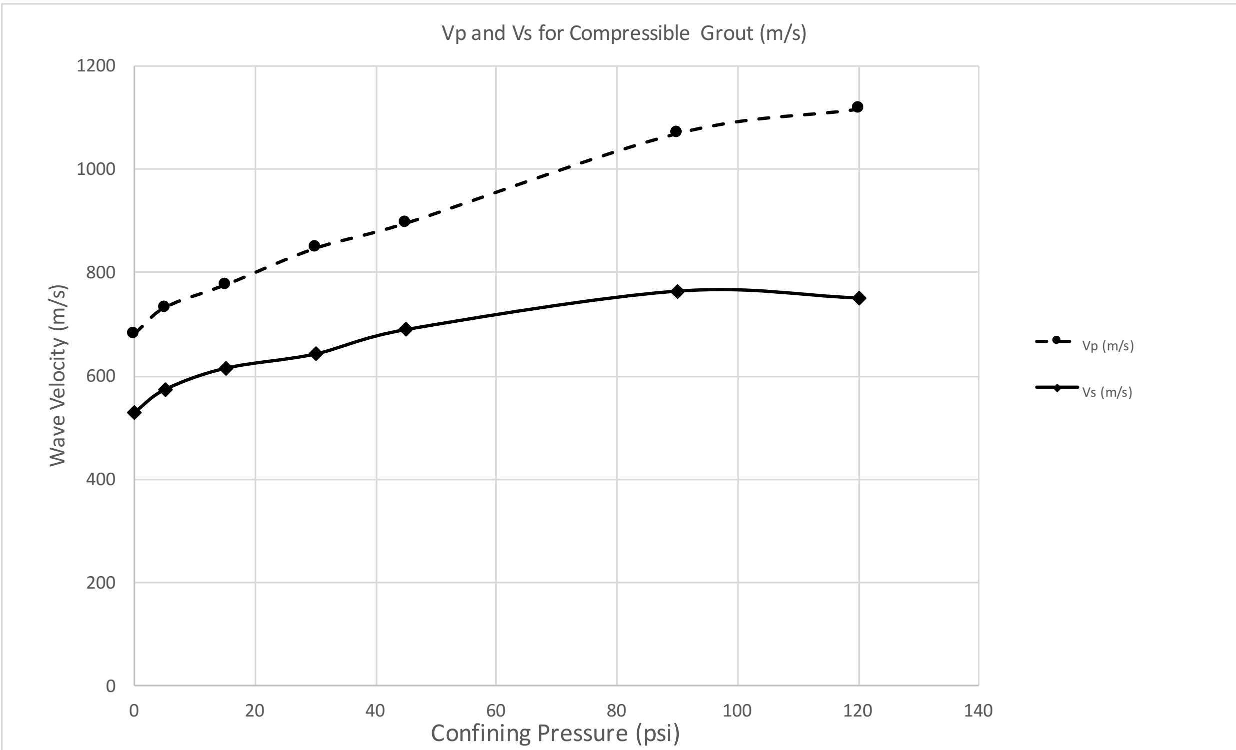
During the mix design the initial parameter was for a low compressive strength. The compressive strength of the material was determined through unconfined and confined methods. The confining pressures were set at 0 (unconfined), 60, 90, and 120 psi. As the confining pressure increased on the material, the compressive strength increased as would be expected. It was noticed that the gain of compressive strength was not directly correlated to the confining pressure. At the 120 psi confining pressure the strength gain was significantly less than the gain from 60 psi to 90 psi.

Compressive strength of KM22 as a function of confining pressures



In addition to testing the compressive strength, the material was also tested for shear and compressive wave velocities. These tests indicate the relative transmissive speed of energy in the compressive and shear direction as would be experienced during a seismic event. These velocities were also tested at increasing compressive pressures. The intent was to determine if the velocities are impacted by geotechnical pressures from the surrounding rock.

As would be expected, as the material experienced increasing confining pressure the effective material density was increased slightly as the material experienced some elastic properties. With increasing sample density due to compression, the wave velocities had a corresponding increase. Increases from 0 psi confining pressure to 120 psi confining pressure resulted in a 64% increase in compressive wave (Vp) velocity and a 42% increase in the shear wave (Vs) velocity.

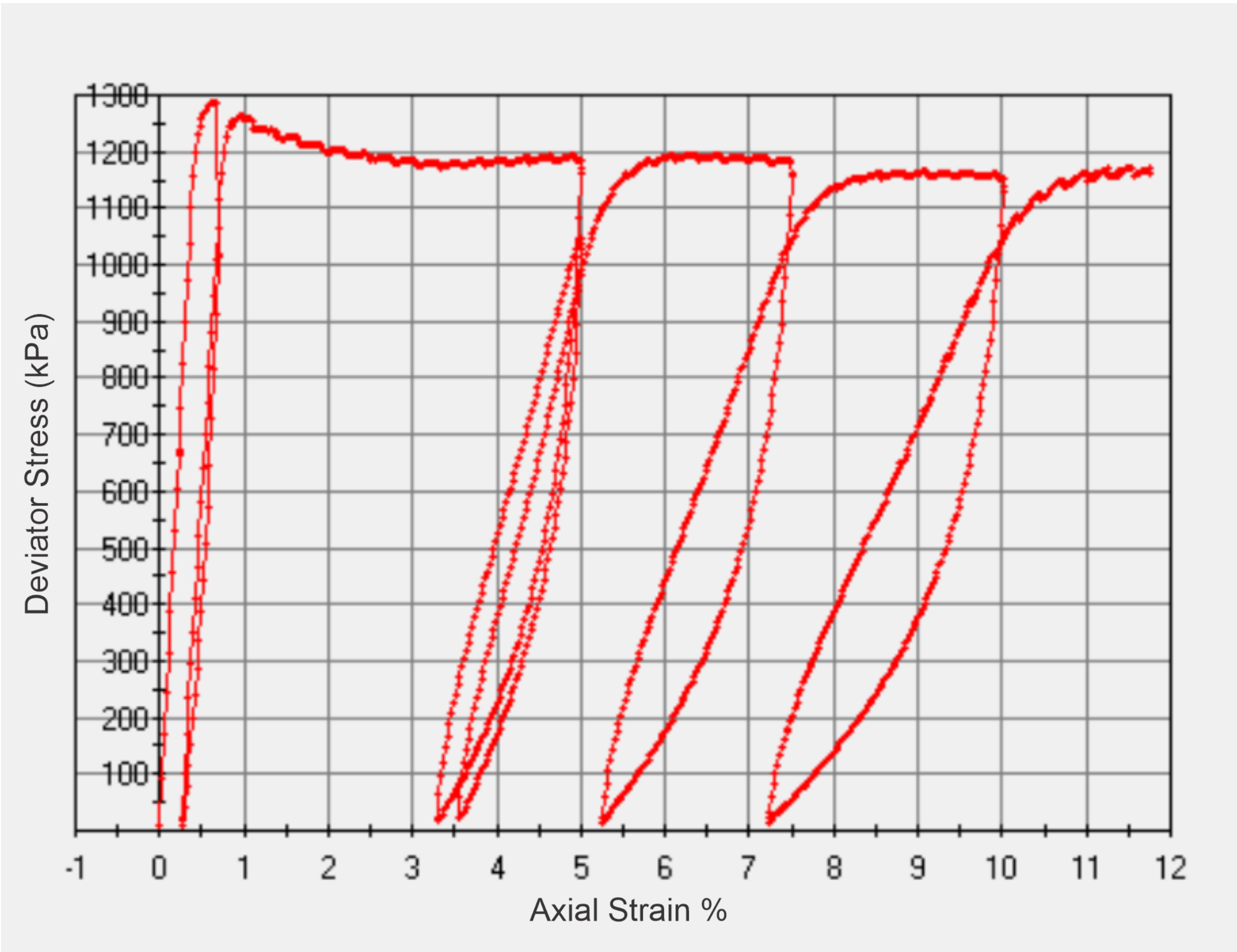


As a comparison, the maximum compressive wave velocity of an unconsolidated shale is 4.4 times faster at 4900 m/s. A material with a lower transmissivity of energy will slow the energy being transmitted to the tunnel liner. It is anticipated that this reduction in wave velocity will reduce the overall impact on the tunnel liner, reducing damage to the tunnel liner altogether.

Testing to measure the rebound of the KM22 was done in a triaxial cell at various pressures. At designated strains the vertical compressive force was relaxed to measure the rebound of the material. The confining pressures for the sample testing were 60, 90 and 120 psi. The table below shows the results at a confining pressure of 120 psi with a relaxation of the axial strain at 1.25%, 5%, 7.5%, and 10%. At 5% the sample was allowed to relax a second time after the reapplication of the compressive force.

The sample rebounded 0.25% after the relaxation at 1.25% strain. This strain was still within the compressive strength of the sample. The first time the sample was allowed to relax at 5% axial strain the sample rebounded 1.5% in volume with the second rebound at 5% resulting in a 1.25% rebound.

As the axial strain increases, the strain is transferred from the cement to the KM22 material and demonstrates a larger rebound. This is demonstrated at the relaxation at 7.5% and 10% axial



strain. The rebounds at these strains are 2.25% and 2.9% respectively.

The measured deviator stress was relatively constant through out the test with the progressive increases in axial strain. This demonstrates the transfer of the load from the grout cement to the KM22 material and the ability to provide a fairly constant resistance to the increasing axial strain. Typically a sample will build to a maximum axil strain, then the failure occurs within a sample. This failure will be indicated by a sharp reduction in the deviator stress.

This testing indicates that the KM22 will absorb and have some permanent deformation as the cement binding the KM22 material fails. However, as the cement binder fails, the load is then carried by the KM22 and will provide an increasing percentage rebound as more strain is carried by the KM22.

With a reduced wave velocity and the ability to provide resistance to the earth movement and rebound as the surrounding earth relaxes, the patent pending KM22 grout clearly demonstrates that it can provide significant improvement in protection to subterranean structures that may be exposed to earth movements.

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