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Effect of Ultrasonic Physical Properties of Cement Grout

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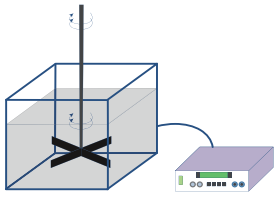
The use of ultrasound to enhance the physical properties of cement grout was investigated with a series of laboratory tests. Test conditions included the power and duration of sonic energy, and curing time. The results of the study show that the use of ultrasound in grout mixing process significantly enhanced the uniaxial compressional strength. A visual decrease in the viscosity of liquid grout was appeared. The degree of enhancement varied with sonication energy, treatment time, and curing duration.

Grouting is one of the most effective methods which improve mechanical properties and sealing of soil and rock in the construction environment. The methodology of grouting technologies is simply injections of liquefied grouting material into the soil and rock media under pressure. [1)] As a result fissures and pores of the media are filled with the grouting material, which subsequently hardens and connects the disintegrated parts of the rock mass or grains of loosen materials. Various chemicals can be used as agents to lower viscosity and to improve strength of grout. However, chemical agents are the most expensive treatment of all. [2)] Therefore, much still remain to be done in order that a generally accepted methodology can be developed for a broad range of applications considering chemical free application. Judina and Verstov[3)] provided an analysis of practical use of magnetic field for solidifying concrete mix and its materials. The results of the experimental research have shown that treatment with a high-voltage electric field promotes intense hydration of clinkers that has an impact on cement stone strength. Azevedo et al. [4)] evaluated the ultimate tensile strength of glass ionomer cements after ultrasonic excitation and different water storage times. They showed significantly higher mean tensile strength with application of ultrasonic treatment. It is suggested that ultrasonic excitation promotes a more homogenous mixture, increasing the particle rate dissolution and the ionic diffusion through the liquid, and accelerates the cross linking of the polyalkenoic acid chains. The possible use of ultrasonic treatment, a simple, effective, and without additive method to enhance mortar properties investigated by Poinot et al. [5)] They represented significant degradation of apparent viscosity of the mortar with sonication. Aforementioned studies were undertaken to enhance the mechanical properties of grout with the aid of ultrasonic energy. However, there is limited and incomplete information on the effects of sonication on the strength of cured grout. In this study, we investigated the use of ultrasonic excitation to increase the material properties of cement grout. In our laboratory experiments, the level of ultrasonic energy, ultrasonic irradiation time, and mixing time were varied.

The test specimens were prepared using a Portland cement that is used very common on the construction sites. The physical properties of the cement are summarized in Table I. Experiments were conducted with and without the application of ultrasonic energy. A bath type processor (Dongshin DSG-1528, 50 x 50 x 50 cm^3) with a maximum output power of 1500kW in conjunction with a 20 kHz frequency, as shown in Fig. 1, was used to apply ultrasonic energy to liquid grout. The average value of the acoustic pressure (the root mean square) in the bath was 69 Pa, which was obtained using a hydrophone(GRAS 10CC).

Table I. Physical properties of Portland cement

Surface area (cm^2/g)		more than 2,800
Autoclave expandability (%)		below 0.8
Vica test	Initial set (min)	more than 60
	Final set (hr)	
hydration heat(J/g)	7 days	Below 10
Compressive strength MPa (N/mm^2)	3 days	more than 12.5
	7 days	more than 22.5
	28 days	more than 42.5



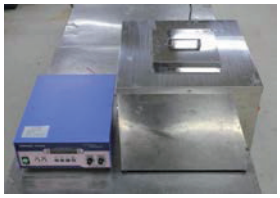


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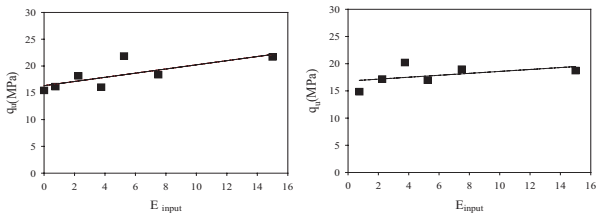
Fig. 1 Bath type ultrasonic processor

The major steps in the experiments were as follows: Cement was added to water as shown in Fig. 2. The ratio of the cement and water was 50:50. The liquid grout was then exposed at sonication with mechanical stirring (mixing). After sonication, the test specimens were prepared using specially designed and fabricated molds. The mold had a diameter of 50 mm and height of 100 mm. Tests were initiated with curing of the specimens in the mold at room temperature. After curing, the specimens were located within a universal testing machine (UTM, YUL-5T) to determine the uniaxial compressional strength. All measurements were done in triplicate under the same conditions, and their average values were used in subsequent analysis.

Fig. 2 Test procedures

It should be noted that the result of these experiments are a function of not only the power of ultrasound, but also the irradiation times and the volume of the grout sample to be treated. Therefore, the applied ultrasound energy level per volume of grout sample could be expressed in terms of the specific supplied energy parameter (E_{input}), which is defined as where p is the consumed ultrasonic power (kW), v is the total volume of the grout (ml), t is the ultrasonic irradiation time (min). The variation of the uniaxial compressional strength of the specimens with ultrasound irradiation and without sonication are shown in Fig. 3. For all conditions, the addition of ultrasound significantly improved the strength of the specimens.

Ultrasound may cause a hydrodynamic variation in liquid grout. Ultrasonic treatment decomposes water molecules and clusters of the cement particle in a purely physical way. It reduces surface tension of water, which significantly improves the wetting capacity and makes water to reacts with the binding agent fast and efficiently. This phenomenon improves the flowability of grout. [6] Fig. 4 shows the flowability change of grout by ultrasound visually. It illustrates a decrease of the thickness of the liquid grout due to sonication. It accords with the investigation which has been undertaken to increase the flow with ultrasound. [7]



(a) **(b)**

Fig.3 Effect of energy level on compressional strength (curing date : 3 days(a) and 5 days(b))

Fig.4 Flowability change due to ultrasonic energy

Acknowledgment

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