Calculating DWi from a drop weight test result

Alex Doll, P.Eng
Alex G. Doll Consulting Ltd.
alex.doll@sagmilling.com

Abstract

The drop weight test is a common laboratory measurement used to determine the comminution characteristics of rock samples. A common metric derived from a drop weight test is a value "A×b". Another common metric that is derived from the SMC Test™ variant of a drop weight test is a "Drop Weight Index", abbreviated as DWi. This work looks at a public database of test results to determine a relationship for DWi as a function of A×b.

Method

A database of publicly published grindability test results has been collected by the Author. This database includes just over two hundred instances of a DWi and A×b being published for the same rock sample. A series of equations were fitted to this database with the goal of finding the best fitting equation.

An equation published by Lane *et al.* (2015) gives a relationship, equation [1], that includes the density of the coarse particles (ρ, or SG for "specific gravity") and two fitted constants, *c* and *d*.

$$DWi = \frac{c}{\rho \times (A \times b)^d} \qquad [1]$$

As the database contains the values for DWi, ρ, and (A×b), the constants *c* and *d* can be determined with some algebraic rearranging and linear regression.

$$DWi \times \rho = c \times (A \times b)^{-d} \qquad [2]$$

$$\ln(DWi \times \rho) = \ln\left(c \times (A \times b)^{-d}\right) \qquad [3]$$

$$\ln(DWi \times \rho) = -d \times \ln(A \times b) + \ln(c) \qquad [4]$$

Equation [4] is in a form suitable for plotting and determining a linear regression. The regression of the database of test results using this equation is given in Figure 1.

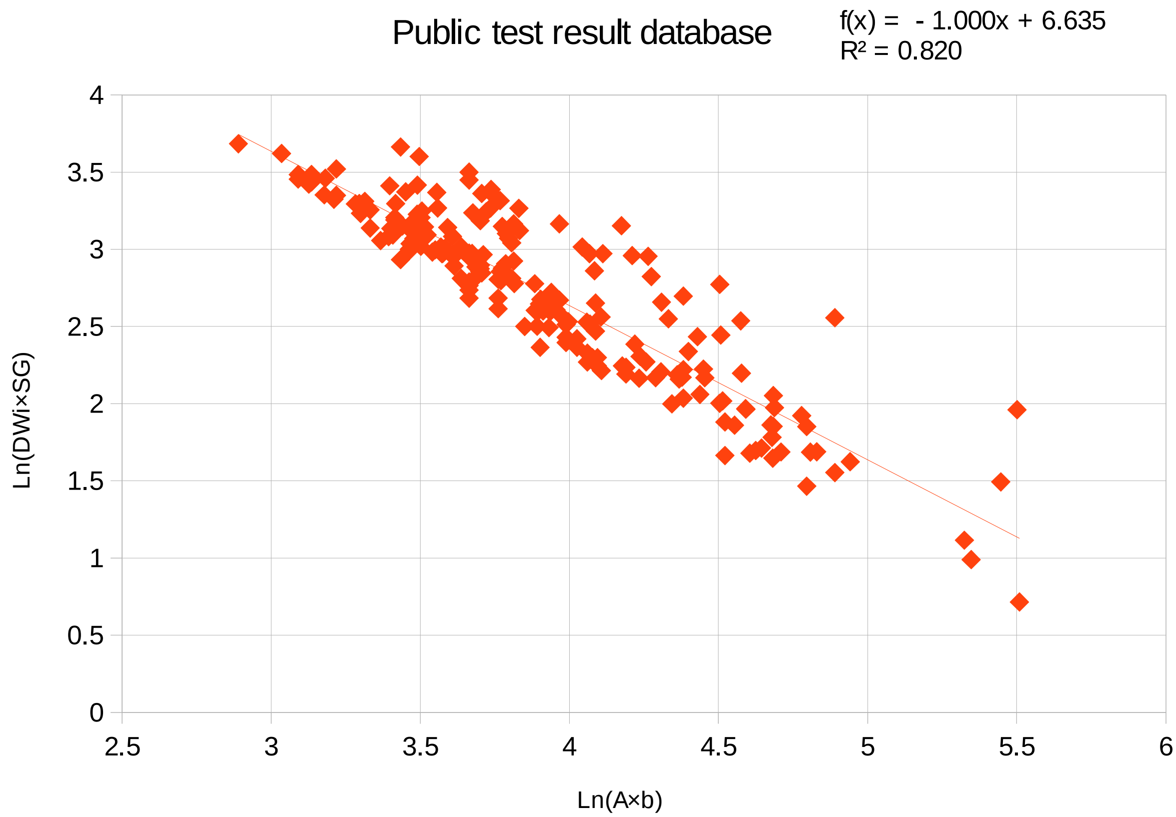

Figure 1: Database fitted to Equation [4]

The fit of this data is not particularly good, and there is quite a bit of scatter that, upon interrogation, is due to high density samples being significantly offset versus the body of the data points.

A different equation

Variations from Equation [1] were tried to see if any gave a better fit. Inverting the density value (equation [5]) was found to improve the data fit dramatically, as given in Figure 2.

$$DWi = \frac{\rho \times c}{(A \times b)^d} \qquad [5]$$

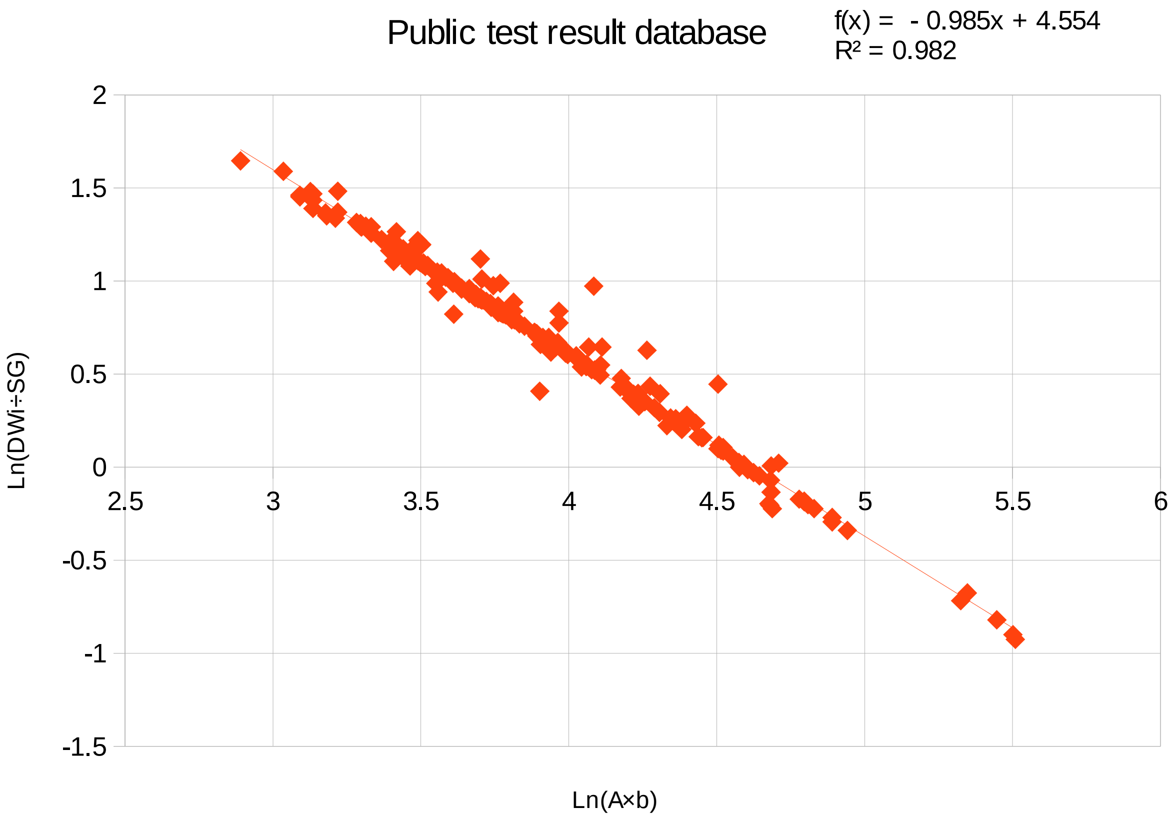

Figure 2: Database fitted to Equation [5]

There is still some scatter about the body of the test results. Interrogation shows that these samples are identified as "averages" or "percentiles" of much larger data sets, and are not single drop weight tests where both of the parameters are reported from a single determination.

Data filtering

It is known that not all grindability parameters are "additive", and the additivity of the A×b parameter is particularly poor. This means that arithmetic averages of a mixture of A×b test results will not give the same value as if you performed a single test on the mixture of the rocks whose individual results were averaged.

It is reasonable to exclude these samples identified as "averages" or "percentiles" from the analysis so that only the parameters determined from the same, discrete drop weight tests are compared. This dramatically reduces the scatter, resulting in the regression in Figure 3.

The regression equation is determined to be:

$$\ln\left(\frac{DWi}{\rho}\right) = -0.992 \times \ln(A \times b) + 4.572 \qquad [6]$$

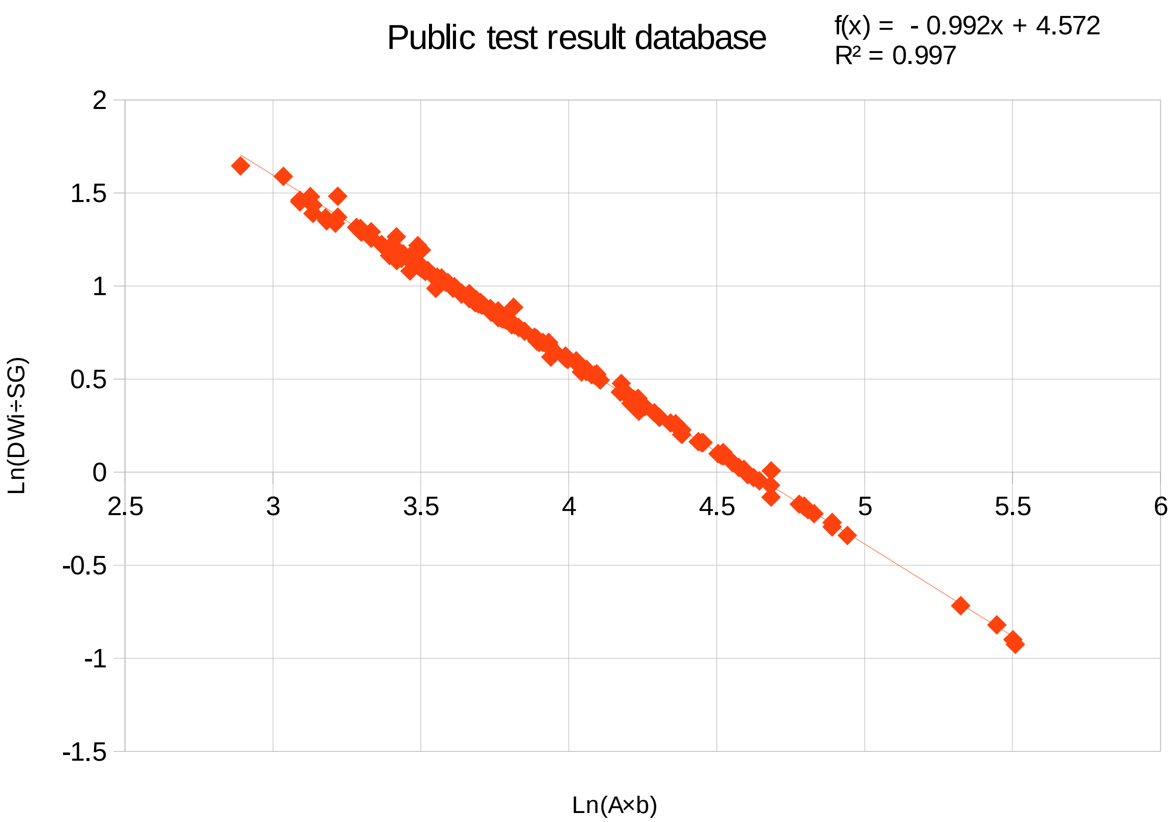

Figure 3: Filtered database regression for Equation [5].

Result

The fitted equation for DWi, given a rock density ρ (kg/L) and a A×b value is:

$$DWi = \frac{\rho \times 96.703}{(A \times b)^{0.992}} \quad [7]$$

References

Grindability database collected from public sources such as conference proceedings and NI43-101 reports. This database includes references for each result and is freely available to the public by contacting the Author.

Lane, G., Dakin, P., Stephenson, D., Johnston, A. and Granados, H. (2015) "The comminution circuit design for the Constancia Project", Proceedings of the *International Semi-Autogenous Grinding and High Pressure Grinding Roll Technology Conference* (SAG 2015), Vancouver, Canada, paper #39.