As discussed in Geotech Chapter 3, pedology is the science dealing with soil as a natural body. It holds that the same parent material subjected to similar influences of time, climate, topography, drainage, and biological forces will develop the same soil profile in all locations. It then follows that this unique soil profile will also have unique engineering properties. Once these properties have been determined, they may be assumed for this specific soil at any location where it may be found.

6-2.1 Keyser's Group Index

In his thesis, Dr. Keyser attempted to relate established engineering properties of specific soils to pavement performance. His investigations centered on the relationship between actual pavement performance and the group index of the subgrade soil. The group index is used in the AASHTO soil classification system to further define soils within each of the seven major groups. The group index is considered to be an indicative soil parameter, since it is derived from the percent of soil passing the # 200 sieve, its liquid limit, and plasticity index. At the time of Dr. Keyser's work, the group index was limited to a range of 0 to 20. Later changes to the definition now allow values greater than 20, but these higher values should not be applied. The group index values used by Dr. Keyser were obtained from the following formula:

$$\text{Group Index} = 0.2a + 0.005ac + 0.01bd$$

Where:

a = that portion of the percent passing the No. 200 sieve, greater than 35 and not exceeding 75, expressed as a positive whole number from 1 to 40

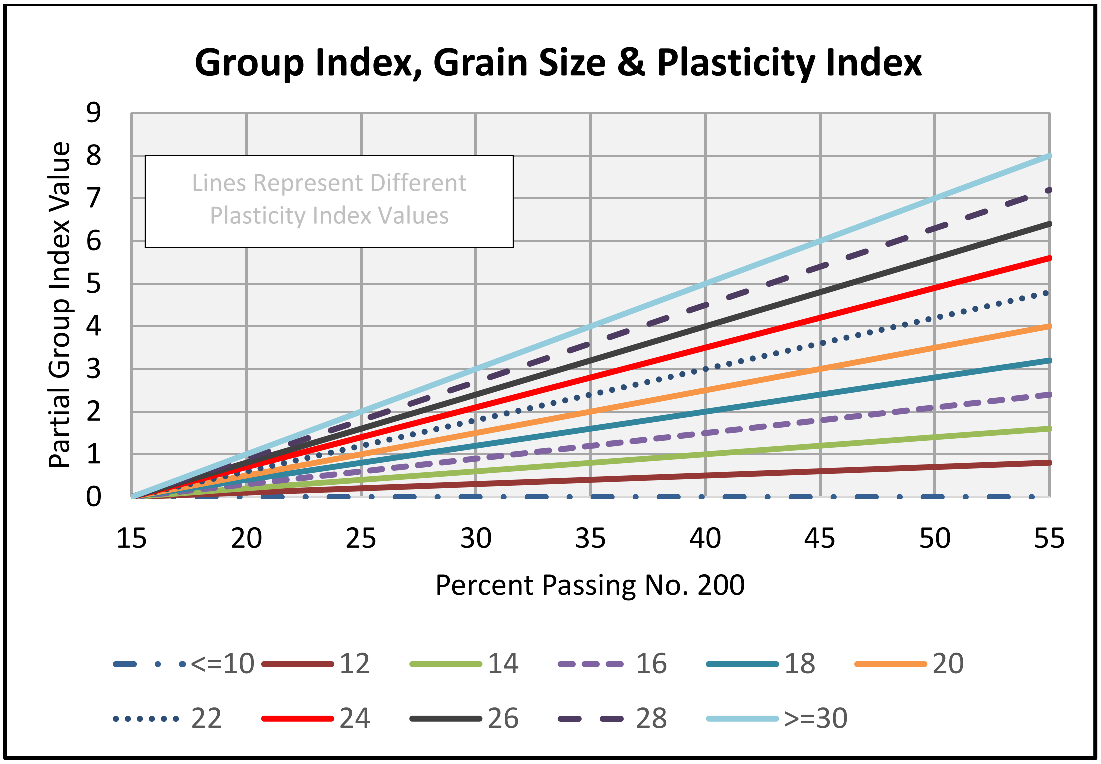
b = that portion of the percent passing the No. 200 sieve, greater than 15 and not exceeding 55, expressed as a positive whole number from 1 to 40

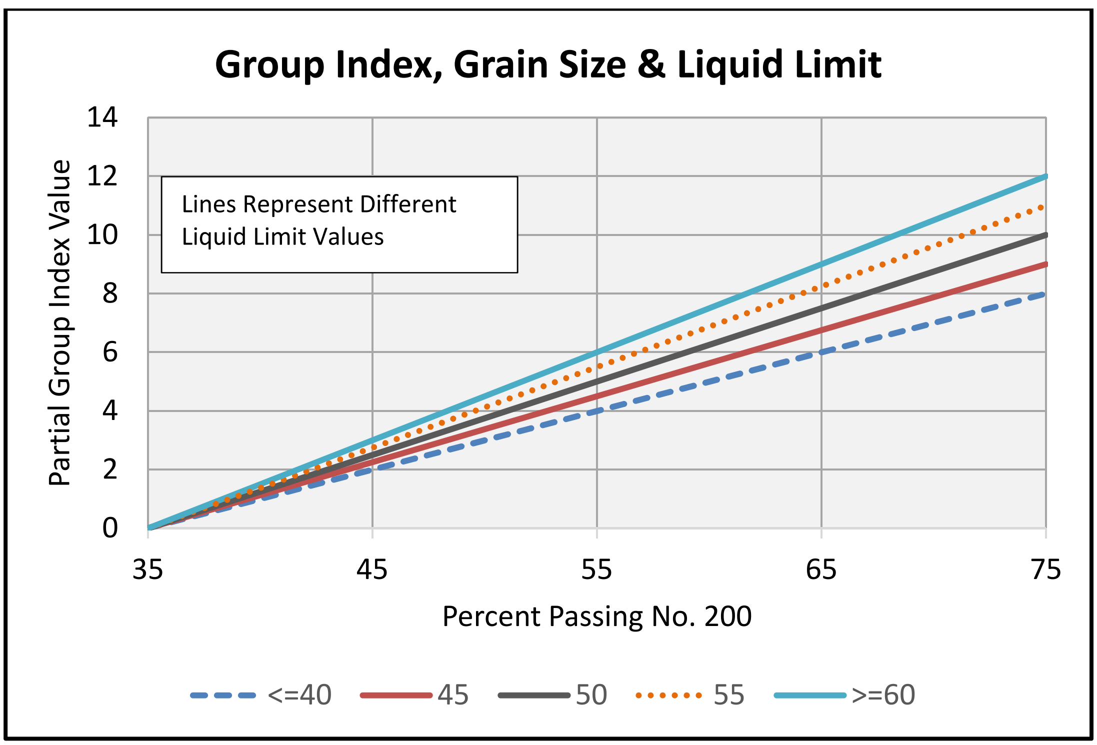
c = that portion of the numerical liquid limit, greater than 40 and not exceeding 60, expressed as a positive whole number from 1 to 20

d = that portion of the numerical plasticity index, greater than 10 and not exceeding 30, expressed as a positive whole number from 1 to 20

The two graphs presented in Figure 1 may also be used to determine the group index value, as used by Keyser in his investigations. Again, the limiting value for group index is 20. To use this Figure, use the Plasticity Index and the Liquid Limit to select the correct line on both graphs, and then determine the individual Partial Group Index Values from each of the vertical axes. These two partial values are then added to arrive at the Group Index Value of the soil.

Figure 1 - Group Index (Is the Sum of Two Partial Index Values)





6-2.2 Design Group Index

Dr. Keyser's investigations revealed that for subgrades in granular soils with low group index values, a direct correlation could be made between flexible pavement performance and group index values. He also determined that a reasonable correlation existed between pavement performance and group index values in high clay content soils with high values. However, in silty subgrades with middle range group index values, no similar correlation could be made. Flexible pavements on silty subgrades were found to perform at a level considerably below that anticipated from a direct correlation to group index values. This poor performance was attributed to the propensity for frost action in the high silt-content soils. The detrimental effects resulted from both the build-up of ice lenses resulting in pavement heave in the winter, and the loss of stability related to high subgrade moisture levels during spring thaw conditions. To account for these variances, Dr. Keyser proposed the use of an empirical modification to group index values, based on actual pavement performance. His designation for these empirical values was the term Design Group Index (DGI). The DGI values that he developed were based on evaluations of pavement performance for subgrades of various soil types. WisDOT has used these findings to develop suggested DGI values for a full range of soils based on pedological names.

It must be emphasized that DGI values are not the same as group index values and group index values cannot be substituted for DGI values. There is no test that can determine DGI and there is no formula to compute it. The DGI value of a soil is a judgmental value based on the texture of the soil, the potential for frost action, and most importantly, the actual performance of pavements constructed on this soil. DGI values range from a low of 0 to a high of 20. Clean granular soils generally have DGI values in the range of 0 to 4, while silty soils range from 10 to 14. Silty clay soils are normally in the 14 to 16 range.

6-2.3 Frost Index

There is also a reasonable correlation between The Army Corps of Engineers Frost Index values and DGI. The criteria for determining Frost Index values are presented in Table 1.

Table 1 – Frost Index Correlations

Frost Index	Application
F-0	Non-frost susceptible material. Generally the better A-1 and A-3 groups.
F-1	Gravelly soils containing between 3 and 20 percent finer than 0.02mm. Generally the finer A-1 group.
F-2	Sands containing between 3 and 15 percent finer than 0.02mm. Generally the A-1 sand and finer textured A-3 sands, and the better A-2 sands.
F-3	Gravelly soils containing more than 20 percent finer than 0.02mm. Sand, except fine silty sand, containing more than 15 percent finer than 0.02mm. Generally the A-2 group, and A-4 material bordering on the A-2 group. Clays with PI > 12. Generally the heavy A-6 and A-7 groups. Varved clays existing within uniform subgrade conditions.
F-4	All silts, including sandy silts. Generally the A-4 and A-5 groups. Very fine silty sands containing more than 15 percent finer than 0.02mm. Lean clays with PI < 12. Generally the light A-6 group. Varved clays with non-uniform subgrade conditions.

The general relationship between DGI and Frost Index is shown in Table 2.

Table 2 – Frost Index and Design Group Index

Frost Index	Design Group Index
F-0, F-1	0 - 2
F-2	2 - 6
F-3	6 - 14
F-4	14 - 20

DGI values were originally developed for each horizon in about 170 key soils in Wisconsin. About another 350 Wisconsin soils have been correlated to this key group, resulting in a listing of DGI values for each horizon in about 520 soils found in the Wisconsin. Dr. Keyser suggested that as more experience was gained with the system, appropriate modifications to values should be made. The DGI values currently used by WisDOT are a combination of the original values and modifications suggested by use, experience, and engineering judgment resulting from the use of the system since 1961.

Geotech Chapter 8 presents a listing of over 500 Wisconsin soils listed by pedological name. For each soil, a brief description of texture and origin along with internal drainage condition is given. The DGI and the Frost Index are also given for each horizon of each individual soil. These tabulated values should be used for flexible pavement design if the following conditions are anticipated to be met:

1. The subgrade will be closely monitored and inspected during construction.
2. The subgrade will be thoroughly and adequately compacted during construction.
3. Wet zones encountered during construction will be dried, drained, or removed.
4. Pockets and lenses of dissimilar material will have been removed, replaced, or mixed to achieve a homogenous subgrade.
5. Adequate subgrade drainage will have been established.

These are all normal construction procedures that should occur on every project. However, if for some reason there are concerns that that these conditions will not be met, it would be advisable to consider an increase in the design DGI values. Such recommended changes should be noted and justified in the Soils Report or in the pavement design report.

In areas of disturbed soil, it may not be feasible to directly correlate the encountered soil with a pedological name. In those cases, it may be necessary to estimate DGI based on textural classification. Table 3 presents guidance in this matter.

Table 3 – DGI Based on Soil Type

Soil Classification	Estimated DGI Range
A-3 Clean Sand	0 to 2
A-1 Gravelly Sand A-2 Non-plastic Sand with Silt	2 to 4
A-2 Plastic Silty or Clayey Sand A-4 Sandy Silt	10 to 12
A-4 Silt A-6 Lighter Clayey Silt	12 to 14
A-6 Heavier Clayey Silt A-7 Silty Clay and Clay	14 to 16

The AASHTO flexible pavement design equations currently used by WisDOT do not allow the direct input of DGI values to account for subgrade soil influence. In these equations, subgrade soil influence is represented by the factor termed Soil Support Value (SSV). Using experience, pavement performance, and judgment, WisDOT has developed a correlation between DGI values and SSV. This correlation is presented in the form of a graph presented as Figure 2. The graph is configured to allow determination of SSV values for subgrades with, or without, select materials. This became necessary when WisDOT began the policy of using select materials in the upper portions of subgrades constructed from relatively weak soils. WisDOT determined that these thick layers of improved material would have a significant beneficial effect on pavement performance. However, since the select materials are defined as part of the subgrade, it was not possible to directly include their influence on pavement design using the current AASHTO equations. In order to account for some of this pavement structure benefit due to the inclusion of these select materials, WisDOT modified the SSV value for soils where these materials are used. The result is an upper correlation line as shown on Figure 2. Note that this methodology is limited to soils with a DGI of 10 or higher, since select materials would only be used on subgrade soils of this type.

Figure 2 – Soil Support Value and DGI