

June 03, 2020

Eric Boehner
Signature Stone, LLC
211 30th Street
Greeley, CO

Subject: Noise and Pollution Control Analysis for 6' and 8' Privacy Fence
CTL Thompson Project Number: FC07305

Dear Mr. Boehner,

Per your inquiry, engineers at CTL|Thompson, Inc. have analyzed the properties of the 6' and 8' tall precast concrete privacy fence for their effectiveness for noise and pollution control. We understand that you would like to know the effectiveness of the precast concrete fence system, particularly in comparison to a typical wood privacy fence. This letter presents our engineering conclusions. For our review, we checked multiple criteria based on the U.S. Department of Transportation's Federal Highway Administration's *Noise Barrier Design Handbook*.

The first acoustical property of the fence examined was the theoretical transmission loss (TL) of sound that could reasonably be expected. TL is defined as the amount of incident sound the barrier will transmit from the source of noise to the receiver and is a property of the barrier material. The U.S. Department of Transportation's Federal Highway Administration's *Noise Barrier Design Handbook* states that, as a rule of thumb, any material weighing 20 kg/m² (4 psf) or more has a transmission loss of at least 20 dB(A). Such material would be adequate for a noise reduction of at least 10 dB(A) due to diffraction, which indicates a noise level behind the barrier half as loud as the source. Therefore, a material that has a TL of at least 25 dB(A) or greater is desired and would always be adequate for a noise barrier (FHWA 2017).

The second acoustical property of the fence examined was the theoretical insertion loss (IL) of the barrier. Essentially, this property is defined as the sound level at a given receiver before the construction of the barrier minus the sound level at the same receiver after the construction of the barrier. Typically, a 5 dB(A) IL can be expected for receivers whose line-of-site to the roadways is blocked by the barrier. This also assumes that the barrier has no openings which would let the full, if not amplified sound, through to the receiver.

These two acoustical properties, based on material (TL) and geometry (IL), both lead to the reduction in perceptible noise levels at the receiver. See the figure on the following page for an illustration of noise barrier mechanics. The dashed lines indicate the reduced level of sound the receiver perceives.

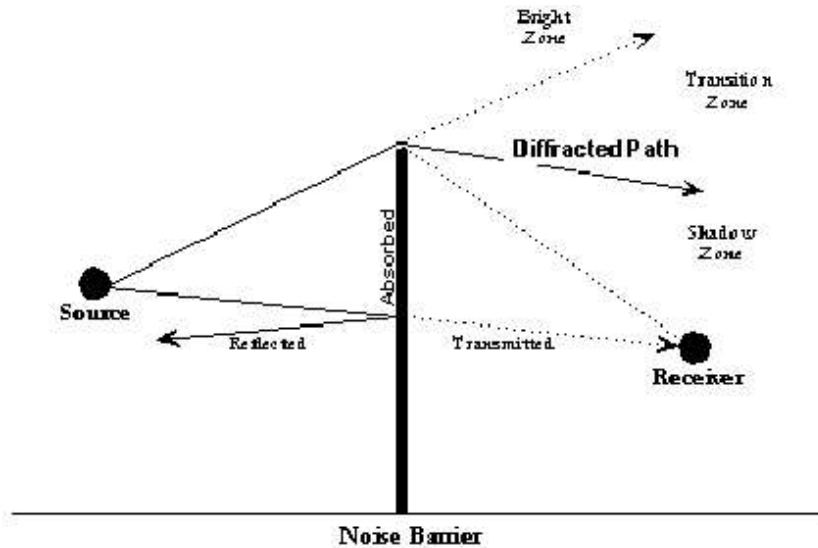


Figure 1. Noise barrier sound mechanics (FWHA 2017).

The Signature Stone privacy fence system was also compared to typical wooden privacy fence systems for effectiveness as a physical barrier against pollution from traffic. We defined pollution in this case as the splash and spray which can be generated by traffic during wet conditions. The spray can contain various chemicals compounds including deicer, oil, dirt, and other vehicular fluids, none of which are desirable compounds to have in a residential yard area.

We began our analysis by examining the material and cross-sectional properties of the 6' and 8' tall privacy fences (see attachment one). The Signature Stone privacy fence system consists of stacked 2" thick precast concrete panels. Concrete typically has a density of 150pcf which translates into a material weight of 25 psf for this system. This material weight falls well within the typical rule of thumb. Additionally, for this fence cross section, an approximate TL value of 33 dB(A) can reasonably be expected. This value was assumed based on TL values reported for light concrete by the FWHA (see the second attachment for the full table). This TL value translates to a sound level at the receiver of 42 dB(A) which is approximately equivalent to the sounds encountered in a residential area at night. See the figure below to help put this value into context.

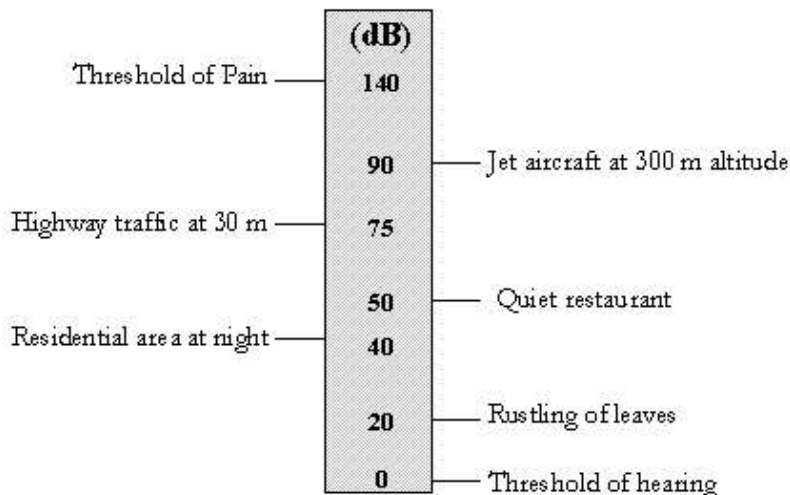


Figure 2. Decibel scale with contextual perception levels (FWHA 2017).

In comparison, a typical wooden fence with a picket thickness of ½” has a density of 33pcf or a material weight of 16.5 psf. The approximate TL value of wood of this thickness is 18 dB(A). Both the material weight and the TL value fall well below the desired threshold for adequate noise barriers. Additionally, the noise level at the receiver would be 57 dB(A) which is exponentially more than the noise level at the receiver using the concrete privacy fence.

Next, the 6’ and 8’ privacy fences are both tall enough to break the line of sight from the average theoretical receiver to the highway traffic, or source. When a barrier does this, an increment loss (IL) of 5 dB(A) can reasonably be expected. Figure 2 illustrates this condition.

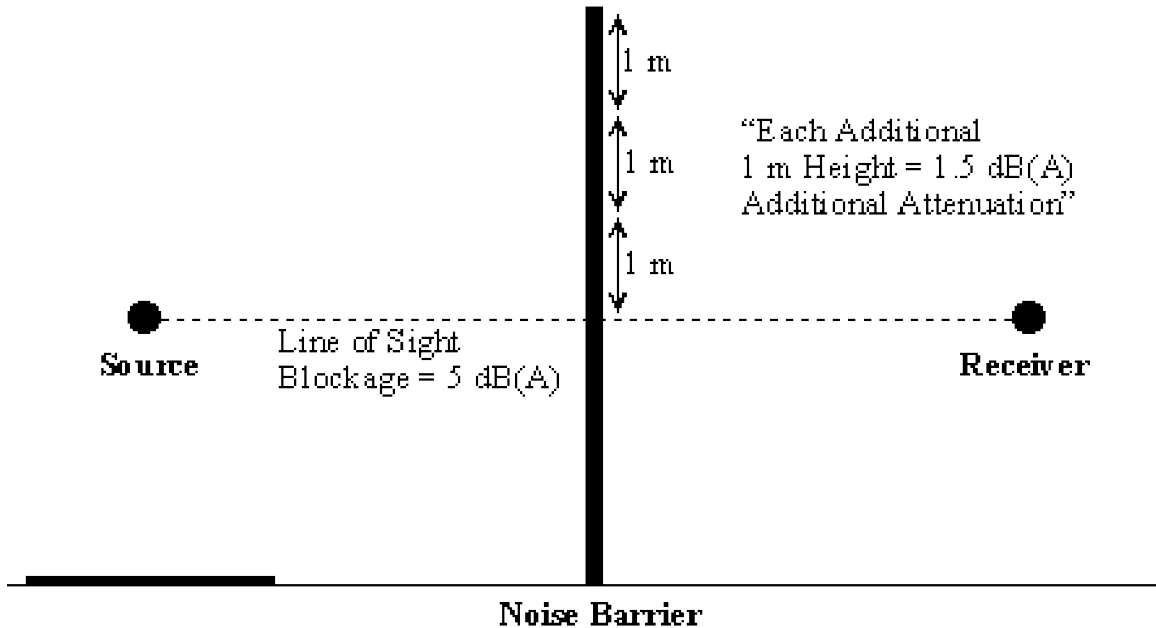


Figure 3. IL expected at receiver due to line of site blockage (FHWA 2017).

Because the Signature Stone privacy fences are manufactured with concrete, CTL|Thompson expects this value to be higher. Openings and gaps in the barrier construction reduce the effectiveness of the noise barrier and lower the IL value. Since the Signature Stone privacy fences are constructed using precast concrete panels, the fences are not expected to develop openings over time due to shrinkage or warping. Wood fences naturally have gaps in their construction which increase over time as the wood dries and deteriorates. The increase in gap size corresponds to an increase in noise levels at the receiver over time.

Additionally, it has been indicated that the project where these fences are to be used as noise barriers is several thousand feet long. A rule-of-thumb is that a barrier should be long enough such that the distance between a receiver and a barrier end is at least four times the perpendicular distance from the receiver to the barrier along a line drawn between the receiver and the roadway (FHWA 2017). This should not be a problem for the proposed project.

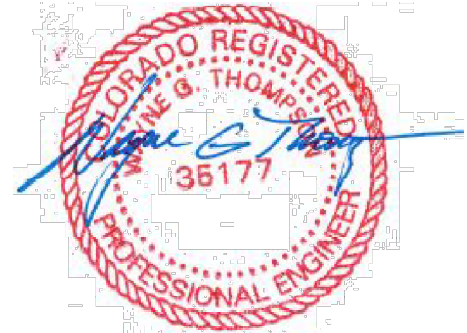
In relation to pollution control, the fence is built as one solid section which will effectively knock down the spray from the road. Additionally, the keyed construction of the fence panels should also effectively disallow any pollution from the road surface from penetrating through the joint areas. The gaps in a wooden fence would more easily allow pollution due to splash through into the residential areas.

Thank you for selecting CTL Thompson for your engineering needs. When we can be of additional service, please contact our office.

Very truly yours,



Cidne Bernhardt, EI
Staff Engineer
CTL Thompson, INC.



Jun 4 2020 10:19 AM

Wayne Thompson, PE
Project Engineer
CTL Thompson, INC.

Attachments (2): 6' and 8' Privacy Fence Drawings (2 Pages), FWHA Approximate Transmission Loss Table (1 Page)

SPECIFICATION DATA

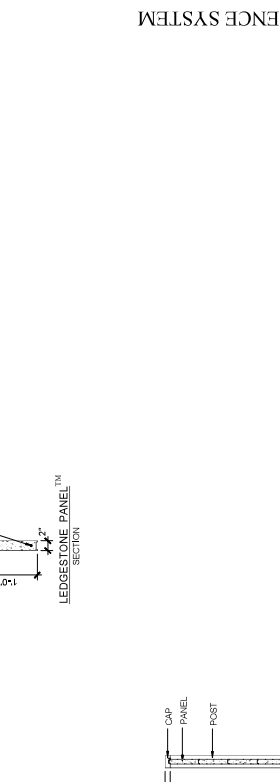
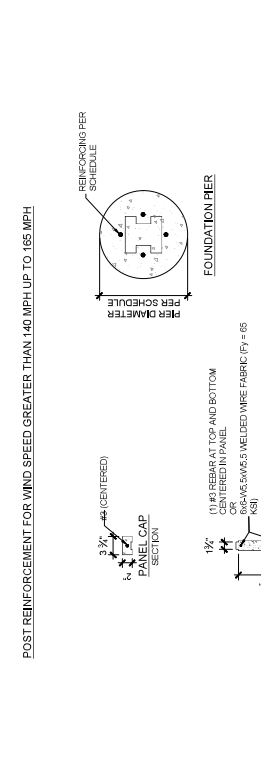
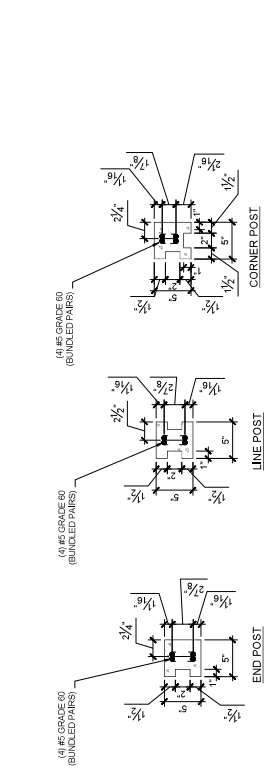
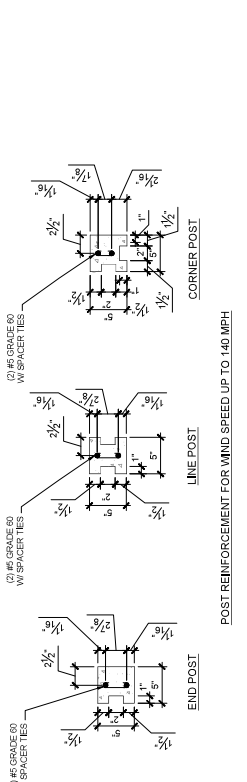
1. **PRODUCTS:**
 LEDGESTONE COLUMN
 UNFINISHED COLUMN
2. **MANUFACTURER:**
 SIGNATURE STONE, L.L.C.
 211 30TH STREET
 GREELEY, CO 80631
3. **INSTALLATION:**
 PRODUCTS ARE INTENDED FOR RESIDENTIAL, COMMERCIAL, AND INDUSTRIAL EXTERIOR FENCING. SEE INSTALLATION MANUAL FOR FURTHER INFORMATION.
4. **COMPOSITION AND MATERIALS:**
 A MIX OF HIGH STRENGTH PORTLAND CEMENT CONCRETE WITH POLYMER FIBERS IS USED FOR ALL CONCRETE. ALL CONCRETE SHALL BE PROTECTED FROM WEATHERING BY THE APPLICATION OF AN ACROLEIN-BASED GLOSS FINISH. ALL CONCRETE SHALL BE VIBRATED AFTER SETUP OF MIX. CURED AND PACKAGED CONCRETE SHALL BE USED.

5. **FOUNDATION:**
 FENCE POSTS ARE TYPICALLY PLACED AT 6 FT. ON CENTER AND APPROXIMATELY 2.0 IN. IN HEIGHT AND APPROXIMATELY 2.0 IN. IN DIAMETER. FOUNDATION SHALL BE CAST BY AN ENGINEER NOT INCLUDED IN THESE SPECIFICATIONS. SEE FOUNDATION MANUAL FOR FURTHER INFORMATION.
6. **LIMITATIONS:**
 THIS SYSTEM IS NOT INTENDED FOR USE IN AREAS OF HIGH WINDS OR SEVERE WEATHER. THE SYSTEM SHALL BE DESIGNED AND CONSTRUCTED IN ACCORDANCE WITH THE REQUIREMENTS OF ALL APPLICABLE LOCAL, STATE, AND FEDERAL CODES AND REGULATIONS. THE SYSTEM SHALL BE DESIGNED AND CONSTRUCTED IN ACCORDANCE WITH THE REQUIREMENTS OF ALL APPLICABLE LOCAL, STATE, AND FEDERAL CODES AND REGULATIONS. THE SYSTEM SHALL BE DESIGNED AND CONSTRUCTED IN ACCORDANCE WITH THE REQUIREMENTS OF ALL APPLICABLE LOCAL, STATE, AND FEDERAL CODES AND REGULATIONS.

7. **TECHNICAL DATA FOR CONCRETE:**
 PRECAST FENCE POSTS AND PANELS:
 MIN. 28 DAY COMPRESSIVE STRENGTH = 5,000 PSI
 CAST-IN-PLACE FOUNDATION PIER PER POST:
 MIN. 28 DAY COMPRESSIVE STRENGTH = 3,000 PSI
8. **BUILDING CODES:**
 ALL CONCRETE SHALL BE CAST AND CURED IN ACCORDANCE WITH THE REQUIREMENTS OF ALL APPLICABLE LOCAL, STATE, AND FEDERAL CODES AND REGULATIONS.
9. **INSTALLATION:**
 THE LONG-TERM PERFORMANCE OF ALL FOUNDATIONS INCLUDING THE SIGNATURE STONE FENCE FOUNDATION SHALL BE THE RESPONSIBILITY OF THE CONTRACTOR. THE CONTRACTOR SHALL BE RESPONSIBLE FOR OBTAINING ALL NECESSARY PERMITS AND APPROVALS FROM THE LOCAL ENGINEER OR ARCHITECT. THE CONTRACTOR SHALL BE RESPONSIBLE FOR OBTAINING ALL NECESSARY PERMITS AND APPROVALS FROM THE LOCAL ENGINEER OR ARCHITECT.

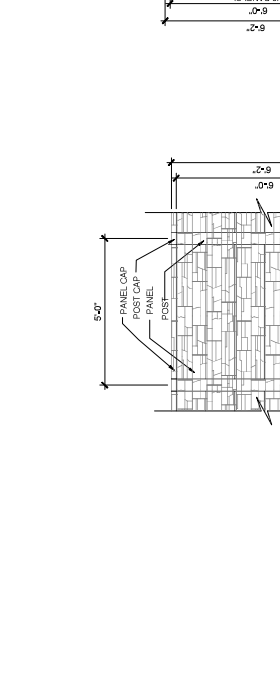
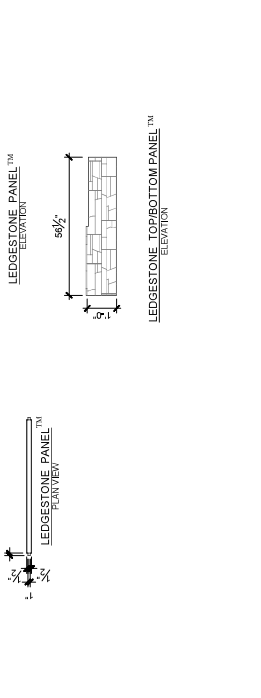
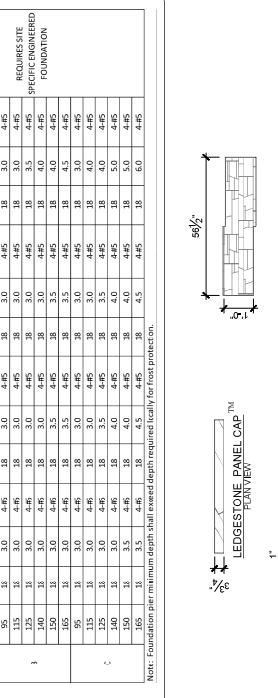
GENERAL NOTES:

1. ALL CONSTRUCTION TO MEET LOCAL CODES AND REGULATIONS.
2. ALL CONCRETE FOOTINGS SHALL USE TYPE W CEMENT.
3. ALL REINFORCING STEEL SHALL CONFORM TO ASTM A 615, GRADE 60 (GRADE 40 FOR REPAIR ONLY).
4. ALL REINFORCING STEEL SHALL BE PROTECTED WITH AN EPOXY-BASED CORROSION RESISTANT COATING IN ACCORDANCE WITH THE REQUIREMENTS OF ALL APPLICABLE LOCAL, STATE, AND FEDERAL CODES AND REGULATIONS.
5. FENCE WALL PANELS SHALL BE DESIGNED FOR A WIND LOAD OF 140 MPH UP TO 185 MPH. THE CONTRACTOR SHALL VERIFY ALL CONDITIONS AT THE JOB SITE.
6. APPROVAL OF THE ENGINEER IS REQUIRED WHEN FENCE IS USED UNDER A CONDITION WHERE THE SPECIFICATIONS ARE EXCEEDED.
7. THE CONTRACTOR SHALL VERIFY ALL CONDITIONS AT THE JOB SITE.
8. SIGNATURE STONE CONCRETE PERFORMS BEST IN WET WEATHER. THE CONTRACTOR SHALL BE RESPONSIBLE FOR OBTAINING ALL NECESSARY PERMITS AND APPROVALS FROM THE LOCAL ENGINEER OR ARCHITECT.
9. ALL DIMENSIONS SHOWN ON THIS SHEET ARE FOR INFORMATION PURPOSES ONLY. ACTUAL DIMENSIONS MAY VARY FROM THE DIMENSIONS SHOWN ON THIS SHEET DUE TO TOLERANCES.



SCHEDULE OF RECOMMENDED FOUNDATION PIER MIN. SIZES

| Footing per minimum depth that meets depth requirements for frost protection. | Gravel | | Sand | | Clay | | Unknown Fill / Organics | |
|---|--------------------|------------------------|--------------------|------------------------|--------------------|------------------------|-------------------------|------|
| | Friction Angle (°) | cohesion, c (psf) (mm) | Friction Angle (°) | cohesion, c (psf) (mm) | Friction Angle (°) | cohesion, c (psf) (mm) | | |
| 85 | 30 | 4.6 | 18 | 3.0 | 4.85 | 18 | 3.0 | 4.65 |
| 115 | 30 | 4.6 | 18 | 3.0 | 4.85 | 18 | 3.0 | 4.85 |
| 125 | 30 | 4.6 | 18 | 3.0 | 4.85 | 18 | 3.5 | 4.85 |
| 135 | 30 | 4.6 | 18 | 3.5 | 4.85 | 18 | 4.0 | 4.85 |
| 145 | 30 | 4.6 | 18 | 3.5 | 4.85 | 18 | 4.5 | 4.85 |
| 155 | 30 | 4.6 | 18 | 3.0 | 4.85 | 18 | 3.0 | 4.85 |
| 165 | 30 | 4.6 | 18 | 3.0 | 4.85 | 18 | 3.0 | 4.85 |
| 175 | 30 | 4.6 | 18 | 3.5 | 4.85 | 18 | 4.0 | 4.85 |
| 185 | 30 | 4.6 | 18 | 3.5 | 4.85 | 18 | 4.0 | 4.85 |
| 195 | 30 | 4.6 | 18 | 4.0 | 4.85 | 18 | 5.0 | 4.85 |
| 205 | 30 | 4.6 | 18 | 4.0 | 4.85 | 18 | 5.0 | 4.85 |
| 215 | 30 | 4.6 | 18 | 4.5 | 4.85 | 18 | 6.0 | 4.85 |



NOTE: SMALL DIAMETER PVC PIPE IS COMMONLY CAST IN PIERS TO LEVEL PANELS. IT IS ACCEPTABLE TO BEAR THE CONCRETE PANELS ON THE PVC LEVELERS. THE PVC LEVELERS MAY EXTEND A MAX. ABOVE THE TOP OF THE CONCRETE PIER.

PANEL SHOULD NOT BE IN CONTACT WITH EARTH LEAVE 1/2" TO 1" GAP BETWEEN BOTTOM OF PANEL AND GRADE (SEE NOTE BELOW)

| Material | Thickness mm (inches) | Weight kg/m²(lbs/ft²) | Transmission Loss (dB(A)) |
|---|--------------------------------------|--|--------------------------------------|
| Concrete Block, 200mm x 200mm x 405 (8" x 8" x 16") light weight | 200mm (8") | 151 (31) | 34 |
| Dense Concrete | 100mm (4") | 244 (50) | 40 |
| Light Concrete | 150mm (6") | 244 (50) | 39 |
| Light Concrete | 100mm (4") | 161 (33) | 36 |
| Steel, 18 ga | 1.27mm (.050") | 10 (2.00) | 25 |
| Steel, 20 ga | 0.95mm (0.0375") | 7.3 (1.50) | 22 |
| Steel, 22 ga | 0.79mm (0.0312") | 6.1 (1.25) | 20 |
| Steel, 24 ga | 0.64mm (0.025") | 4.9 (1.00) | 18 |
| Aluminum, Sheet | 1.59mm (0.0625") | 4.4 (0.9) | 23 |
| Aluminum, Sheet | 3.18mm (0.125") | 8.8 (1.8) | 25 |
| Aluminum, Sheet | 6.35mm (0.25") | 17.1(3.5) | 27 |
| Wood, Fir | 12mm (0.5") | 8.3 (1.7) | 18 |
| Wood, Fir | 25mm (1.0") | 16.1(3.3) | 21 |
| Wood, Fir | 50mm (2.0") | 32.7 (6.7) | 24 |
| Plywood | 12mm (0.5") | 8.3 (1.7) | 20 |
| Plywood | 25mm (1.0") | 16.1 (3.3) | 23 |
| Glass, Safety | 3.18mm (0.125") | 7.8 (1.6) | 22 |
| Plexiglass | 6mm (0.25") | 7.3 (1.5) | 22 |