Guide to Glass Selection

Acoustic Performance Of Glass

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Moulding Ideas
Abstract

Karnataka Metal Company/ KMC Glass and Aluminium Pvt Ltd, is a processor and trader of glass in Bangalore. This report was created to either be an internal document to capture knowledge and be used for induction of new employees or used as a specifier’s guide to glass selection.

Aim

This document has not been referenced because it wasn’t deemed necessary but can be provided if required. The aim of this report is to simplify the engineering behind the acoustic properties of building materials and hopefully enable the reader the ability to not only understand the acoustic properties of glass, but also that of other building materials.
Acoustic Performance Of Glass

There are many misconceptions about the acoustic performance of glass, and there is a very good reason for it, it’s not very straightforward.

Some of the questions that I have been asked about the acoustic performance of glass are, how much of a difference will there be if DGU or laminated glass is used instead of single glazing? If we have a fixed frame size, what should be maximised in a DGU, airgap or glass thickness? The following sections hopes to answer these questions.

The following flowchart describes the process that needs to be followed when glass is being selected based on its acoustic properties.
What Level Of Sound Is Required?

Before we study the acoustic properties of glass, it is important to define the acceptable level of noise or select a target noise intensity level inside the building’s façade. The best place to start would be the noise pollution laws in India which is provided in Table 1.

<table>
<thead>
<tr>
<th>Zone</th>
<th>Permissible Noise Level Standards In The Daytime (Db)</th>
<th>Permissible Noise Level Standard At Night (Db)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industrial Zone</td>
<td>75</td>
<td>70</td>
</tr>
<tr>
<td>Commercial Zone</td>
<td>65</td>
<td>55</td>
</tr>
<tr>
<td>Residential Zone</td>
<td>55</td>
<td>45</td>
</tr>
<tr>
<td>Silent Zone</td>
<td>50</td>
<td>40</td>
</tr>
</tbody>
</table>

Noise regulations in India
Sound Insulation introduction

If we want to design facades with adequate sound insulation properties, we must know the sound reduction index values (R) of windows tested in the laboratory. The sound reduction index of windows depends on various subjects as: type of glass, dimension of glass, glass thickness, air cavity and interlayers (laminated glass).

Glass Thickness Effect

The sound attenuation of any material depends on its mass, stiffness and damping characteristics. With single glazing the only way to decrease sound attenuation is by increase the thickness of glass, because stiffness and damping cannot be changed. As you will see later, the sound reduction of glass varies with the frequency of sound.

It is very important to remember that every pane has a critical frequency at which it performs poorly. For example, 4 mm glass has a poor sound reduction index at high frequencies at the range of 3500 Hz; 10 mm glass perform poorly at 1300 Hz. However, higher the mass of the glass, lesser of a problem the critical frequency seems to be: 25mm thick glass has no weak point. This is why we recommend insulating glass units be selected with different thicknesses.

Although we suggest the use of different thicknesses of glass, this suggestion is only applicable for higher frequencies. For example, a 6-12-4 mm glass will absorb more noise at higher frequencies (above 2000 Hz) than a 6-12-6 mm glass even though it has less mass. On the other hand, at low frequencies (125 to 250 Hz such as traffic noise), 6-12-6 mm glass reduces noise more effectively. This is because, at low frequencies, sound attenuation is directly proportional to mass.
Air Cavity

In general, air cavity doesn't play a major role in sound reduction, however, the width of the air cavity plays a significant role in the thermal performance of glass.

The width of the air cavity required to make a significant impact on the acoustic properties of glass is very large, and for practical reasons, this effect can be ignored.

What About The Use Of Argon Glass In The Cavity Instead Of Air?

In theory a denser gas should have a better acoustic performance, however in practice, it does not seem to make much of a difference.

In the above section we have described the basics glass selection criteria, but to better understand these effects and add some numbers into the discussion let's look at the following experiment.

Optimising DGU Glass

To improve sound insulation, DGU glass must be used. The ability of DGU units to reduce noise is measured by its sound reduction index values (R). The ability of DGU or any glass unit for that matter, largely depends on the frequency of sound it is exposed to. For the purposes of studying glass sound performance let's consider low frequency to be between 0-400 Hz, middle frequency range to be between 400-2000 Hz, and high frequency to be above 2000 Hz.

Four different combinations of DGU glass (shown in Table 3) were tested in 1/3 octave bands from 100 Hz to 5000 Hz. Remember, the human ear can only perceive sound in the range 20 Hz- 20,000 Hz.
<table>
<thead>
<tr>
<th>No.</th>
<th>1st Glass (mm)</th>
<th>Air Cavity (mm)</th>
<th>2nd Glass (mm)</th>
<th>Thickness Of Glass Unit (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>4</td>
<td>18</td>
<td>6</td>
<td>28</td>
</tr>
<tr>
<td>02</td>
<td>4</td>
<td>24</td>
<td>6</td>
<td>34</td>
</tr>
<tr>
<td>03</td>
<td>4</td>
<td>24</td>
<td>8</td>
<td>36</td>
</tr>
<tr>
<td>04</td>
<td>4</td>
<td>24</td>
<td>12</td>
<td>40</td>
</tr>
</tbody>
</table>

**DGU Units**

The results of the test are shown in the graph below.
Results & Discussion

Low frequency range - As it can be seen from the graph, glass has poor sound insulation in low frequency range. Low values of sound reduction index are conditioned by resonant effects of the system mass – gas – mass. From the graph it can be seen that DGU 1 and 2 show the same curve character though the gap in the DGU 2 is 6 mm wider. By keeping the same air cavity, and increasing the second glass thickness by 2mm, does not result in an improvement in the noise reduction at low frequencies. It was observed that only a reduction of 1-2 dB was observed by increasing the second glass by 4-6mm.

Middle frequency - In the middle frequency range the sound reduction index values are between 35 and 40 dB. The curve character of the glass was the same throughout even though different glass thicknesses were used. Thickness has no influence in this range.

High frequency - In the high frequency range, there is a slight reduction in the sound insulation due to the coincidence effect. The coincidence effect occurs when the wavelength of sound is the same as the bending waves of the glass. In the DGU 1 and 3, the reduction is nearly the same (1-2 dB); In unit 4 however, due to the use of 12 mm glass which has higher bending stiffness, the performance was significantly better at higher frequencies. Also, the use of two glass panes of different thicknesses (4 and 12 mm) resulted in a smooth sound insulation curve because when there was a coincidence dip in the thinner glass, the thicker glass compensated for it and resulted in higher sound reduction index. Thus, in the high frequency range, having a two to three times difference in the thickness of the first and second pane results in achieving better sound insulation.
Acoustic Terminology & Test Summary

Before we summarise and discuss the experiment using the table below, let us first briefly understand the meaning of the various terms used.

Rw index: Rw is the weighted sound reduction index (expressed in decibels). It represents the acoustic performance of a specific glass unit. This index includes a weighting for the human ear and measures actual sound transmittance. It can be assumed to be an average sound reduction index across the entire frequency range. Two glass units can have the same Rw index while one performs well at low frequencies and poorly at high ones, and the other performs just the opposite.

C and Ctr factors: To avoid the issue mentioned above, two spectrum adjustment factors C and Ctr must be added to the Rw value to modulate it for the frequency range of interest. For high frequency sound, the C factor is added to the Rw value. For low frequencies, factor Ctr needs to be added. Therefore, if the acoustic performance of a building component was Rw (C, Ctr) = 40 (-1, -4), it means that the average insulation performance of the component is 40 40dB. For high frequency sounds the insulation is lessened by 1 dB (39dB), and for low pitch sounds it is reduced by 4 dB (36 dB).

<table>
<thead>
<tr>
<th>Glass Unit</th>
<th>Rw (dB)</th>
<th>C</th>
<th>Ctr</th>
<th>Rw + Ctr (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DGU 1</td>
<td>37</td>
<td>-1</td>
<td>-5</td>
<td>32</td>
</tr>
<tr>
<td>DGU 2</td>
<td>38</td>
<td>-2</td>
<td>-5</td>
<td>33</td>
</tr>
<tr>
<td>DGU 3</td>
<td>38</td>
<td>-1</td>
<td>-5</td>
<td>33</td>
</tr>
<tr>
<td>DGU 4</td>
<td>39</td>
<td>-2</td>
<td>-5</td>
<td>34</td>
</tr>
</tbody>
</table>
Conclusion

As you can see from the above experiment, it is not easy to optimise glass selection for better acoustic performance. So let's make it simpler. Most fabricators in India use a maximum frame thickness of 24mm. From the results of the experiment above that having dissimilar glass thicknesses had the best performance, more specifically, the combination of 4mm and 12mm glass. This is mainly down to the fact that they have vastly different critical frequencies. Therefore we recommend the use of 4 – 8 – 12 mm DGU glass.

It is possible to further improve the sound insulation behaviour of glass if laminated glass is used in a DGU unit. For practical reasons, panels with such thickness are simply not feasible and hence not discussed.
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