

## IMPROVED WINDOW AND SYSTEM OF WINDOWS

### Field of the Invention

The present invention relates to a window and a system of windows, in particular noise-reduction windows.

### 5 Background Art

The following discussion of the background to the invention is intended to facilitate an understanding of the present invention only. It should be appreciated that the discussion is not an acknowledgement or admission that  
10 any of the material referred to was published, known or part of the common general knowledge of the person skilled in the art in any jurisdiction as at the priority date of the invention.

In high density urban environment where land is a premium, new housing developments are inevitably built near existing noise sources such as busy arterial roads and/or transportation corridors. Noise pollution from vehicles  
15 along busy roads is a problem for residents, especially for housing units fronting or facing the roads.

Most noise-reduction windows, also known as 'acoustic windows', are targeted at reducing noise through closed windows. For example, windows with double-glazing and/or air-tight seals disposed around the windows  
20 provide certain level of sound-proofing when closed. Current solutions of noise mitigation involves double layer façades or double-glazed windows. These current solutions and methods are relatively expensive to construct and may not be suitable for deployment in mass market housing projects where costs are concerns. In addition, they require the windows to be fully closed to  
25 achieve substantial noise reduction and no ventilation of air is allowed. This may not be suitable for deployment in housing projects where ventilation is encouraged for thermal comfort.

It is an object of the invention to mitigate one or more of the aforementioned problems.

## Summary of Invention

Throughout the specification, unless the context requires otherwise, the word “comprise” or variations such as “comprises” or “comprising”, will be understood to imply the inclusion of a stated integer or group of integers but not the exclusion of any other integer or group of integers.

Furthermore, throughout the specification, unless the context requires otherwise, the word “include” or variations such as “includes” or “including”, will be understood to imply the inclusion of a stated integer or group of integers but not the exclusion of any other integer or group of integers.

10 This disclosure seeks to reduce noise transmission with open windows, allowing for natural ventilation of the interior area or rooms. A further motivation is the need to provide one or more windows to reduce noise transmission while achieving some form of ventilation for use in public housing projects where low cost, low maintenance and simple to use devices  
15 are preferred over expensive or complicated systems. Such noise reduction or acoustic bay windows may afford the same or even better acoustic mitigation via the use of one or more passive strategies such as side-facing vertical slit ventilation windows, and noise-blocking canopies that use only a single layer of facade windows to reduce construction cost.

20 In an aspect of the invention there comprises a window comprising a first window panel; at least one second window panel; a side window panel adjoining the first window panel with the at least one second window panel in a manner such that the first window panel lies in a first plane and the at least one second panel lies in a second plane; wherein the side window panel  
25 provides for an opening which lies in a third plane, the third plane which is non-parallel with respect to the first plane and/or second plane.

The window preferably comprises a fixed main panel, and a plurality of side panels, the main panel having a surface displaced at a distance relative to a  
30 surface of at least one of the side panels. In some embodiments, there

comprises two side panels, and the distance is preferably relative to the surface of both the two side panels. In some embodiments, the fixed main panel, in the form of a fixed window panel is arranged to protrude outwards from an interior of a housing unit by a distance of a minimum of 150  
5 millimetres (mm) to a predetermined distance. In some embodiments, the predetermined distance is about 1000mm, which is typically the maximum canopy depth for structural stability, although such maximum canopy depth may vary depending on structural considerations. The distance is preferably between 200 mm and 600 mm relative to the adjacent window panels to the  
10 left and right of the fixed main panel. The consideration for the distance is at least based on a space for at least one ventilation slit and maximum canopy depth for structural stability.

In other embodiments, the fixed main panel, in the form of a fixed window panel, is arranged to protrude inwards towards an interior of a housing unit by  
15 a distance of a minimum of 150 millimetres (mm). The distance is preferably between 200 to 600 mm relative to the adjacent window panels to the left and right of it. The consideration for the distance is at least based on a space for at least one ventilation slit and the competing objective to maximize interior space.

20 In operation the main panel is arranged to face a noise source such as roads, railway tracks, airports, temporary construction sites, etc.

In some embodiments, there comprises one or more secondary noise reducing element working in tandem with the windows. In some embodiments, such secondary noise reducing element may be in the form of one or more  
25 canopies arranged in tandem with at least one window of the invention or with conventional windows to further reduce noise. The noise reducing element may be further enhanced with one or more sound refraction surfaces to further achieve minimization of noise.

### **Brief Description of the Drawings**

30 The present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Fig. 1a to Fig. 1c are plan views of the noise reduction window in different operating modes in accordance with some embodiments;

Fig. 2 shows a perspective view of the noise reduction window in a noise reduction mode while allowing some ventilation in accordance with some  
5       embodiments;

Fig. 3 shows a system comprising a plurality of noise reduction windows forming a system in accordance with some embodiments;

Fig. 4 shows another embodiment of a noise reduction window in accordance with some embodiments;

10       Fig. 5a to Fig. 5c shows another embodiment of a noise reduction window in accordance with some embodiments;

Fig. 6 shows an embodiment with one or more secondary noise reducing elements in the form of canopies arranged to further reduce noise;

Fig. 7a to 7c respectively show an embodiment of the noise reduction window,  
15       a low vent and a normal top hung window configuration used for comparative studies;

Fig. 8a and 8b show results of sound transmission tests performed on the embodiment(s) of Fig. 5a and Fig. 5c.

Other arrangements of the invention are possible and, consequently, the  
20       accompanying drawings are not to be understood as superseding the generality of the description of the invention.

### **Description of Embodiments of the Invention**

In accordance with an aspect of the invention there comprises a noise-reduction window, hereinafter referred to as or used interchangeably with the  
25       term 'acoustic bay window'.

Throughout the specification, the term 'window' is an element which selectively allows the passage of light, sound, air or fluid from the environment into an interior (e.g. a room or house). The term 'window panel' refers to a

relatively flat surface having a frame that can be formed or set into the surface of a wall, ceiling, door, or used to be join with other window panels. A window panel can include at least one element (e.g. sliding, rotatable or hinged element) for covering or exposing the frame so as to facilitate the window panel between an open state and a close state.

The proposed acoustic bay window works primarily by reducing the area of exposed openings directly facing a potential noise source (e.g. traffic), while maintaining the overall operable window area needed for adequate ventilation.

In an aspect of the disclosure, the acoustic bay window comprises a first window panel; at least one second window panel; a side window panel adjoining the first window panel with the at least one second window panel in a manner such that the first window panel lies in a first plane and the at least one second panel lies in a second plane; wherein the side window panel provides for an opening which lies in a third plane, the third plane which is non-parallel with respect to the first plane and/or second plane.

In some embodiments, the third plane is orthogonal to the first and/or second plane.

In the embodiments illustrated in Fig. 1a to 1c, and Fig. 2, the acoustic bay window 100 comprises a first window panel also referred to as a main panel 120 and two second window panels also referred to as adjacent window panels 140. The main panel 120 is joined to the adjacent window panels 140 via two side window panels 160. In the embodiments shown in Fig. 1a to 1c, the two planes are substantially parallel with respect to each other.

The main panel 120 may be a transparent panel which is permanently sealed (i.e. without any opening to allow air and sound to pass therethrough). Each of the second window panels may be pivotably or slidably attached to a frame which enables the second window panel to move between an open position (thereby allowing air and sound to pass therethrough), and a closed position

(thereby preventing air and sound to pass therethrough). The second window panel may be partially transparent, translucent or opaque.

5 The side panels 160 are arranged to adjoin to the main panel 120 on one end of the side panel 160 and adjoin to the adjacent panel 140 at the opposite end of the side panel 160. Each of the side panel 160 includes an opening for allowing air and sound to pass therethrough. Likewise, each of the side panels 160 may be pivotably or slidably attached to a frame which enables the side panel 160 to move between an open position (thereby allowing air and sound to pass therethrough), and a closed position (thereby preventing  
10 air and sound to pass therethrough). The side window panel may be partially transparent, translucent or opaque. The side panels 160 are shown in Figs 1a to 1c and 2, opening inwards. It is however also envisaged that the side panels 160 open outwardly. The present disclosure is therefore not restricted to the opening direction of the side panels 160 as shown in the abovenoted Figures.  
15

When installed, the panels 140 preferably faces a sound source, and the side panels 160 preferably does not face sound source(s), and additionally when opened faces a windward side. When installed the main panel 120 protrudes  
20 outwards relative to an interior of a house unit.

In some embodiments, the main panel 120, in the form of a fixed window panel, protrudes outwards by a distance D1 of a minimum of 150 millimetres (mm) to a predetermined maximum distance with respect to the adjacent  
25 panels 140. In some embodiments the predetermined distance is about 1000 mm, which is typically the maximum canopy depth for structural stability, although such maximum canopy depth may vary depending on structural considerations. In some embodiments, the distance D1 is preferably between 200 mm to 600 mm relative to the adjacent window panels to the left and right  
30 of it. The consideration for the distance is affected by or based on objectives such as the amount of space for a ventilation slit for ventilation to be effective, and maximum allowable canopy depth for structural stability.

Such a fixed window panel arrangement creates a modified bay window configuration. The side panels 160 of this 'bay window' are operable, creating vertical slit-windows for ventilation, which face left and right, rather than forward.

- 5 The proposed window 100 can be based on at least three different usage modes, allowing the user to vary or control the amount of sound/noise entering their unit, while maintaining natural ventilation.

In a fully closed position as shown in Fig. 1a, the window panels 120, 140, 160 are fully closed. Both noise and air flow are blocked,

- 10 In operation modes A and B, the noise-reduction window may operate in different modes to allow varying amount of air-flow into the interior of the housing unit. In a mode 'A' (see Fig. 1b and Fig. 2), for maximum noise reduction with some natural ventilation, the forward-facing window panels 120, 140 are kept closed, and the only opening allowing passage of air is the  
15 side-facing vertical slit-windows 160 for ventilation and wind-movement. As the window panels 120, 140 facing directly forward are all kept closed, this minimizes the direct conduction/transmission of sound into the room/housing unit.

- In another mode 'B' (see Fig. 1c), the window arrangement allows the user to  
20 choose a maximum natural ventilation, as the window panels 140, 160 can be opened. Although this use-case is less effective at reducing noise, the main panel 120 mitigates the noise and the window 100 can be supplemented by one or more secondary noise blocking elements (see Fig. 6). Mode 'B' represents a maximum natural ventilation, and partial noise blocking via the  
25 first window panel 120.

- The illustration of Fig. 2 may be appreciated as a perspective view of the Acoustic Bay Window 100. The key feature is the protruding 'bay window' portion (i.e. the first window panel 120) with side slit windows (i.e. the side panels 160) for ventilation. The first window panel 120 is therefore located in a  
30 forward position relative to the second window panels 140.

Fig. 3 illustrates a plurality of acoustic bay windows arranged to form a system of continuous window-wall 300 for a residential or commercial housing project,

producing what is known as a 'ribbon window' effect for aesthetic benefit. In particular, the ribbon window effect enables an inhabitant to have a relatively larger field of vision when he/she is near the bay window 100, and the perception of larger space. The central fixed panel, i.e. the main panel 120 can  
5 be undivided by mullions, creating a 'picture window' effect.

In some embodiments as shown in Fig. 5a to 5c, the central panel 120 can also be designed to be opened so as to allow sound and passage of air. From outside the building, the bay windows produce a more three-dimensional (3D) façade effect. If the protruding bays are variably positioned within the window  
10 opening, for example from left to right on different floors, this can create a randomised and dynamic effect on the façade (see Fig. 3).

Fig. 4 shows another embodiment/configuration of an acoustic window 400, wherein when installed, the first window panel 420 protrudes towards the interior of the housing unit. The first window panel 420 is therefore located in a  
15 rearward position relative to the second window panels 440. The first window panel 420 adjoins the side window panel 460. Each of the side window panel 460 in turn adjoins the second window panel 440.

Fig. 5a to 5c show other embodiments of the acoustic window 500. As may be appreciated, the acoustic window 500 comprises a first window panel 520  
20 having a plurality of sub panels 522, 524. Each of the plurality of sub panels 522 can be opened and closed as shown in Fig. 5a. The sub-panel 522 may be a transparent panel, a translucent panel or an opaque panel. The sub-panel 524 is permanently closed. The sub-panel 524 may be transparent, translucent or opaque. The acoustic window 500 also includes two second  
25 window panels 540 and two side window panels 560. Like the acoustic window 100, the first window panel 520 is adjoined to one end of the side panel 560, and an opposite end of the side panel adjoins a second window panel 540. The second panel 540 comprises two sub-panels 542 and 544. The plurality of sub panels 542 can be opened and closed. The sub-panel 542 may be a  
30 transparent panel, a translucent panel or an opaque panel. The sub-panel 544 is permanently closed. The sub-panel 544 may be transparent, translucent or opaque. The side window panel 560 comprises two sub-panels 562 and 564.

The sub panel 562 can be opened and closed as shown in Fig. 5b. The sub-panel 562 may be a transparent panel, a translucent panel or an opaque panel. The sub-panel 564 is permanently closed. The sub-panel 564 may be transparent, translucent or opaque. Fig. 5c shows only the side panel 562  
5 open.

It is to be appreciated that in the various embodiments, the side panels 160, 460 and 560 may be arranged at right, obtuse, or acute angles with respect to the corresponding first window panels 120, 420 and 520. The side panels 160,  
10 460, 560 may also be arranged at right, obtuse or acute angles with respect to the corresponding second window panels 140, 440, and 540.

The described acoustic windows 100, 400 and 500 may be used to mitigate the effects of environmental noise/sounds entering into a housing unit, while allowing ventilation. When installed, the frame  $F_1$  defining the opening(s)  
15 provided by the side window panels 160, 460, 560 for ventilation is at a non-parallel plane, preferably almost orthogonal plane with respect to the frame  $F_2$  defining the opening(s) provided by the first and/or second window panels 120, 420, 520, 140, 440, and 540.

It is to be appreciated that in other embodiments (not shown), the second  
20 window panels 140, 440, 540 may be located in a non-parallel plane with respect to the first window panels 120, 420, 520.

It is to be appreciated that the acoustic windows 100, 400 and 500 may be supplemented by secondary noise blocking elements when installed as part of a housing unit/project.

25 In some embodiments as shown in Fig. 6, the secondary noise blocking element may be in the form of one or more canopies 620, such as a canopy positioned at an upper and/or lower portion(s) relative to the installed acoustic window 100, 400 and/or 500. The canopy may be a horizontal canopy for mitigating rain/ bird droppings entering a housing unit. For further protection  
30 against any secondary reflection of noise due to the extended canopy over the window 100, 400 and/or 500, the secondary noise reduction element may be enhanced by adding a noise-refracting texture on the under-side of the canopy

(see Fig. 6). Such an arrangement can reduce direct reflection of noise from a low angle from reflecting directly into the housing unit/room via an open window panel, due to a uniform under-surface of the canopy. The noise-refracting surface could be an uneven surface 620 formed by a series of undulating ribs, grooves, grids, dots or other shapes. Such uneven surface(s) are arranged to refract or diffract incident noise away, preferably in multiple directions away from the window 100, 400 and/or 500. Noise refracting/diffraction hard surfaces may be used as an overlay on the underside of the canopy. In particular, such noise refracting/diffraction hard surfaces may include non-porous materials and can withstand environmental or natural elements such as rainfall, wind etc. As another embodiment, various surfaces on the canopy or canopies can be broken up into multi-faceted and multi-angled patterns to reduce standing sound waves and sound echoes. Advantageously, the uneven surface(s) can minimize reflection of noise/sound into units. Making the surface(s) of the canopies uneven does not require additional material, and hence reduces material cost, and is relatively low maintenance. As there is no separate installation, falling hazard is also reduced. In some embodiments, the uneven surfaces may form part of an thematic design to enhance the overall building façade. Such thematic design may include nature (e.g. leaf design) and/or wave design.

In some embodiments, a canopy may be a 1000mm, or at least a 300 mm to 600 mm deep horizontal canopy designed as an extended sill at the base of an acoustic window 100, 400 and 500, which helps to block noise originating from below the level of the window. This is of particular use in high-rise residential buildings, as traffic noise tends to get louder at the mid-to-high-rise levels near a road. The canopy may have a canopy depth greater than the extent of outward protrusion of the one or more first or second window panels when the window is installed so that the canopy is not blocked by the installed window.

It may be appreciated that the present disclosure enables a staggered window configuration via one single layer of windows 100, 400 or 500. This is in

contrast with prior art solutions which require the introduction of one or more secondary layers of sliding windows or screens to achieve a staggered window configuration, which represents a relatively large added cost. This invention achieves a staggered window configuration with only a single layer  
5 of windows, thus minimising wastage of materials, and simplifying operation and maintenance by users.

It is appreciable that the window 100, 400 or 500 may be implemented at public and private housing fronting heavy roads with noise nuisances without complicated detailing and excessive materials, which can increase cost of  
10 construction and also the purchase price of housing units.

It is appreciable that in use for public housing projects where low cost, low maintenance and simple to use devices are preferred over expensive or complicated systems, the windows 100, 400 or 500 afford the same or even better acoustic mitigation via use of both the window configuration with at least  
15 one set of openings arranged to be orthogonal to another set of openings. In particular, passive strategies (i.e.: side-facing vertical slit ventilation windows, and noise-blocking horizontal canopies) may be adopted in a single layer of façade windows to bring construction cost down.

It is to be appreciated that the acoustic bay window 100, 400 or 500 can be  
20 deployed in combination with normal windows, such as casement and/or top-hung windows which can be flush with the façade of a high-rise building.

One or more embodiments of the described windows 100, 400 or 500 may be implemented within public housing developments fronting busy roads. Such busy roads may include Expressways, Cat 1 Roads, Cat 2 roads, etc. Such  
25 public housing developments may also face the problem of traffic noise, especially for specific stacks of housing or dwelling units that front the noise sources.

The window 100, 400 or 500 can be manufactured or developed as a modular part of a precast façade for maximum productivity. This allows it to be easily  
30 replicated to multiple housing developments. It can also subsequently be adapted for use by the private sector in apartments and condominium projects.

In some embodiments, the width of the main panel or fixed window panel 120, 420, 520 can vary, for example within the range of 300mm to 1500mm wide, depending on the context it is deployed in.

5 In some embodiments, the overall width of the compound window including one or more side panels can also vary, for example from a minimum of 800mm to 3000mm as a single stand-alone window. This bay window pattern can also be repeated and extended indefinitely to create a system of continuous window-wall, or 'ribbon window' effect.

10 In some embodiments, the window or system of windows may comprise side window panels which are arranged at an angle with respect to the main panels. Such angle may be an obtuse or acute angle.

In the described embodiments, one or more first, second and side window panels may be formed from glass, such as tinted float glass and/or laminated glass. In some embodiments, the glass may be between 4 mm and 15 mm  
15 thick.

### **Efficacy**

To test the efficacy of the acoustic bay windows in reducing sound/noise entering into a building/housing unit, comparative studies are performed on the acoustic bay window as illustrated in Fig. 7a, low vent window as  
20 illustrated in Fig. 7b, and normal top hung as illustrated in Fig. 7c. The acoustic bay window design of Fig. 7a is arranged in maximum ventilation mode.

Table 1 shows the STC estimation of the three windows of similar overall dimensions.

| Window Type     | Frequency |      |      |      |      |      |      |      |      | STC |
|-----------------|-----------|------|------|------|------|------|------|------|------|-----|
|                 | 31.5      | 63   | 125  | 250  | 500  | 1000 | 2000 | 4000 | 8000 |     |
| Acoustic Bay    | 12.3      | 13.9 | 14.4 | 14.5 | 14.5 | 14.6 | 14.5 | 14.6 | 14.6 | 14  |
| Low Vent        | 10.9      | 11.2 | 11.3 | 11.3 | 11.4 | 11.4 | 11.4 | 11.4 | 11.3 | 11  |
| Normal Top Hung | 9.6       | 10.1 | 10.3 | 10.3 | 10.3 | 10.3 | 10.3 | 10.3 | 10.3 | 10  |

Table 5-1: Transmission Loss Performance in Ventilation Mode

- 5 performance of the three window designs tested, with a Sound Transmission Class of 14.

Table 1 demonstrates the noise reduction superiority of the acoustic bay window design over other window types such as the 'low vent' and 'normal top hung' window configurations. The Acoustic Bay Window (shown in Fig. 7a) was found to have the best transmission loss performance when in ventilation mode, followed by 'low vent' and 'normal to hung window'.

- The acoustic bay window shown in Fig. 7a was physically fabricated and exposed to sound transmission at different frequencies ranging from 31.5 to 8000 Hz in a controlled environment and a parameter is calculated.
- 15 In some embodiment, the parameter is the sound transmission class (STC) in class 14. This is a single-number rating of the sound transmission loss performance of a building element or material measured at sixteen (16) one-third octave bands between 125 Hz and 4 kHz and agrees with the earlier estimation shown in Table 1. In both cases, a higher STC means that the building element or material is better at reducing sound passing through it.
- 20 The facade building elements for individual space will be evaluated and its combined STC calculated.

Fig. 8a is a plot of Sound Transmission Class (STC) and Transmission Loss (TL) for the window 500 in a 'closed mode', i.e. all window panels closed having an STC of class 28. Fig 8b is a plot of Sound Transmission Class (STC) and Transmission Loss (TL) for the window 500 in a 'ventilation mode'. i.e. side window panels 560 opened for ventilation while first and second window panels 520, 540 closed to block sound. This plot shows that the window in the ventilation mode has an STC of 14 as shown in Table 1. Therefore, the STC of the window 500 in ventilation mode, while lower than when the window 500 is in the closed mode, will still nevertheless provide significant noise reduction when compared with more conventional window designs.

It should be further appreciated by the person skilled in the art that variations and combinations of features described above, not being alternatives or substitutes, may be combined to form yet further embodiments falling within the intended scope of the invention.

**CLAIMS**

1. A window comprising
  - a first window panel;
  - at least one second window panel;
  - 5 a side window panel adjoining the first window panel with the at least one second window panel in a manner such that the first window panel lies in a first plane and the at least one second panel lies in a second plane; wherein the side window panel provides for an opening which lies in a third plane, the third plane which is non-parallel with respect to the first plane and/or second  
10 plane.
2. The window of claim 1, wherein the first plane and the second plane are substantially parallel with respect to each other.
3. The window of claim 1 or 2, further comprises two second window panels, each of the second window panel arranged at a side of the first window panel  
15 and joined to the first window panel via corresponding side window panels.
4. The window of any one of the preceding claims, wherein the perpendicular distance between the first plane and the second plane is between 150 millimetres (mm) to 1000 mm.
5. The window of any claim 4, wherein the perpendicular distance between  
20 the first plane and the second plane is between 200mm to 600mm.
6. The window of any one of the preceding claims, wherein the first window panel is located in a forward position relative to the at least one second window panel.

7. The window of any one of claims 1 to 5, wherein the first window panel is located in a rearward position relative to the at least one second window panel.
8. The window of any one of the preceding claims, wherein the third plane is at an acute or obtuse angle with respect to the first plane and/or second plane.
9. The window of any one of claims 1 to 7, wherein the third plane is orthogonal with respect to the first plane and/or second plane.
10. A window system comprising a window of any one of the preceding claims, having a secondary noise reducing element.
11. The window system of claim 10, wherein the secondary noise reducing element comprises at least one canopy having a side comprising an uneven surface arranged to diffract or refract sound.
12. The window system of claim 11, wherein the at least one canopy has a canopy depth greater than a maximum extent of protrusion of the one or more first or second window panels when the window is installed.