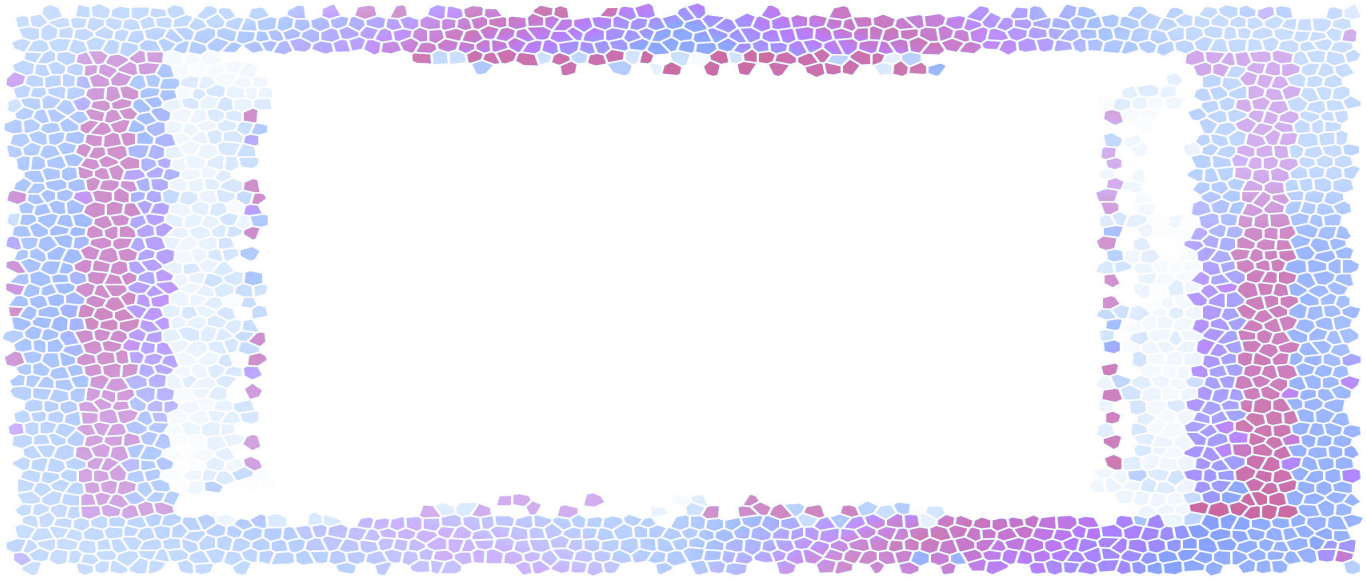
Design of an Integrated Window System

Industrial Design Project 2 Report



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Avowal

I asseverate, that the present work has been produced without the help of third party and only with the denoted references All parts that have been taken from sources are indicated. This work has never been presented to an examination board.

Name:

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Date:

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Approval

Industrial Design Project II

"Design of an integrated Window system" - By Baisampayan Saha

M.Des, Industrial Design Batch 2013-15, is approved as a partial fulfillment of requirement of Post Graduate degree in Industrial Design.

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Abstract

Windows are an integral part of every house. It comes in every possible shapes and sizes. The material of construction also varies with the type of function it is supposed to provide. With the advancement of technology, windows are now becoming smart and can control the behavior of their function by using advance technologies. On the other hand we have windows which are still based on traditional technologies and are used in homes and buildings for general purposes.

An attempt is made to understand the humble house window and come up with a new window which is equally functional as well as equally aesthetically beautiful when compared to some of the best traditional windows.

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Introduction

There are various types of windows that are available in the market. From traditional windows to the highly automised ones. But some things are still the same when windows are installed in a house.

When apartments are built by builders, they sometimes provide grills outside the window for protection purposes and sometimes don't. Sometimes they install mosquito covers into the window and sometimes they don't. These are few points the people don't usually talk about while installing a window but it still plays a very important part of the house.

Some other points that one might not consider during window installations be cleaning of the outer side of the window, onsite fabrication of it, how easy would it be for maintenance, can it be maintained by the user itself or some special mechanic has to be called in for the maintenance. When windows are opened, they either take up spaces in the outside of the house or occupy spaces in the inside of the house, eating away inside space of the house, where some other things could have been juxtaposed.

A window is a part of a building sold to the user. The user may have to add grills, mosquito nets, curtains, etc and sometimes have to do some makeshift arrangement to add all these things on the window.

A study and an attempt is done to understand these difficulties that a user has to go through while installing a window and also maintaining it and come up with a better window design.

Theoretical Foundation

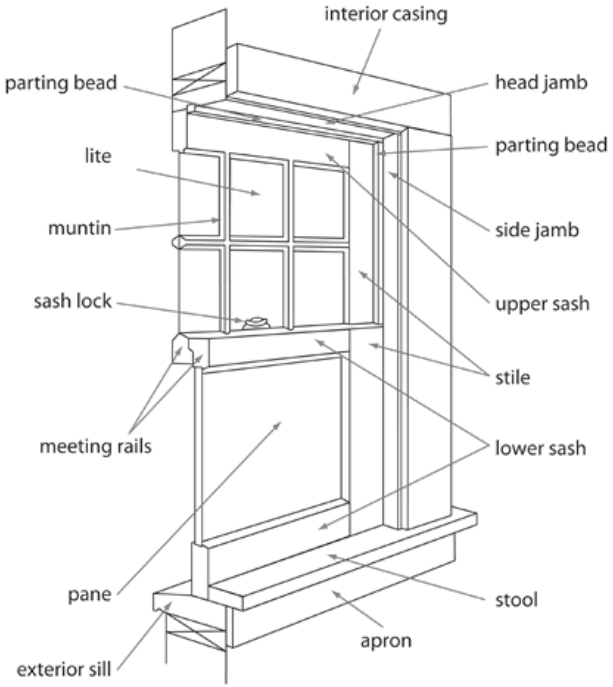


Fig 1: Anatomy of a window

Ref: http://www.efficientwindowcoverings.org/sites/all/sites/default/files/images/factsheets/overview/overview-diagram.png as seen on 30.10.2014

The word 'window' is derived from a old Norse word 'vindauga' [1]. The word vindauga is made of two separate world - Vindr means wind and auga means eye. The word window is first coined in the 13th century. It meant an unglazed hole in the wall. Therefore, the earliest windows were usually just holes left into the walls. so that light and wind can enter the building. Later as time progressed, windows were covered with animal hide, wood or cloth. At around 100 A.D, near Alexandria the first forms of glass windows with poor optical properties began to appear. It took a millennium before transparent glass window came into existence.

As technology has developed leaps and bounds, development of windows also took place. Windows can be found in different types and also in different materials. Windows can be categorized into [2]

- Fixed windows
- Pivoted windows
- Double hung windows
- Sliding window or slider
- Casement windows
- Glazed windows
- Louvered windows
- Bay windows
- Clerestory windows
- Corner windows
- Dorner window or Gable window
- Awning windows

Fig 1 shows the anatomy of a typical window. Most of the parts are common for any type of windows and vary minimally depending upon the functions and designs. While some windows are pivoted or hinged at sides or some are rolled using rollers, but the basic concept remains the same.

Fixed windows

Fig 2 : Fixed window

Ref: http://www.ezventwindows.com/images/fw_window.jpg as seen on 30.10.2014

In this type of window, the glass pane of the window is directly fixed to the frame. These type of windows do not open and also sometimes called as picture windows [3]. The window does not open and thus does not vent in any way. Due to this reason and because they have no operable part, fixed windows are relatively cheaper. The large pane of glass lets in loads of light and gives a pristine view of the outside. One of the biggest disadvantage of fixed windows is the lack of ventilation. So this type of window has to be used in conjunction of other operable windows. The only way to clean such windows is to go outside and clean it. Fig 2 is a typical example of fixed window.

Pivoted windows

The shutter of the window is pivoted to the window frame. The shutter can be pivoted horizontally or vertically [2]. They are found in various shapes and sizes depending upon the required design. One of the main limitation of this type of windows is that is eats up significant space inside th house. Sealing the window airtight is also a difficult task. Since the window panes are supported by two pivot points only, much of the load is carried by them. As a result if the pivot hinges fails, the whole window fails. Maintenance at this point becomes an issue. Fig 3 shows two different variations of pivoted windows.

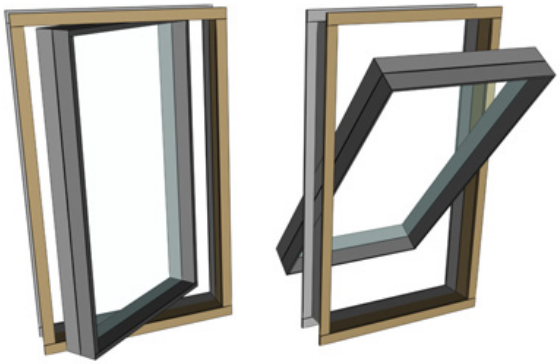


Fig 3: Pivoted windows
Ref: http://help.autodesk.com/cloudhelp/2015/ENU/3DS-Max/images/GUID-0A43754B-B15E-4DE4-BF8E-02300F557830.png as seen on 30.10.2014

Double hung windows

This type of window has two panes that slide up and down in tracks called stiles [2]. The window pane is usually divided into smaller sections by dividers called muntins or they snap on for decorative purposes [4]. Double hung windows are compatible with most window styles and they are come in variety of shapes, sizes and colors. The newer double hung windows has tilt mechanisms that makes them easy to clean. One of the disadvantages of double hung windows is that it is not as airtight as other windows. Since only half of the windows is always closed when kept open, the ventilation is limited. Fig 4 shows a typical double hung window.

Sliding Window or Slider

This type of windows open horizontally along the window frame by sliding. They are similar to double hung windows. They open side to side instead of opening up and down. Maintenance is less as compared to conventional windows as they have fewer operating parts. They require very little effort and dexterity to open and close. One of the main disadvantages of sliding windows is cleaning the outside. It can be challenging as it does not have tilting mechanism for easy cleaning [5]. Fig 5 shows a typical sliding window.

Casement Windows

Fig 4: Double hung window
Ref: http://www.infinitywindows.com/images/products/doublehung/Infinity-Ultrex-Fiberglass-Double-Hung_500x600.jpg as seen on 30.10.2014

Fig 5: Sliding windows
Ref: http://www.dwdwindowsanddoorslondon.com/wp-content/flagallery/double-slider-windows/slider-window-angle-view.jpg as seen on 30.10.2014

This type of windows are hinged at the sides and are either cranked outward or inward. One of the most important design feature of this type of windows are that it offers a variety of designs. From french to flat top to with grill or without grill. Possibilities are numerous here. Casement windows are the second most energy efficient after fixed pane windows. Since they use single user latches or tandem latches, it is easy to open and close and most of the windows nowadays can also be fitted with automatic openers. Since they can open fully, casement windows provide excellent ventilations. Since most of the casement windows crank outward, it is difficult to accommodate air-conditioners. Another disadvantage wof casement window is that since it opens up fully outwards, there is a size limitation. The windows cannot be too large of heavy.[6] Fig 6 is an example of typical casement window.

Double Glazed Windows

Fig 6: Casement windows

Ref: http://www.georgebarnsdale.co.uk/wp-content/uploads/2011/10/casement_hotspot.jpg as seen on 30.10.2014

This type of windows are use two layers of glass and with an inert gas filling in-between them. This helps in creating nearly twice the insulation that is achieved by single pane glass. Since the two panes are air-tight, it creates a thermal insulation, which traps in solar heat. This heat keeps the room warm during winter seasons. But this may cause the room to become hot and stuffy during summer season. Due to this sometimes glazed windows are tinted to block solar heat to get trapped. Another disadvantage of glazed windows are that if the insulation between the two glass panes fail then the whole glazed window has to be replaced. Glazed panes cannot be repaired. But on the brighter side, these windows are safer then single pane windows as they are tougher to break and sound insulation is better than the single pane windows. [7] Fig 7 is an example of typical double glazed window

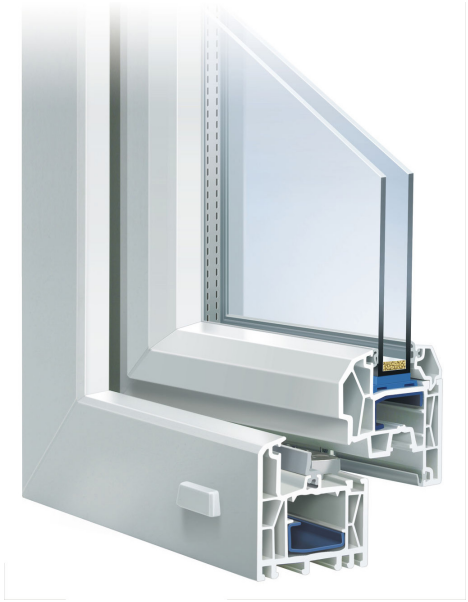


Fig 7: Double glazed windows

Ref: http://img.archiexpo.com/images_ae/photo-g/swinging-windows-pvc-double-glazed-67521-1622247.jpg as seen on 30.10.2104

Louvered Windows

Fig 8: Louvered windows

Ref: http://i01.i.aliimg.com/img/pb/649/414/282/282414649_894.jpg as seen on 30.10.2014

Louvered windows comprises of horizontal pieces of either wood, glass, plastic, or other material fitted to the window frame. The horizontal pieces can be of fixed type of can be adjusted to allow light to allow light and breeze to come inside or can be closed to completely block light and breeze. One of the disadvantages of louvered windows are the cleaning of the outward part of the louvers. Adjustable louvers has many moving parts, so over the time, it gets difficult to operate them. [8] Fig 8 is a typical example of louvered window.

Bay Windows

These type of windows project outward from the side of the house. The construction of bay window can be divided into two parts: the central window and the two side windows on left and right. The side windows are fixed at 300, 450, 600 or 900 angle. They are usually a type of either casement or double hung windows. These type of windows allow more natural night and breeze into the room. One of the disadvantage of bay windows is that it is difficult to add a window treatment to it due to its unique design and tighter angles between the two side windows and the central window. Bay windows are also not cheap. [9] Fig 9 is a typical example of bay window.

Fig 9: Bay windows

Ref: http://windowpro.com/wp-content/gallery/marvin-bay/DHB_SWClad_SNH_06_MW_c4.jpg as seen on 30.10.2104

Clerestory Windows

Clerestory windows are built above the line of sight atop the roof lines They help in bringing in daylight and breeze and helps in ventilation of inner spaces of a building. These types of windows were originally designed for temples and cathedrals in the 1300 BC. Nowadays they are used in passive solar home designs. [10] Fig 10 is a typical example of clerestory window.

Corner windows

Corner windows as the name goes are put at the corner of the room. Light and air is admitted from two directions. Since the window is kept at the corner, it has to bear some of the structural load at the corner. Due to which the jamb post at the corner is made of heavy sections. [2] Fig 11 is a typical example of Corner Window.

Fig 10: Clerestory windows

Ref: http://www.nps.gov/tps/images/guidelines/3-monarch-building-skylight-after-lrg.jpg as seen on 30.10.2014

Fig 11: Corner windows

Ref: http://cdn.decoist.com/wp-content/uploads/2013/01/Corner-window-statement-chair.jpg as seen on 30.10.2014

Fig 12: Dormer windows

Ref: http://www.stormking.co.uk/Images/Dynamic/cache/product/product_9-633724703282119290_cm-scale_w-640_h-480_q-80_wm-.jpg as seen on 30.10.2104

Dormer or Gable Window

Dormer is an extension of a building that protrudes from a sloping roof. To install a dormer or gable window, one must create a frame within the window. They are also known as rooftop windows. These type of windows improve upon the ventilation of a house and allow in plenty of sun light inside the house. They are available in various shapes, sizes and styles. [11] Fig 12 is a typical example of dormer window.

Awning Windows

Awning windows are a type of casement windows. In traditional casement windows, the window is pivoted on hinges mounted on the sides. Awning windows are pivoted at the top. Awning windows provide good ventilation and weather tight construction. One of the main disadvantage of this type of window is that it gets dirty very fast. So maintenance of it becomes an issue. [12]. Fig 13 is a typical example of awning windows.

Fig 13: Awning windows

Ref: http://www.blueskywindows.com.au/ufiles/images/products/awningwindow.jpg as seen on 30.10.2014

Fig 14: A Sliding window

Ref: http://www.houzz.com/photos/5730784/The-Pointe-rustic-family-room-other-metro as seen on 30.10.2014

Contemporary Windows

Fig 15: Contemporary Corner window
Ref: http://www.houzz.com/photos/sliding-window-/p/16 as seen on 30.10.2014

Fig 16: Contemporary Sliding window
Ref: http://www.houzz.com/photos/2198856/Ruther-ford-Residence-traditional-patio-san-francisco as seen on 30.10.2014

Lets now look into some of the contemporary windows available. In the facing page, we can see three different types of windows: from sliding and folding to majestic corner windows giving pristine view to sliding windows that get into the walls to open up fully. All of them has benefits as well as limitations. When one considers designing windows to be used in India, many factors come into play. Dust, weather conditions, mosquito, security, etc.
Fig 14 shows a sliding and folding window. One of the unique selling point of this type of window is that there is very less or minimum visual clutter or noise caused the framework or supporting structure of the window. Aesthetically the window design looks nice but there are few limitations to it. One side of the window is fixed to the rail. That means it would not fully open up. When opened up, each panes of the window is actually supported by

top and down roller hinges and thus acting as a cantilever. Thus too much load are being put to the roller hinges. Thus frequent maintenance is required and the joints and hinges have a certain life after which they have to be changed. Some of the other limitations are: cleaning the outer side is a tough job and making it airtight is also an issue. Fig 15 shows a corner window. As we can see the window is of fixed type, but its giving a very clean and pristine view of the outside. Cleaning of the windows from outside is easy if the windows installed are in the ground floor. Otherwise, cleaning the windows from outside becomes a huge task as accessibility is a problem. The frames and jamb posts of these types of windows are to be made heavy as they have bear some of the structural load of that section. That means this type of windows are typically heavier than their contemporaries. Fig 16 shows a sliding window. This sliding window seams to go inside the walls of the house when opened. This seams to well use the walls of the house to accommodate the sliding panes. But cleaning the inside of the wall sections is an issue. Without proper equipments, the wall openings cannot be cleaned properly and also there is a fear of infestation by insects into the wall opening or the crevices formed there.

Window Accessories

Fig 17: Insect protection net or mosquito net put as a sliding component

http://i00.i.aliimg.com/photo/v0/1695658896/Security_Sliding_Window_with_Mosquito_Net.jpg as seen on 30.10.2014

There are numerous types of window accessories. But when windows are thought of in an Indian context then some accessories stand out from others. Some of these are grills, mosquito nets or window curtains, which have become a quintessential part of every house windows. Every house installs a grill either from inside or outside of the window. Grills are not only used as a security against theft but also from small animals and birds getting inside the house. First a window is installed and then grills are installed, sometimes during the window installation or sometimes later on. Grills are put directly on to the wall by drilling holes and then screwing them up, thus damaging the wall.

Then mosquito is a very big nuisance in India. Some of the house installs a separate mosquito net and some do not prefer to install it. The mesh size of mosquito nets are small enough to get the pores getting blocked due to dust and debris getting stuck into it. Washing is a huge problem if the mesh cannot be taken out for washing. In fig 17, we can see an example of mosquito or insect net that is being used as a sliding part of the sliding window. As removing the sliding window is a problem, washing becomes a huge task when the nets get clogged due to dirt and dust.

Another important accessory is the window curtain or the blinds used for ensuring privacy. Most of the windows does not give any provision for blinds. The accessories for putting up the curtains or blinds has to be bought separate. Holes are then drilled and then these accessories screwed up to the wall. Thus damaging the wall.

Generally we see people usually fix grills outside their windows as a measure for security against unauthorized entry into their house,

Fig 18: Grill fixed as a cantilever in one of the building inside IIT Bombay

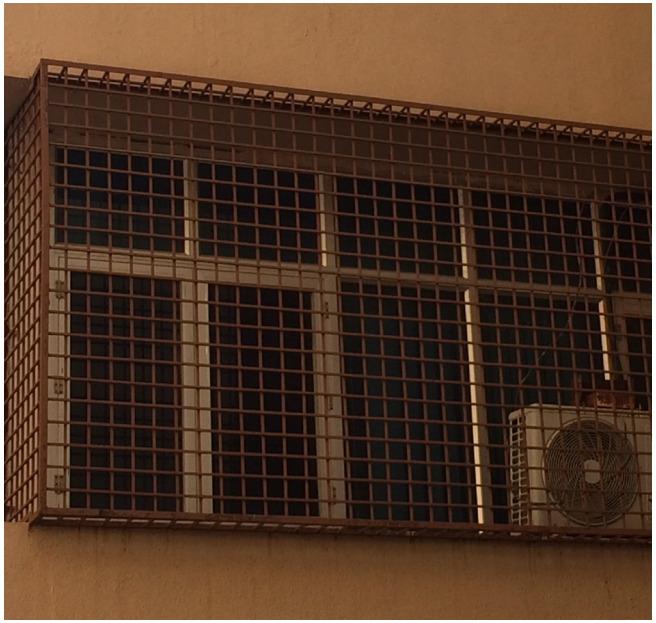


Fig 19: Grill fixed in one of the building inside IIT Bombay

larceny and theft or for preventing small animals and birds entering their house. But while doing so they damage the building wall in many ways. First of all, the building walls are not designed to take cantilever load such as that of a hanging grill that we generally see. Fig 18 shows a photo inside IIT Bombay, where the grill is fixed as an cantilever. In doing so they drill holes in the wall, which damages it structurally and also in the longer run, the walls are subjected to earlier failure than walls that do not have grills attached to them. In Fig 19, we can see another building inside IIT Bombay itself where the grill is put on the sill of a window and another external wall. The joints and boundaries are not treated properly, thus rendering a very bad taste visually to the look of the building.

Parallel Products

Fig 20: Glass windows used in cars

http://www.weetect.com/wp-content/uploads/2014/08/HRMAW-1.jpg as seen on 30.10.2014

Fig 21: Glass windows with weather stripping around its periphery

http://www.the-online-market.com/Vendor_Images/35/3.jpg as seen on 30.10.2014

Windows are not only used in house and buildings but also used in vehicles. Starting from cars to ships to planes to spaceships each one has evolved their typical window. The window we seen in homes and buildings are of very different build quality then that is used in planes, cars and vehicles or ships or sub-marines. In Fig 20 we see a car, having windows all around to give a full of what is around. The front and back windows are of fixed type and the sides are adjustable opening type. The side windows are sometimes manually operated and sometimes automated, which are called power windows. By the gentle push of a button, the windows can be operated. The fixing details also vary for the front and side windows. But none of the methods are used in fixing house windows. Generally front and back windows are fixed with the assist of a weather stripping. The weather stripping has

Fig 22: Glass windows in a ship

http://thumbs.dreamstime.com/x/ship-metal-windows-18933418.jpg as seen on 30.10.2014

Fig 23: Glass windows in a spaceship

http://spaceflight.nasa.gov/gallery/images/station/crew-28/hires/iss028e028792.jpg as seen on 30.10.2014

a nylon rope inside. One side of the window is fixed on to the slot of the car and then pushed a bit so that some portion gets fixed to the car. As one proceeds, the rope is also pulled, this helps in pushing the weather stripping to get locked into the slot of the car window frame. The power windows are fixed very differently . They have a very complex assembly in which they are fixed. The assembly contains all the linkages and elements for automatic movement. Fig 21 shows a the front glass of a car before being fixed in the car. The glass has weather strips around it.

`Fig 22 shows windows of a ship. These are metal windows and these windows have to fulfill certain working conditions. Since these are ship windows, there are subjected to very high pressure. Under these circumstances, the windows should perform and not fail. Thus, if we compare these windows with domestic

windows or windows in commercial buildings, they differ a lot. Many other accessories and electronic equipments are also used to track the performance of these windows working under high performance pressures.

Fig 23 is an example of window fixed in a spaceship. These windows are more demanding in performance than any other windows that are used in parallel products. They have to withstand the harshest of environmental conditions and still not succumb to it. Many electronic circuitry is also used in it to give added features to it. These windows are multi-layered glass pane windows. The thickness of the glass is thicker than conventional window glazings. Sometimes, the glazings in the spaceships have integrated wafers sandwiched between layers of glass. This enables them to darker the windows when required by just the push of a button. These are called photo chromic glazings.

Traditional material Vs New materials for windows

Fig 24: Wooden framed window

http://www.mmexports.com/images/plasticpvc/wood-wind.jpg as seen on 30.10.2104

Fig 25: Wooden framed window

http://www.inthrissur.in/assets/gallery/cdcace-7764d5ac94f8b6c8312f39aaaba as seen on 30.10.2014

Both traditional material such as wood and new material such as new aluminum has their own pros and cons. Wood as a material for windows is an excellent material. It is a natural thermal dampener. The grainy finish of wood is aesthetically pleasing and when stained and not colored, the wood becomes more beautiful. But use of depends upon in which condition the window is to be used in and also the cost factor. As new technologies are coming up, new materials are getting cheaper day by day, which can replace wood as a material for windows. Fig 24 shows an example of wooden window.

But new materials like alloys of aluminum also have advantages. The alloys are lighter and easier to work with. They are structurally strong and can be easily formed or extruded into desired shaped sections of channels. Thus fulfilling many design requirements which

were not possible before by using traditional materials. Fig 25 shows an example of a window made by using aluminum alloy which is a new modern age material. [15]
Both of these materials have trade off. Cost and functionality are some of the important factors that decide what materials are to be used for making windows.

Window sections and channels

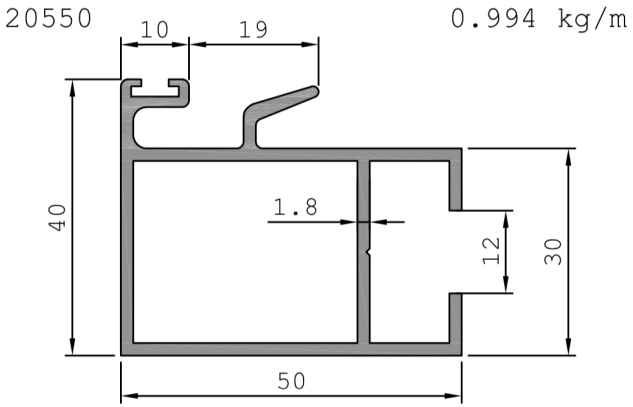


Fig 26: Sliding window section

Ref: http://www.jindalaluminium.com/catalog/aluminium/21)%20SLIDING%20WINDOW%20SECTIONS.pdf as seen on 30.10.2014

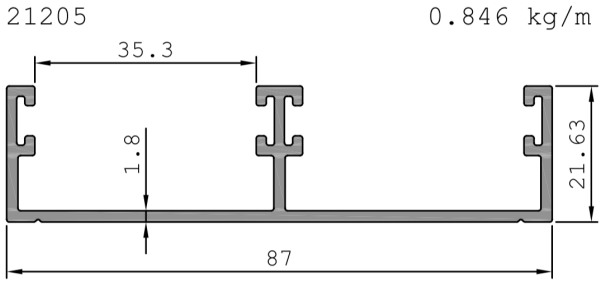


Fig 27: Sliding window rail section

Ref: http://www.jindalaluminium.com/catalog/aluminium/21)%20SLIDING%20WINDOW%20SECTIONS.pdf as seen on 30.10.2014

The frame of a window supports the whole load of the window structure. The frame is the part where it is mounted or fixed in the wall and the panes are either pivoted or hinged or slided over. Traditionally window frames were made of wood and then glass panes were fixed. As new materials and processes developed due to advancement of technology, nowadays windows frames are available in different sorts of materials and designs. Starting from metals to frames made of plastic to metal extrusions covered with plastics like PVC.
As sliding windows are becoming more popular these days due to its ease of use and not occupying much space [13] either in the inside or the outside of the house, various designs of channels and sections are available depending upon the designs and requirements. Fig 26 is one of the many types of sections that are available for sliding windows. The gap in the right hand side allows glass and rubber strip to go in. The tapered part at the top interlocks two panes when joined together. The grove at the top accommodates a weather stripping for air tight sealing. Fig 27 is an example of the shutter section where panes were allowed to slide. The groves at the sides accommodates weather stripping for sealing against entry of rain water or for air tight sealing.

Design Opportunities

With the technological advancement and invention of various new processes and materials, the window systems have also evolved a lot. In the Indian market, when one searches for a good quality window system, most of the high-end windows are either imported or their functions does not match in totality the functions when compared in the Indian context.
Selection of the correct window becomes a factor of paramount importance as climatic conditions vary very differently from one region to another region in the country and other factors like dust, protection from insects like flies and mosquito and security from small animals and theft come into play.
It is seen as a general practice that windows are part of a building and fitted into a house first and then other additional accessories are fitted as per the requirement. Grills are sometimes screwed and fitted to the window frame itself which are of fixed type and cannot be opened to get a clear view or fitted to the outside of the wall which are of collapsible type by drilling holes into it and thus damaging the wall in the process. The grill then acts as a cantilever load on to the wall, thus damaging the wall in the longer run. Cleaning of mosquito nets are also a problem as most of the times either they are glued on to the wall or are fitted with the window pane itself.
When window spans are increased, the window frames are reinforced by giving additional supports. These supports increase the weight of the whole frame but also add visual noise or clutter to the elegant window.
Some other problems arise when monsoon starts and rainwater either seeps inside or starts to get inside due to water splashes caused by the outside wind.

Window sections have to be drilled and then screwed to form one half part or cut into 45 degrees and then with the help of an insert screwed together. Though many jigs and fixtures are developed and available in the market, according to carpenters and fabricators a straight cut is easy to manage dimensionally than cuts in different angles and then joining them to form a new part. Sliding windows are generally constructed with straight cuts.
As accessories like grills, mosquito nets, curtains etc are attached to the windows as per requirement, and in the process damaging portion of the wall, a window system can be designed in this either the parts are modular and can be easily fixed to the window or a system of window which has all the components and can be taken out easily whenever required. Usually walls are not designed for cantilever load. As grills and other accessories are fitted, they act as a cantilever to the wall.

Thus damaging the wall in the longer run. The channels and sections can also be designed in such a way that they look more aesthetically pleasing and functionally sound. The current sections and channels used for sliding windows come in a thicker forms. The width can be optimized and new features can be added to it so that the sections and channels perform much better then the existing ones.
A mind map of different aspects of a window is plotted and is shown in Fig 28. The various points of mind maps can be taken as separate design opportunities.

Mind-map

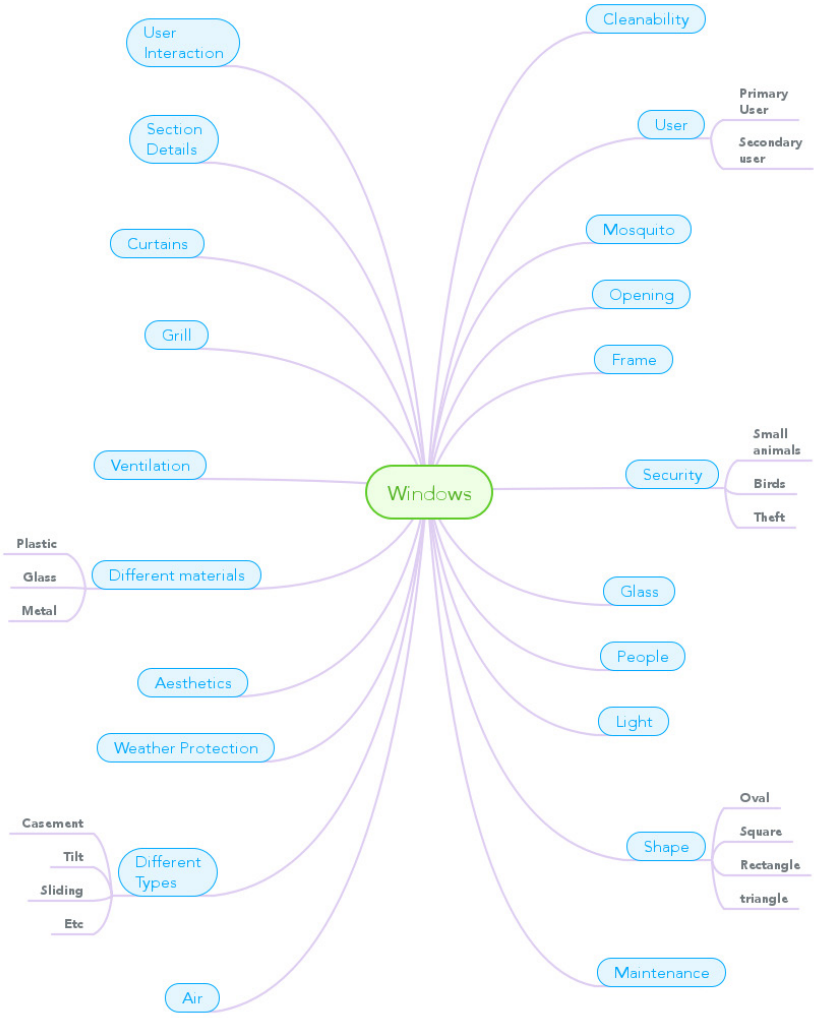


Fig 28: Mind-map of design opportunities

Design Brief

"To design an integrated window system and hardware details for window fabrication which would give maximum view of outside with less / no visual noise and also addressing improved functionality, aesthetics, user interaction with the product."

The design brief can be divided into two parts. One relating to the primary user and the other related to the secondary user. The functions related to primary user can be categorized in the primary functions of the window and the functions related to the secondary users can be related to the secondary functions of the window.

Lets look into the primary and secondary functions of the window.

Primary functions:

1. Aesthetically pleasing
2. No / less visual clutter or noise
3. Open fully
4. Full view of outside
5. Easy to operate
6. Proper Ventilation
7. Easy to clean
8. Accessories to be easily fixed
9. Ease of maintenance
10. User can choose what to install as an accessory

Secondary functions:

1. Easy to fabricate / assemble at site
2. Easy for maintenance
3. Easy to transport

Ideation

The initial thought process for the ideation was to design something that is aesthetically nice and was predominantly based on passive cooling techniques. The main idea was to use solar heat in a passive form to take out heat from the house and induce a forced ventilation so that irrespective of the position of windows, i.e, it is closed or open, ventilation will happen and stale air will be taken out by specially designed holes in the window system. The main focus in earlier concepts were ventilation, proper entry of light in the house and also aesthetics.

After the early phases of ideation, the ideas were evaluated and scrutinized out and it was found out that early concepts over-looked user interaction and user needs. So, the next phase of ideation started, where the window is dis-sected into different parts and then evaluated with the user needs and interaction, the ease of use and all other points that have been jotted down in the mind map. Different idea were generated for each part of the window and then evaluated with the user need. Thus after rejecting a lot of ideas, we arrived at the final concept which closely addressed all the issues related to user needs and function.

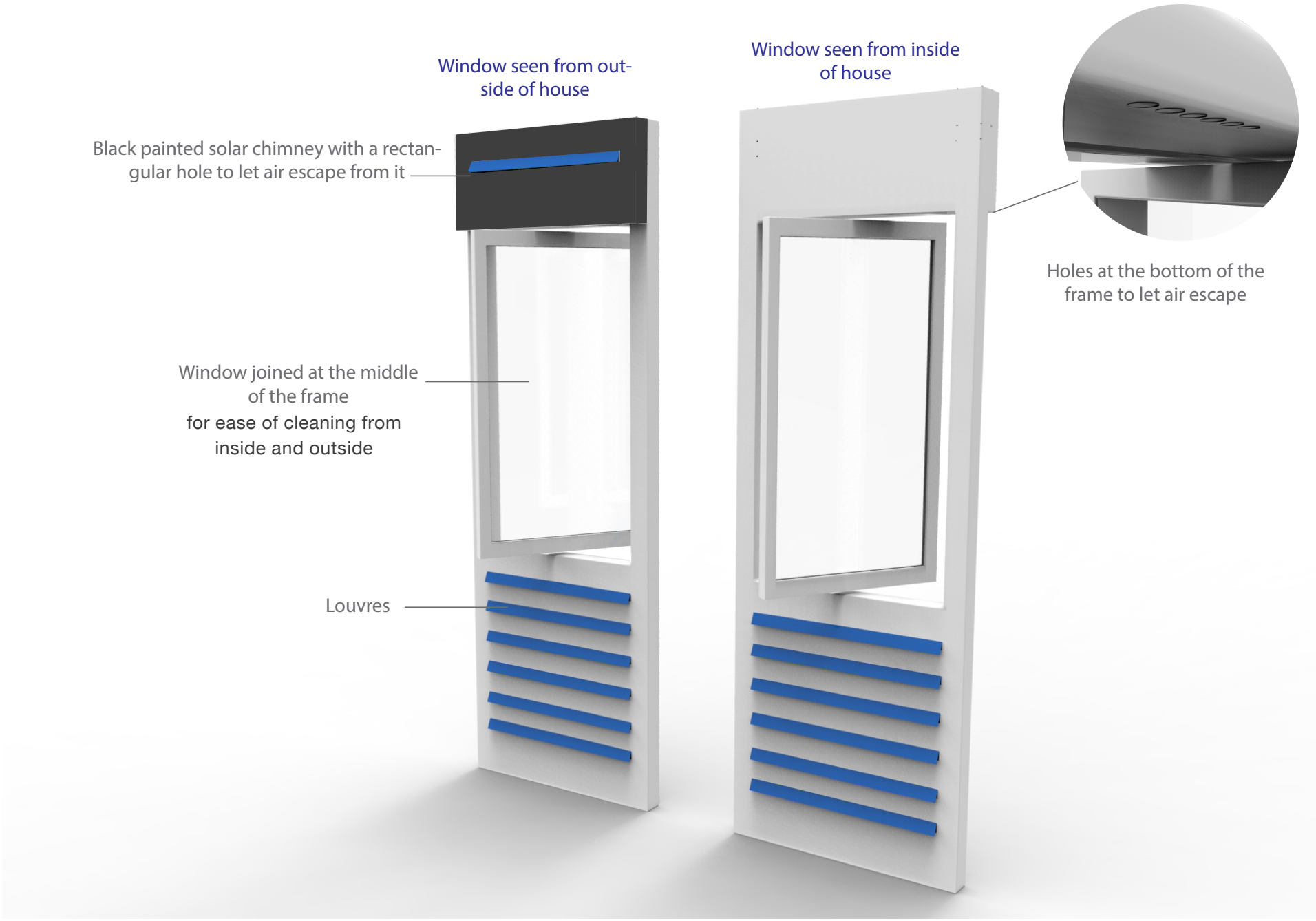


Fig 29: Schematic view of the window

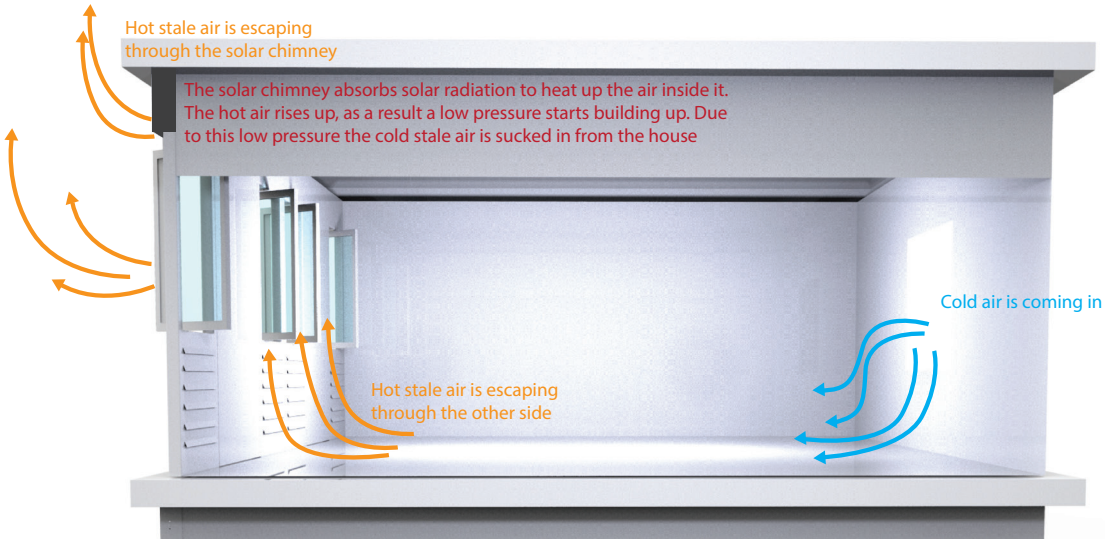


Fig 30: Air flow when window is open

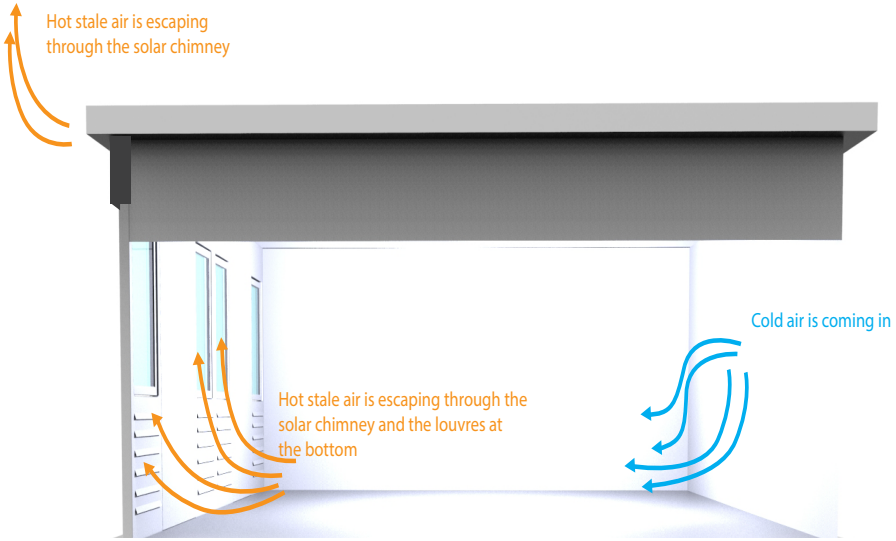


Fig 31: Air flow when window is closed

Ideation 1

Ideation 1 is based on passive solar cooling techniques. It is a modular unit, the height of which is equal to a room height. Similar pieces can be stacked together to form a pattern of window sets. At the bottom, there are adjustable louvers. The window pane is centrally pivoted for a rotating action. The top has holes for letting out stale air when the window remains closed. At the outer side, a solar chimney is fitted with a slit on it, the solar chimney would create a draft in the air and stale air from inside would be taken out, thus ensuring ventilation all the time. Fig 29 is a schematic representation of how the window will look. Fig 30 & 31 shows the flow of air in scenarios where windows are open and close. As the solar chimney absorbs solar radiations and heats up the inside air, the hot air passes through the slit at the solar chimney. As a result, a low pressure is created which sucks in the stale air from the house.

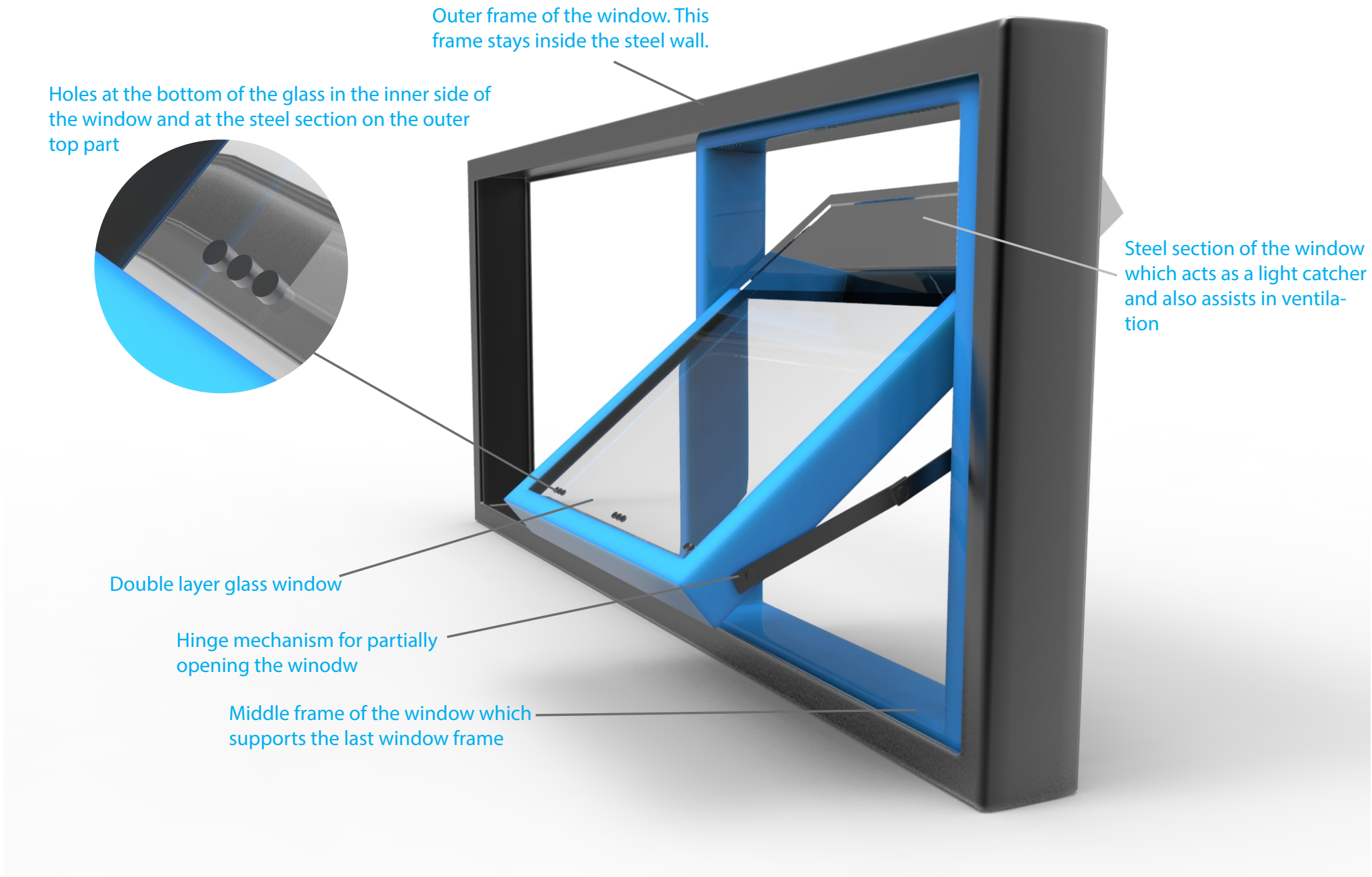


Fig 32: Air flow when window are open

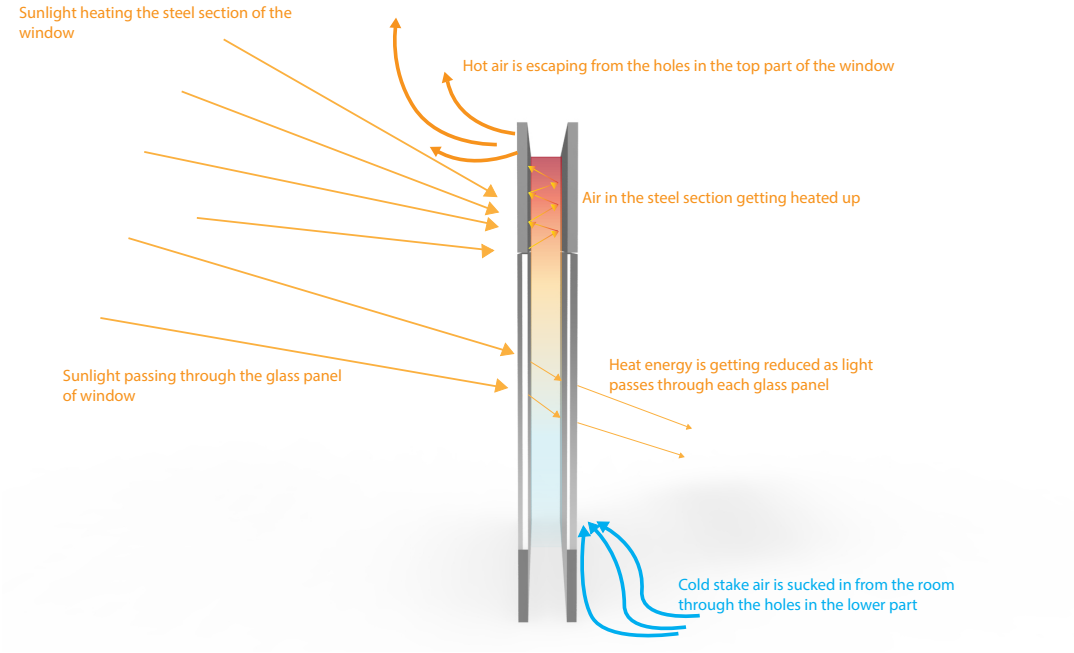


Fig 33: Mechanism of the new window pane

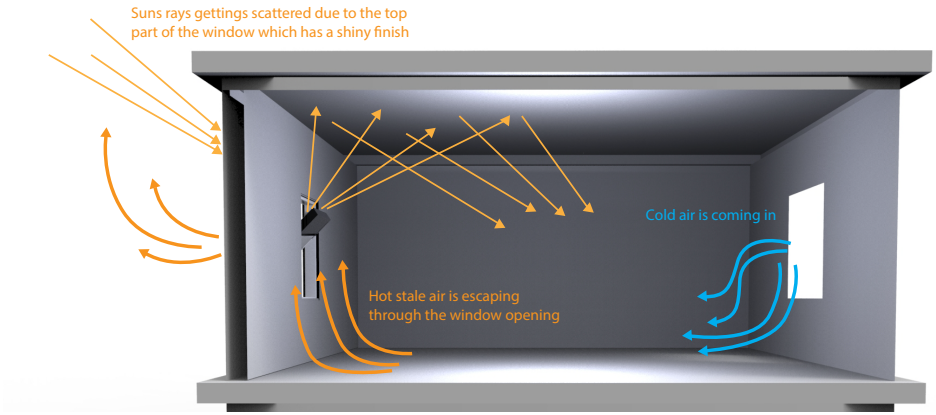


Fig 34: Air flow when window are open

Ideation 2

Ideation 2 is again based on passive cooling techniques. It is a sliding window. The frame of the window goes inside the walls so that the window can be fully opened when required. It has a double pane glass with holes at the bottom of the inward section and holes at the top in the outward section. The pane is horizontally pivoted at 3/4th its height. The 1/4th portion of the outer part is given a chrome finish so that it can reflect sunlight inside to increase the ambient light inside. As it is a double paned window, heat from sunlight would get trapped inside it and would heat the air around it, thus creating a draft. The holes at the bottom would let the stale air inside the house to get sucked in and thrown out by the outer holes, thus ensuring proper ventilation. Fig 34 shows a 3D representation of the window. Fig 32 & 33 show how the window works.

Ideation 3

Fig 35: Air-flow in the house with louvered windows

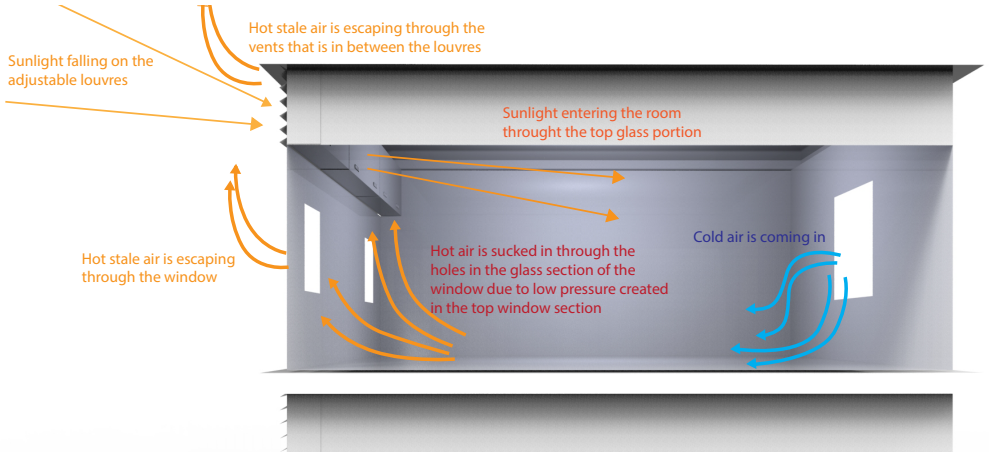


Fig 36: Air-flow in the house with louvered windows

Ideation 3 is based on a similar concept of using a solar chimney for ventilation. But this concept uses louvered windows. The louvered windows can be of fixed type or adjustable type, depending upon the requirement. Fig 35 shows the 3D representation of the window. At the outward side the louvers are fixed and at the inner side a glass is fitted. The glass has holes at the bottom part. When the air inside the box heats up, the hot air trapped inside will escape though the gaps of the louvers. As air passes through the louvers, a low pressure zone is created. This low pressure zone sucks in the stale air from inside, thus ensuring ventilation even if the windows are closed. This type of window cannot be used as a standalone window. This type has to be used with an existing main window. This can be used in toilets where ventilation is requird and normal windows cannot be fixed. Fig 36 shows the air flow in the house using this type of window.

Ideation 4

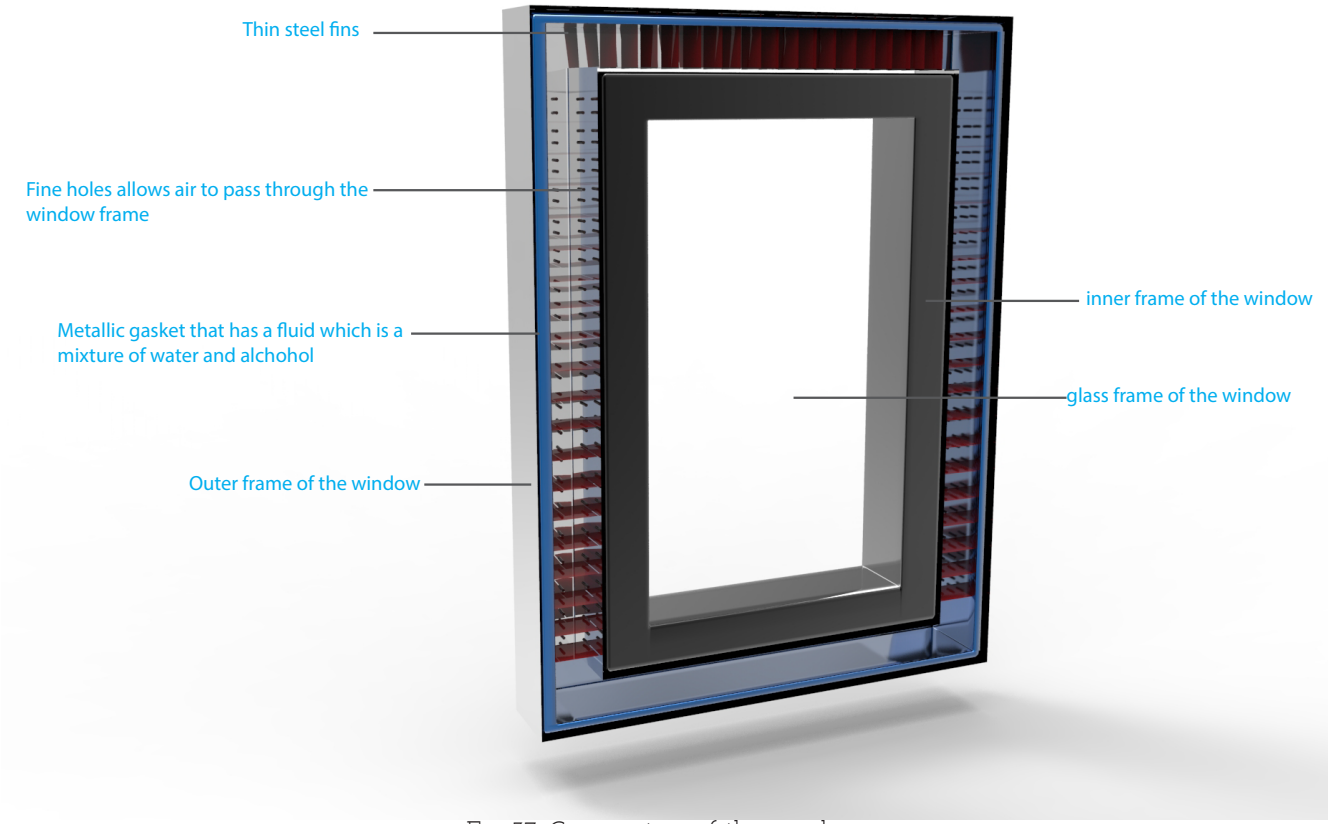


Fig 37: Cross-section of the window

Ideation 4 is based on again using passive cooling techniques. The window is conceptualized in such a manner that it would act as a natural AC. Fig 37 shows the vertical cross-section of the window. The inside of the window frame has a metal jacket that has a cooling agent or a fluid which is a mixture of water and alcohol. The jacket is connected with very thin fins. On one side, the fins are attached with the jacket and on the other side the frame of the window. The front and back facing sides have small pores in it, that allow breeze or air to come in. The breeze or air then cools down as the fins absorbs up all heat. The cooling liquid in turn then absorbs all the heat from the fins. As the cooling liquid evaporates, it absorbs the heat from inside and as it rises up, it looses the heat and returns back to liquid phase. The calculations for the model has to be carried out to find if the concept can actually work.

Lacunae till Ideation 4

These ideation are more technically biased and need a lot of experimentation and engineering to prove the viability of the concepts.
So a fresh though was given to how to design a window. Now different orientation of opening of the window to how different accessories would come as an attachment were looked into. Emphasis were given on the shape and size of the window also.

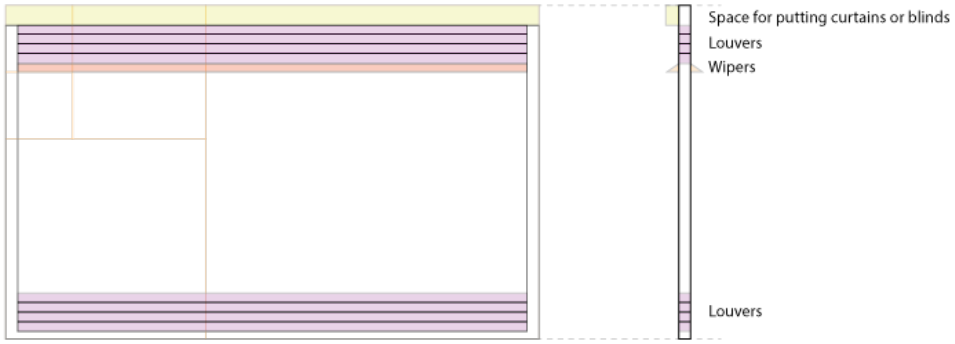


Fig 38: Fixed window (with wipers)

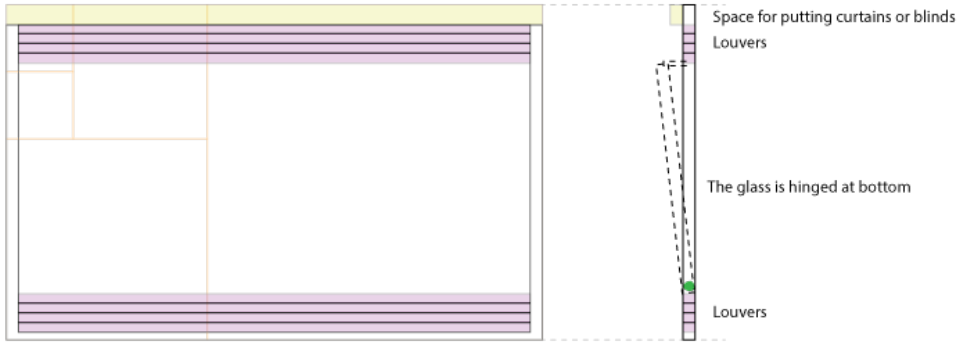


Fig 39: Horizontal pivoted window (at the end)

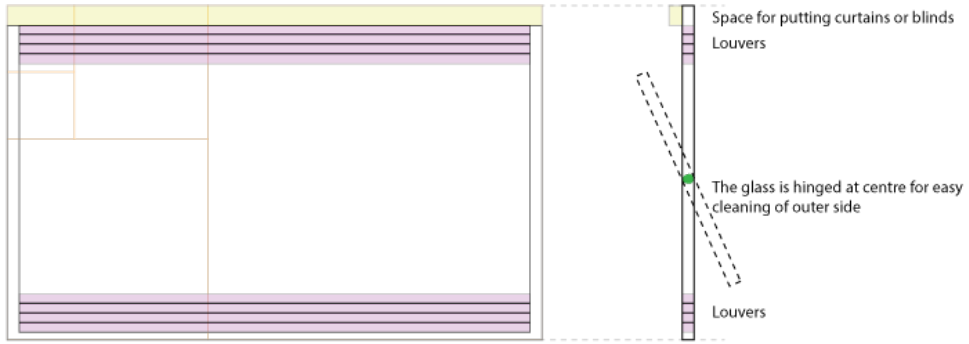


Fig 40: Horizontal pivoted window (at the middle)

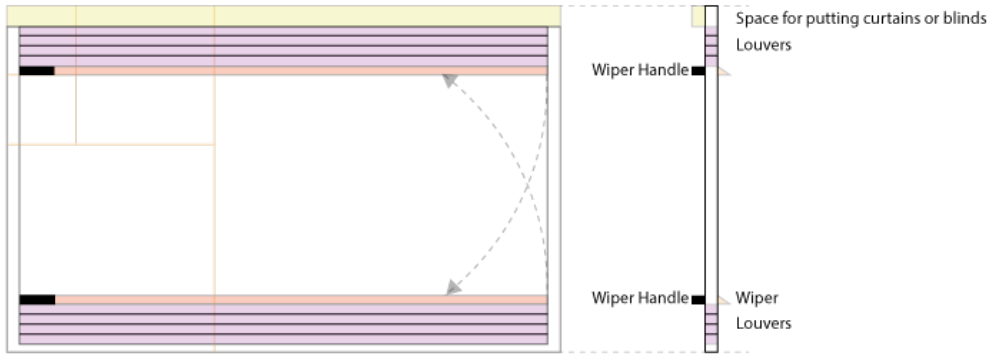


Fig 41: Fixed window with wipers(as found in cars)

Ideation 5

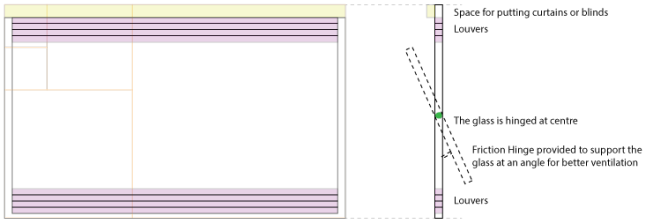


Fig 42: Horizontal pivoted window with a friction hinge

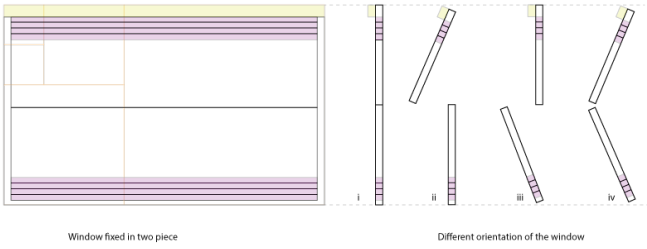


Fig 43: Horizontal pivoted window at top and bottom

Here the window is based on a two types of window. One type is where the glass pane is fixed. The other type is where the glass pane can be adjusted to variable degrees of angle. All other basic parts are same in all of the six variations. The basic form of the window has a glass pane in the center. The glass pane is attached with two louvered windows at top and bottom for ventilation. The top has a case or cover in which curtains or blinds can be fixed. Fig 47 shows a fixed window. The window has a wiper at both the sides. A mechanism is put in the frame of the window, which enables the user to move both the wiper at the same time, thus cleaning the window easily. Fig 39 shows a window in which the window can be opened a bit for ventilation when someone feels that the louvers at the top and bottom are not enough for ventilating the room. Fig 40 shows a window in which the glass pane is pivoted horizontally at the center and is pivoted with a ratchet mechanism. The mechanism would enable the glass pane to move in only one direction. The outside of the window can be cleaned easily by just by rotating the window and bringing the outward side to inside. Fig 41 shows a window idea in which two wipers are placed and act in a similar way as wipers in automobile work. Fig 42 shows a window in which it is pivoted in the center horizontally and the degree of rotation is constrained. So the whole window pane cannot rotate 360°. Fig 43 shows a window where it can be opened from the center making it easy to clean.

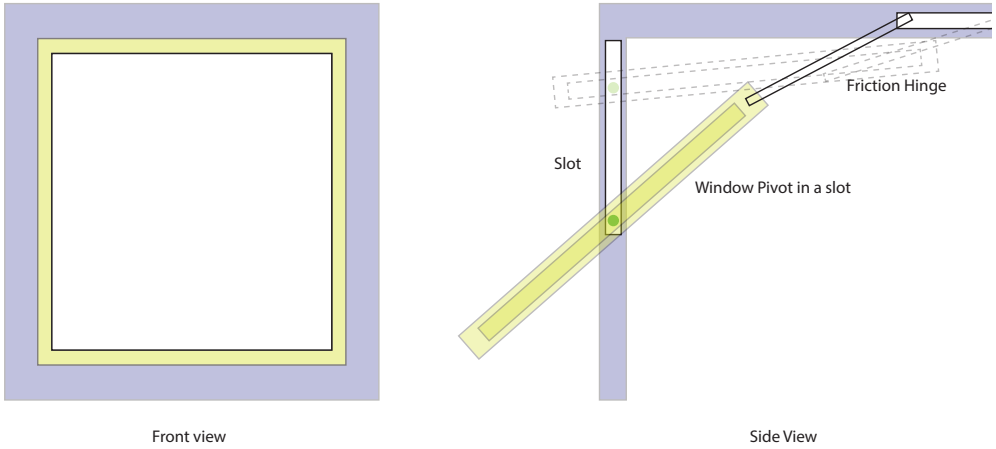


Fig 44: Window pane can be pushed upwards

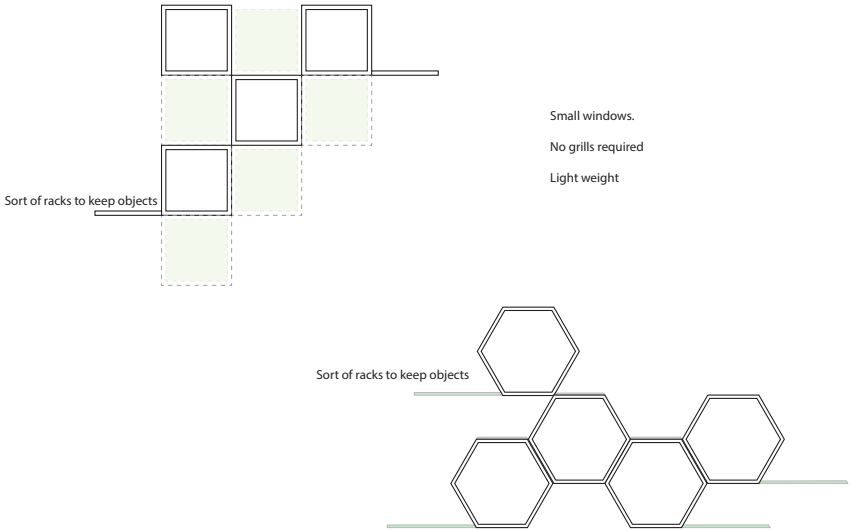


Fig 45: Window as a modular unit

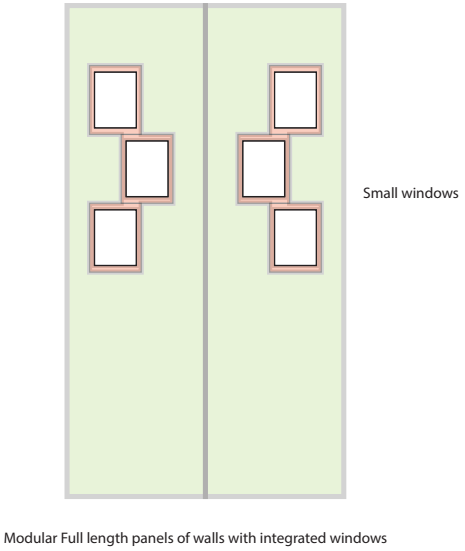


Fig 46: Window in different shapes (modular)

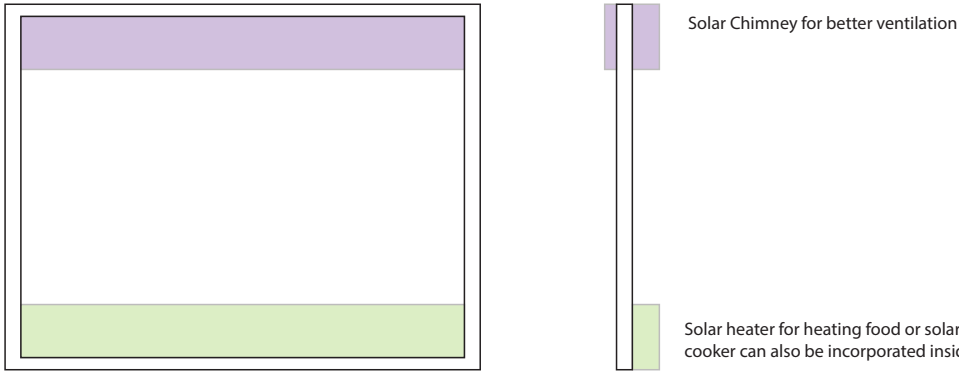


Fig 47: Window with solar heater and chimney

Ideation 6

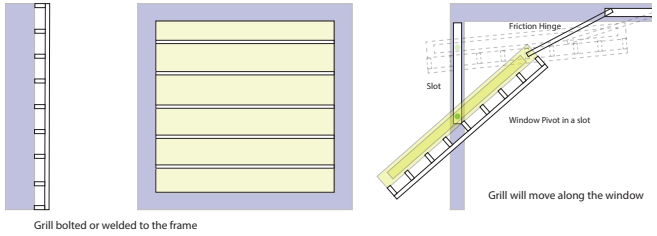


Fig 48: Window with grill attached to it

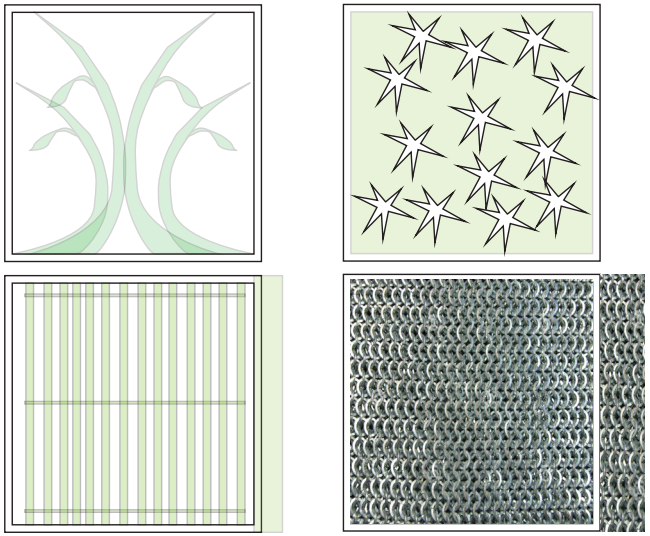


Fig 49: Different variations of grills

In this set of ideation, different shapes of the window were explored and accessories like grills and solar heater were tried to be incorporated into the design. Fig 44 shows a window that can be opened by pushing it upwards. The window is pivoted at the center in a slot and a friction hinge is attached to it. This helps in easy movement of the window. Wherever the window is pushed and left, it stays there without the fear of it being coming down and hitting the sill. Fig 45 shows windows in different shapes and sizes. Each part is a separate unit which can be joined to form a pattern. The window frame is slightly extruded inwards, so that the gap between two frames can be used as shelves. Fig 46 shows a full length window of the height of a wall. The windows are cutout in the modular piece and can form a set of small windows when joined together to form a wall. In Fig 47, we see a window with solar chimney at the top and a solar heater at the bottom. The top solar chimney would help in the forced ventilation of the house and the solar heater at the bottom can be used to heat water or food. Fig 48 shows a concept that is same as the concept shown in Fig 44 but now it has an additional member attached to it, that is the grill. All other functions are same as the earlier concept. Fig 49 shows different possibilities of the grill that can be used for concept shown in Fig 48. The first one in the left topside is a grill made up of small diameter wires, next right side top is laser cut grill, left bottom are tambour slats and the last one is a chain mail.

Lacunae till Ideation 6

After this stage of ideation, another round of evaluation were done. The concepts were tallied with the design brief and then checked if anything idea can be piggy-backed and combined with the previous set of ideation. But that did not bear any fruitful results. The idea generated did not satisfy all the user needs formulated in the design brief. So fresh train of idea were tried to be generated where the concepts generated till now could be mixed and matched to form a concept or a totally new concept is developed that takes into consideration user interaction and that satisfies most of the points in the design brief.

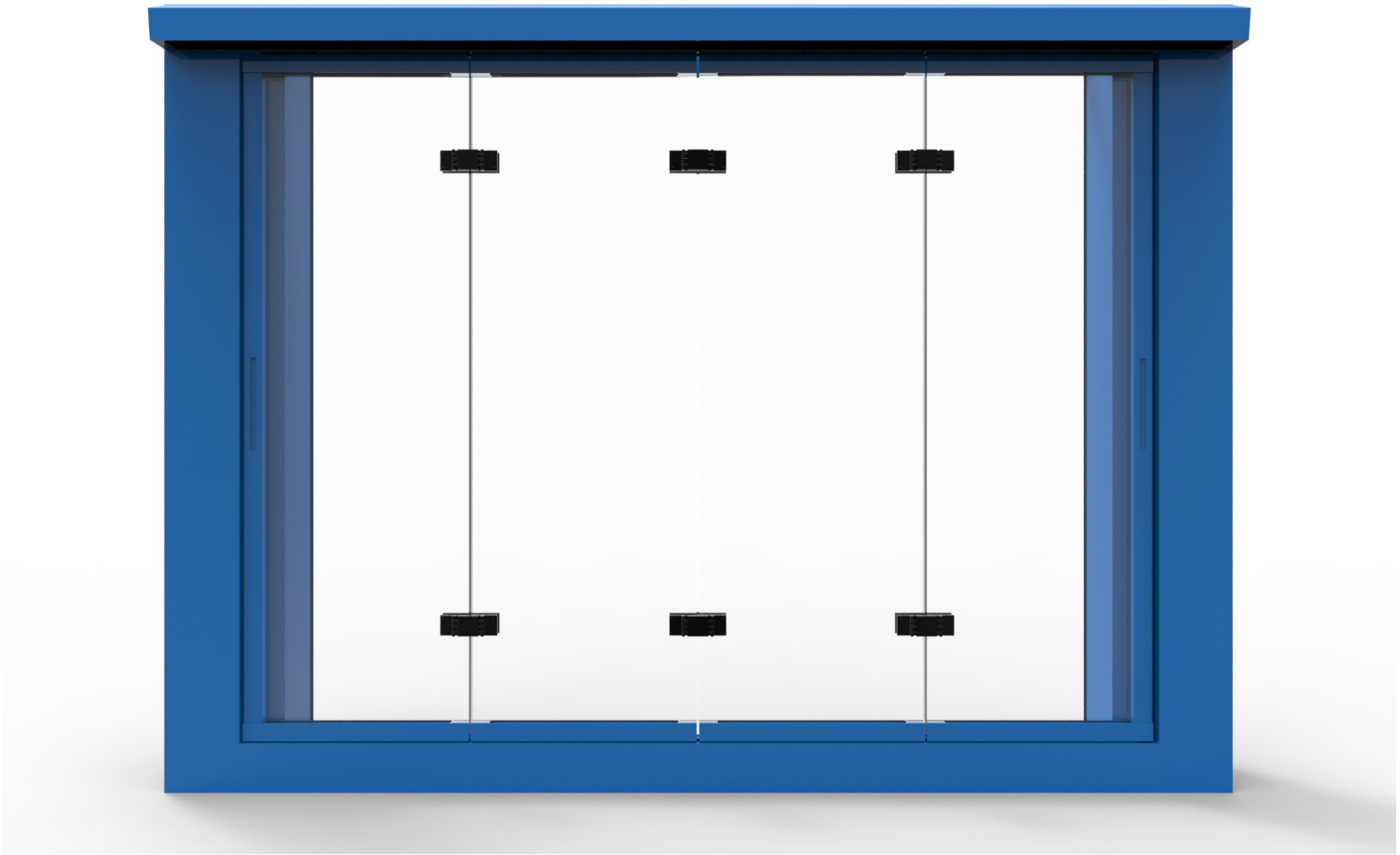


Fig 50: Window seen from inside the house

Ideation 7

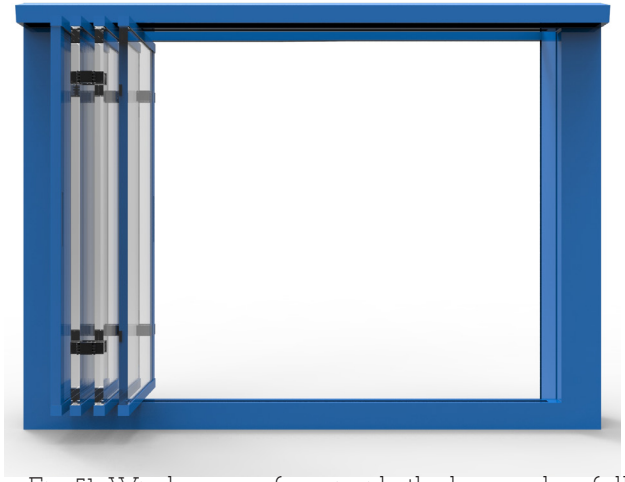


Fig 51: Window seen from inside the house when fully opened

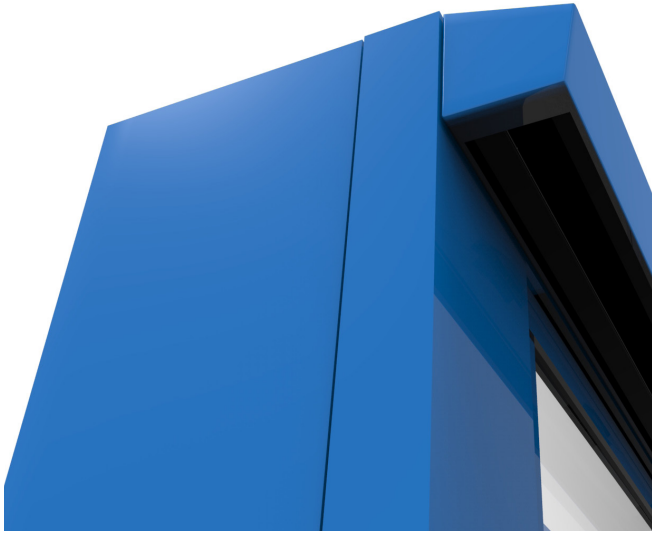


Fig 52: Window attachment at the top for blinds or curtains

Before we started again to design the window, we went back to our design brief. We started looking into what was missing in the previous designs. So one of the main issue that came up was that visual noise was not reduced in each of the previous designs. Though the idea of integrating the accessories like grill and space for putting curtains and blinds were put but the point of getting a pristine view of the outside without visual noise created by meeting stiles. So the essence of the older ideas were taken and a new idea tried to be developed. Fig 50 shows the view of a sliding and folding window from the inside of a house. The panes does not have frames on the left and right sides. Only the top and bottom sides are given frames that holds the glass on to the window frame. The extreme left and right side panes are given frames at their left or right side for installing push locks. One more reason of putting vertical frames at the extreme left and right side of the panes is that they would assist in moving the window from one position to the other and the frame would act as a support for the movement. The top and bottom frames are then vertically pivoted with rollers. Fig 51 shows the view of the window when fully opened. From Fig 51 we can clearly see that the top and bottom are fitted with roller balls. The panes of the windows are pivoted exactly at the center.

This balances the panes perfectly and then it does not put extra load on the rails. In Fig 52 we can see at the top part, there is an extruded part that is fitted on to the main frame. This part is given so that curtains and blinds can be easily fixed to the window. Generally what is done is that for fixing fixtures for putting curtains or blinds, one needs to drill holes in the wall. By providing this attachment, one

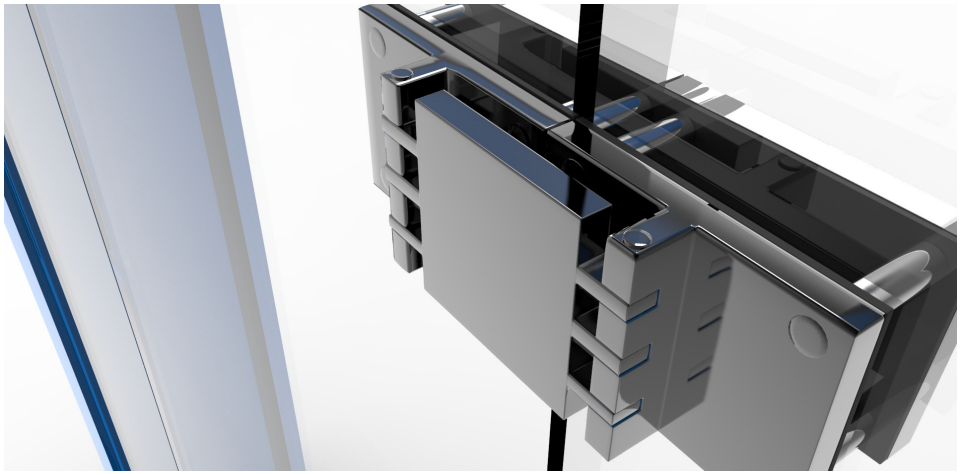


Fig 53: Hinge that produces gap when opened up

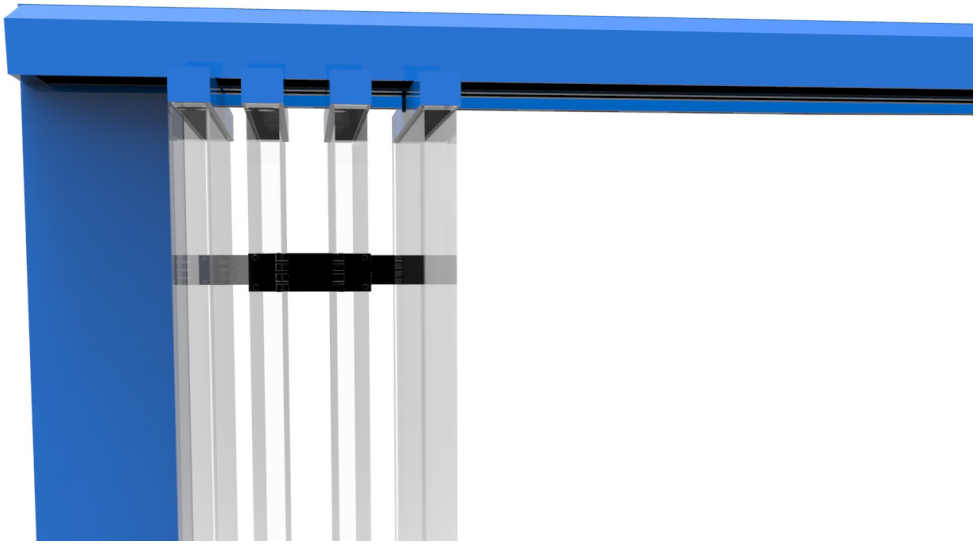


Fig 54: Gap created by the hinge for easy cleaning

can simply fit in their curtains in the space provided. No hassles are to be taken now for putting on the curtain. One can either install a curtain of their choice or go for a blinds as per the requirement.

One of the problem that we found out in traditional sliding and folding windows are that the cleaning of the outwards side is very difficult and if someone is living in a multi-story apartment the task is even more cumbersome and daunting. To facilitate this problem, a special type of hinge is used for connecting the glass panes together. Fig 53 shows the hinge that is used for connecting the panes. If we look into the picture, we can see that the hinge joint is not at the edge of the pane, rather it is away from it. So when the panes are opened, the hinge would create a space that is equivalent to the middle member of the hinge. Thus, when one opens up the window, we now get space in-between each panes. The gap would help clean the outward side of the glass panes which is shown in Fig 54.

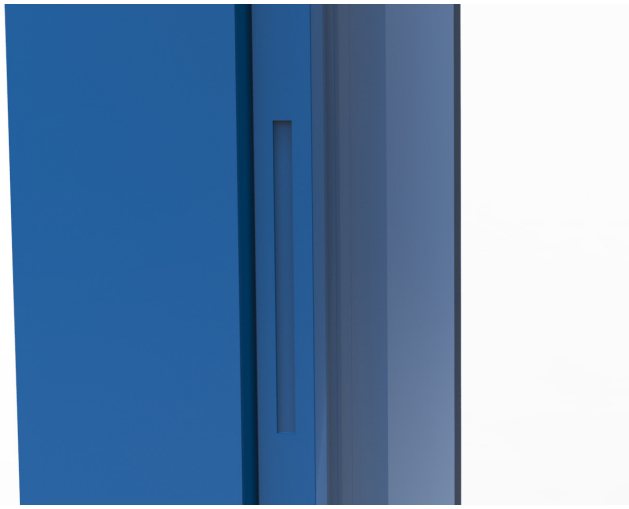


Fig 55: Push lock for easy locking of panes

Fig 56: Clear view with no frames

In figure 55 we can see a cutout section in the frame. This cutout section is a push lock. Since the window cannot be opened or accessed from outside, instead of going for complex locking mechanism, a simple yet functional push lock is used. When the panes are pushed and slided into the window frame, the lever in the push lock just gets snapped into the groove, thus giving a secure locking position. If we notice, the panes are not hinged in any side to the frame of the window. That means we can move the panes either to the left side or to the right side, depending upon our requirement.

One of the important point in the design brief was that about how structural members like meeting stiles actually creates visual noise and takes out the total aesthetics of the window when opened up fully. Keeping this point in mind, the panes were designed in such a way that only the extreme left and right side of the first and the last panes were given vertical members or stiles. Thus giving a clean look to the window members. We can see that there are no vertical members in the window pane in Fig 56.

Another thing that can be noticed in Fig 56 is that there is a rectangular frame with a gap in between that seems attached to the whole window frame. This rectangular frame is none other than the frame that is holding the grill. The grill can be a tambour slat type or chain mail rolled up and one vertical frame attached to the side so pulling it out of the slot in which the chain main roll is installed. Rails are provided at top and bottom for easy movement of the chain mail grill system. The rails also serves another purpose. The rails does not allow anyone to tamper with the bottom of the chain mail. The vertical frame that is attached with one of the side of the chain mail houses a push lock. When the chain mail is rolled out from the slot and slided to the other extreme side of the frame, it gets locked, which can be opened from the inside only.

Lacunae till Ideation 7

As usual, after completion of this ideation, another round of idea evaluation against the design brief was done. Some flaws came up with the design. Since we did use frames or stiles for holding the panes, a thicker glass would have to be used, that means increase in the cost. The grill system did not seem to be full proof and the extra frame for the grill was adding volume and weight to the main frame of the window, and also structurally it was not a sound idea. Provision of accessories like mosquito net was not looked into this design. Thus it was decided to take the base frame of this concept and improve upon it, depending on the short-comings.

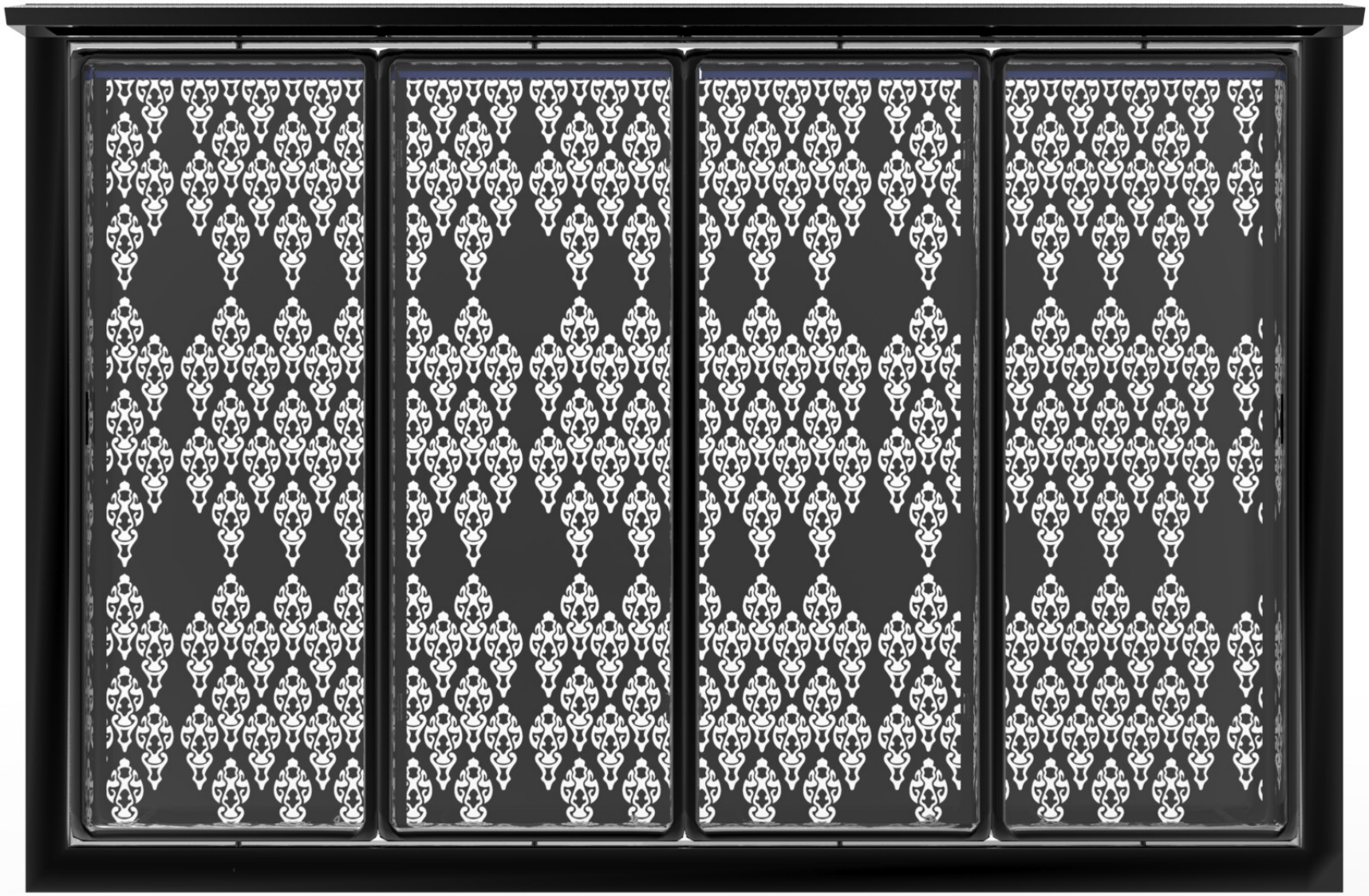


Fig 57: View of the window from inside the house

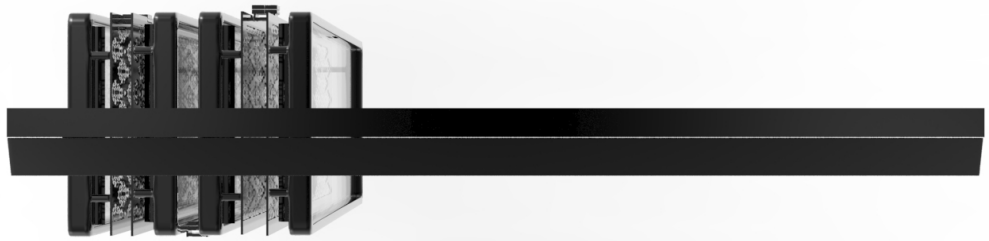


Fig 58: Top View of the window when opened

Fig 59: View of the grill that is directly fitted to window pane

Ideation 8

Philosophy Behind the new ideation:

- To have a window system that would give maximum view of the outside without creating any visual noise
- The grill should be a part of the window. When user wants, it should be there and when the user does not wants it should not be there
- Ease of cleaning and maintenance
- A window that is sleek and aesthetically beautiful
- Maintenance to be easier for the maintenance guy
- Easy to operate

Taking the framework of the earlier ideation, i.e. Ideation 7, a new concept is developed based on idea evaluation of previous concepts. The basic mechanism of sliding and folding is kept the same, but other features such as grill, shape of shutter panes or stiles is looked

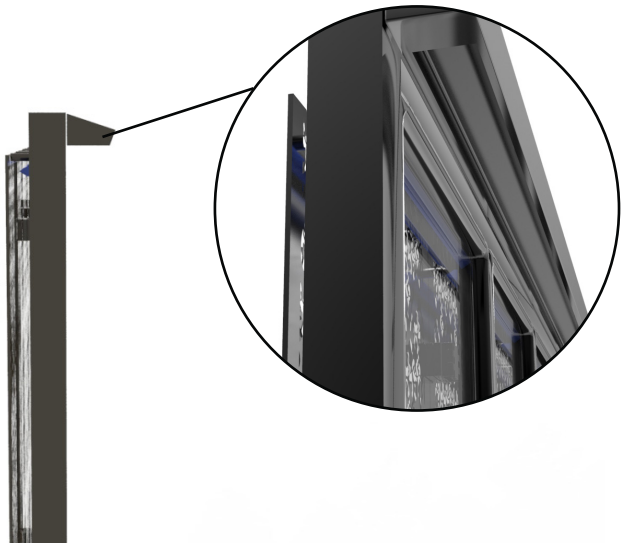


Fig 60: Provision at top for curtains or blinds

Fig 61: Wipers for cleaning the panes and grill

into. The emphasis was given to make it more functional yet a sophisticated and aesthetic product. Fig 57 shows the view of the window when fully closed and viewed from inside the house. To reduce the thickness of the glass, frames around the window panes were again introduced. Though frames were introduced gain, since it had a sliding and folding mechanism, when opened fully gave a clear view of the outside without giving visual noise that was earlier created by the meeting stiles or frames. But the cross section of the frames were reduced and fillets were provided to give it a thinner and sophisticated look. The window comprised of several parts which when assembled together produced the window we see in Fig 57. The window comprises of 4 window panes, four stainless steel grills which were directly fixed to the window pane frames, two rails one at top and another at bottom to provide for the sliding action of the window. Fig 58 shows a view of the window when it is fully opened. The panes are mounted on the rails with hinge that rotates on its own axis and is also able to slide. The hinges are fixed on the middle of each panes at top and bottom and then mounted on to the rails.

Fig 59 shows a part of the grill which is directly mounted on to the window frame. Roller joints and push locks were put for rotating the window panes and locking the window panes. The grill that is attached is of 1.5 mm stainless steel sheet metal. The sheet metal is the laser cut as per different design of motifs available. The designs of the grills can also be customized according to the user to give it a more personalized look. Fig 60 shows the provision for curtains that was retained from the earlier concept that was Ideation 7. But one of the change that was done to this idea was that the

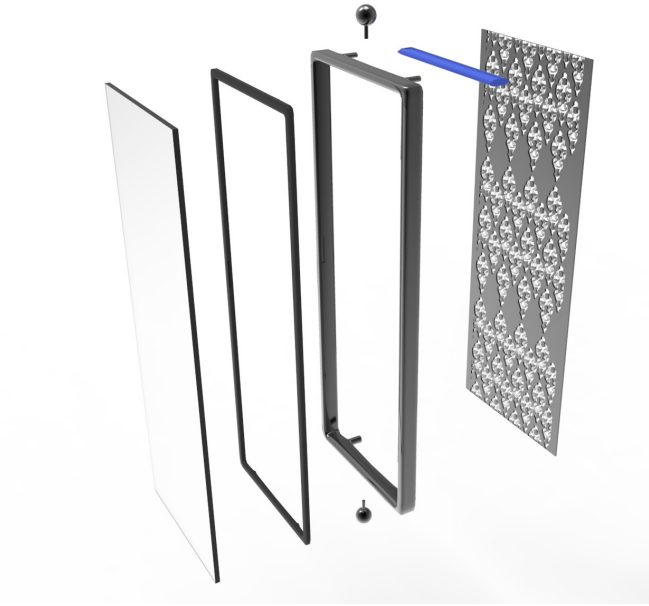


Fig 62: Exploded view of window pane

Fig 63: Different parts of the frame of window pane

overall frame size were reduced due to which the frame for holding curtains also became very compact and neat, thus giving it a much cleaner look.

Cleaning was one of the issue that most of the users face while cleaning the outward sides of the window panes. Since now the grill is also attached to the frame, cleaning would get difficult if no means of cleaning the glass as well as the grill is provided. So a wiper was provided, that stays within the frame and can be moved up and down for cleaning the glass panes as well as the grill. The idea of wiper is taken from the wind shield of vehicles that have a wiper attached with it. The wiper in the window pane stays inside it due to the force of friction. One has to just move it up and down to clean the glass panes. Fig 61 shows the wiper

The pane is a very complex structure. It has got the outer frame. Then a glazing is inserted in the slot provided in the frame. Then a weather stripping is inserted around the periphery of the glazing to seal it properly against outside environment. Then comes the rotating and sliding hinges that are pivoted at the center of the frame. The wiper is then fixed on to the frame. The grill is then attached to the top and bottom part of the frame by welding. Fig 62 is showing an exploded view of the construction of a single window pane.During maintenance, to take out a window pane is one of the most difficult task for the maintenance guys. So to make it easy, the frame has been divided into 4 or 6 parts. The vertical 2 sections can be either divided into 2 parts each or can be kept full length depending upon the height of the window. Each part can be joined by inserting a small reinforcement member and then applying silicon glue which

Fig 64: Part of window pane being fitted with the grill

Fig 65: Assembly of the window pane frame

can be opened easily using a heating the joint using any hot air gun. This arrangement of joining the pieces of the frame not only creates a cleaner joint but also is easy to disassemble, thus making it easy for the maintenance guy. Since the joints would be fastened using silicon glue, the necessity of drilling holes and using screws are not required now. Thus giving a very clean joint which is aesthetically more pleasing and clean. Fig 63 shows an exploded view of the frame of the pane.

If we look back into Ideation 7, one of the disadvantage of the grill system there was that it was a separate unit in the window and it was not getting blended with the form of the window. It seemed the grill was taken out from somewhere and fixed in the window. The was also making the window look bulkier. To overcome that we have attached the grill itself to the window frame, making it much thinner then earlier concept. The top and bottom frame of the panes are welded to it. If the glass pane breaks then the just the sides of the frame has to be opened by heating the joints using a hot air gun and the just sliding the new glazing and then fitting it with a weather stripping. Fig 64 shows a grill with the top and bottom frame attached to it.

Fig 65 shows the assembly of a window pane frame. Each joint has three components. The vertical member, a reinforcement member, top or bottom member. silicon glue is put on to the reinforcement member and then inserted into the vertical and horizontal part of the frame. The glue is then allowed to dry. The reinforcement member not only strengthens the joint but also enables the joint to be formed without the use of screws, thus creating a very clean joint. Dismembering the joint is also very easy. One has to just heat the joint either using a hot

air gun or using some other heat source. The silicon glue melts away and the parts can be easily taken out.

Lacunae till Ideation 8

Again an evaluation of the concept was done. Some problems were found out which we had not fathomed earlier while designing. The window when opened still occupied space in the interior as well as the exterior of the house. Too much of load was being put on the rollers. The rails were not well designed to stop rain water from being splashed inside the house. The corners of the joint has a sharp bent which is very difficult to manufacture. The combination of grill and frame when opened up is taking up too much of window space. So, reviewing the drawbacks, we decided to give it a fresh look, yet keeping the design philosophies same as we have kept for Ideation 7 and keep the design brief in mind while making design changes to Ideation 7 or creating a new design.

Final Concept

After evaluation of Ideation 8, the design brief was again studied thoroughly. It was understood that the design missed some basic things. So again a list was made which would help is improving the earlier design. Some of the points in the list are :

- Replacement of parts
- List down all parts
- List all functions that will come in the window
- In how many ways can the mosquito net be fixed or removed

A revised brief

Each point is then explored so that while implementing design changes, we do not miss on points like we missed on earlier concepts. After doing a detailed study of the various parts of the window, a checklist was prepared. The different points in the checklist would be different design criteria. The checklist points are as follows:

- No visual noise
- Grill as a part of the window
- Easy installation and removal of mosquito net.
- Easy cleaning of mosquito net
- New design of rails
- Aesthetics of the window pane channels
- Locking mechanism
- Opening mechanism
- Wheels for bottom rails

The main idea was to create a window which would be aesthetically pleasing and functionally sound. The user interaction with the product should be as less complicated as possible. Accessories such as grill and mosquito net can be easily installed in the window without much hassle. When opened it should give a pristine view of the outside with least possible visual noise. The grill should be there when it is needed and can be opened up fully when needed. Emphasis was given in the design of channels and rails also. New channels were designed which are thinner in width then the existing window by at least forty percent. Thinner channels added to the aesthetics of the whole window. The channels were redesigned in such a way, that drilling of the channels and screws are not required for fixing it. The idea from Ideation 8 was taken for channel fixing and a whole new set of channels were designed. The design of rails were given focus. The rails were designed in such a way that rain water does not get accumulated in the rails and thus get splashed inside the house. The main idea was to give the user a pristine view of the outside with all the added benefits of a traditional window. To do that, the properties of a casement window and a sliding window were taken and then mixed to form a new window. Now we have a window that has a sliding motion and also a rotating motion.

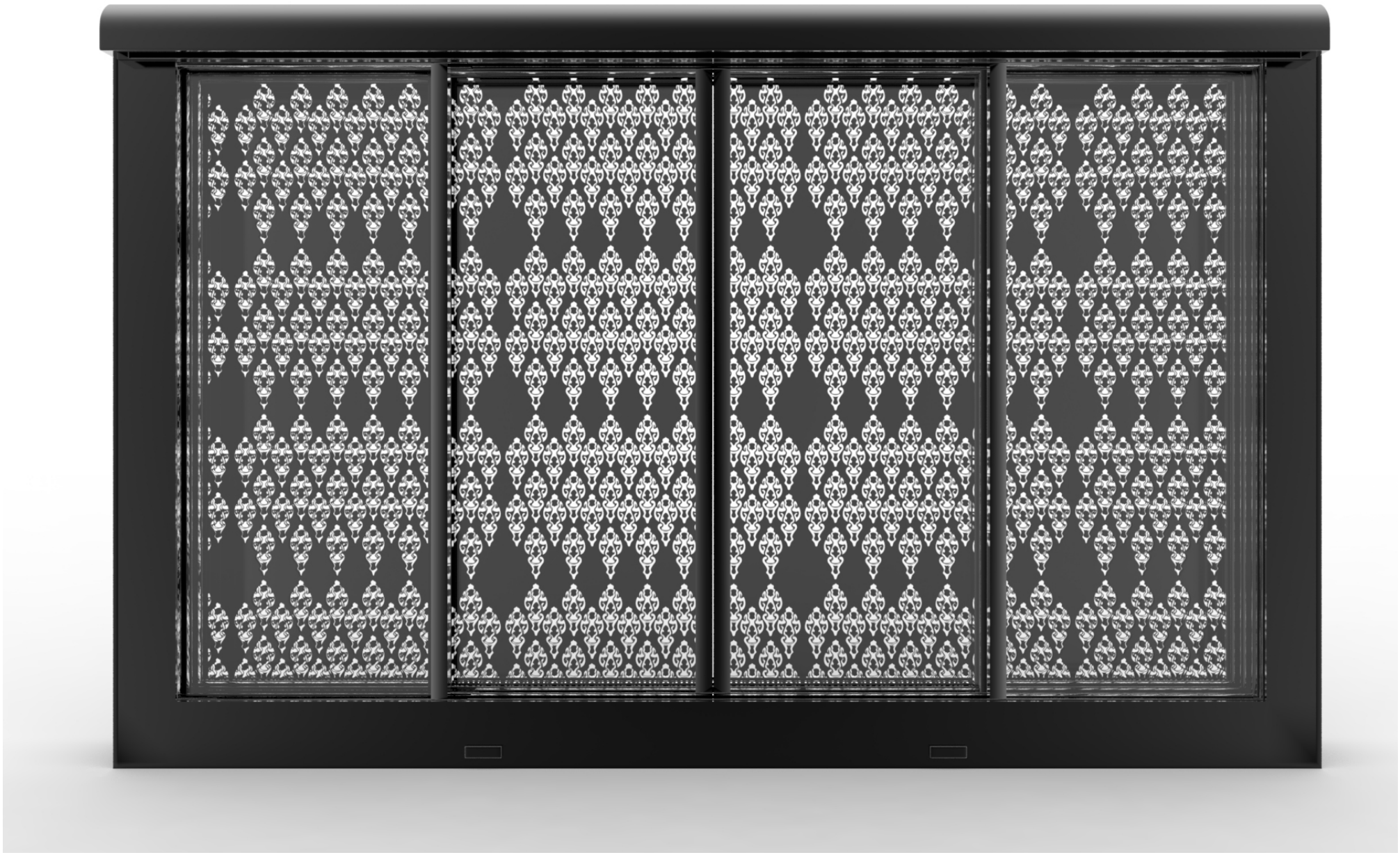


Fig 66: View of the window from inside the house

Fig 67: View of the window from inside the house when half opened

Fig 68: View of the window from outside the house when fully opened

When the panes are taken to the extreme side, they gets locked to the side rails and the rails can be opened up as they are hinged to the sides of the main frame.

Fig 66 show the view of the window when it is fully closed. The window can be divided into various parts. The various parts are:

- The grills
- The window panes
    - The glazing
    - The channels
    - Roller wheels
    - Locks
    - Weather Stripping
- The rails
- The hinges
- Mosquito net

The window has four rails. The first two rails are used to house the four panes of glass. The other two rails are used to put four grills. Each pane is of 1.5 feet length and the height is 4 feet. The rails at the extreme end is cut into 2 pieces. So the total rail at the bottom and top is of 3 parts. The extreme two parts are pivoted by friction stay hinge and normal rotating window hinge. The rails at the inward side of the house would be used for the glass panes and are pivoted to the main window frame by friction stay hinge. The rails that carry grills are joined to the main frame using normal rotating hinges used in traditional casement windows. The middle part of the rail is screwed to the main frame.

Fig 67 shows the position of windows when opened half and the panes of the window are slided to the right side of the window. Since the span of the window is large, it has been covered by 4 panes of glass and grills. Usually for 4 panes of glass, we need 4 rails. So traditionally for 4 glass panes and 4 panes of grills, there would have been 8 rails tracks, but since the window can be opened fully using rotating action, the number of rail tracks has been reduced to 50%. Now only 4 rail tracks can accommodate both the window panes and the panes of the grills.

Fig 68 shows the view of the window when it is opened and viewed from the outside. As the grills and panes get locked with the rails and opened outwards, the whole window opens up, thus giving a full pristine view of the outside without any visual noise.

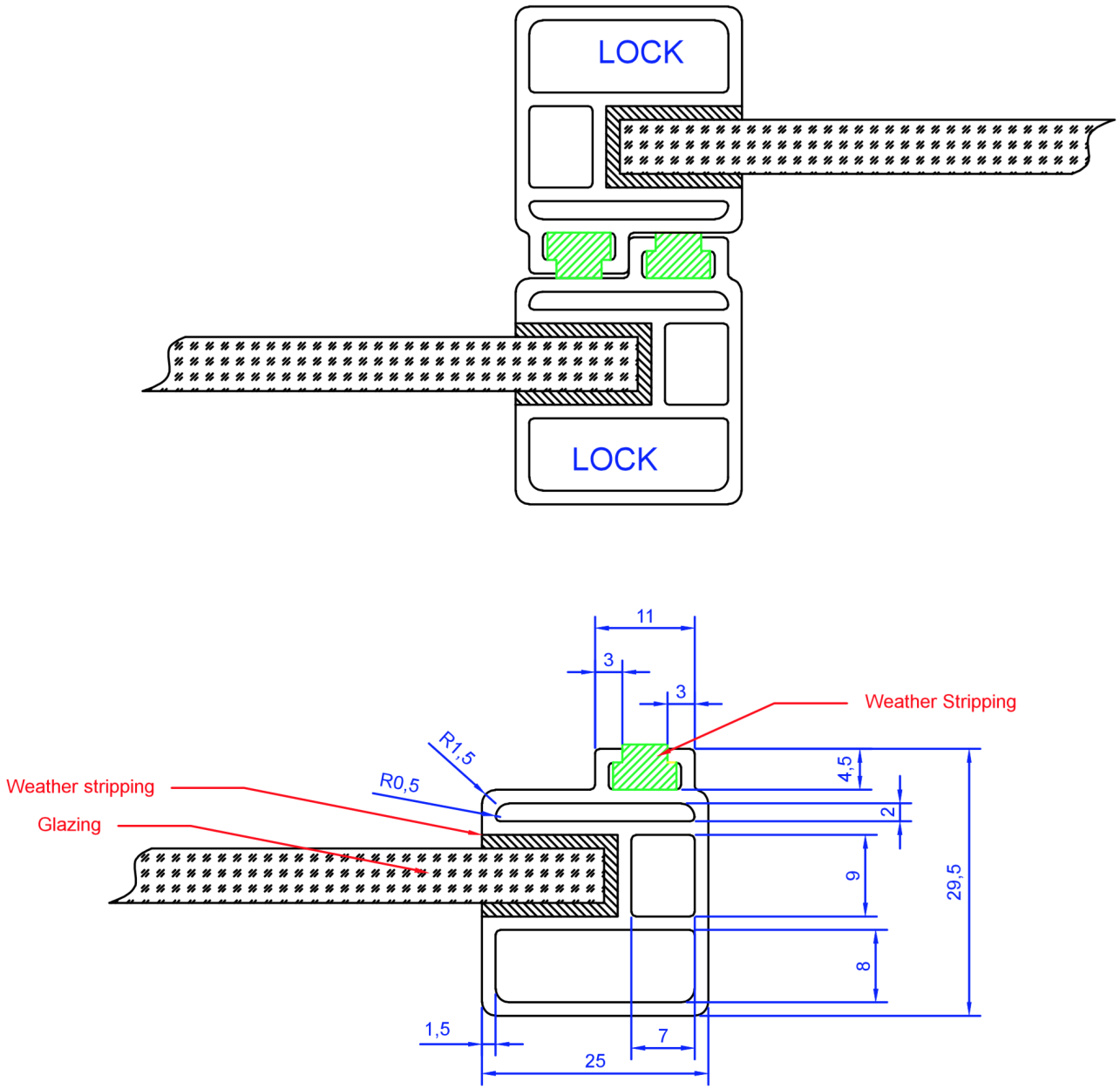


Fig 69: Dimensional details of the channel with weather stripping

Channels

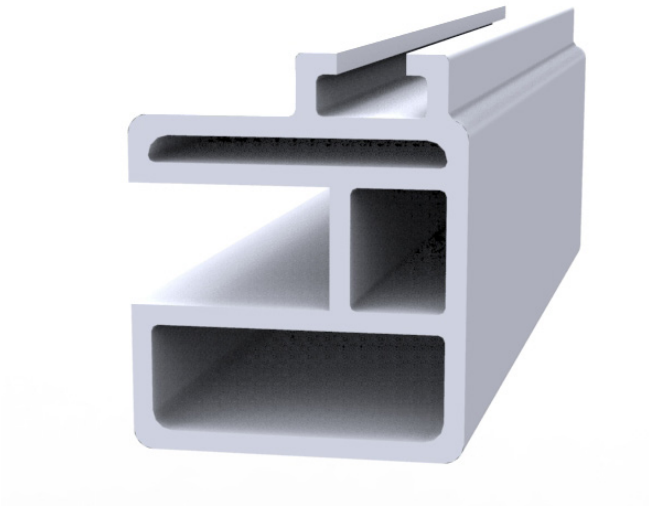


Fig 70: 3D view of the channel with weather stripping

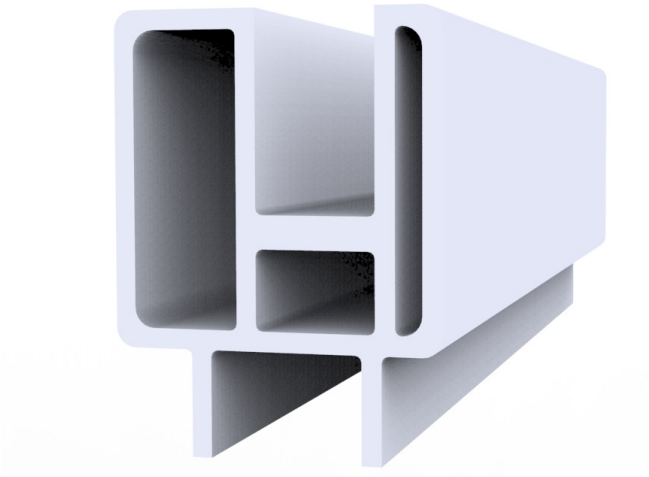


Fig 71: 3D view of the channel used at the bottom

Channels for Window panes

Fig 69 shows the dimensional details of the channel used in framing the glass pane. The channel has been redesigned to reduce the width of the channels, so aesthetically the channels become more beautiful. The channel shown in the figure is one of the vertical member of the frame. It has the provision for the weather stripping. The slot has two benefits. When two channels touch each other, the slot blocks each pane, so that when any one of the pane is moved, the other pane also moves. The weather stripping makes the contact between the two panes air tight so that when air conditioners are used or the season is winter, the room air does not interact with the outside environment. This is not a newly designed thing. This feature has been borrowed from the existing window channels. The mating of two channels is shown in the top figure in Fig 69. Fig 70 shows a 3D representation of the channel. The slots inside the channels are used to connect two channels without the use of screws. The other vertical channel is exactly the same, but just without the slot for the weather stripping. Fig 71 shows a 3D representation of the bottom channel. Fig 72 show the dimensional details of the same. The bottom has two extruded parts which helps in sealing the window from outer environment when closed and also houses the roller wheels. The joining mechanism of two channels is same as other vertical channels.

Fig 75 shows the dimensional details of the vertical channel of the frame with no weather stripping. The channels also houses push locks that would assist is locking the panes when pushed inside the slot of the vertical rails.

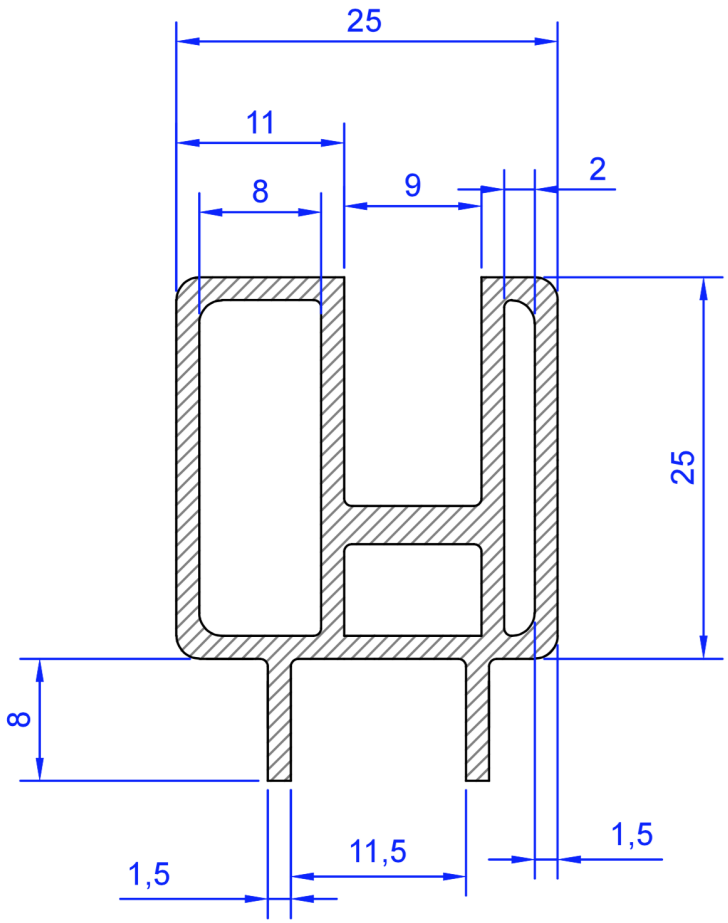


Fig 72: Dimensional detail of the channel used at the bottom

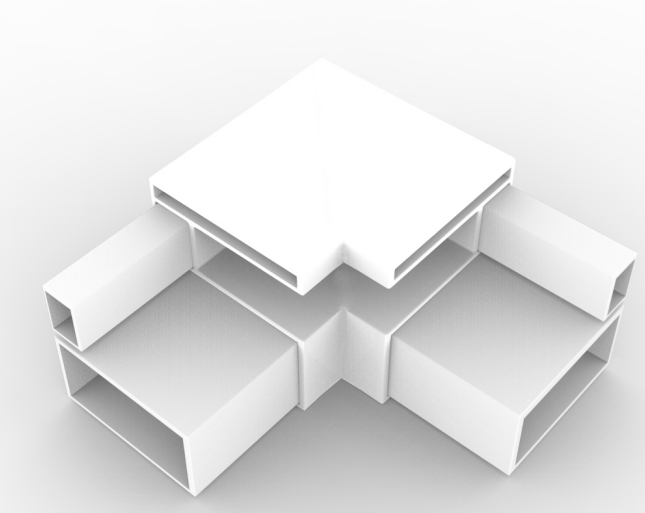


Fig 73: 3D view of the die-cast joint

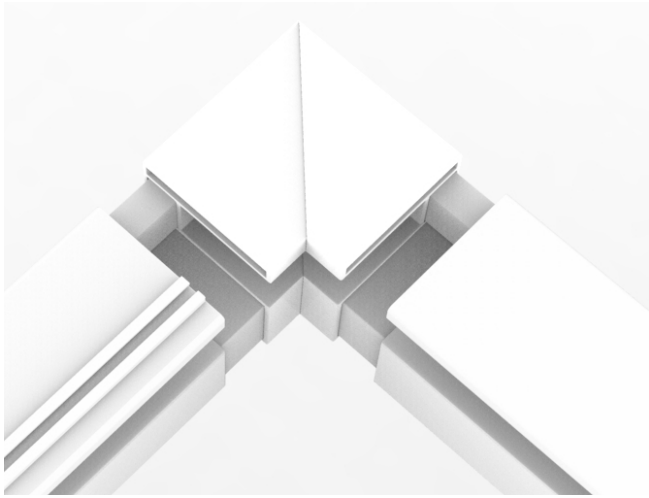
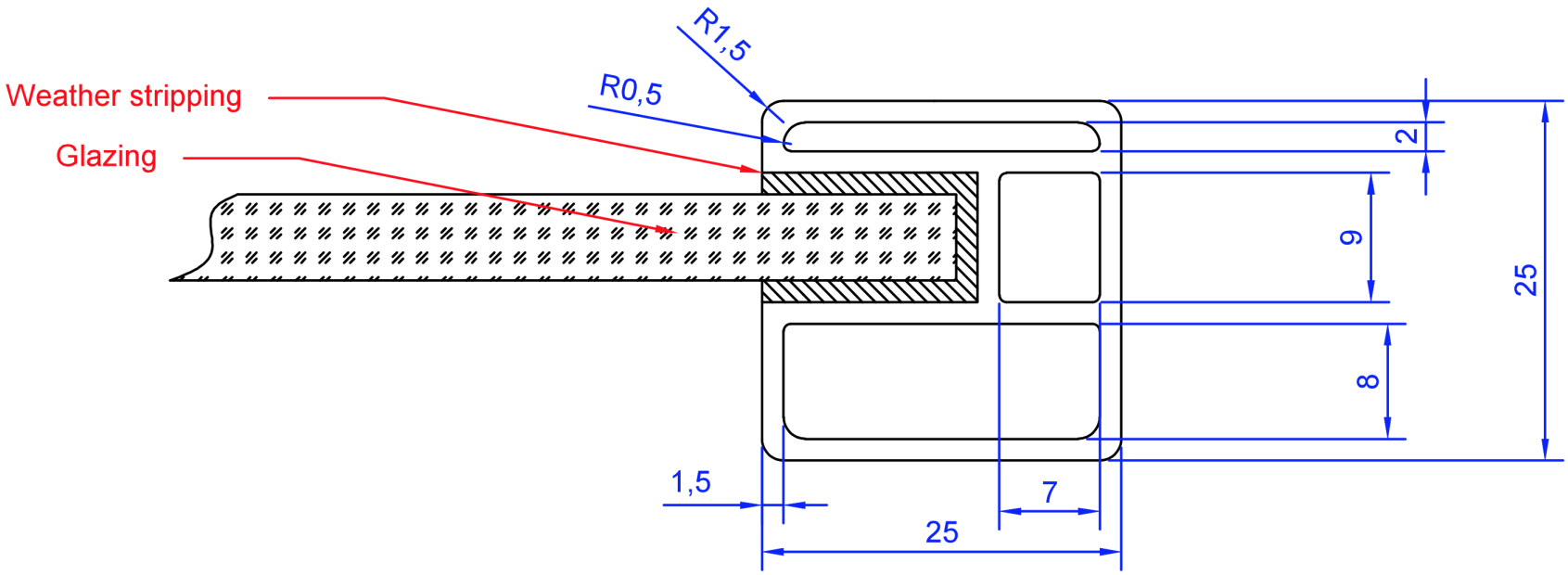


Fig 74: Joining detail of the channel

Corner Detail

The channels are joined by using a separate piece, that is prefabricated. It is a die-cast part and its cross-section at both sides is same as the channels. The die cast part has protruding extrusions, that goes inside the channels for joining. Fig 73 and 74 shows the prefabricated joint and how it is used in joining two channels. During assembly of the window pane, the inserts coming out of the joint would be applied silicon glue and the vertical members are pushed so that the inserts gets into the vertical channels, thus producing a perfect 90 degree angle. The silicon glue is allowed to dry up. This type of joint eliminated the need of drilling and then fastening with screws, thus creating a messed up and unclean joint. Now the joints are clean and the fabricators do not have to worry about getting correct 45 degrees or maintaining perfect dimensions after cutting 45 degree angles. When the joints are to be opened for glass replacement or other maintenance works, the joint just have to be heated with a hot air gun so that the silicon glue melts and the joints can be taken out.



All dimensions are in mm.

Fig 75: Dimensional details of the channel used at the sides

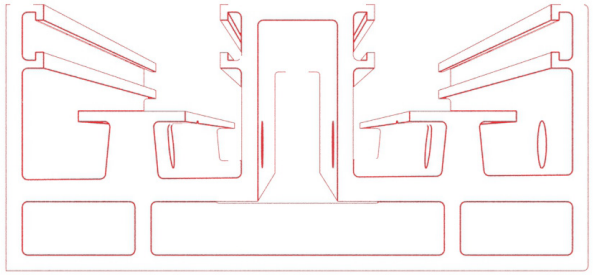


Fig 76: 3D view of the middle rail

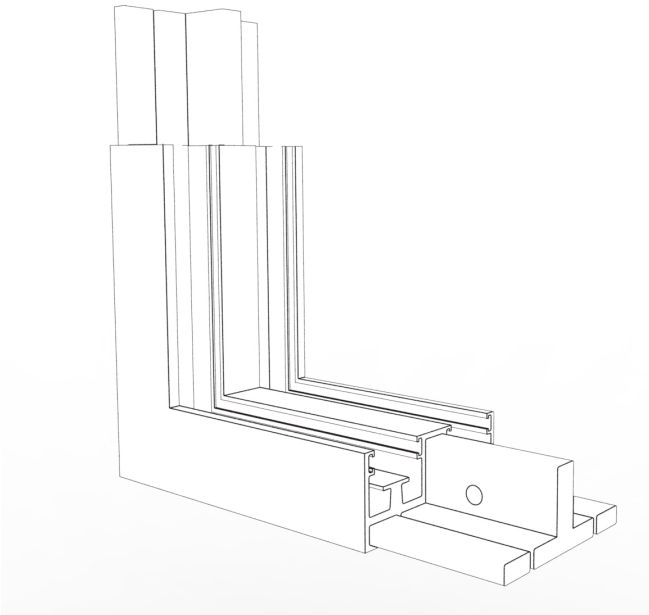
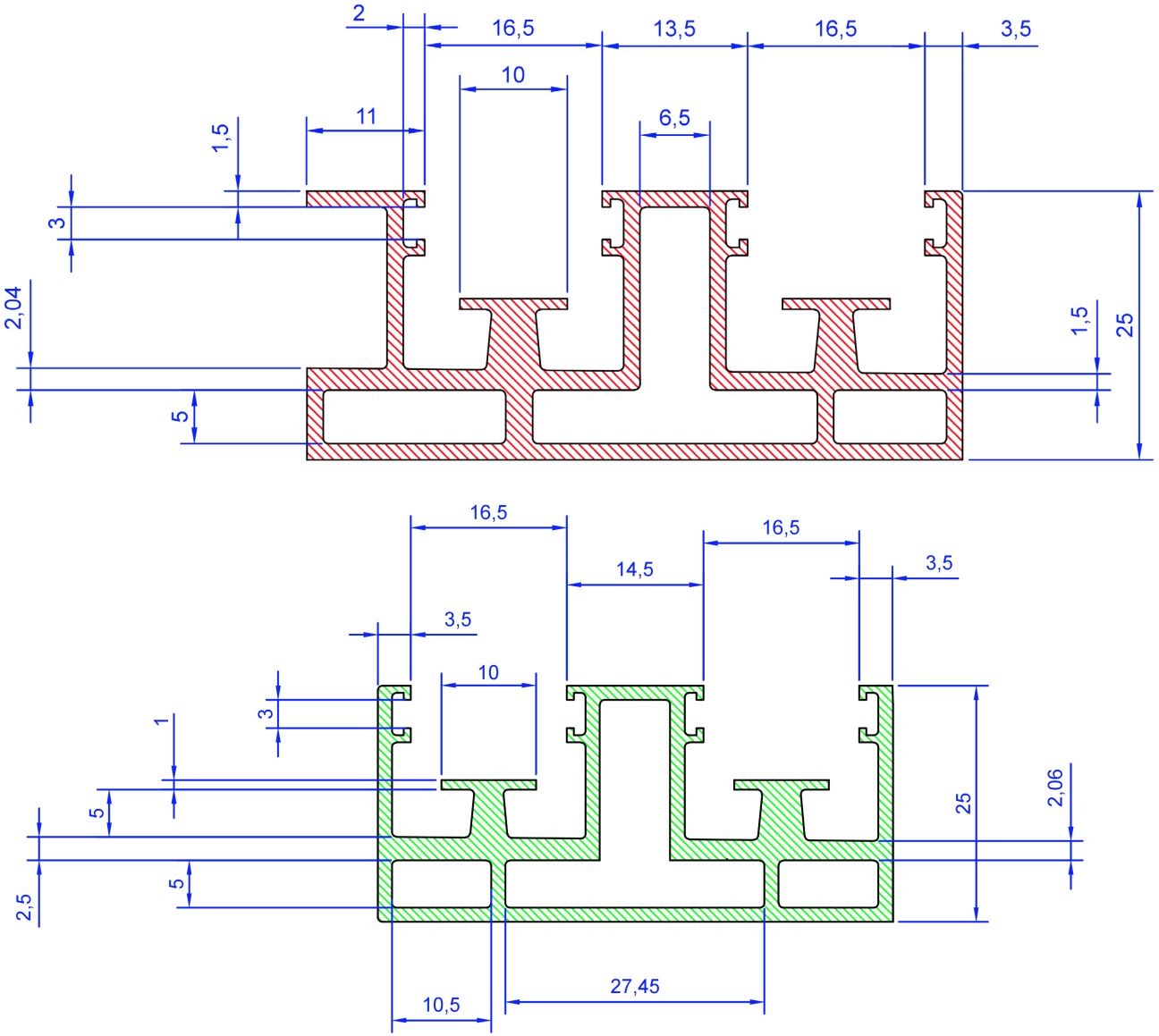


Fig 77: Corner Joint of the rail. The joint has a hole for letting water out

Rails

One of the main problem that the user faces during monsoon is that the rails get clogged with rain water. If there is wind outside, the clogged water gets splashed inside the house. Therefore a new thought was given to the design of the bottom window rails. The basic design is kept same as what is available in the market but few minor tweaks were done. Fig 78 shows the dimensional details of the window rail. The top drawing is the rail that is used for the movement of the grill. The bottom drawing is the rail that is used for the window frame. The main difference between the two type of the rails is that the top has extra protrusions at the left and side which the bottom does not have. The seat like protrusions at the middle are used as a guide for the roller wheels. The rails are given a slope of 1mm. The slope is given so that if water gets clogged inside the rails then due to the slope the water would come to the outward rail and pass out through the holes provided in the rail. Fig 76 shows the 3D front view of the rail. From the view it is very clear that the holes were given at each partition for easy removal of water. Fig 77 show the corner detail of the rail. The joining mechanism is same as the joining mechanism of the frames of the window panes. The die cast part also has a hole that is matching with the position of the hole in the rail. So when the two parts are joined, an opening is created that would let the water inside the rails to flow out.

Fig 79 shows how the corner would look like after joining. The die-cast corner joint has a t-shape extruded part coming out of it that acts as the insert for the joint. Fig 80 shows the side view of the corner when joint. Since the joint is made by using inserts, the joint is very clean and thus the parting lines can not be easily figured out.



All Dimensions are in mm

Fig 78: Dimensional detail of the bottom rails

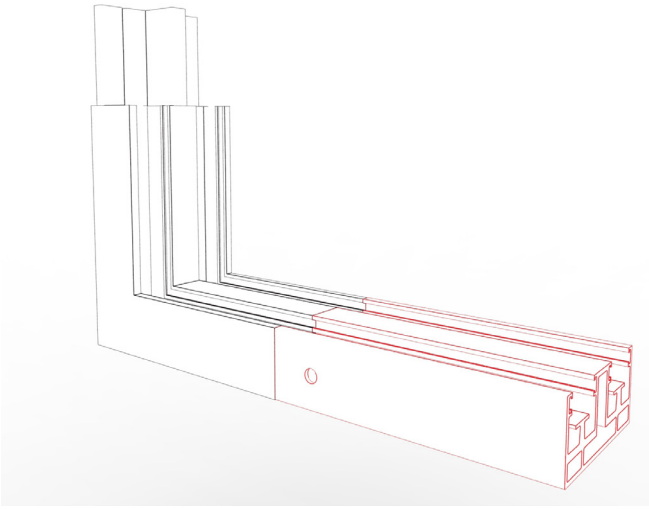


Fig 79: Joining detail at the corner of the rail

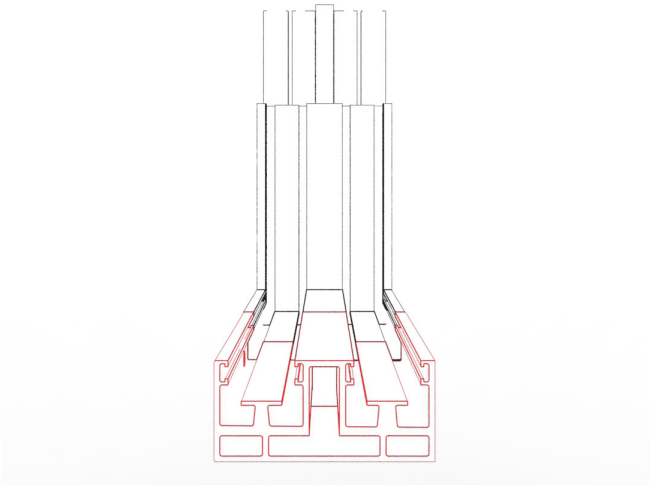
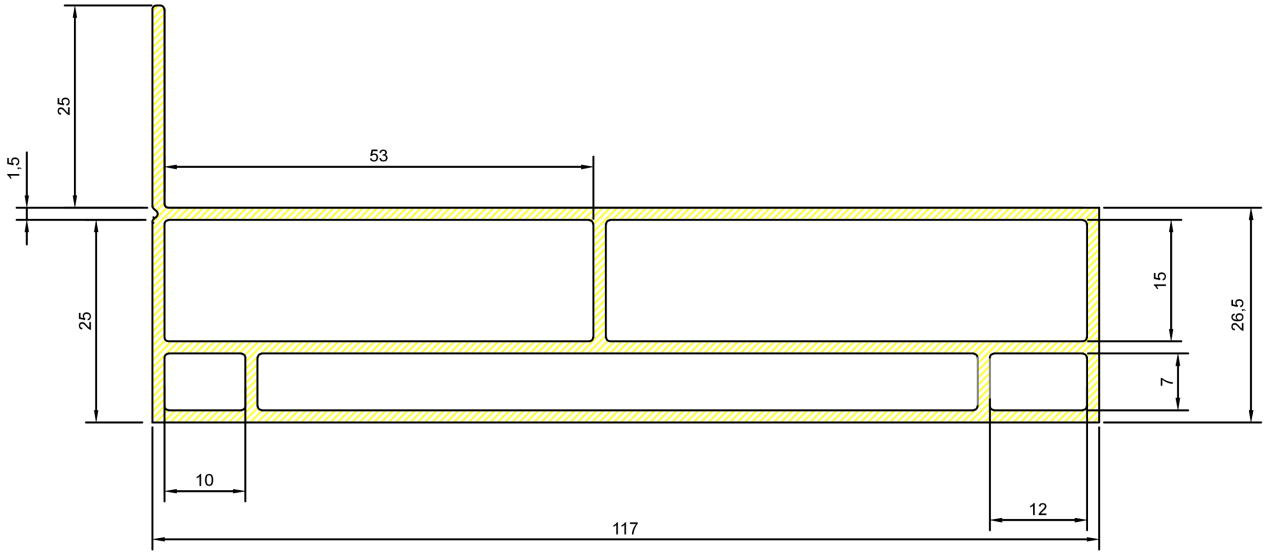


Fig 80: Side view of the corner when joined

Outer Frame

While fitting the window, a box is made first and fitted into the hole kept for the window. The box ensures that, the angles at the corners are exactly 90 degrees, so that the window fits perfectly. Where ever, gaps are found, it is usually filled by fillers. So instead of making the box at the site and worrying about creating the perfect corners, the same design philosophy is applied as before and a channel is designed specifically for this purpose of housing the rails and the channels. This channel will act as the outer frame of the window. The joining detail of this channel would be same as the joining detail of the other channels. The channel would be joined by a die cast part. Fig 81 shows the dimensional details of the channel. The top drawing shows the dimensional details of the channel and the bottom part shows the assembly of various channels with this outer channel.

The extreme two rails at the two ends of the window are kept separate. i.e. the glass panes go into a set of rails and the grills go into a set of rails. Fig 78 show the two type of rails. The top rail is for the grill and the bottom rail is for the window pane. This helps in the easy opening of the grills when required and easy opening of the glass panes when required.



All Dimensions are in mm

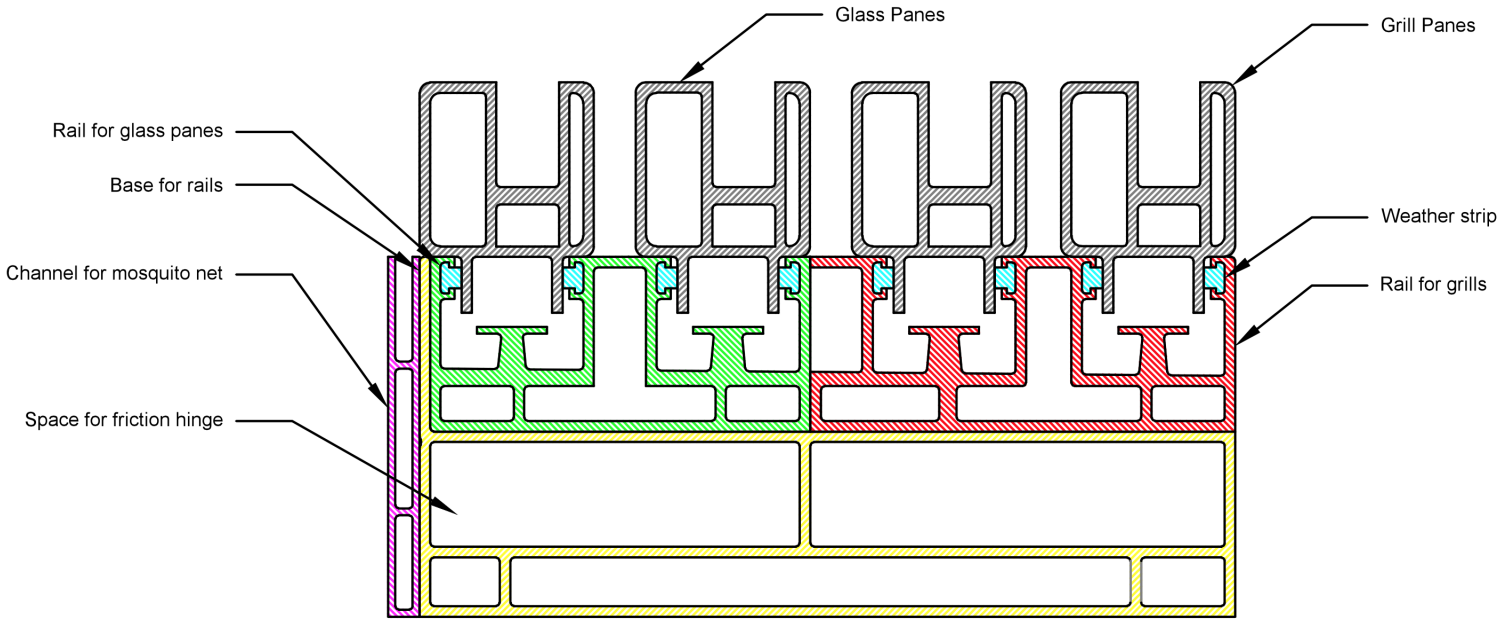


Fig 81: Cross-section of the bottom frame and its assembly

Joining Detail: Rails

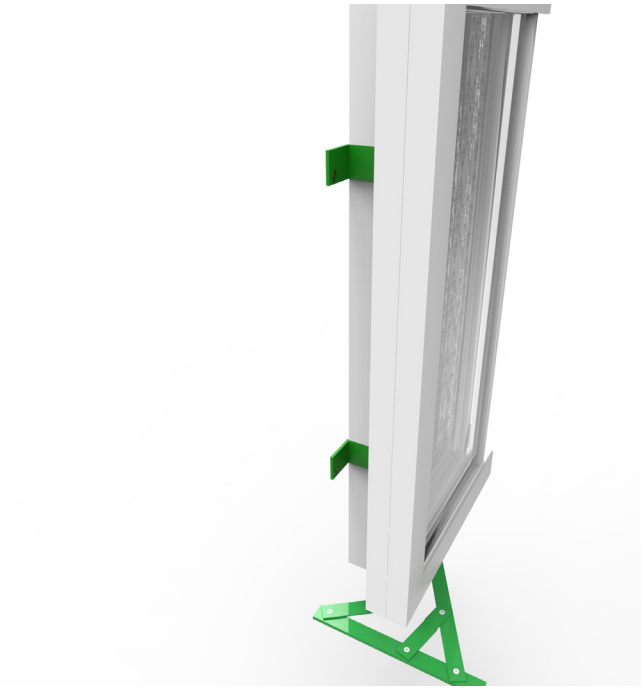


Fig 82: The positions of the window hinge

The inward side rails, that holds the glass pane is fixed or pivoted with friction stay hinge. This is done so that when it opens, it creates a gap in between the frame and itself, so that the outer rail can open easily. The top and bottom of the right side and the left side vertical rails are connected using friction stay hinge. The position and arrangement is shown in Fig 83.

The outer rail is fixed using normal rotating hinge, which is generally used in pivoting casement windows. The outer rail is hinged from the inside to the main frame of the window. This can be viewed from Fig 82 which shows the orientation of the hinges with respect to the rails.

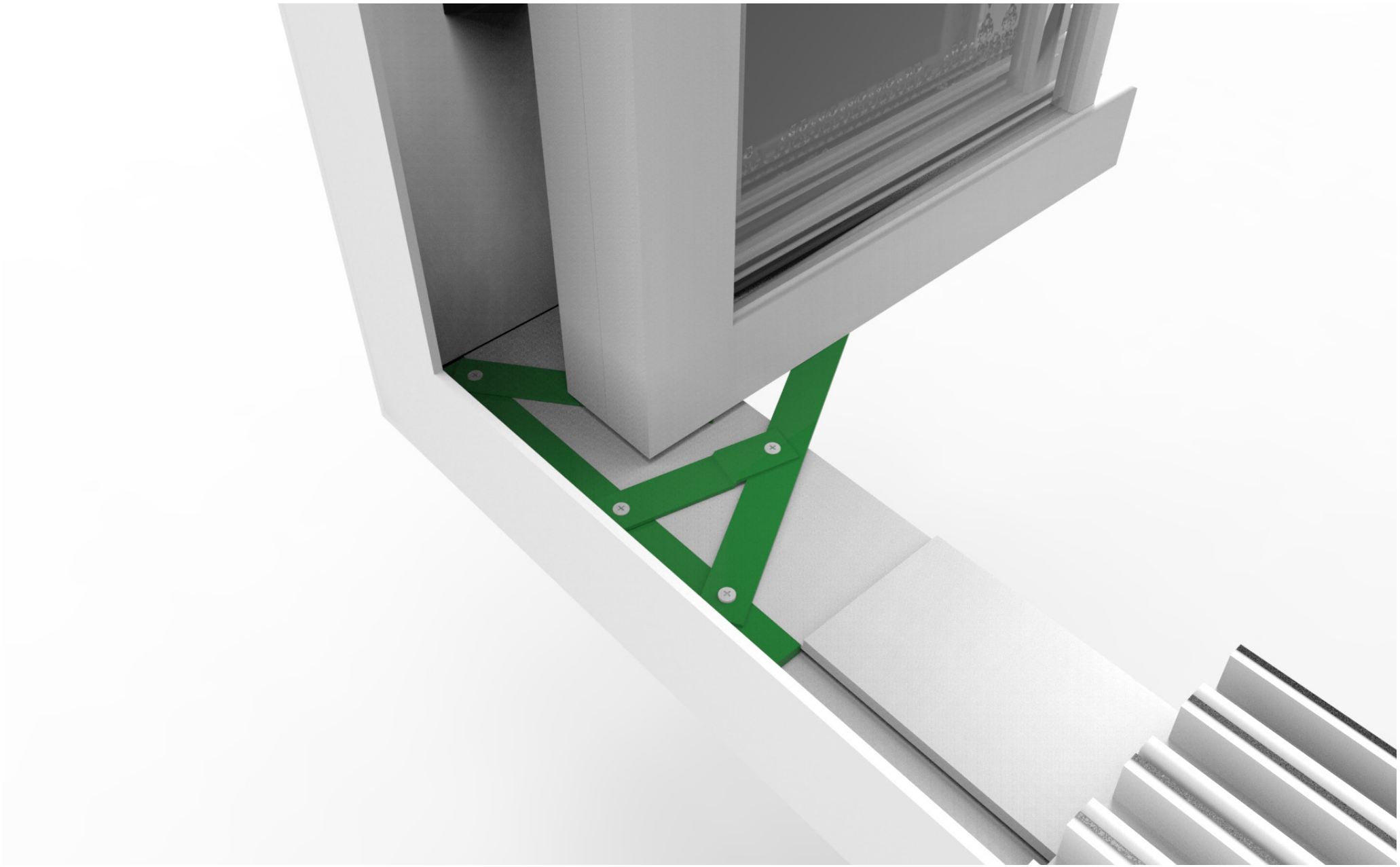


Fig 83: The glass pane is pivoted to the main frame using a friction hinge

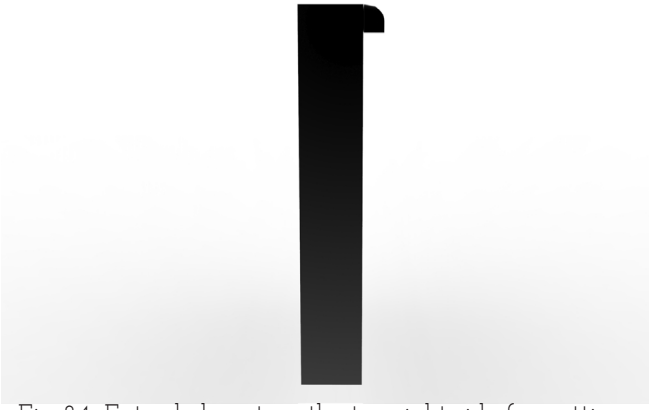


Fig 84: Extruded part on the top right side for putting curtains and blinds

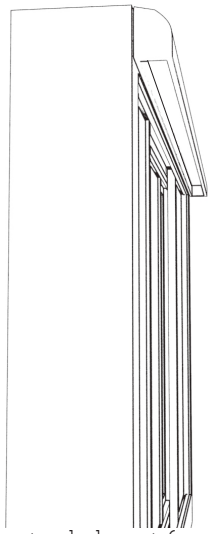


Fig 85: Gap in the extruded part for easy installation of curtains or blinds

Provision for curtains / blinds / mosquito nets

In India, mosquito is a very big menace. Different places of the country uses mosquito nets fixed to their windows so that they could prevent mosquito from entering the inside of the house. Since they are fixed to the window and generally could not be taken out, due to the small pores of the net, they get clogged very easily with dust and debris. Cleaning them is a very big headache. So the mosquito net is kept separate here in this design. Fig 86 shows a view of the window from inside the house when a mosquito net is fixed to the window. The mosquito net is made of flexible material and can be rolled up and stacked up at the top, where a provision for installing curtains, blinds or mosquito net is provided. Since it can be opened easily, it can be taken under a running flow of water to clean the dust and debris. In Fig 84, we can see a black extruded part coming out at the right hand side. This part will house the curtain or the blinds or the mosquito net. This part is provided keeping in mind that the user has to struggle a lot, every time the user wants to install a curtain or a blind. Since this part is provided, the user can easily now install the curtains and blinds. In Fig 85 we can see a gap in the cover where the accessories would be installed.

Attachment for mosquito net

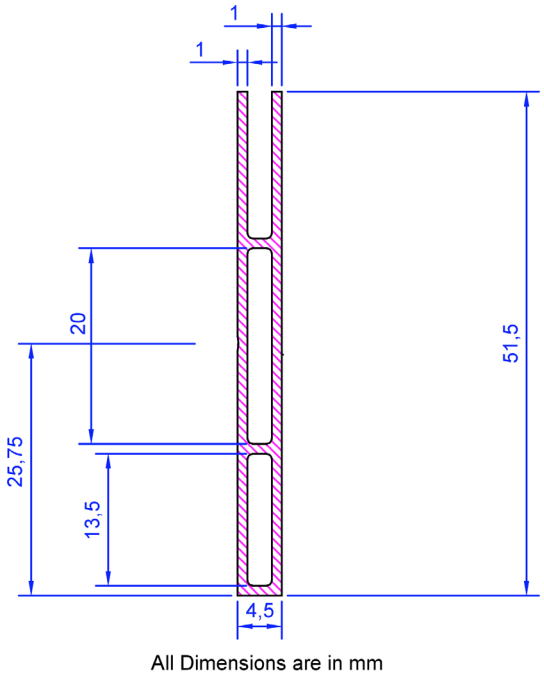


Fig 86: Dimension of the slot

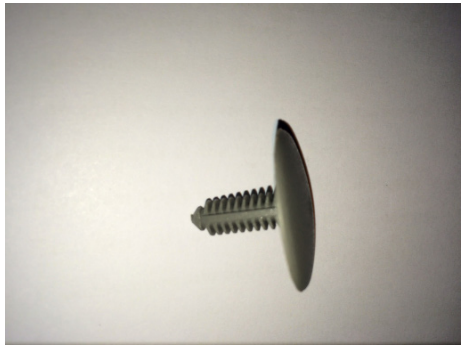


Fig 87: Screw for fixing the slot

Fig 86 shows the dimensional detail of the attachment for the mosquito net. This attachment is a simple C-channel of 4.5mm width with a 2.5mm gap in it. The channel is joined in the similar way as the other channels are joined. The channel would be fitted at three sides of the frame excluding the top part. The gap provided in the channel would house the mosquito net. The mosquito net is installed at the top, where provision for curtains or blinds is provided.

The mosquito net can be a rolled curtain type net, which can be operated by ropes fitted to it. The bottom of the net is fitted into the gap of the channel. So when the mosquito net is rolled down, the net gets sealed from the outside as both the side of the net is actually inside the channel.

The channel can be fitted to the main frame in different ways. It can be screwed to the main frame or it can be glued to it by using lugs or can be fitted by drilling holes on both the channel and frame and then using a separate snap on piece to fasten both the pieces together. Fig 87 shows a type of screw that is specially designed for this type of applications.

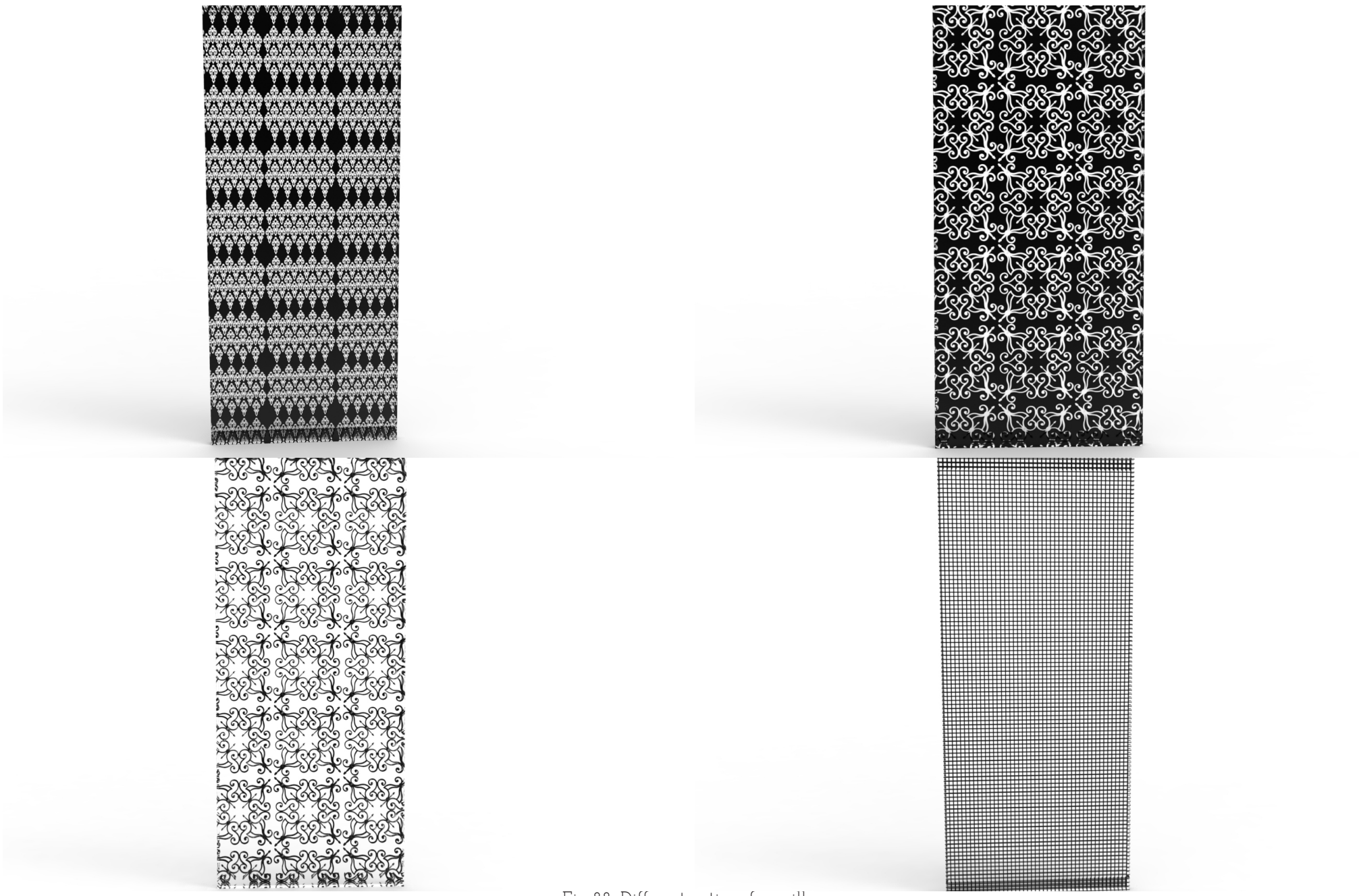


Fig 88: Different options for grill

Grills

Last but not the least, another important member of the window structure is the grill. In Fig 87, different option of grills are given, the first two are 1.5 mm stainless steel sheet metal laser cut to form a pattern and increase the monotonous form of the opaque grill. The laser cut can be replaced with punching for larger patterns and mass manufacturing. The plates are then assembled as glazings are assembled using channels.

The bottom two are grills are made of 3 mm wire bent to form beautiful grills and the next is a wire mesh grill, that is actually a product of woven steel wires. The grills can be cut into the required shape and can be put into the channels that were used as the frame for the window panes to form the grill part of the window.

The grill can be given a personal tough by customizing the design of the grills by the user itself, thus producing unique grills every time. The possibilities of different types of grills are many, starting from laser cut ones to punched ones to grills of rods and woven wires.

Grills not only protect a house from theft and larceny but also from unwanted small birds and animals coming inside the house.

The grills work in the same way as the window panes. The frame has push locks installed in the extreme right and left side pane. So when the grills are pushed into the slots of the rails, the grills gets locked, thus the chances of grills or panes falling out of the rail frames are not there now.

Thus grill which was a completely separate thing before, can be incorporated with the window, thus reducing the damage to the main wall. The grill part is a separate thing. If one wishes not to install it then the window can be kept as it is.

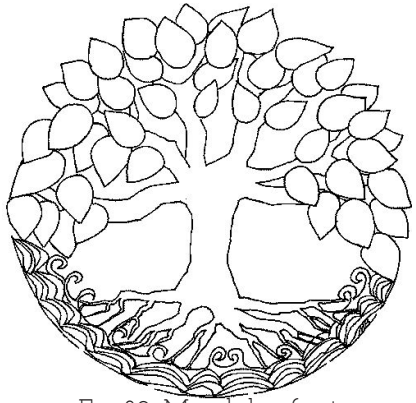


Fig 89: Mandala of a tree
http://mandalasparaimprimir.com/wp-content/uploads/2014/10/Dibujos-de-mandalas-para-imprimir-31.jpg as seen on 14.11.2014

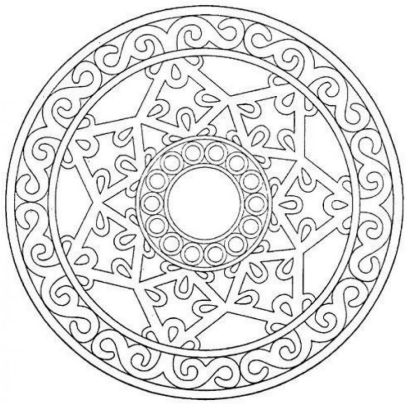


Fig 90: Another mandala pattern
http://images.hellokids.com/img/mandala-20-812l7.jpg as seen on 14.11.2014

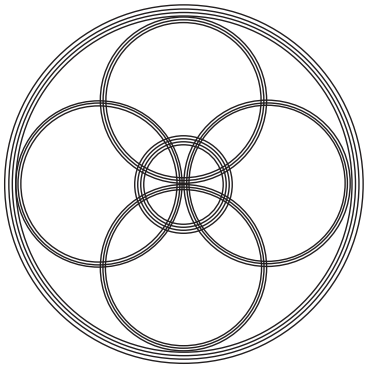


Fig 91: Mandala made using concentric circles

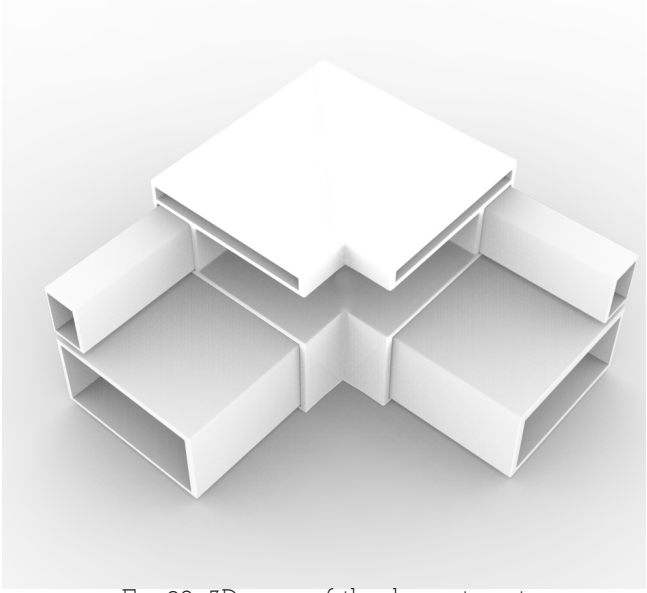


Fig 92: 3D view of the die-cast joint

Aesthetic detailing of the corner joint of window pane

If we observe Fig 91, we can see that the corner detail is pretty mundane and lacking any kind of aesthetic detailing. Fig 89 and 90 shows examples of mandalas. Mandalas are sacred circles and are considered as spiritual and ritual symbols in Hinduism and Buddhism, but the concept can be seen in many cultures across the world.

To treat the corners aesthetically and also give an identity to the window designs as made in India, the corners can be treated with various designs of mandalas or any other patterns. The inside corner of the joint can be extruded a bit more either in the form of an arc or may be in the form of a box and then patterns cut on to the corners according to the mandala designs. Detailing out the corners with mandala pattens is still under progress and I am exploring different details for the same.

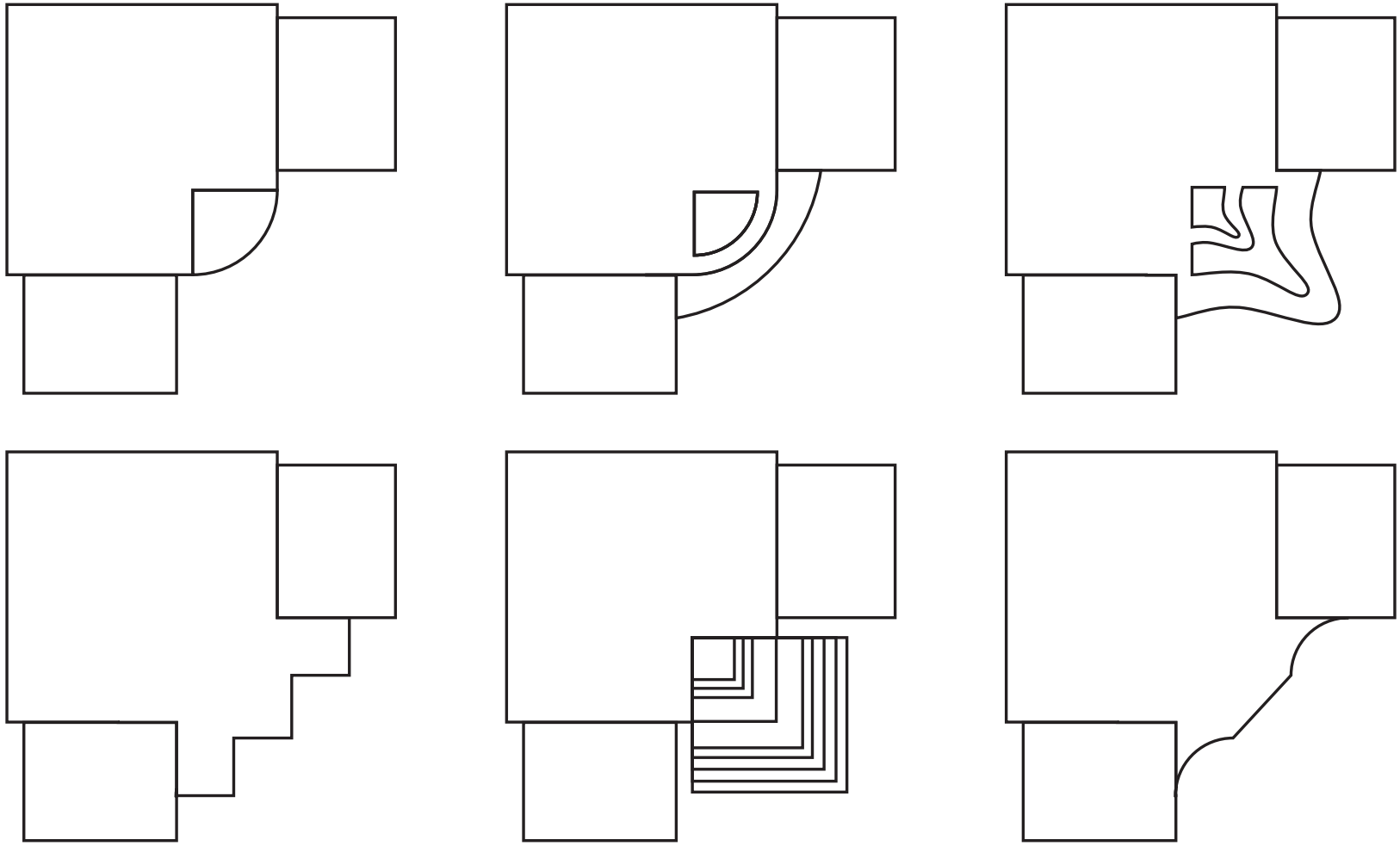


Fig 93: Examples of mandala inspired treatment on the corner joint

Conclusion

The new designed window opens up fully and pristine view of outside can be seen. Can there be a better mechanism to achieve the same? The mechanism can be simplified to make the maintenance more simple.

The design of locks in the window and the various handles used in the window can be looked into. The locks and handles can be re-designed to make it more aesthetic. The mechanism of the locks can also be a area, where the locks can be made more fitted to the new design of the window.

The Channels can be redesigned to make it more sleek and also the FEA analysis of the structure can be done to know the weak areas of the design and make the design of more robust.

References

[1] WIKIPEDIA
Window
In-text: (Wikipedia, 2014)
Bibliography: Wikipedia, (2014). Window. [online] Available at: *http://en.wikipedia.org/wiki/Window* [Accessed 20 Sep. 2014].

[2] SLIDESHARE.NET
Doors and windows
In-text: (Slideshare.net, 2014)
Bibliography: Slideshare.net, (2014). Doors and windows. [online] Available at: *http://www.slideshare.net/animesh91/doors-and-windows* [Accessed 20 Sep. 2014].

[3] REPLACEMENT WINDOWS CONNECT
Fixed Windows | Fixed Frame Window Costs, Pros And Cons
In-text: (Replacement Windows Connect, 2014)
Bibliography: Replacement Windows Connect, (2014). Fixed Windows | Fixed Frame Window Costs, Pros And Cons. [online] Available at: *http://replacementwindowsconnect.com/styles/fixed-frame-windows/* [Accessed 20 Sep. 2014].

[4] REPLACEMENTWINDOWSFORDUMMIES.COM
Double Hung Windows: Advantages and Disadvantages | Replacement Windows for Dummies
In-text: (Replacementwindowsfordummies.com, 2011)
Bibliography: Replacementwindowsfordummies.com, (2011). Double Hung Windows: Advantages and Disadvantages | Replacement Windows for Dummies. [online] Available at: *http://www.replacementwindowsfordummies.com/articles/double-hung-windows-advantages-and-disadvantages* [Accessed 20 Sep. 2014].

[5] REPLACEMENTWINDOWSFORDUMMIES.COM
Slider Windows: Advantages and Disadvantages | Replacement Windows for Dummies
In-text: (Replacementwindowsfordummies.com, 2011)
Bibliography: Replacementwindowsfordummies.com, (2011). Slider Windows: Advantages and Disadvantages | Replacement Windows for Dummies. [online] Available at: *http://www.replacementwindowsfordummies.com/articles/slider-windows-advantages-and-disadvantages* [Accessed 20 Sep. 2014].

[6] REPLACEMENTWINDOWSFORDUMMIES.COM
Casement Windows: Advantages and Disadvantages | Replacement Windows for Dummies
In-text: (Replacementwindowsfordummies.com, 2011)
Bibliography: Replacementwindowsfordummies.com, (2011). Casement Windows: Advantages and Disadvantages | Replacement Windows for Dummies. [online] Available at: *http://www.replacementwindowsfordummies.com/articles/casement-windows-advantages-and-disadvantages* [Accessed 20 Sep. 2014].

[7] REPLACEMENTWINDOWSFORDUMMIES.COM
Double Glazed Windows: Advantages and Disadvantages | Replace

ment Windows for Dummies
In-text: (Replacementwindowsfordummies.com, 2011)
Bibliography: Replacementwindowsfordummies.com, (2011). Double Glazed Windows: Advantages and Disadvantages | Replacement Windows for Dummies. [online] Available at: *http://www.replacementwindowsfordummies.com/articles/double-glazed-windows-advantages-and-disadvantages* [Accessed 10 Oct. 2014].

[8] BUILD
Louvre windows
In-text: (BUILD, 2014)
Bibliography: BUILD, (2014). Louvre windows. [online] Available at: *http://www.build.com.au/louvre-windows* [Accessed 10 Oct. 2014].

[9] REPLACEMENTWINDOWSFORDUMMIES.COM
Bay Windows: Advantages and Disadvantages | Replacement Windows for Dummies
In-text: (Replacementwindowsfordummies.com, 2011)
Bibliography: Replacementwindowsfordummies.com, (2011). Bay Windows: Advantages and Disadvantages | Replacement Windows for Dummies. [online] Available at: *http://www.replacementwindowsfordummies.com/articles/bay-windows-advantages-and-disadvantages* [Accessed 10 Oct. 2014].

[10] SUNLIGHT HOMES
Clerestory Windows - Sunlight Homes
In-text: (Sunlight Homes, 2014)
Bibliography: Sunlight Homes, (2014). Clerestory Windows - Sunlight Homes. [online] Available at: *http://www.sunlighthomes.com/solar/clerestory-windows/* [Accessed 10 Oct. 2014].

[11] DOITYOURSELF.COM
Pros and Cons of Dormer Windows | DoItYourself.com
In-text: (Doityourself.com, 2014)
Bibliography: Doityourself.com, (2014). Pros and Cons of Dormer Windows | DoItYourself.com. [online] Available at: h*ttp://www.doityourself.com/stry/pros-and-cons-of-dormer-windows#b* [Accessed 10 Oct. 2014].

[12] REPLACEMENTWINDOWSFORDUMMIES.COM
Awning Windows: Advantages and Disadvantages | Replacement Windows for Dummies
In-text: (Replacementwindowsfordummies.com, 2011)
Bibliography: Replacementwindowsfordummies.com, (2011). Awning Windows: Advantages and Disadvantages | Replacement Windows for Dummies. [online] Available at: *http://www.replacementwindowsfordummies.com/articles/awning-windows-advantages-and-disadvantages* [Accessed 10 Oct. 2014].

[13] ANON
In-text: (Anon, 2014)
Bibliography: Anon, (2014). [online] Available at: *http://www.jindalaluminium.com/catalog/aluminium/21)%20SLIDING%20WINDOW%20SECTIONS.pdf* [Accessed 10 Oct. 2014].

[14] ANON
In-text: (Anon, 2014)
Bibliography: Anon, (2014). [online] Available at: *http://metlspan.com/wp-content/uploads/2012/03/HollowMetalDoorWindowTechBullfinalJul081. pdf* [Accessed 10 Oct. 2014].

[15] ARCHITECTURE AND DESIGN
Timber versus aluminium
In-text: (Architecture And Design, 2008)
Bibliography: Architecture And Design, (2008). Timber versus aluminium. [online] Available at: *http://www.architectureanddesign.com.au/news/industry-news/timber-versus-aluminium* [Accessed 10 Oct. 2014].