i) State the problem:

Construct an innovative and aesthetic piece of façade of exactly 30 x 30 cm – assume it is for a London location. The design must consider the fact that a façade needs to be the *lightest* and that is weathertight (and it's thermal performance, such as effects on rain and wind).

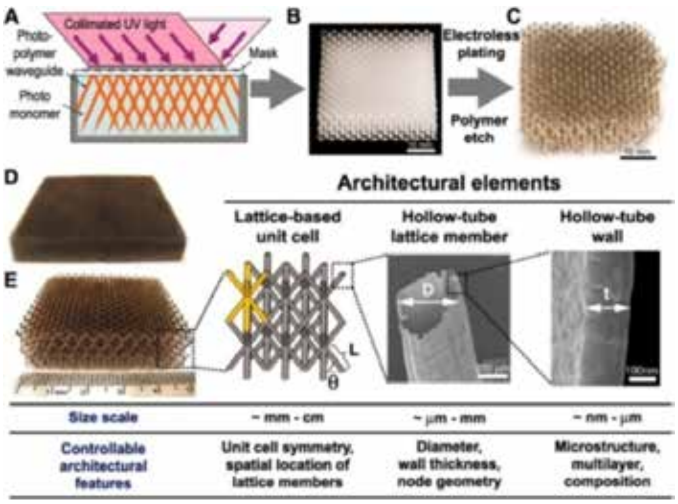
ii) Gather information:

i) Lightest
ii) High thermal performance
iii) Weathertight
iv) Aesthetic
v) Location and type of façade

Lightest Materials – Micro Lattice

The new nickel-phosphorus lattice is as light as a feather, © HRL Laboratories, LLC/Photo by Dan Little

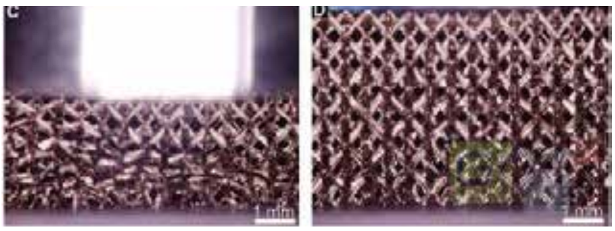
The metal-based microlattice structures are significantly less dense than the rarest aerogels and other ultralight foams, while exhibiting high strength and an unexpectedly high ability to absorb energy and recover shape after compression.



The materials could find use in a range of applications, from aircraft structural components to acoustic damping and shock absorption.

The microlattice, created by a team led by Tobias Schaedler of HRL Laboratories in Malibu, consists of a highly controlled, ordered network of interconnected hollow struts made from a nickel-phosphorus alloy. In the prototype sample, the struts are around 100 μm in diameter with walls around 100nm thick.

To create the structure, a polymer template is first produced by placing a mask patterned with circular holes over a reservoir of a photosensitive thiol-ene monomer. UV light is shone on the mask and where the light meets the monomer it polymerises it. 'The structure is so fine that it is 99.99 per cent air,' says Schaedler, and around 10 per cent less dense than the lightest aerogels - just 0.9mg/cm^3. Intriguingly, the microengineered structure has remarkably different properties from the bulk alloy. "The lattice can be compressed to half its volume but still springs back into its original shape".



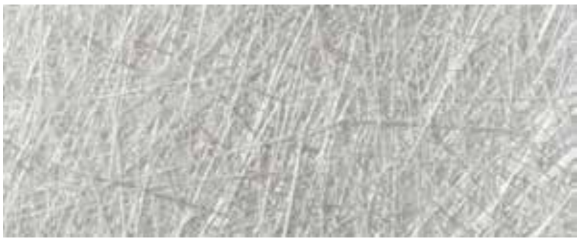
Micro Lattice, RSC = http://www.rsc.org/chemistryworld/news/2011/november/17111103.asp

Lightest Material – Glass Fibre vs. Carbon Fibre

Glass Fibre

Glass fiber (also spelled glass fibre) is a material consisting of numerous extremely fine fibers of glass.

Glass fiber is commonly used as an insulating material. It is also used as a reinforcing agent for many polymer products; to form a very strong and light fiber-reinforced polymer (FRP) composite material called glass-reinforced plastic (GRP), popularly known as "fiberglass". Glass fiber has roughly comparable properties to other fibers such as polymers and carbon fiber. Although not as strong or as rigid as carbon fiber, it is much cheaper and significantly less brittle.



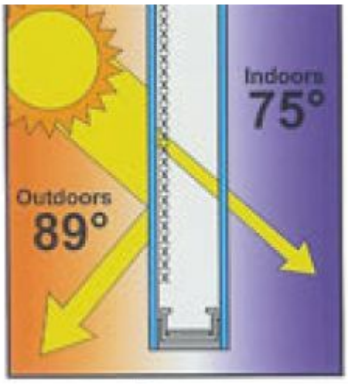
Carbon Fibre

Carbon in the form of graphite is soft, slippery and easily broken. But very thin filaments of carbon are very stiff. These carbon fibres are useful for reinforcing other materials to make them tougher. They are embedded in strong plastics to make composite materials. These are usually very strong but lightweight, so they are used for skateboards, boat hulls and high performance sports equipment.

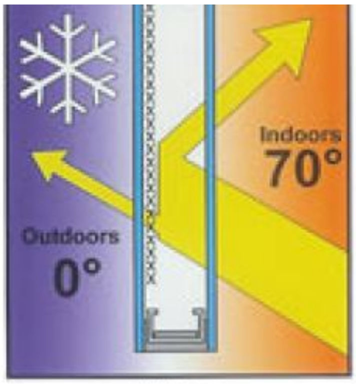
Example: Kevlar

Kevlar® is a very strong artificial fibre. It is woven to make a material that is used for light and flexible body armour. It is strong and tough because:
its molecules can pack closely together
there are chemical bonds between adjacent molecules

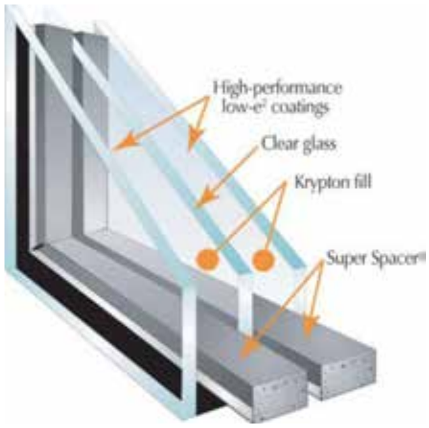
High Thermal Performance – Glass Block



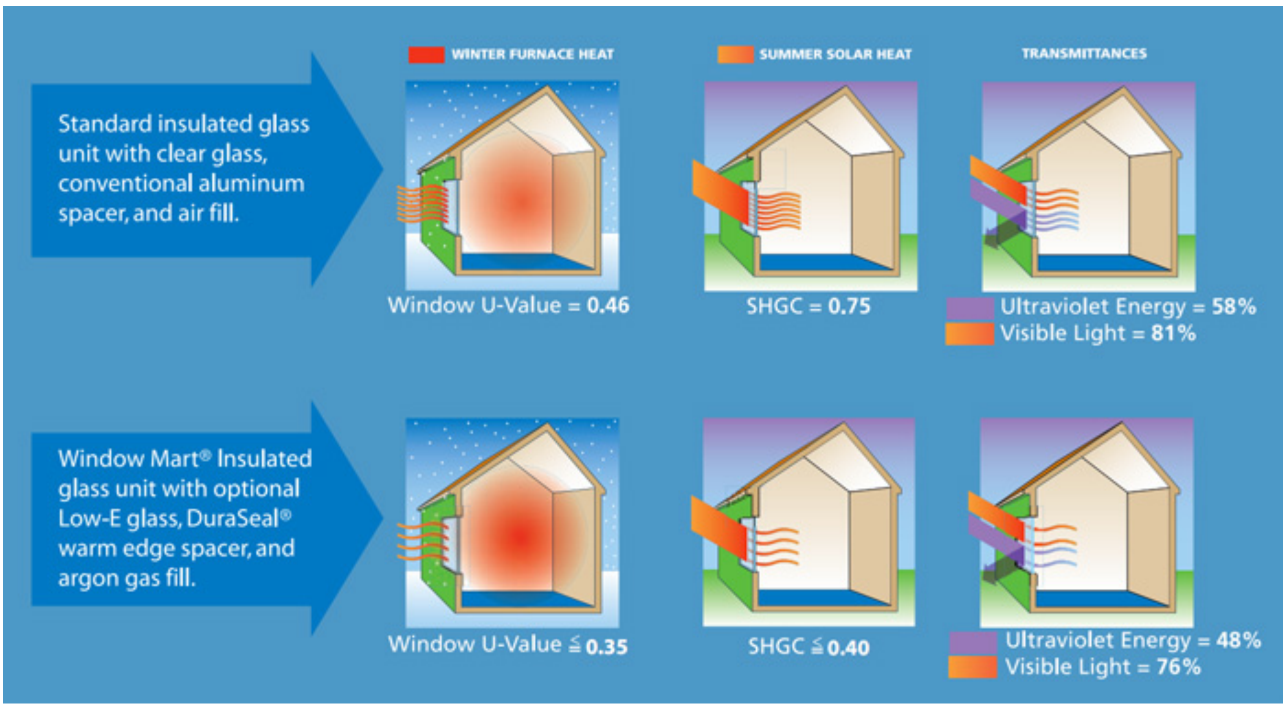
Summer



Winter

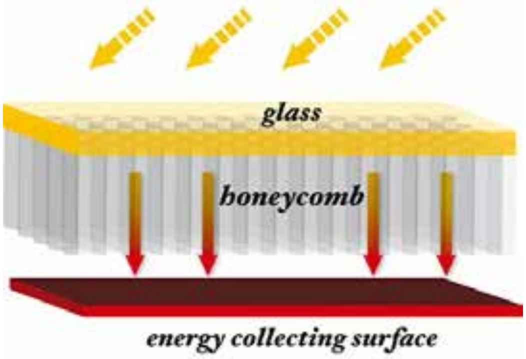


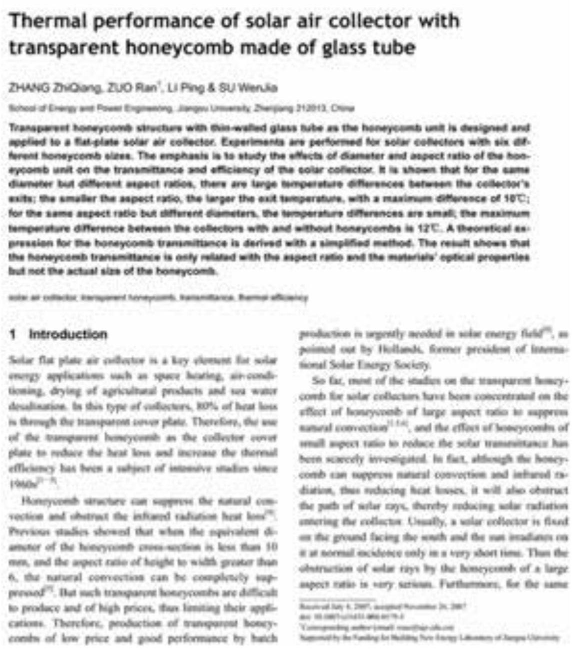
Different layers



High Thermal Performance – Honeycomb Collector

On the surface of the Honeycomb Collector is a proprietary "transparent insulation technology", shaped like a honeycomb, which allows sunlight to pass through to heat the collecting surface while suppressing heat losses from convection and conduction at the same time. This design is said to be very energy-efficient, enabling the sun's energy to easily enter the collector while keeping energy losses to a minimum, even with large temperature differences between the ambient air and that inside the collector itself.





Thermal performance of solar air collector with transparent honeycomb made of glass tube

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Transparent honeycomb structure with thin-walled glass tube as the honeycomb unit is designed and applied to a flat-plate solar air collector. Experiments are performed for solar collectors with six different honeycomb sizes. The emphasis is to study the effects of diameter and aspect ratio of the honeycomb unit on the transmittance and efficiency of the solar collector. It is shown that for the same diameter but different aspect ratios, there are large temperature differences between the collector's exits; the smaller the aspect ratio, the larger the exit temperature, with a maximum difference of 10℃; for the same aspect ratio but different diameters, the temperature differences are small; the maximum temperature difference between the collectors with and without honeycombs is 12℃. A theoretical expression for the honeycomb transmittance is derived with a simplified method. The result shows that the honeycomb transmittance is only related with the aspect ratio and the materials' optical properties but not the actual size of the honeycomb.

solar air collector, transparent honeycomb, transmittance, thermal efficiency

1 Introduction

Solar flat plate air collector is a key element for solar energy applications such as space heating, air-conditioning, drying of agricultural products and sea water desalination. In this type of collectors, 80% of heat loss is through the transparent cover plate. Therefore, the use of the transparent honeycomb as the collector cover plate to reduce the heat loss and increase the thermal efficiency has been a subject of intensive studies since 1960s[1–5].

Honeycomb structure can suppress the natural convection and obstruct the infrared radiation heat loss[6]. Previous studies showed that when the equivalent diameter of the honeycomb cross-section is less than 10 mm, and the aspect ratio of height to width greater than 6, the natural convection can be completely suppressed[7]. But such transparent honeycombs are difficult to produce and of high prices, thus limiting their applications. Therefore, production of transparent honeycombs of low price and good performance by batch production is urgently needed in solar energy field[8], as pointed out by Hollands, former president of International Solar Energy Society.

So far, most of the studies on the transparent honeycomb for solar collectors have been concentrated on the effect of honeycomb of large aspect ratio to suppress natural convection[1,14], and the effect of honeycombs of small aspect ratio to reduce the solar transmittance has been scarcely investigated. In fact, although the honeycomb can suppress natural convection and infrared radiation, thus reducing heat losses, it will also obstruct the path of solar rays, thereby reducing solar radiation entering the collector. Usually, a solar collector is fixed on the ground facing the south and the sun irradiates on it at normal incidence only in a very short time. Thus the obstruction of solar rays by the honeycomb of a large aspect ratio is very serious. Furthermore, for the same

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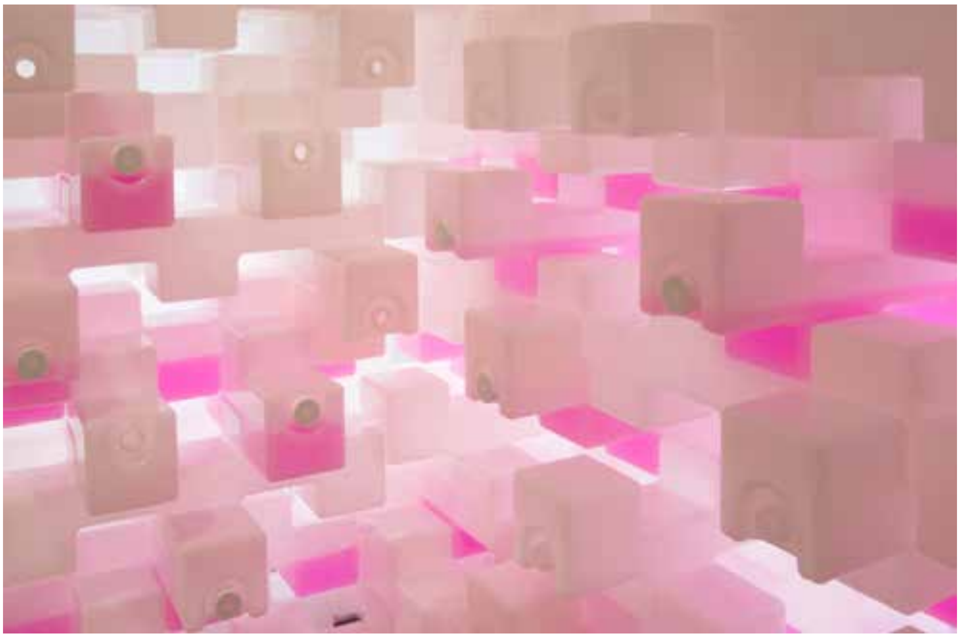
http://www.treehugger.com/solar-technology/honeycomb-solar-hot-water-heater-promises-higher-efficiency-lower-cost.html

Weather tight – Kengo Kuma's Waterbranch House



Water block is a piece of plastic tank. By piling them up, you can build anything from furniture to a house. It is very light and easy to carry around. Water or other types of liquid can be stored inside. It is in the shape that each cube of 100×100mm is connected staggeringly so they can be turned into a variety of shapes. Furthermore, it can form a strong structure by joining its concave and convex firmly.

The weight of Water Block can be adjusted by the volume of liquid that you pour inside, and it also can be used as a safe to keep the water for emergency. By connecting the pieces, liquid can flow into the next block and run around within the tanks. By doing so, Water block can function not only as a structure but also as many other roles:

- Thermal insulation
- Network wiring
- Filtering by concave and convex, water purification system with precipitation tank
- Absorbing shock with its soft material
- Lighting equipment
- Storing rainwater
- Greening of wall and floor
- Change its role by the thing you put inside (such as mud, sand, concrete, opaque liquid, etc.)
- Hydroelectric generation

Moreover, Water block is a trial case of using PET, the Hydro/Biodegradable polyester that can eventually go back to the ground. If it is successful, a new sustainable recycling system will be realized that takes the route from a container, to construction material, and to soil.

weblink: http://kkaa.co.jp/works/water-branch-house/

Aesthetic – ARUP Marketing Suite

Architect: Camlins and Woods Bagot Engineer: ARUP Associates Client: Ballymore Group
Date: 1st September 2012 Building component: opaque glass facade
Material Study:
The first goal here is to improve thermal mass while reducing weight and depth. This will need cheap (not there yet) phase change particles embedded in thin plasterboard. Or with exposed, very efficient concrete located at ceiling level. The target? Lightweight, prefabricated, opaque fac¸ades that are easy to install and to reuse and that behave thermally as heavy massive walls. We only have to cross the cost threshold, and we can do that using existing materials and aggregates.

iii) State Purpose of the Project

Transparent thermal insulation functions only in conjunction with glass or acrylics, which protects the insulation from the weather, and thanks to its transparency, admits daylight and especially solar radiation. Inside the building the light is converted into the heat and contributes to the space-heating requirement. In addition, transparent thermal insulation reduces heat losses from inside to outside and therefore functions as a thermal insulation. In contrast to the majority of customary insulating products, this material also very frequently remains visible from the outside behind a pane of glass. Transparent thermal insulation elements are also permeable to wavelengths of the solar spectrum other than visible light.

Construction

- Protective layer of glass
- Layer of insulation
- Protective layer of glass

There are three principal forms gradually appeared in the evolution of applications for transparent thermal insulation. These can be distinguished according to the way in which the solar energy is used:

i) Direct gain system:
The transparent thermal insulation is employed as an enclosing element without any wall behing. It is therefore light permeable. The solar radiation passes through the transparent thermal insulation directly into the interior. The interior temperature changes almost simultaneously with the temperature of the surfaces.

ii) Solar Wall:
The incident of solar radiation is converted into heat on the outside face of a solid externl wall. Controlled by the insulating effect of the transparent thermal insulation material.

iii) Thermally decoupled system:
In the thermally decoupled system the incident solar radiation is concerted into heat at an absorber surface isolated from the interior. The heat is fed either directly into the interior via a system of ducts, or into a heat storage medium, which can be a part of the building itself (i.e. hollow floor slab or double leaf wall), or part of the building services (i.e. pebble bed or water tank). With thermally isolated storage media the release of heat into the interior can be controlled irrespective of the absorber or storage temperature.

When gathering information, I have specified 5 key points that influence my design, I want a façade that is as light as possible, a good insulator, weathertight, aesthetically pleasing and it's adequate location. Leading to the idea of using: acrylic (polyporpelene, such as straws, since they are extremely light and can potentially serve as honeycomb insulators), I will add air or any noble gas in the chamber of the straw to make it as insulated as possible, the straws will be transparent – making an opaque light performance and lastly, it serves as a wall.






iv) Hypothesis

By considering the *criterias* to generate a 30 x 30 facade sample:

- Lightest
- Weathertight
- Thermal performance
- Aesthetics
- Location

Recycling
Using straws (for pearl bubble tea straws), they are straws that have a diameter between 9mm to 12mm. Most of these are used in many populous asian cities and metropolis. Millions of them are consumed every day. So it should be wise to use them as a tool to create a lightweight facade.

Lightest
Straws will be used, as they are fairly light, and can serve as closed chamber, acting as honeycomb collection. The only difference of it is that is a recycling process.

38 grams for 100 pieces. 1 piece = 0.38 gram

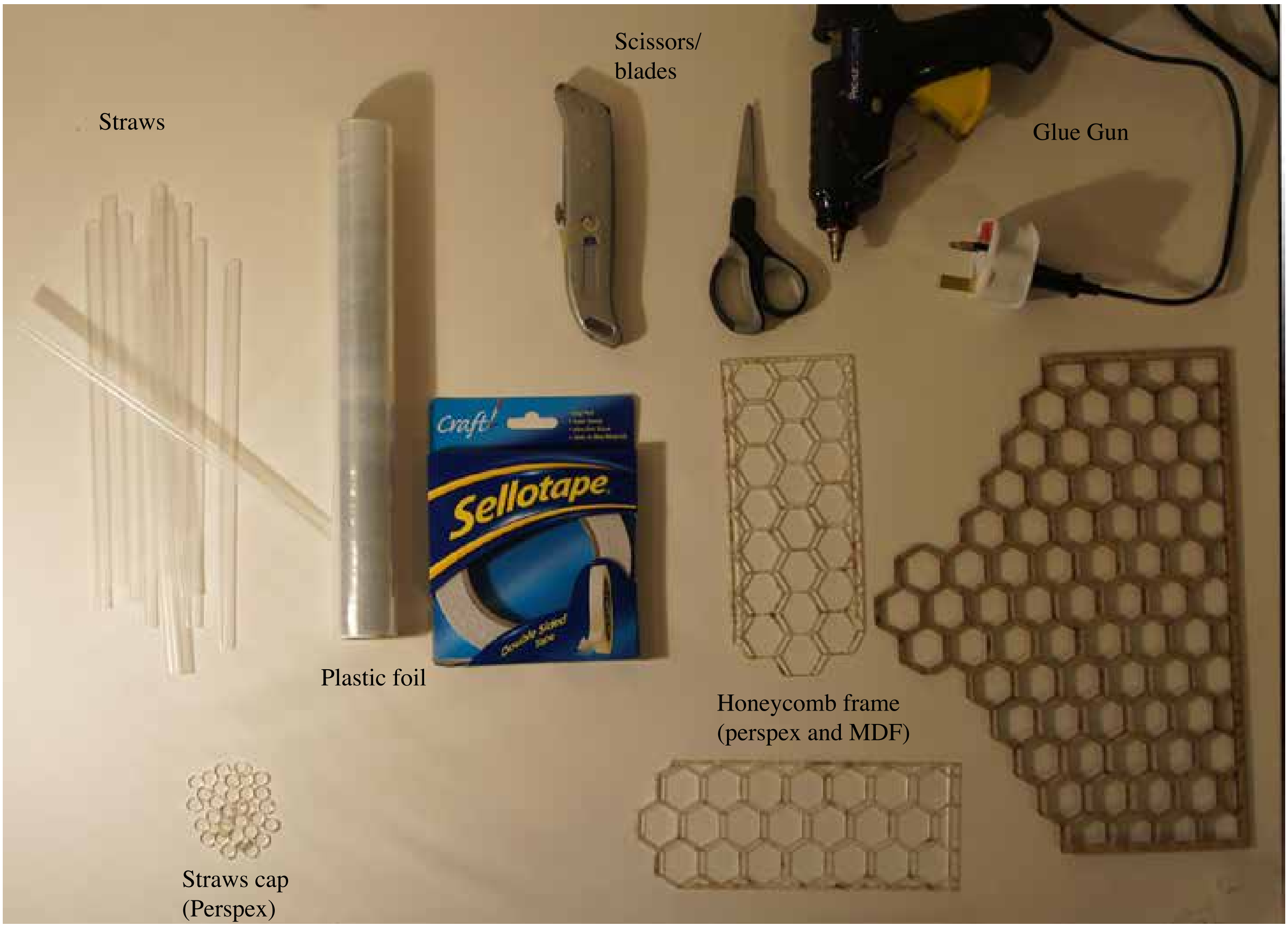
Weathertight
The way I will interlock them is by following a honeycomb pattern. Made of perspex 3mm thickness. As they are structurally strong and they serve as firm joints for the straws to pass through. This will make it weathertight as possible.
Secondly, it is very easy and practical to construct. You do not need glue, just straws and the honeycomb frame.

Thermal performance
The straws will be sealed by a cap, to isolate the air, as acts similarly as the glass block.

Aesthetics
The perspex where the straws will be inserted, is through the honeybomb frame, Which will be seethrough, in order to allow as much radiation as possible. The straws will be seethrough simultaneously.

Location
Can be applied to any location in London, as it is resistant to rain, wind and radiation.

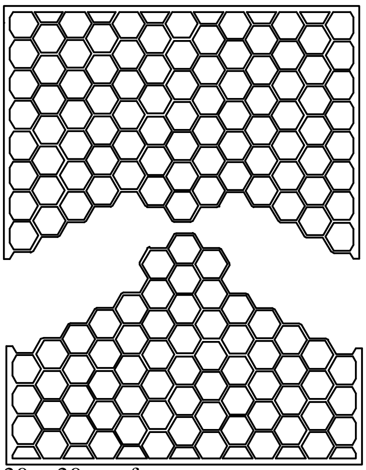
v) Equipments



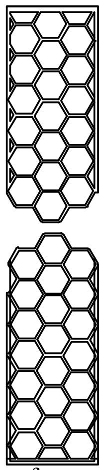
Formal list of the required equipments to construct the facade:

- 9mm diameter straws
- 8.8mm diameter perspex caps
- Muji Plastic Foils (better quality)
- Double sided tape
- Scissors
- Glue gun
- types of frames: Honeycomb in MDF and perspex

Layout of the two types of frames, which will be used in a different order:



30 x 30 cm frame



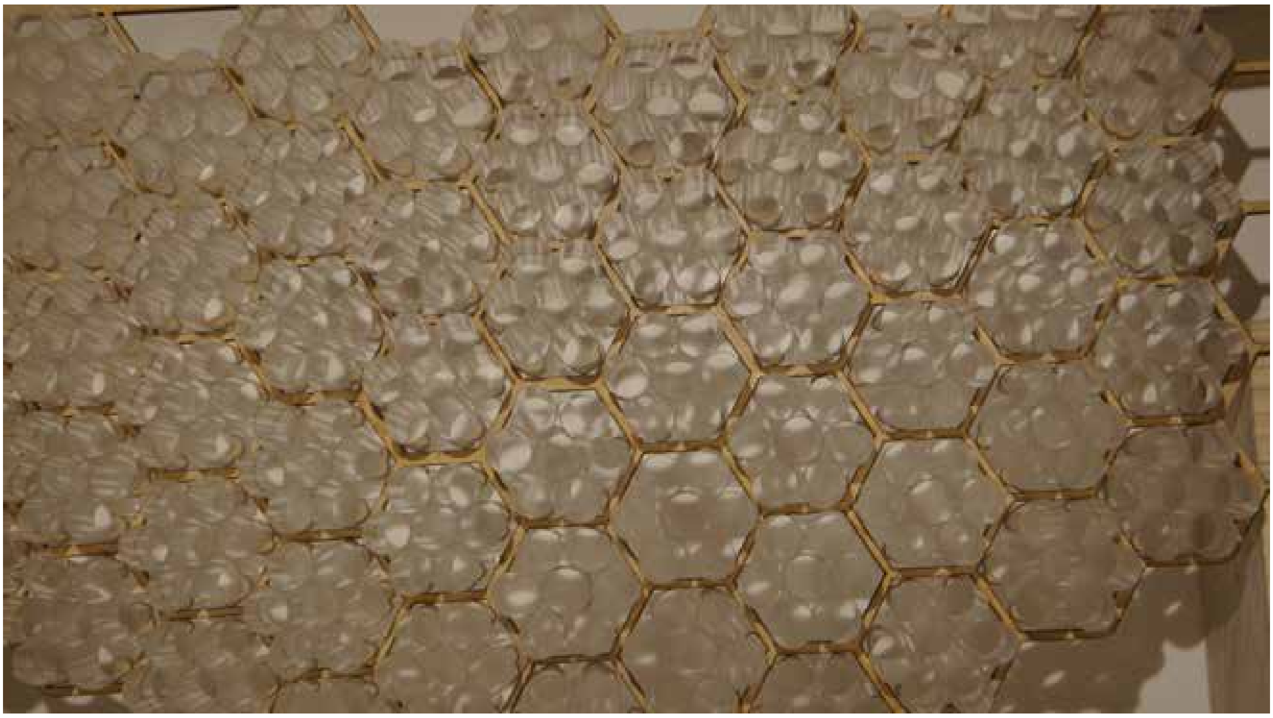
30 x 7 cm frame

vi) Producing the sample 1

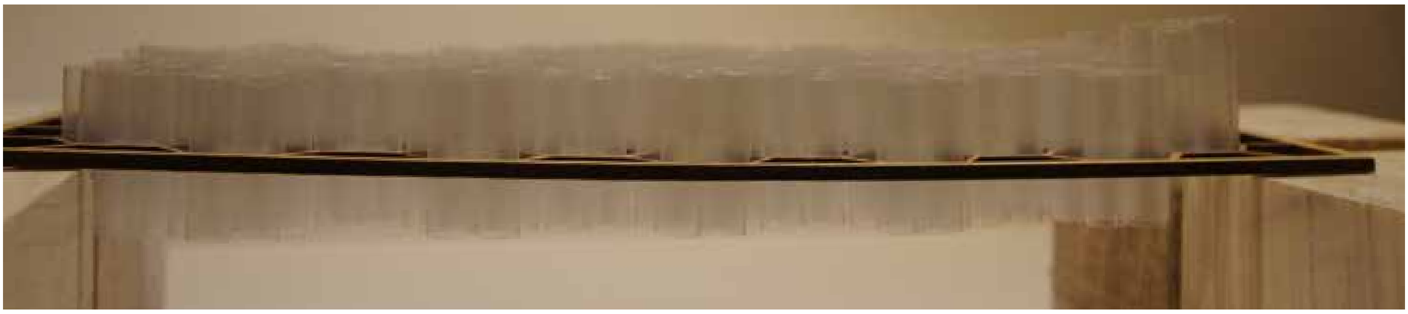
Wrapping the plastic foil

Preparing the straws

Wrapping the plastic foil and applying glue gun.



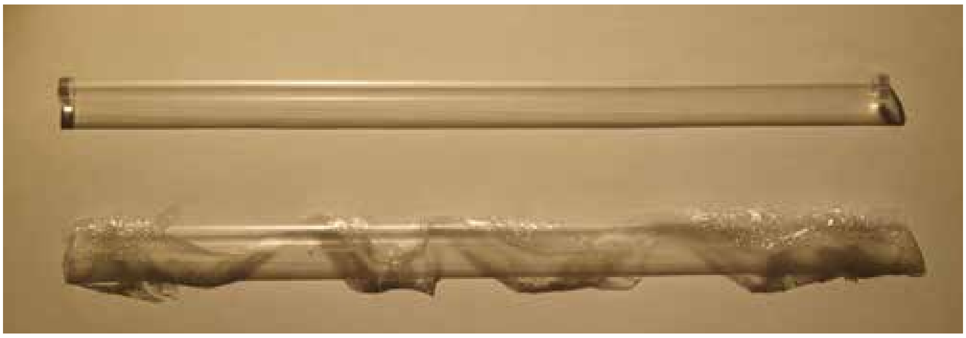
Top View honeycomb



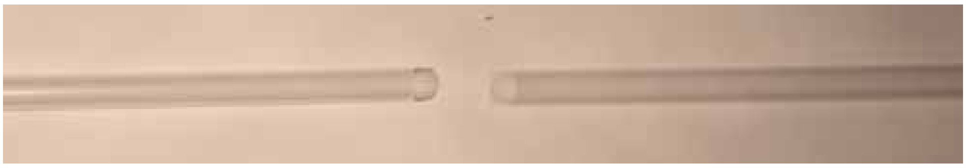
Elevation of the honeycomb

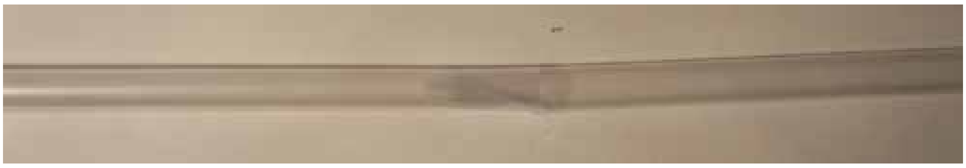
v) Producing sample 2

Testing how
to cap the straw

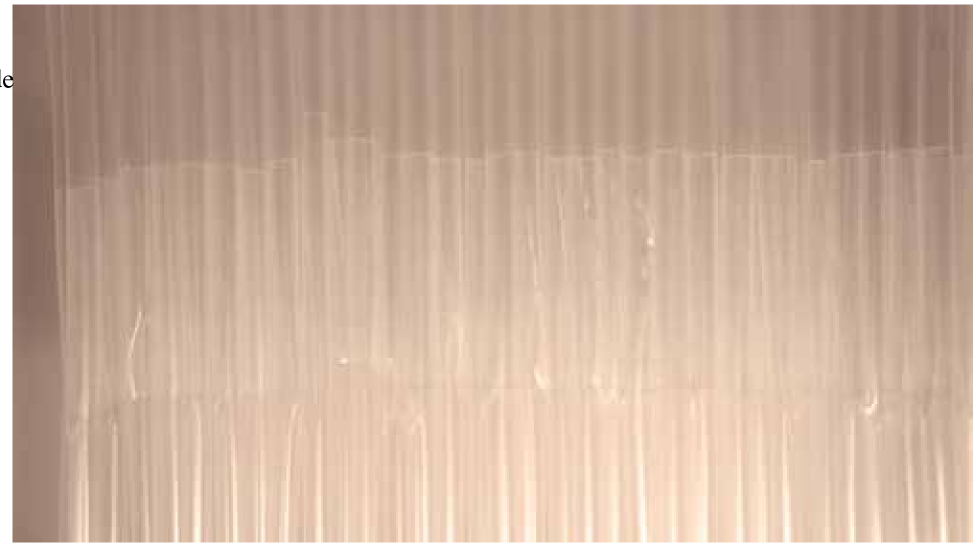


Capping the straw
without any glue



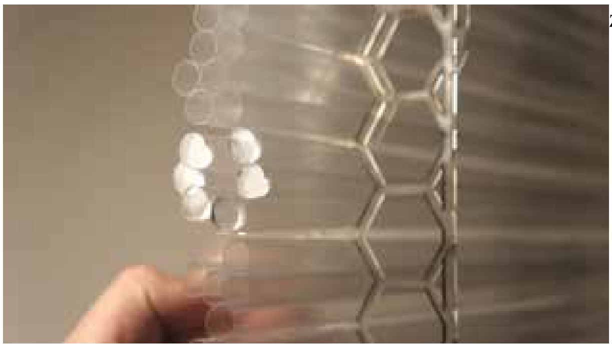


Completing the
first layer of the facade



Placing 6 straws in every honeycomb ring (make sure its tight and that it doesnt slip easily)

Applying the 88mm perspex cap, for insulation:

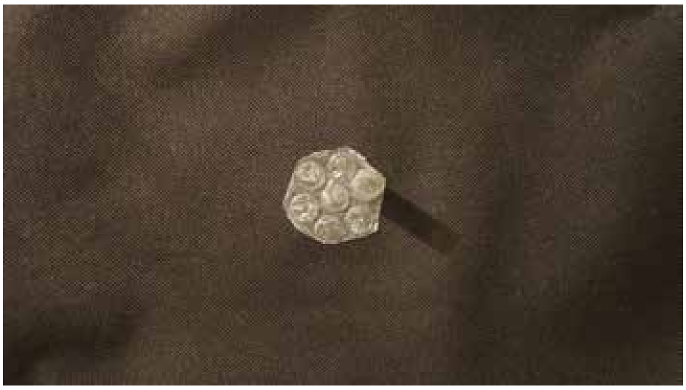


Do the same and apply in the same horizontal honeycomb rings.

vi) Experiment: Glueing

Failed types of glue for the straws

More successful types of glue for the straws



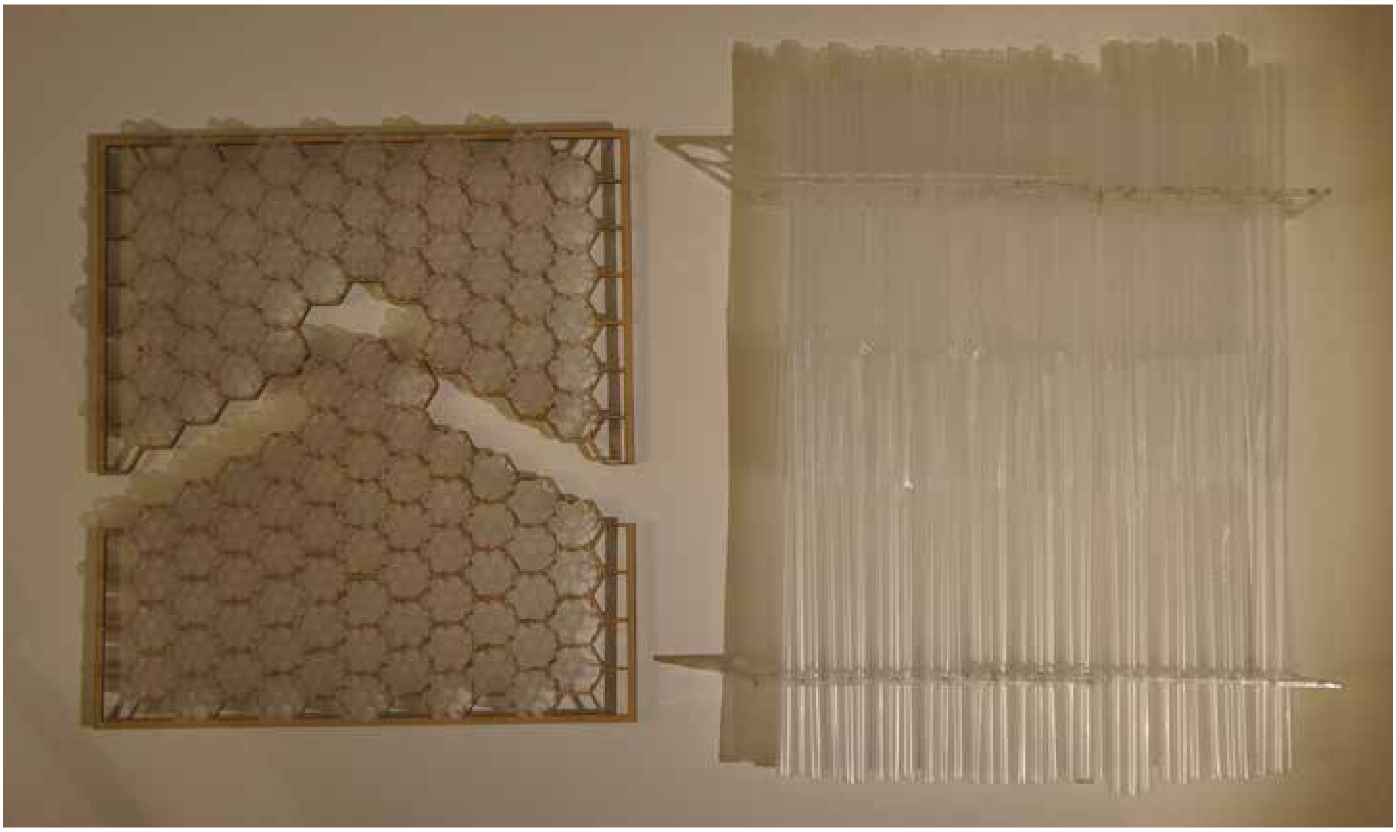
Successful way of glueing:

1) Use double sided tape to join all of the pieces together. Make the strip as thin as possible.

2) Apply glue gun on the surface of the straws cylinder and do not let it cool before applying the plastic foil.

3) make sure the glue in the glue gun is applied on all the surfaces of the straw, immediately and delicately apply foil to cover the hole.

vii) result



SAMPLE 1

Advantages

- Aesthetically pleasing
- very innovative
- produces a very organic honeycomb pattern
- highly insulative
- highly weathertight
- easy to construct and deconstruct
- very light by using MDF and cutting the straws by 4 cm of height.
- lighter than sample 2

Disadvantages

- takes longer to do compared to sample 2

SAMPLE 2

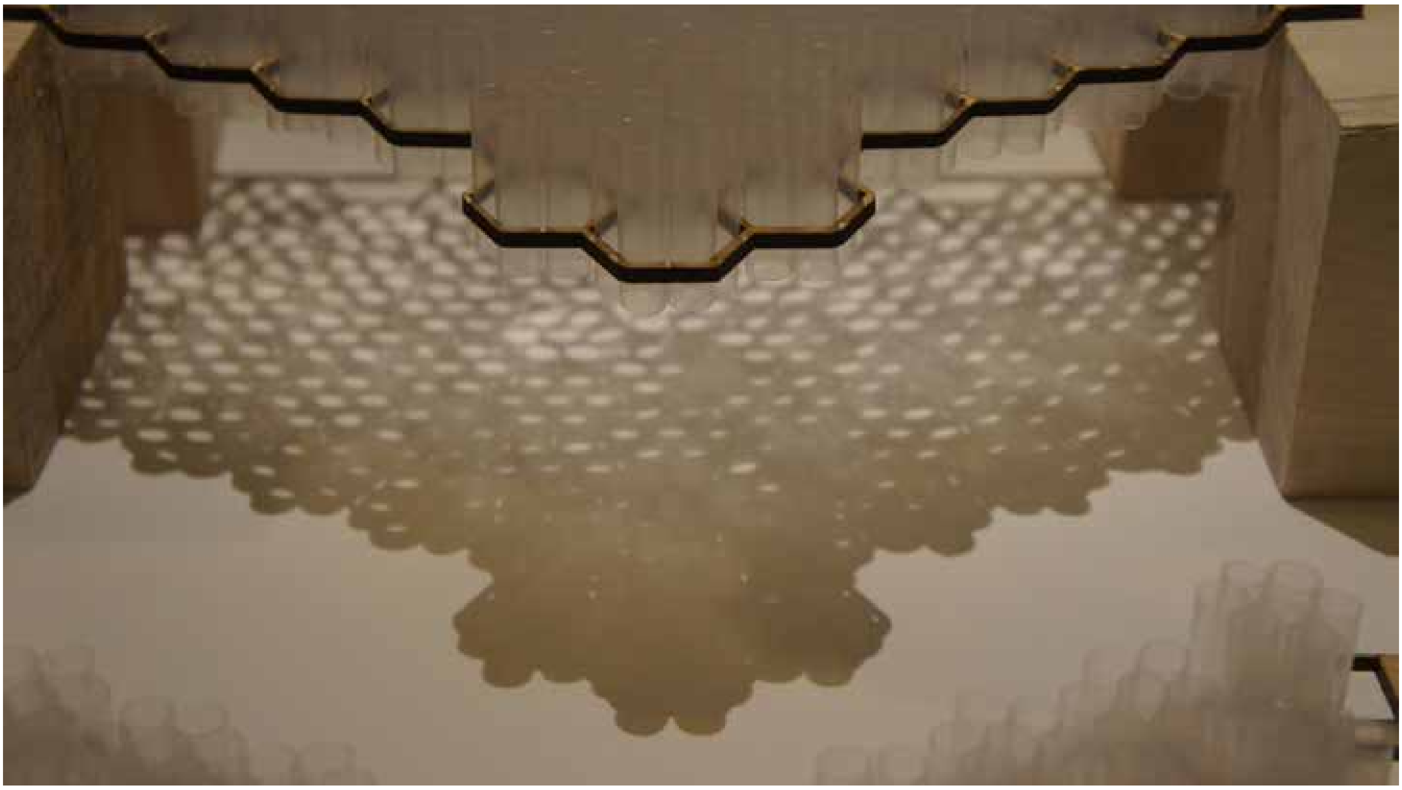
Advantages

- quicker to construct compared to sample 1
- very light
- innovative
- weathertight

Disadvantages

- not aesthetically pleasing, but more practical.

viii) Aesthetic Photographs



Final Lightweight Facade