assignment 2.material case study.

aaron.gahr. arch6231. quale.

introduction.springtecture b.

introduction.springtecture b.

southestern view.

shuhei endo.

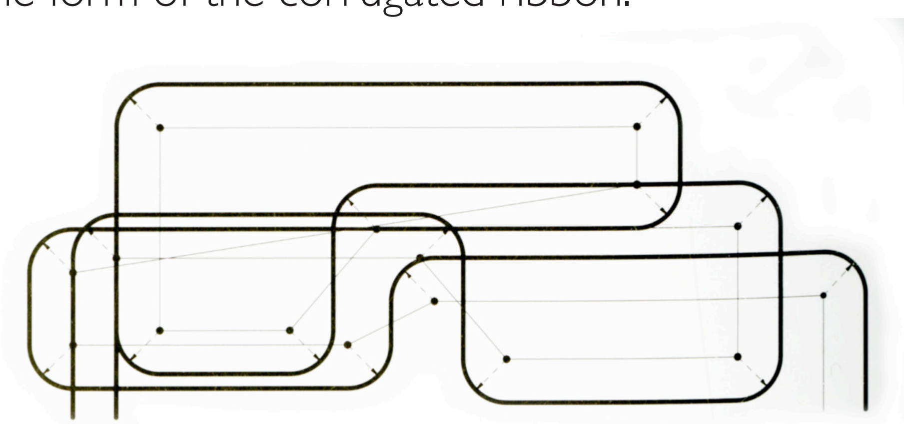
springtecture b shown from two opposing views to show the overall form of the building along with showing the connection to its landscape, both near and far..

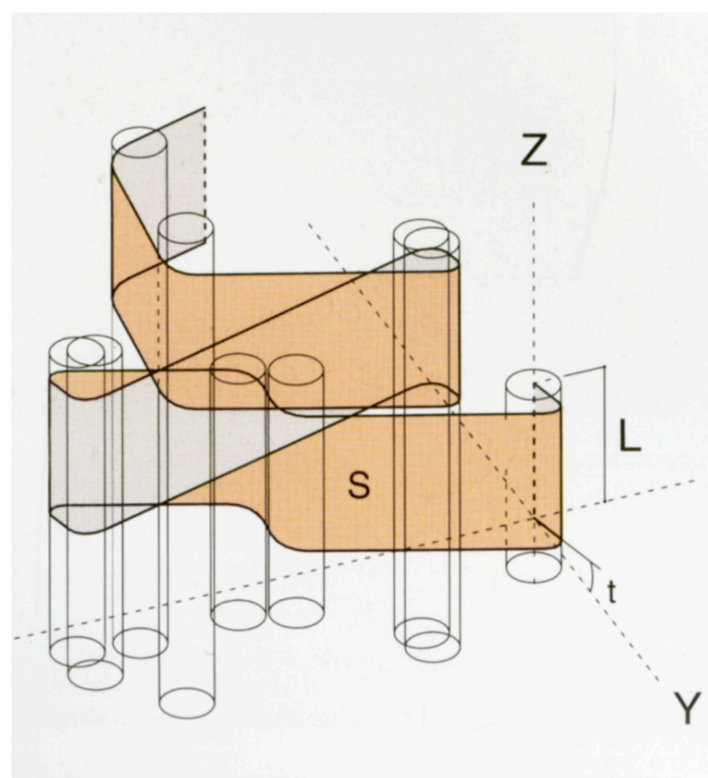
northwestern view.

springtecture b is a structure that tries to blur the line between what one would typically believe is an exterior or exterior space, and through architect shuhei endo's use of corrugated steel strips he is able to achieve continuous interior and exterior space. shuhei endo is a progressive modern architect that while relatively unheard of in the united states is well known in japan for his creation of buildings that express a sense of freedom and lightness that's not found in other designs (paramodern architecture, p.7). some of his other works are cyclestation m, rooftecture s, springtecture s and halftecture h. springtecture b was constructed from 2001-2002 and is located in biwa-cho, shiga japan, and serves as a vacation home and office. in many, if not all of his current works, shuhei endo uses corrugated steel sheets to construct the outer skin of his buildings. this material contains several properties that he sees as favorable in design. corrugated steel sheets are an inexpensive material that is easy to work with and requires little skilled labor. along with affordability it is also a material that can be broken down, added upon to, and easily recyclable when the lifespan of the building has come to an end (takahasi, p.127). in order to create spaces of habitation inside the structure masonry walls are placed along the axis of the coiled skin. these walls break the space to create a bedroom, bathroom, dinning room, kitchen, rest space, gallery, entrance, parking and multiple terraces.

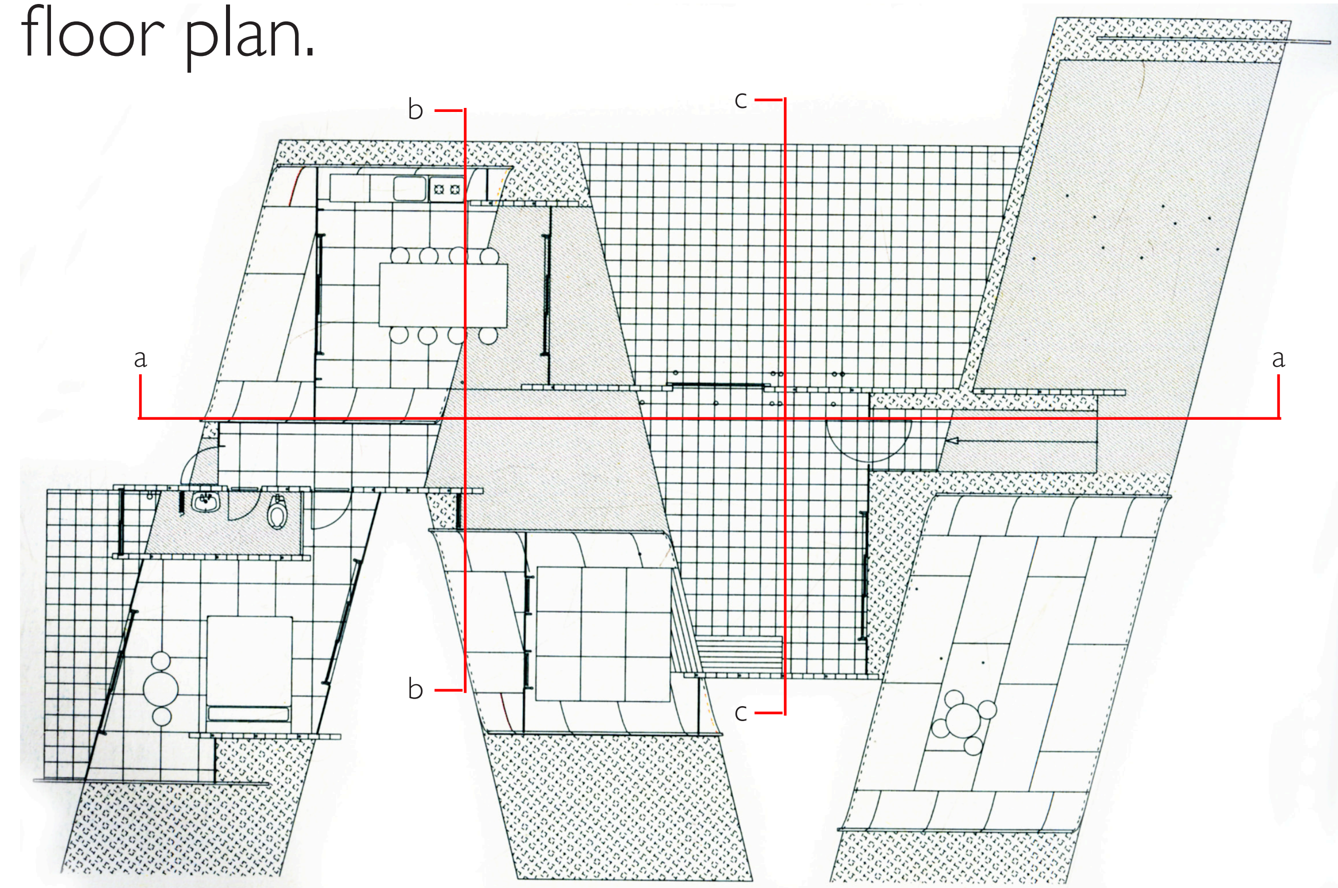
the site that springtecture b is located on is relatively small, containing a building of only 1,120 square feet (mcleod, p.128). the building is located in the middle of an agricultural area covered in rice fields and a mixture of thatched roof buildings and modern equivalents (takahasi, p.125). openings and alignment of the building are designed to frame views of the surrounding area in order to connect it to the japanese landscape. while much of the site is flat and surrounded by very few trees there is a small pool located at the southeast end of the site. the folds of the building stretch out over top of the pond and appear to just barely grave the surface of the water

Above depicts the relation of biwa-cho, shiga to japan. located towards the southern half of the country this area sees fairly low average yearly temperatures of roughly 60F. to the left are a series of plans, sections, and a diagram that depicts the form of the corrugated ribbon.

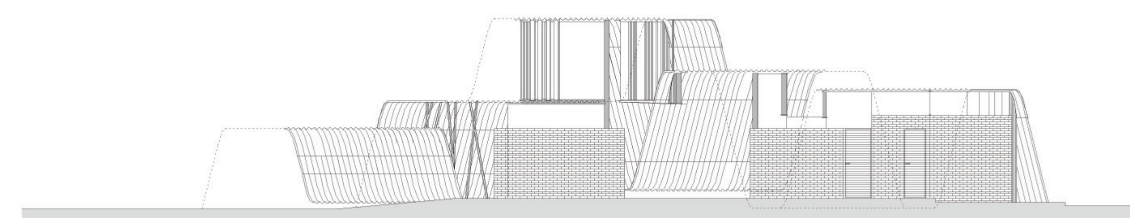




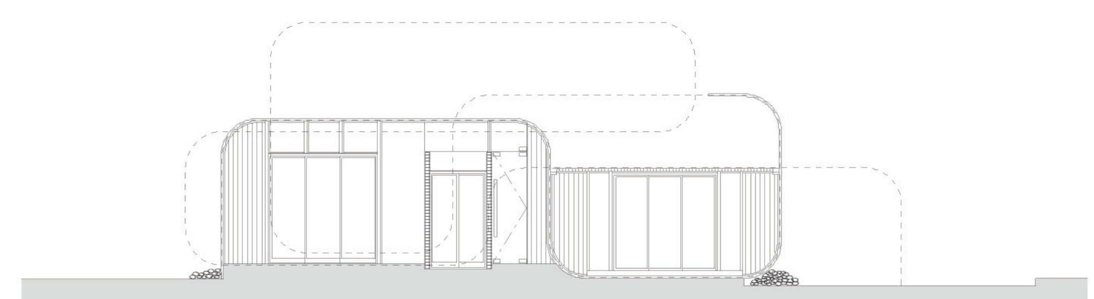
floor plan.



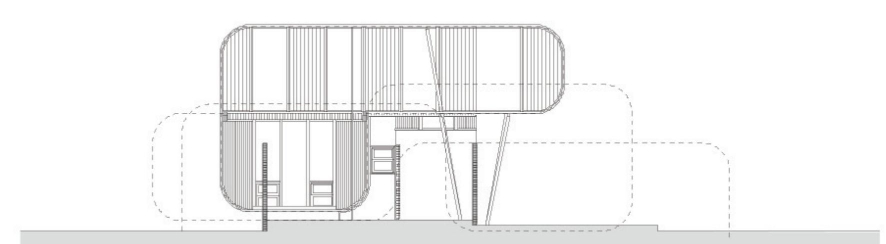
section a-a.



section b-b.



section c-c.

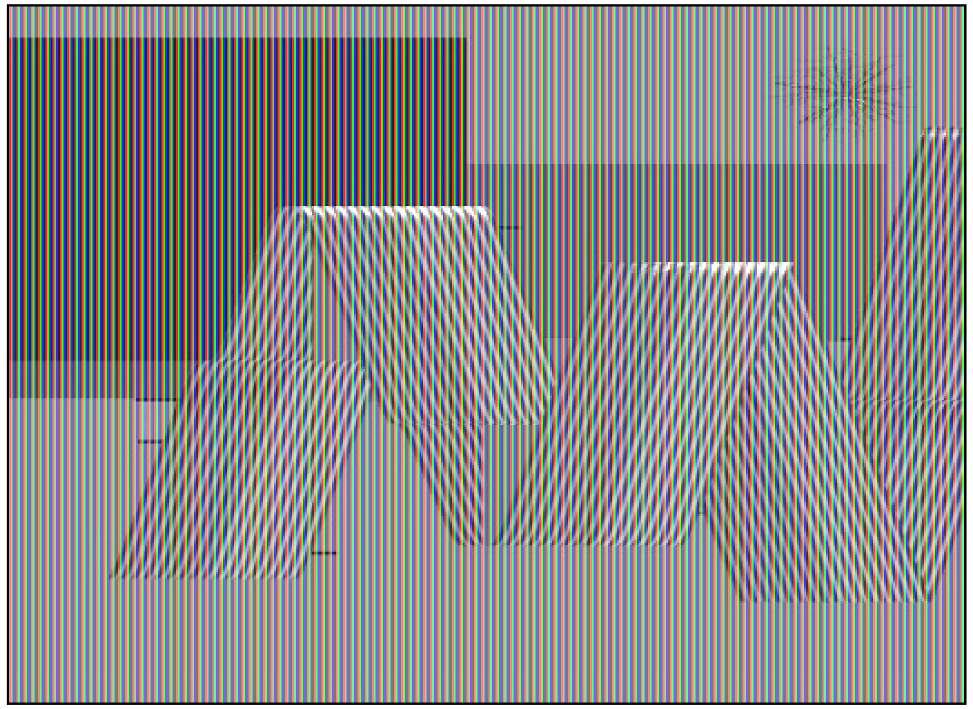


3d model.sun animations.construction.

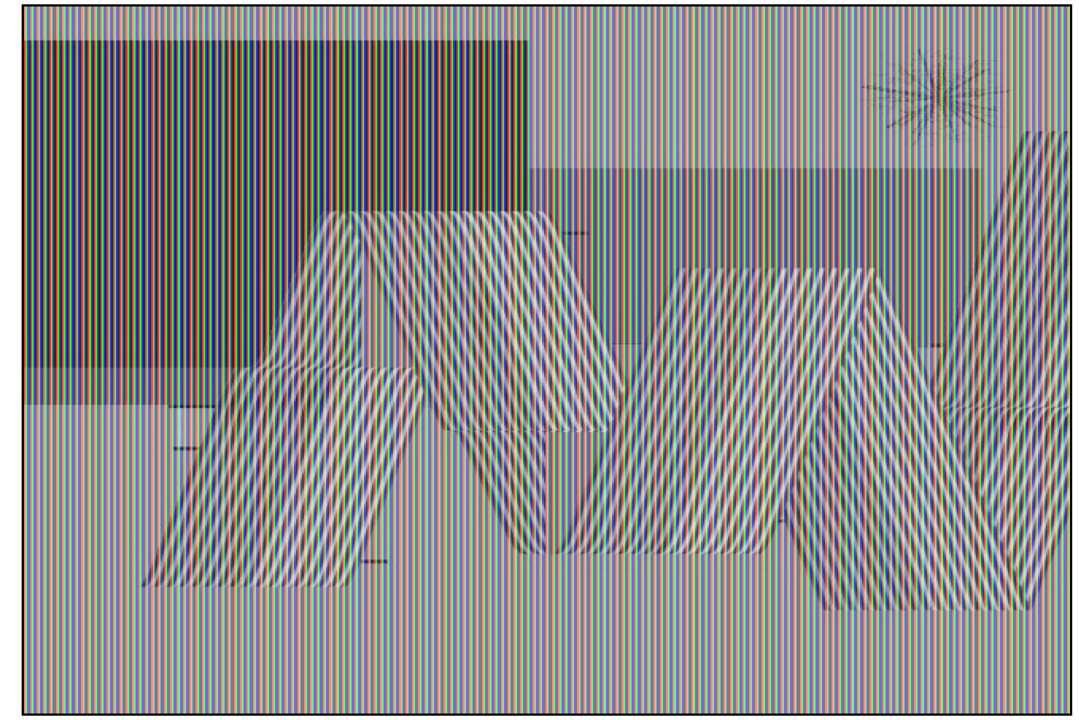
sun animations.

top view.

solstices.

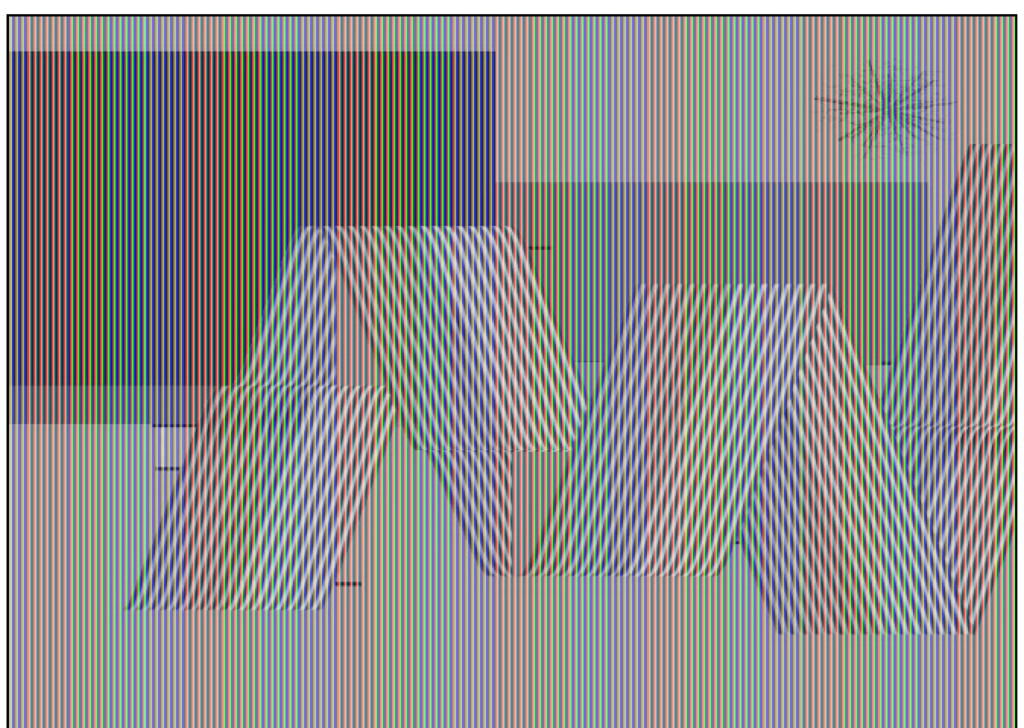


june 21, 2010

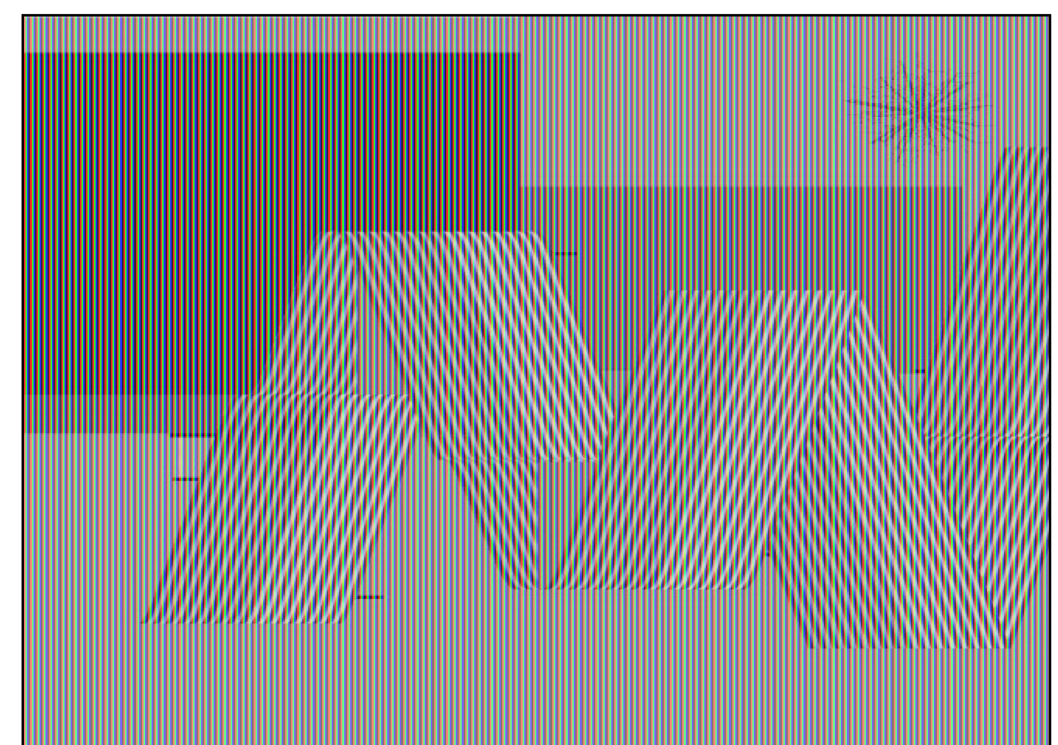


december 21, 2010

equinoxes.



march 21, 2010



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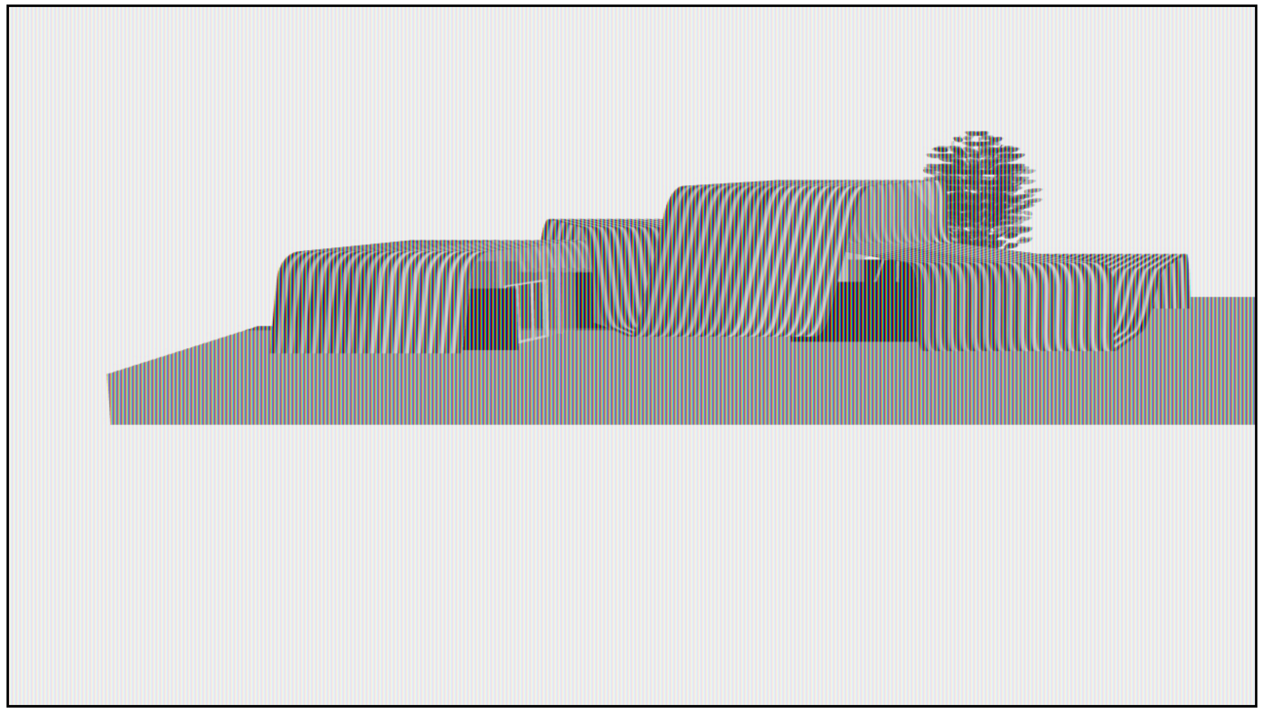
southview.

solstices.



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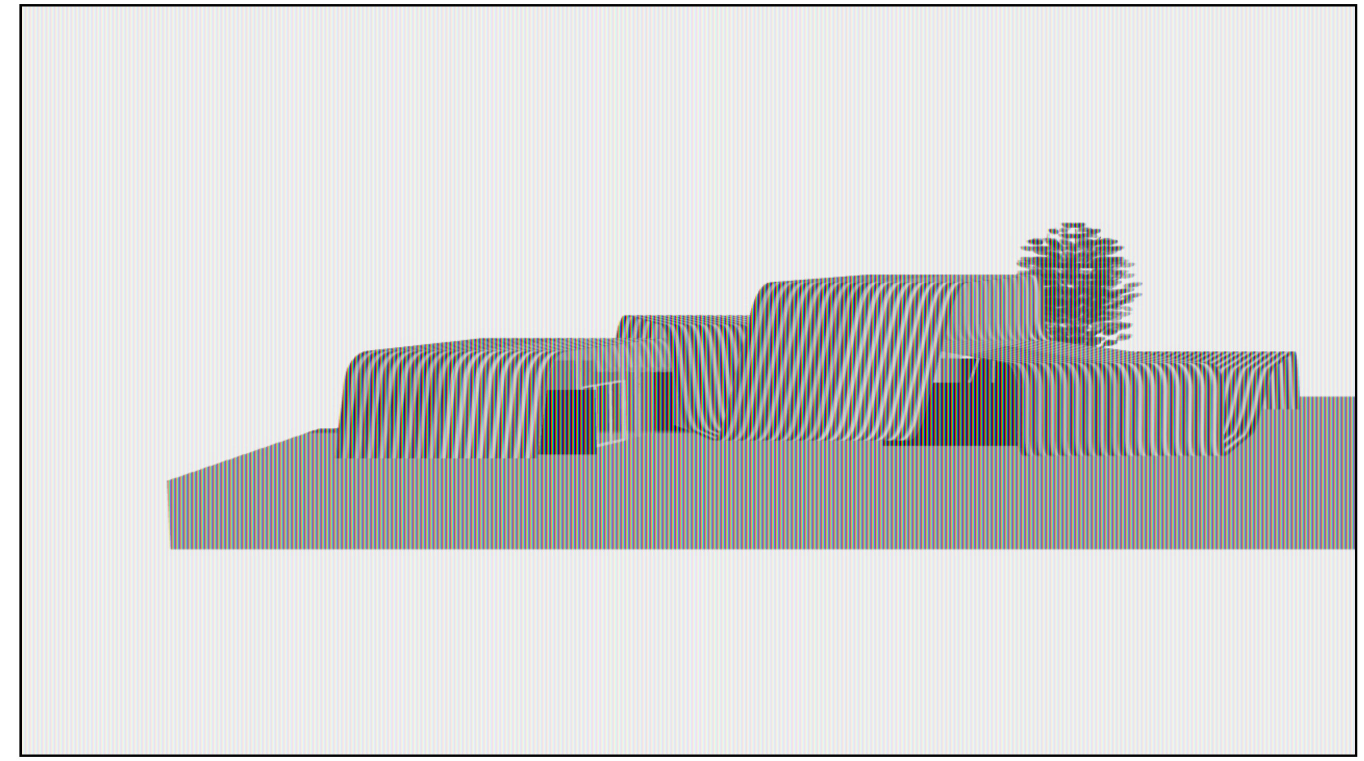

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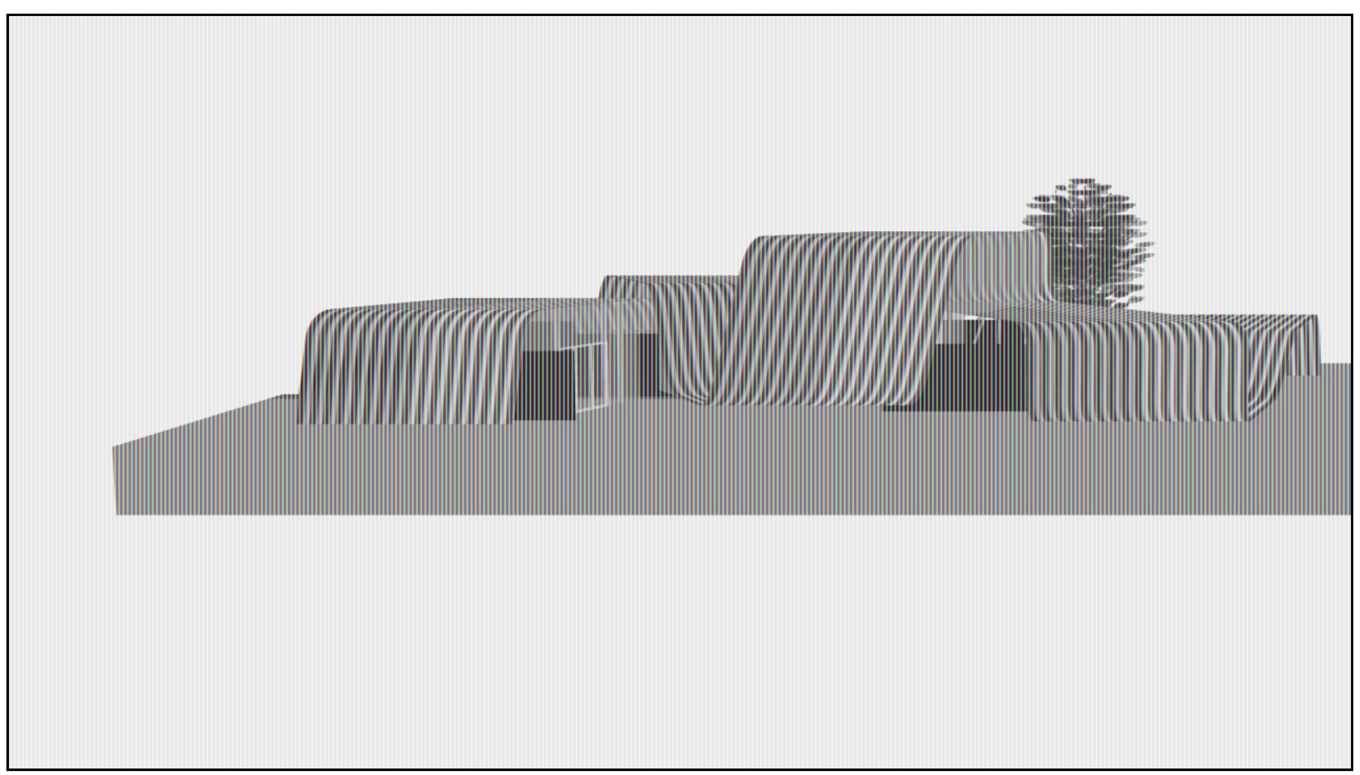

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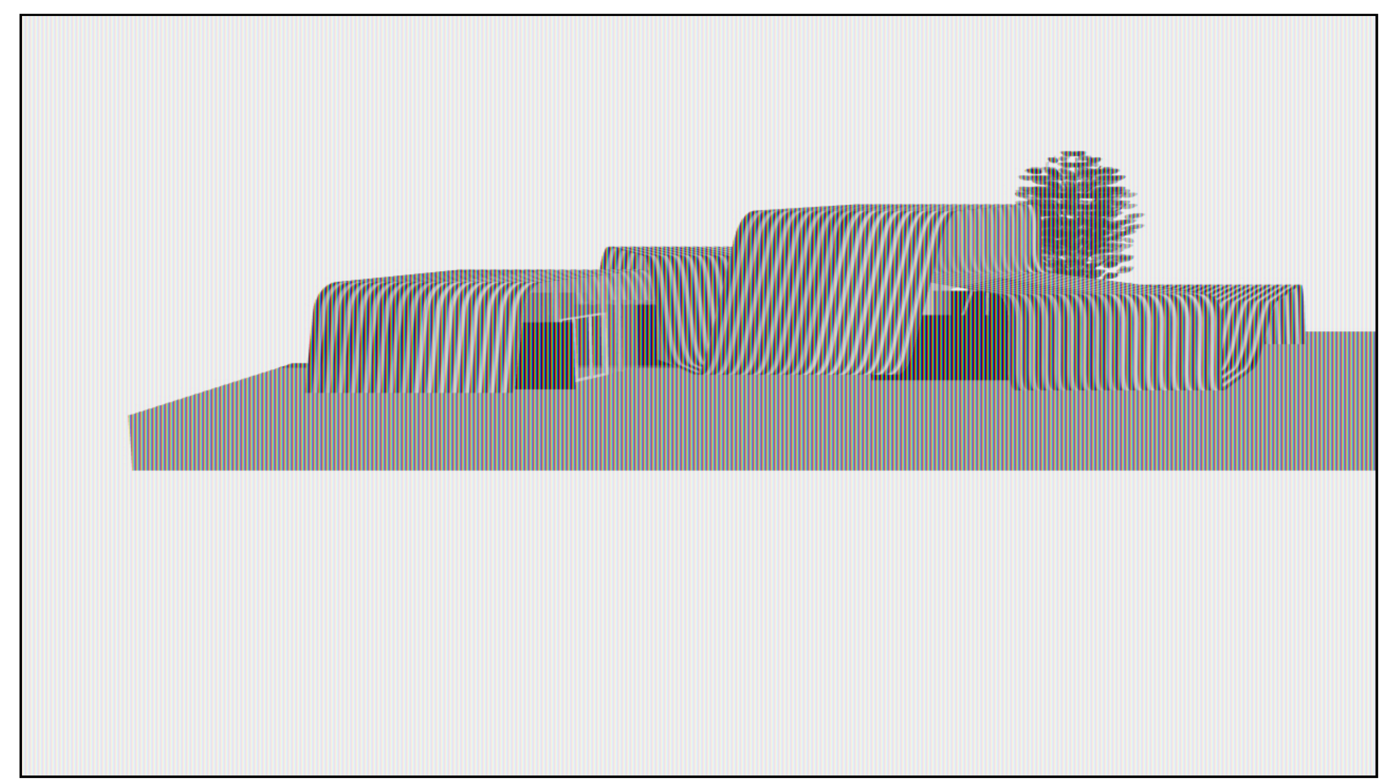

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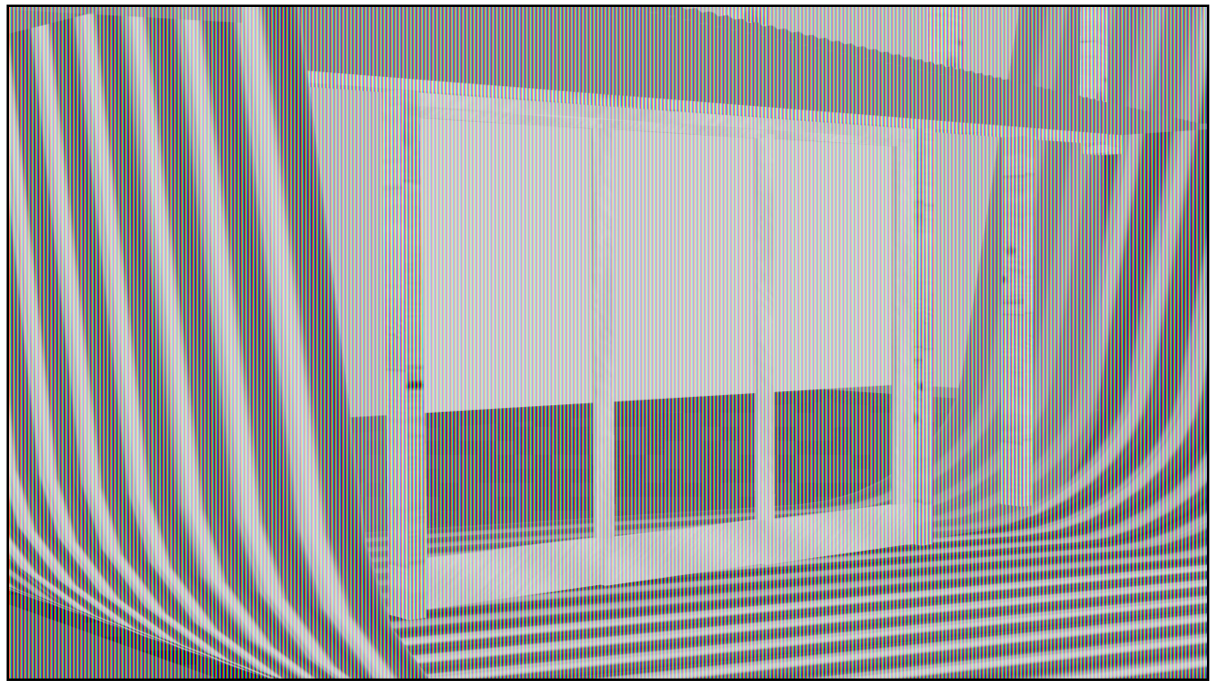
dinning room.

solstices.



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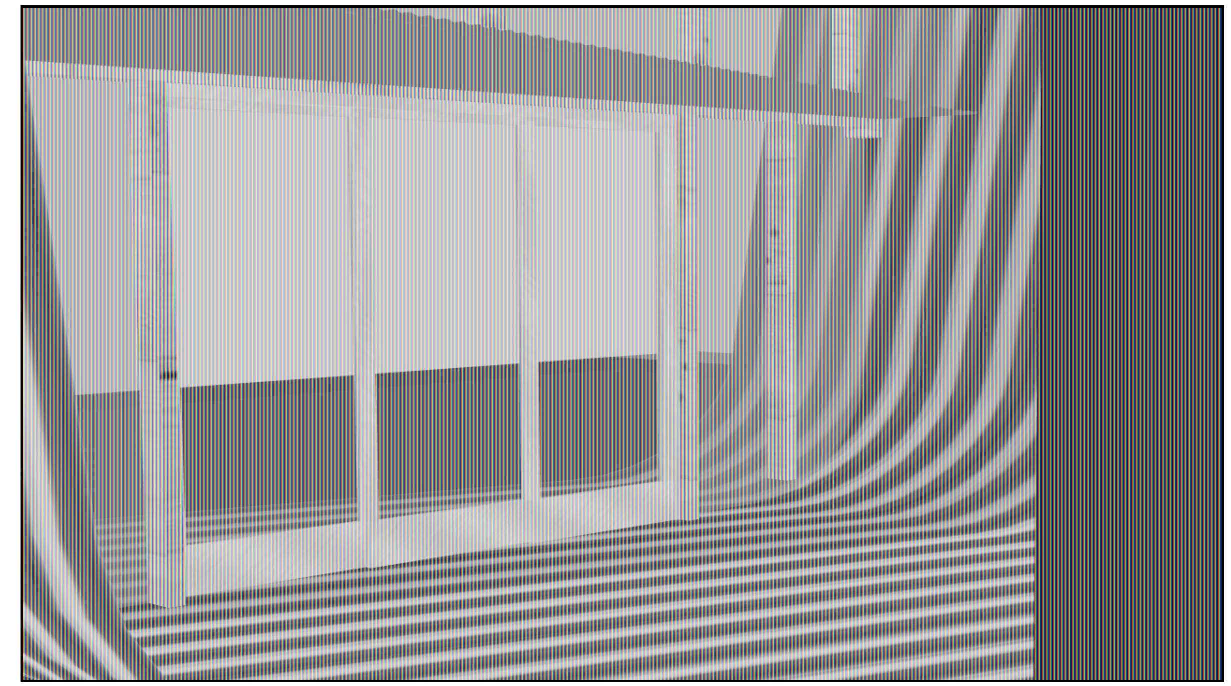

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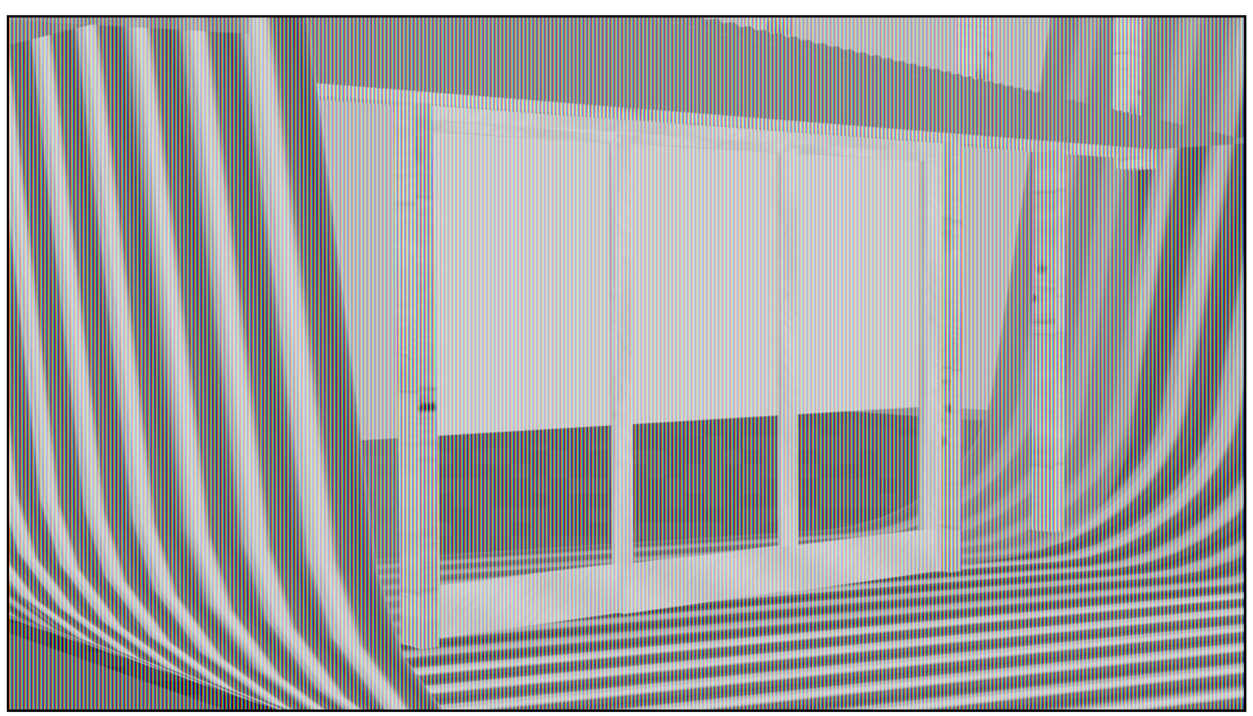
equinoxes.



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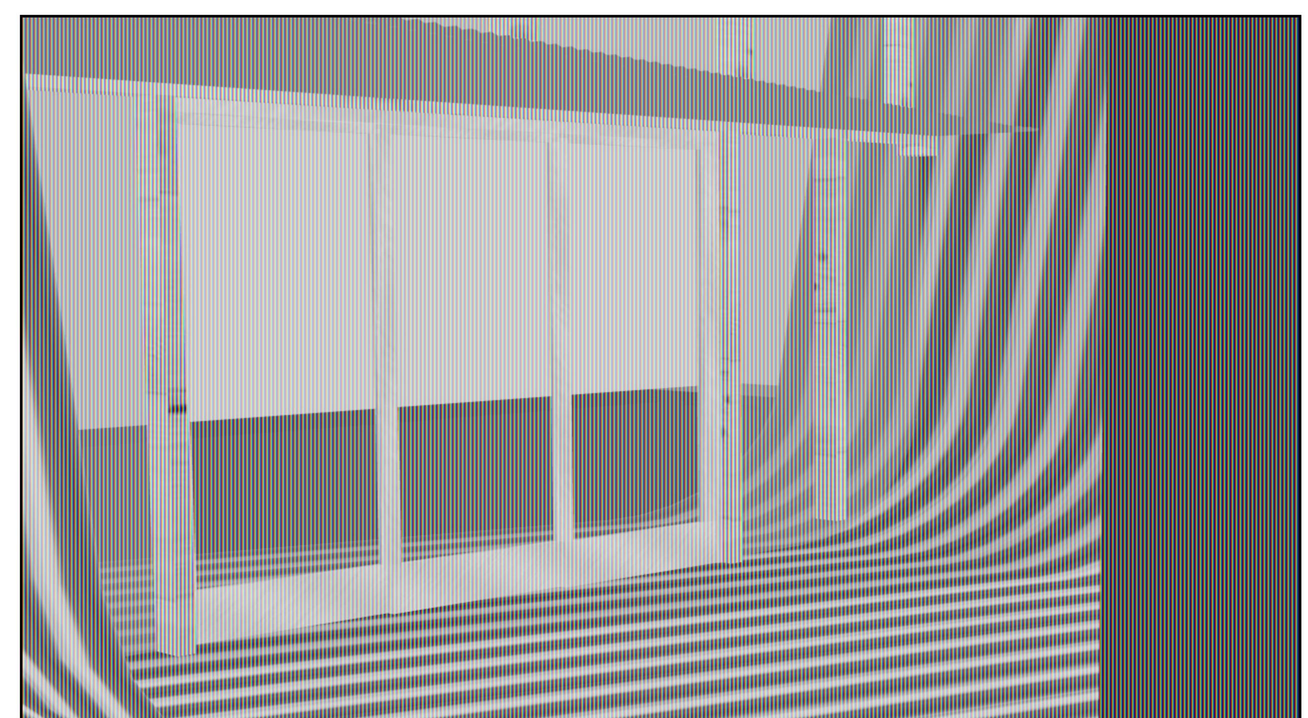

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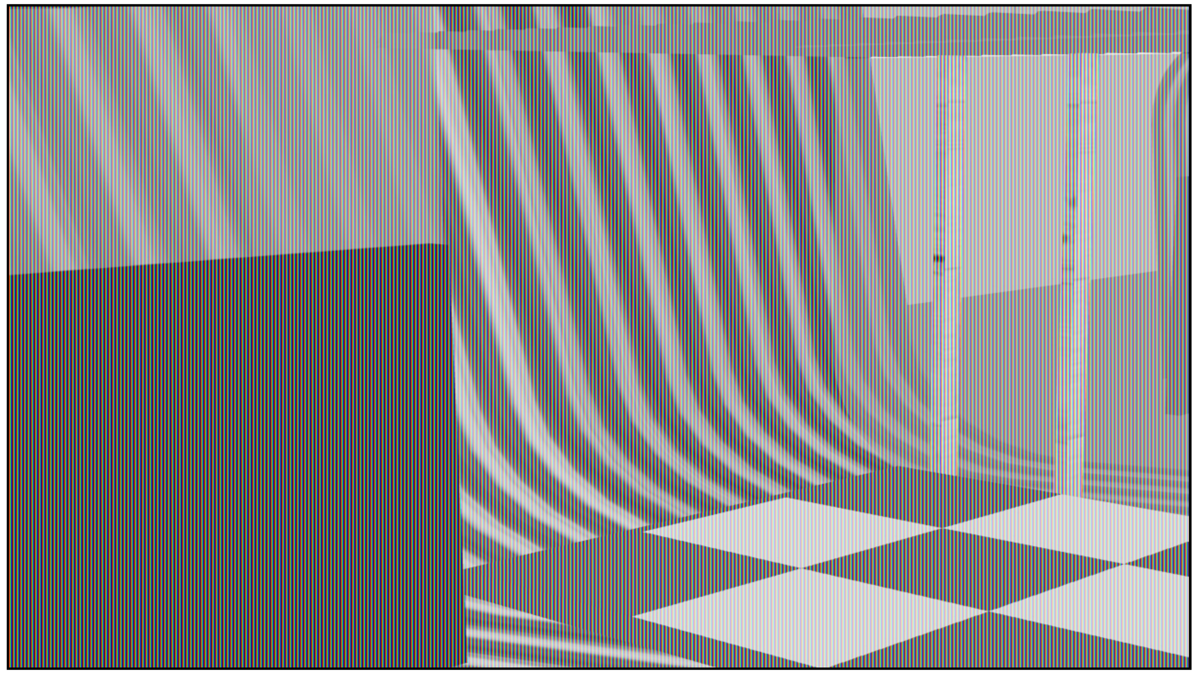
quiet room.

solstices.



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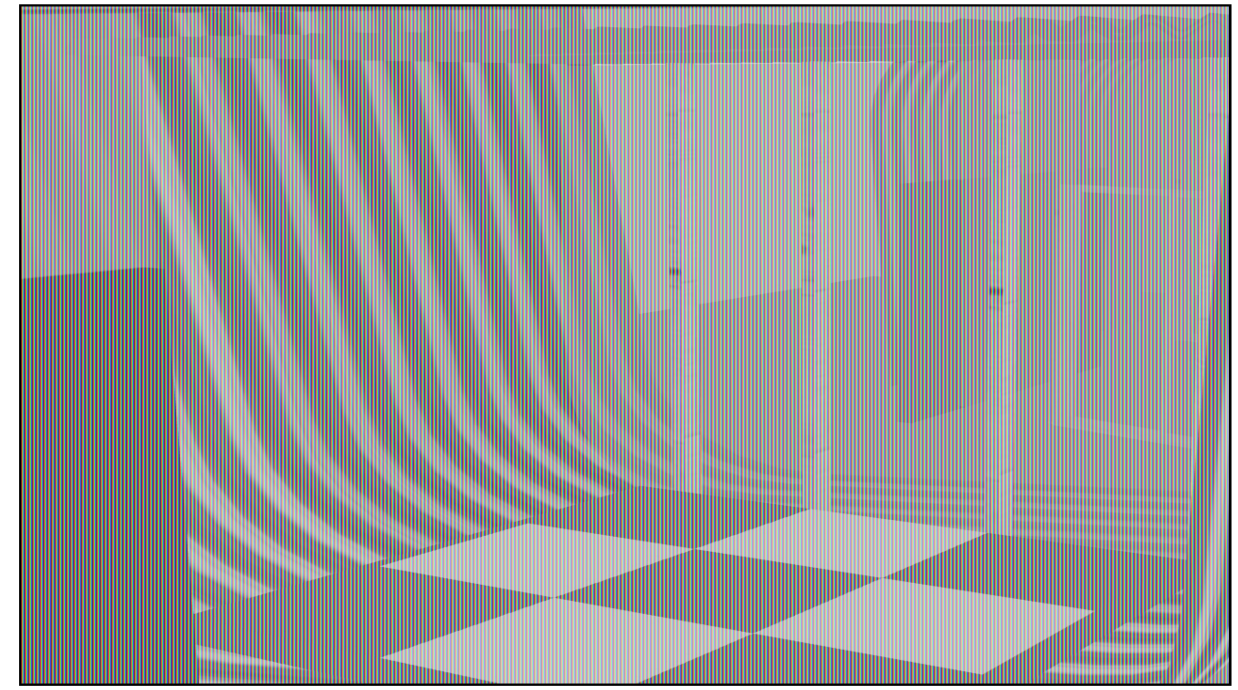

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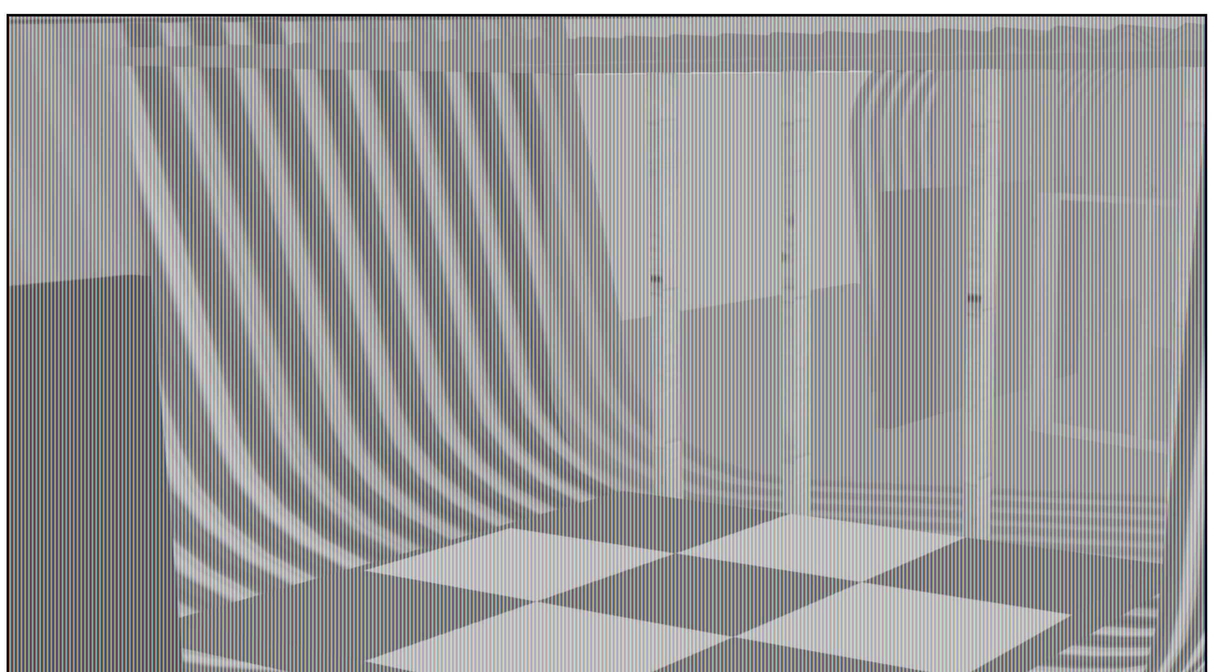
equinoxes.



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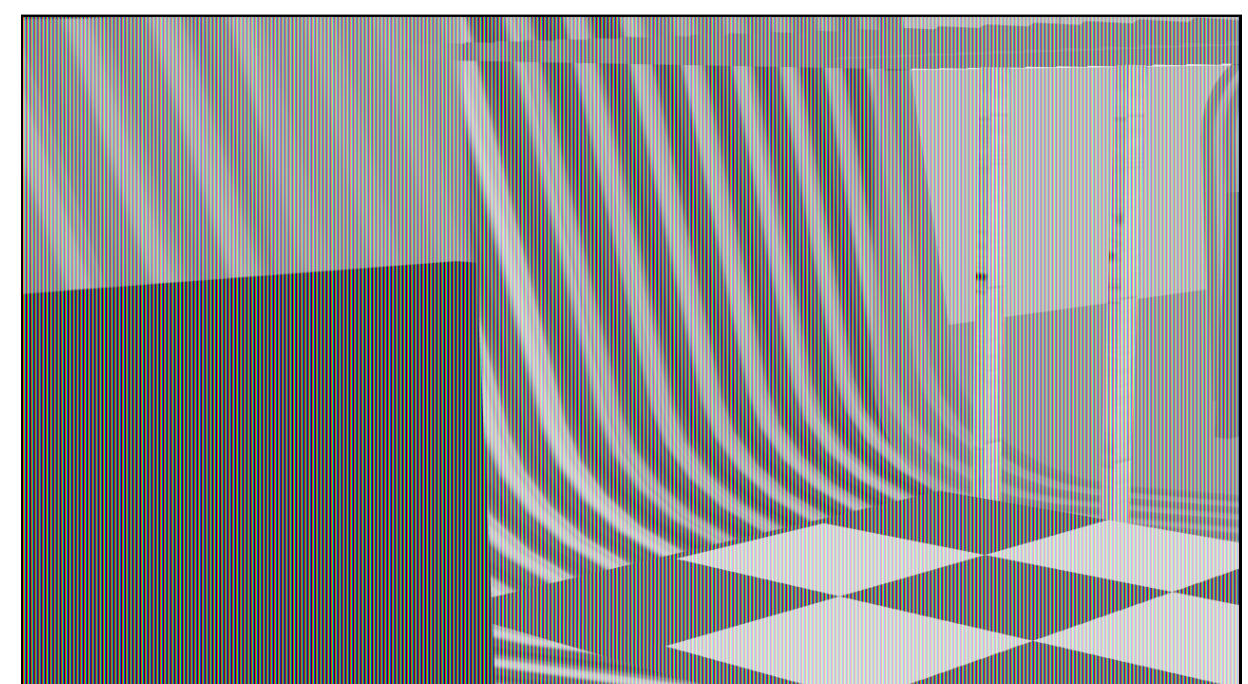

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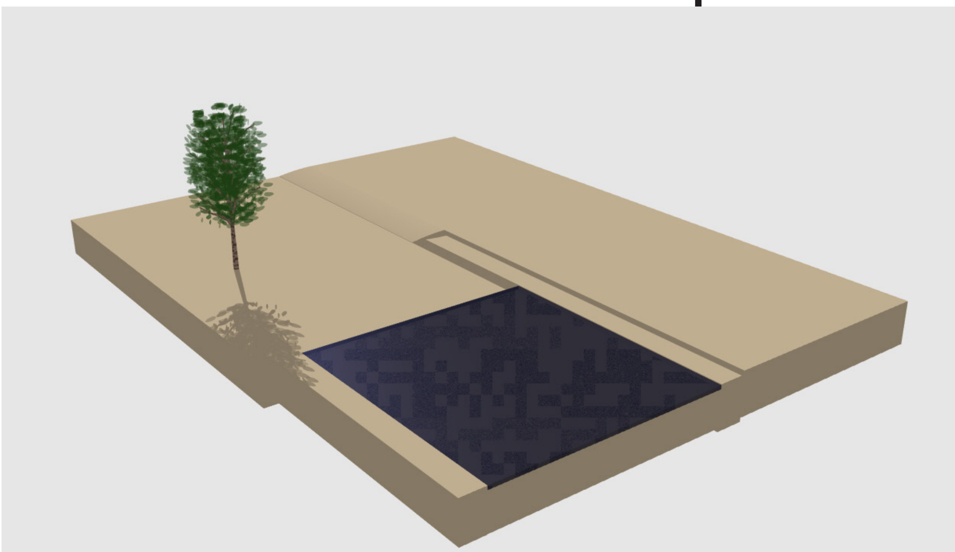
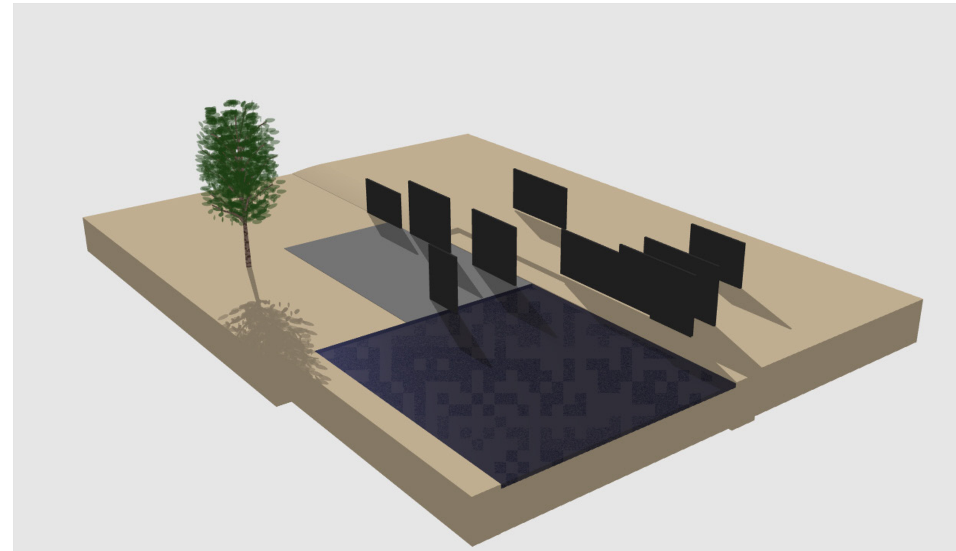
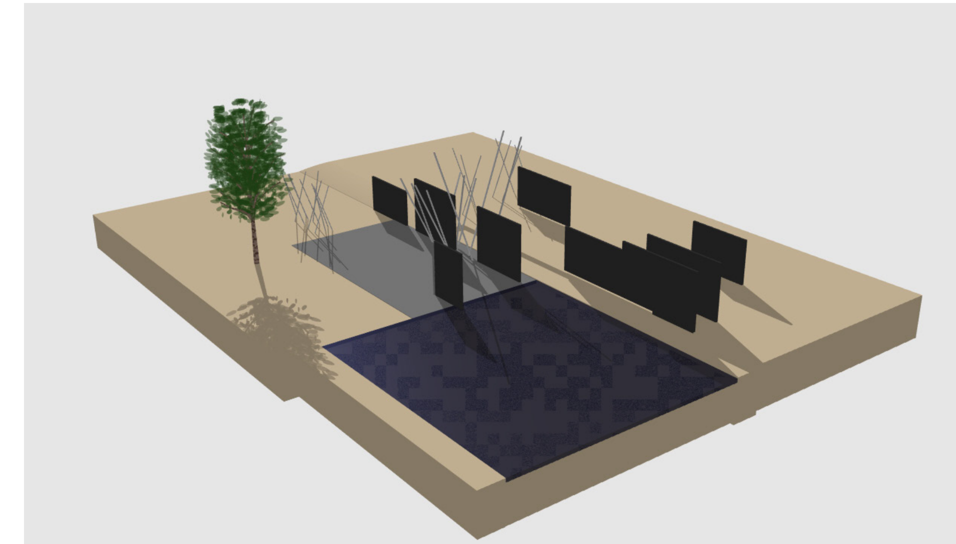
construction process.



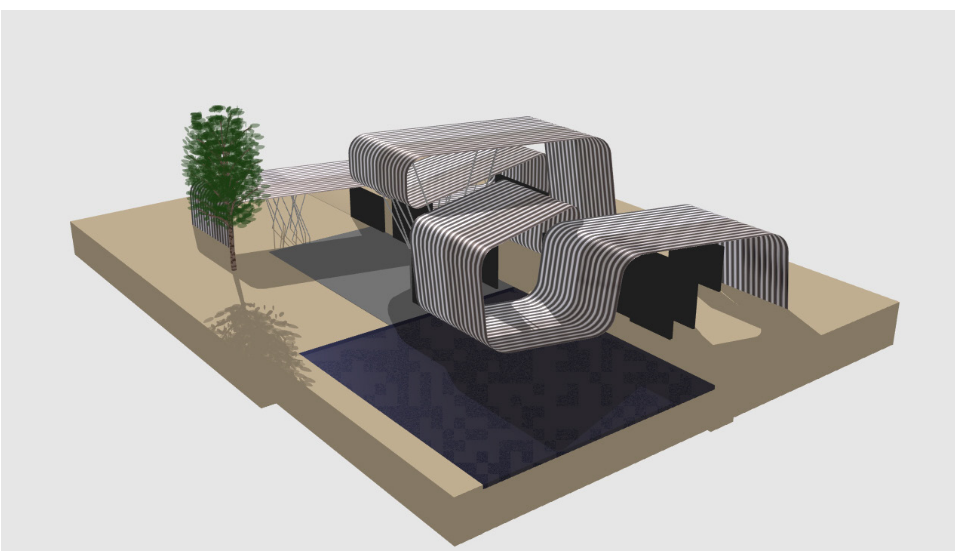
site.



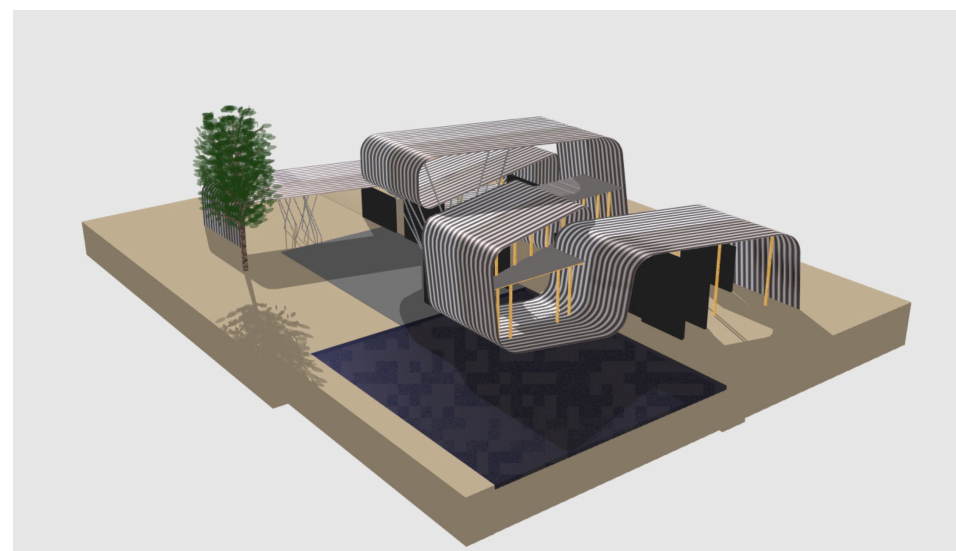
1. supporting walls



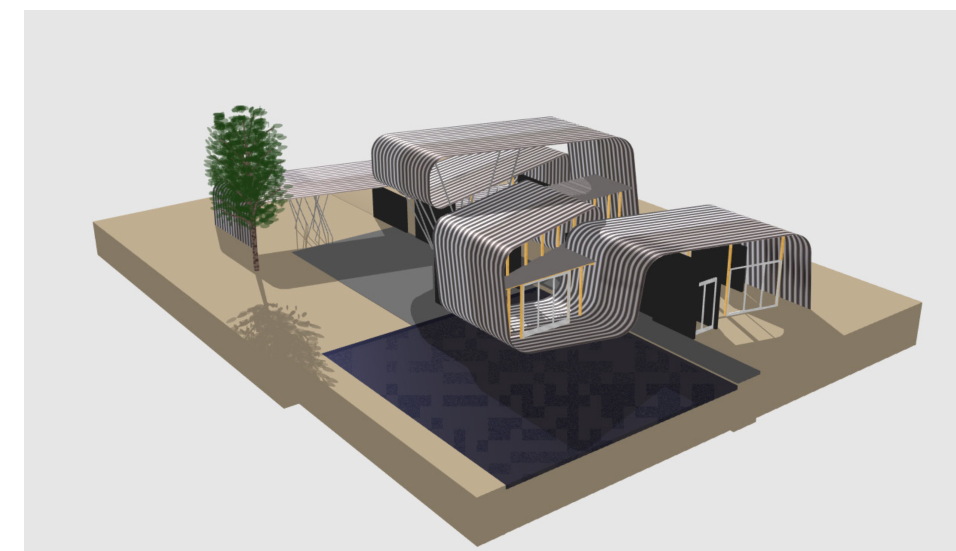
2. steel supports.



3. corrugated steel ribbon.



4. framing



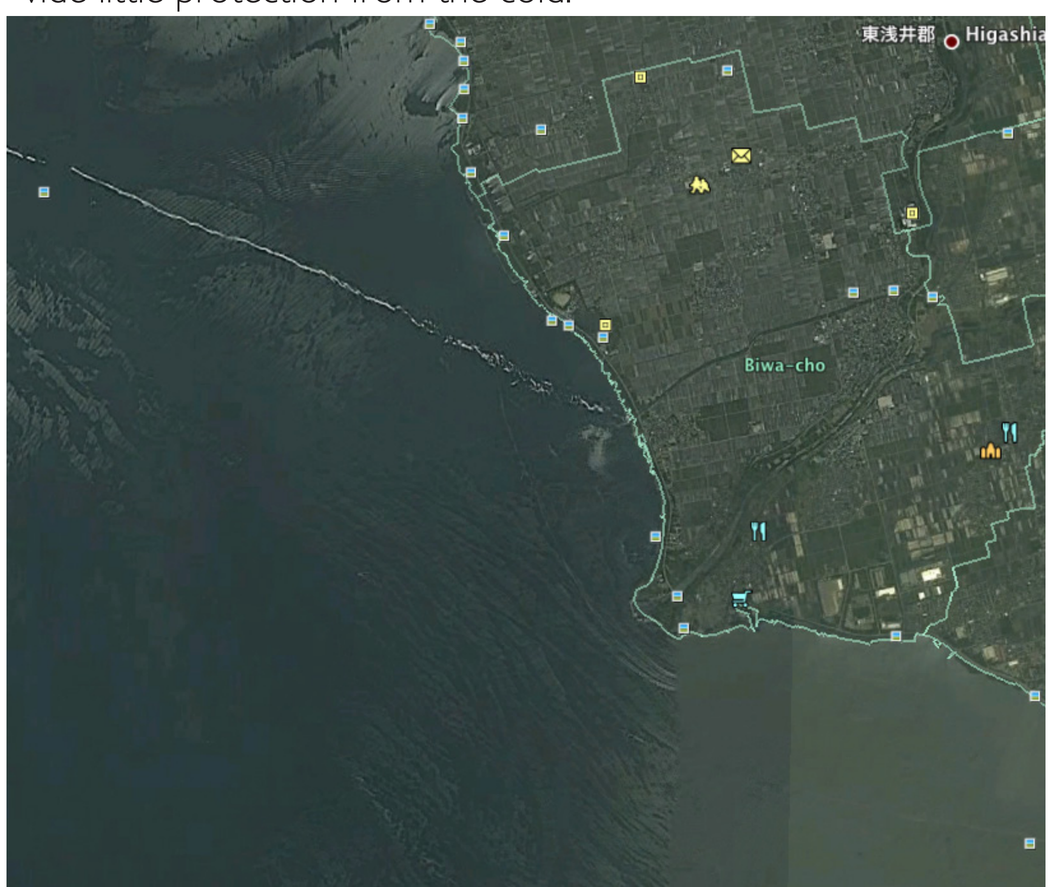
5. doors and window frames.

6. glass.

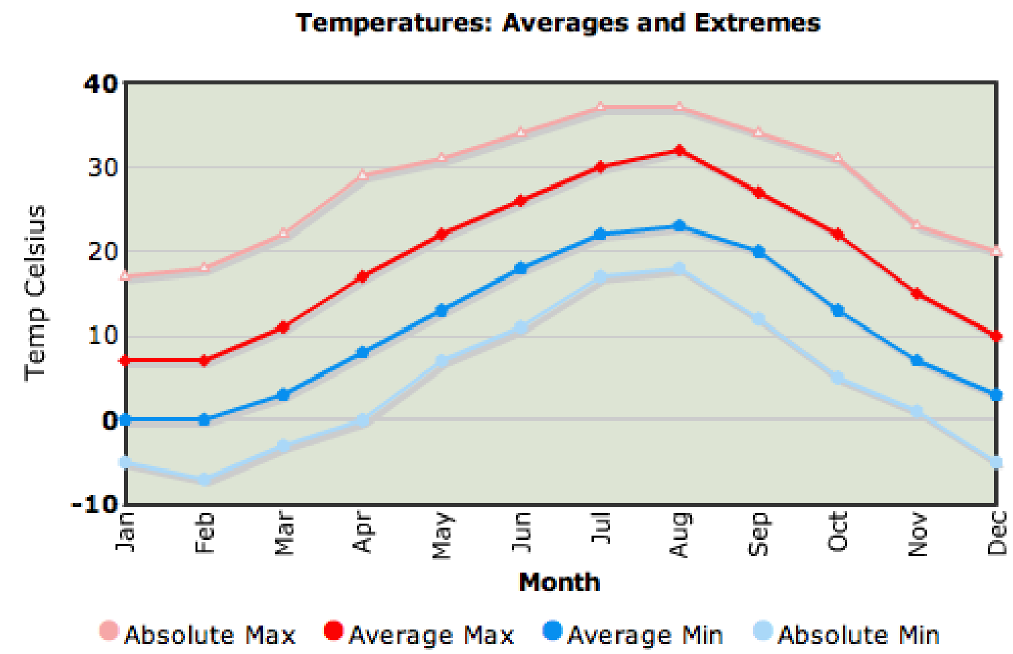
climate response assessment.

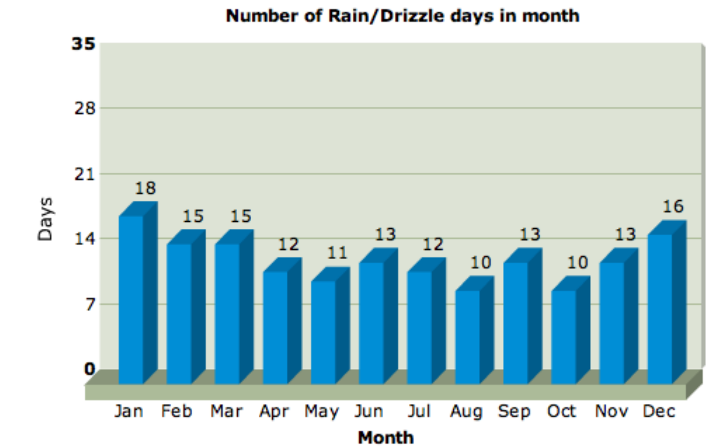
climate response assessment.

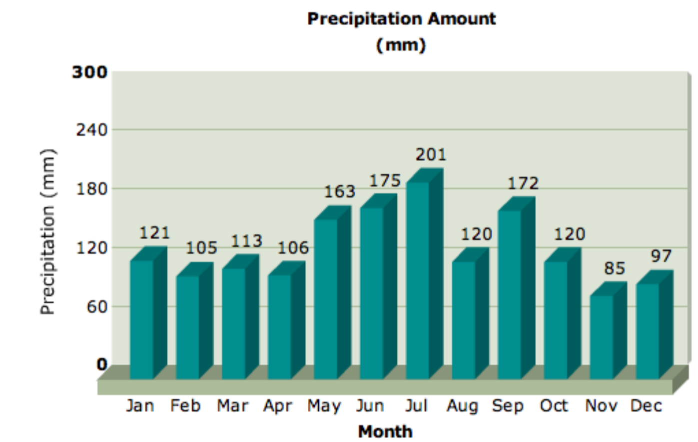
springtecture b is located in the shiga prefecture of japan, and more specifically located in biwa-cho. biwa-cho is located to the east of lake biwa. the lake covers over 259 square miles, largest in japan, has an impact on the local weather climate. this large body of water creates a form of a microclimate where it tends to rain much of the month, on average 13 days out of the month (myweather2.com), and with accumulations of approximately 5.2 inches. in comparison charlottesville has precipitation on average 10 days out of the month, and has an average accumulation of 3.3 inches (myweather2.com). by comparing these two locations one can see that the presence of a large water body, in this case lake biwa, can have a dramatic effect on the climate of an area. in addition to precipitation levels the average temperature of the area is fairly low for the area surrounding where springtecture b is built. the yearly average for the area rests between 57 and 60 degrees fahrenheit with a peak in temperatures in the month of august (myweather2.com). with a climate that could be described as fairly cold for much of the year with only a handful of months with warm weather, the fact that this is merely a vacation home and office makes senses. during the cool months of the year living in this house would be fairly uncomfortable and provide little protection from the cold.



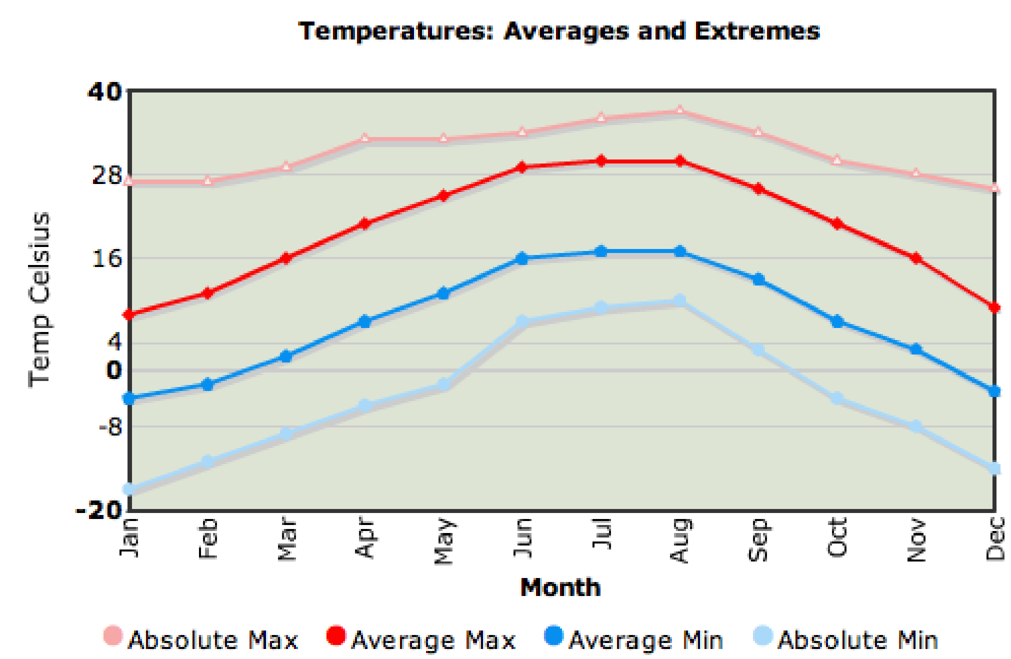
biwa-cho, japan.

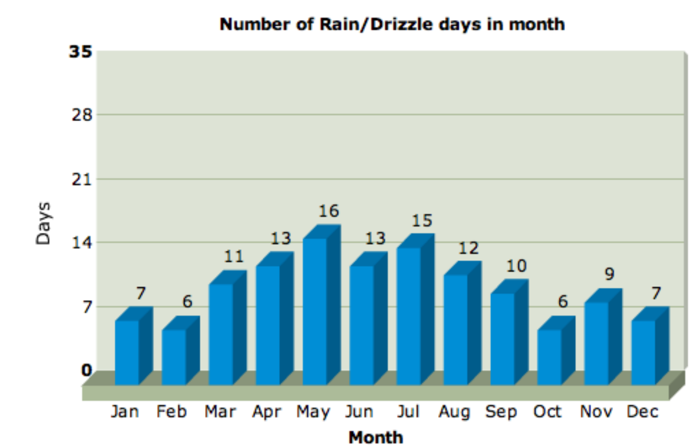


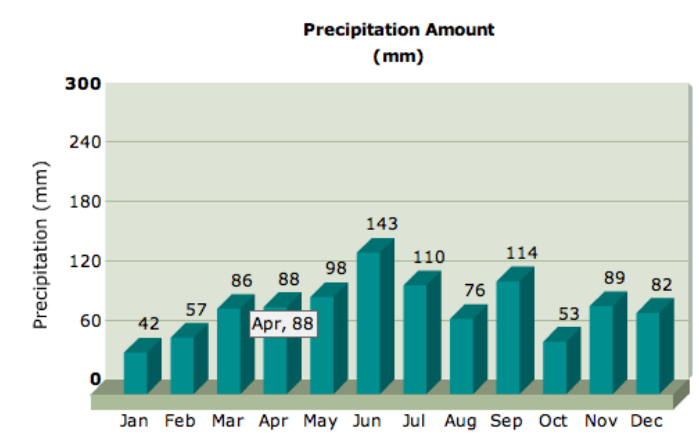




charlottesville, va.

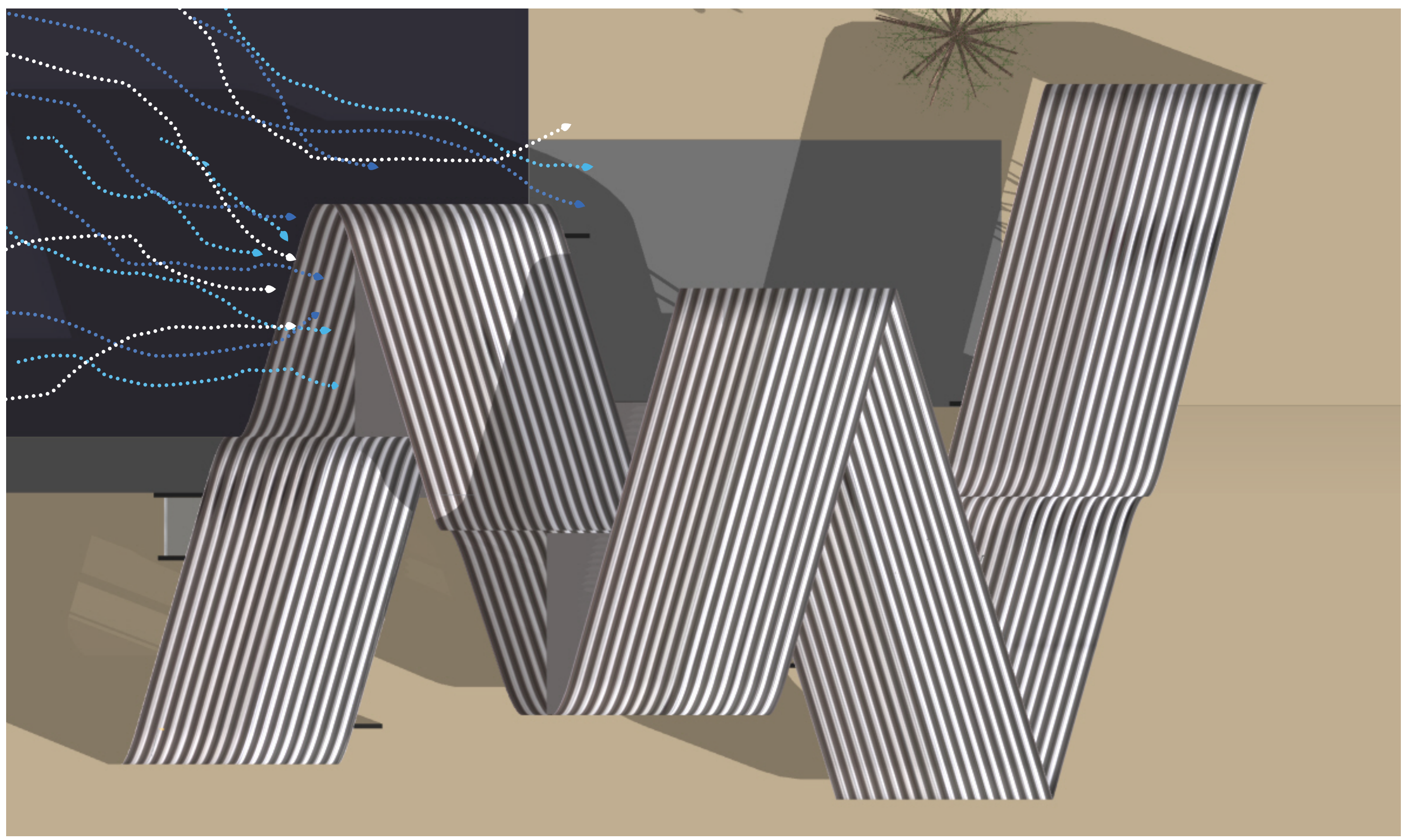


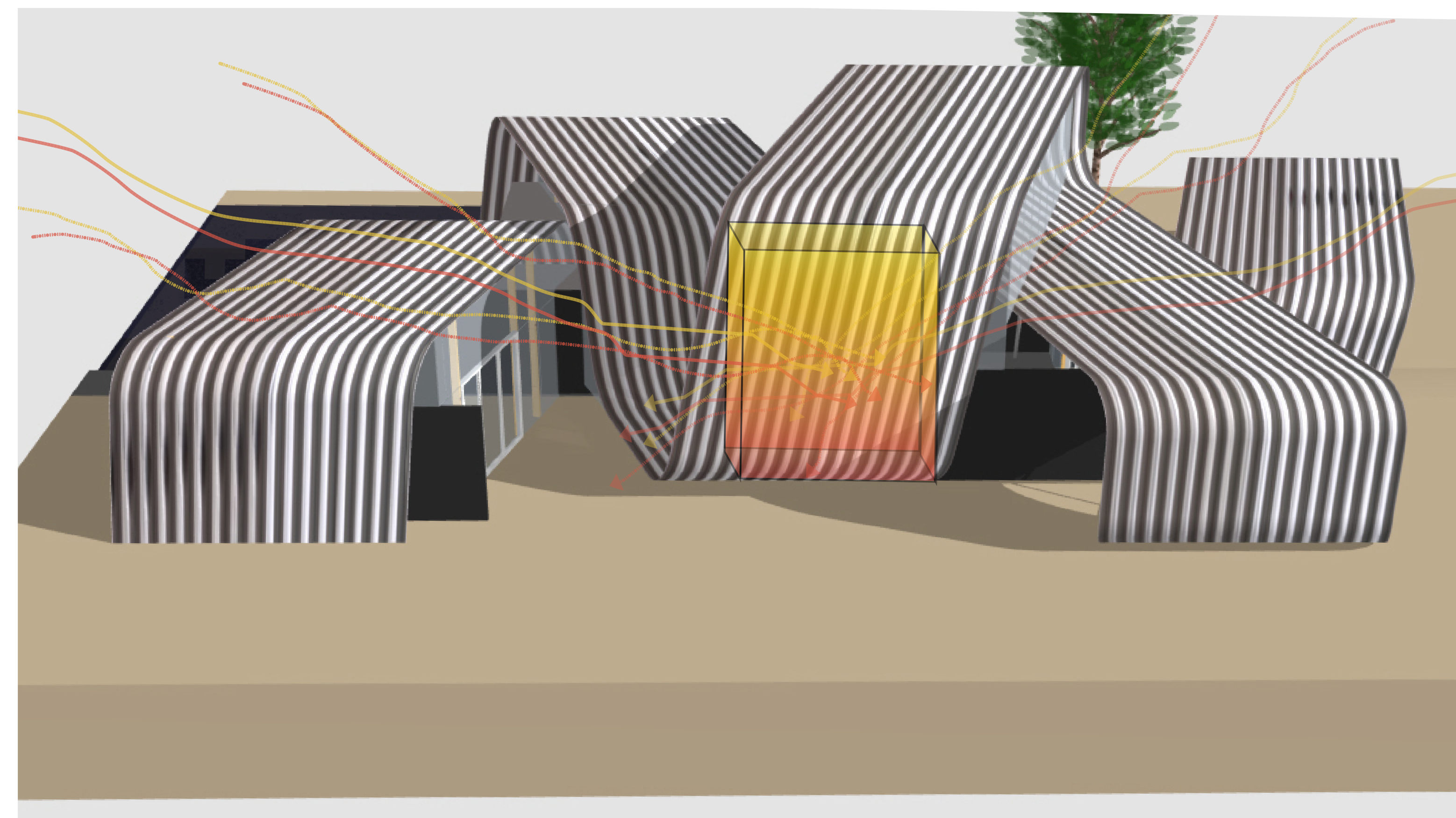




microclimate assessment.

besides the localized climate created by lake biwa, springtecture b and its site also creates a few microclimates. on the northwest end of the building, beside the dinning room, there is a small pond. this area is titled a terrace on the floor plans and thus implys that it is an area of inhabitation. in addition to this, there are doors that open up to the area to connect the dinning room to the terrace and pond area. assuming that in the warmer month the prevailing winds are coming from the northwest this pond could be used for evaporative cooling. this effect would help keep the terrace along with the dinning room at a temperature lower than other parts of the house. another microclimate that could be formed exists in the quiet room, located along the southern wall. this double height space has windows on both the eastern and western side, ensuring direct sunlight into the space for much of the day, and a thin corrugated steel wall to the south that would also heat up during the day. with the combination of these two elements one could expect that the quiet room would typically be much warmer during the day than the rest of the house.



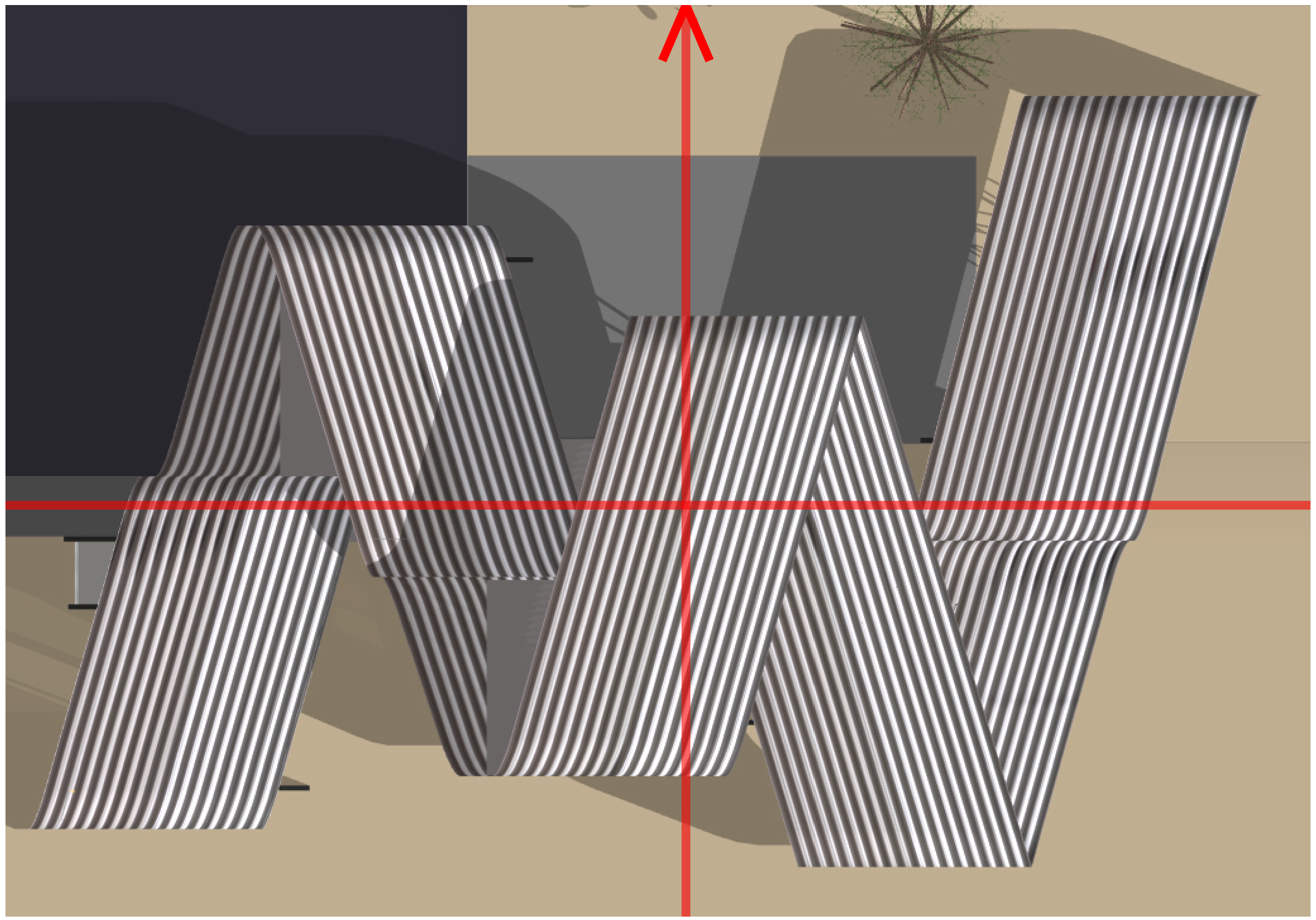


the pond at the northwestern side of the lot provides and opportunity for evaporative cooling to help cool down the space during the warm months in biwa-cho, japan. provided there is wind coming from the northwest the breezes would be able to filter into the dinning room and adjoining areas. also the moisture could be carried onto the northern terrace to form an additional cool microclimate. the arrows in the diagram represent the path of the wind and their picking up of moisture.

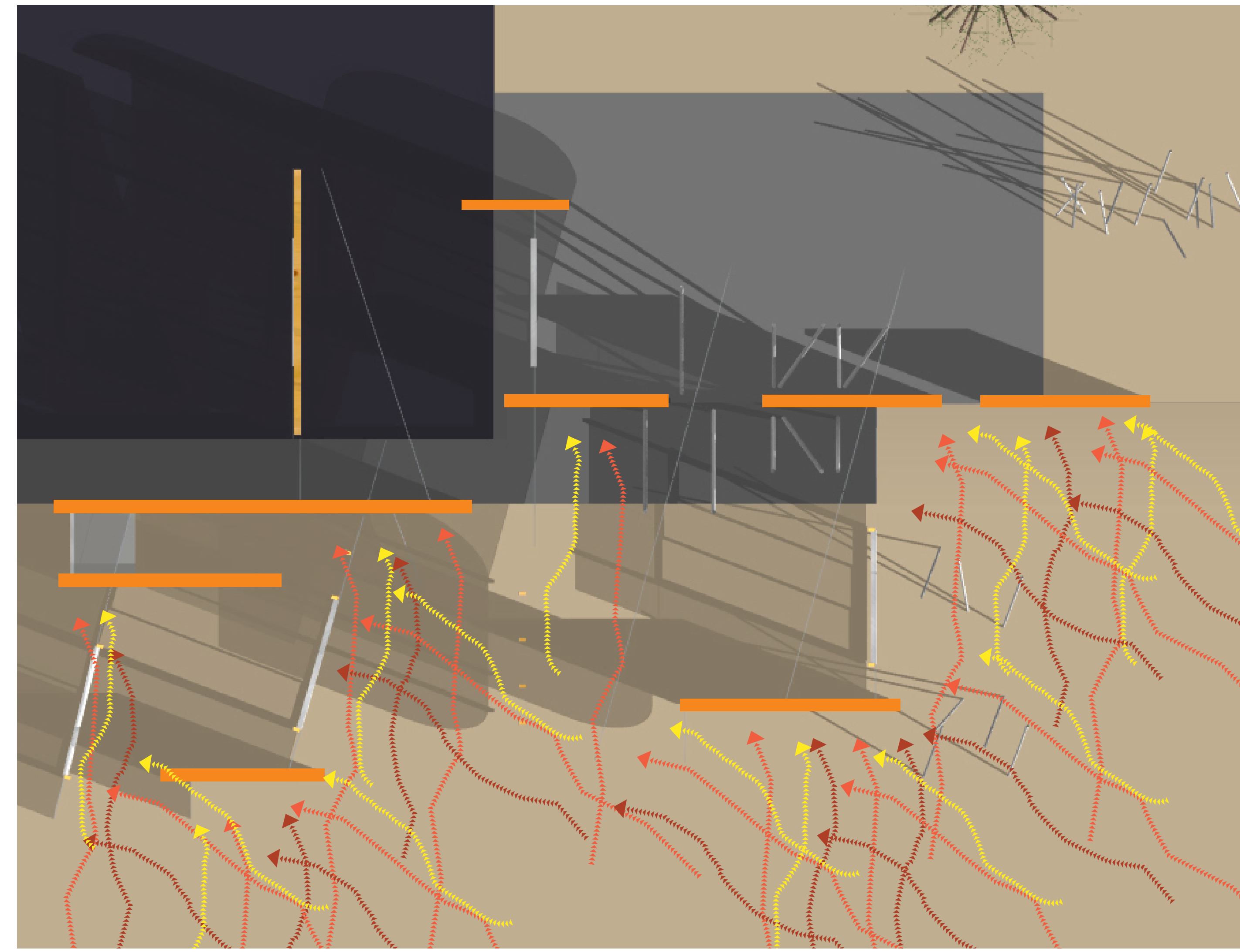
an additional microclimate that forms in springtecture b is located in the quiet room, along the southern edge of the buidling. this is a two level space with glass walls on both the east and west side. with this level of exposure the the space would recieve high levels of light and thus keep the area much warmer than the surrounding rooms in the cool months. also with the thin steel wall to the south it would quickly warm up and transfer its heat to the interior of the quiet room.

passive design elements.

When analyzing at the building there does seem to be some consideration to incorporate passive design elements, but not enough to make one believe that passive design was a priority during the design process. The assumption that passive design was not pursued in this building comes from the research into the building and also that of Shuhei Endo. Ideas of simplicity and minimalism are much more important to the deisgn than passive design elements. Areas where unintentional passive design might have slipped into the project is with the inclusion of insulating paint in the bedroom, radiant floor heating, and to align the building along the east-west axis in order to get good sun exposure. One other aspect of the building, the inclusion of glass to make up many of the exterior walls, helps to let in large quantities of light during the daytime, and thus needing no supplemental lighting.

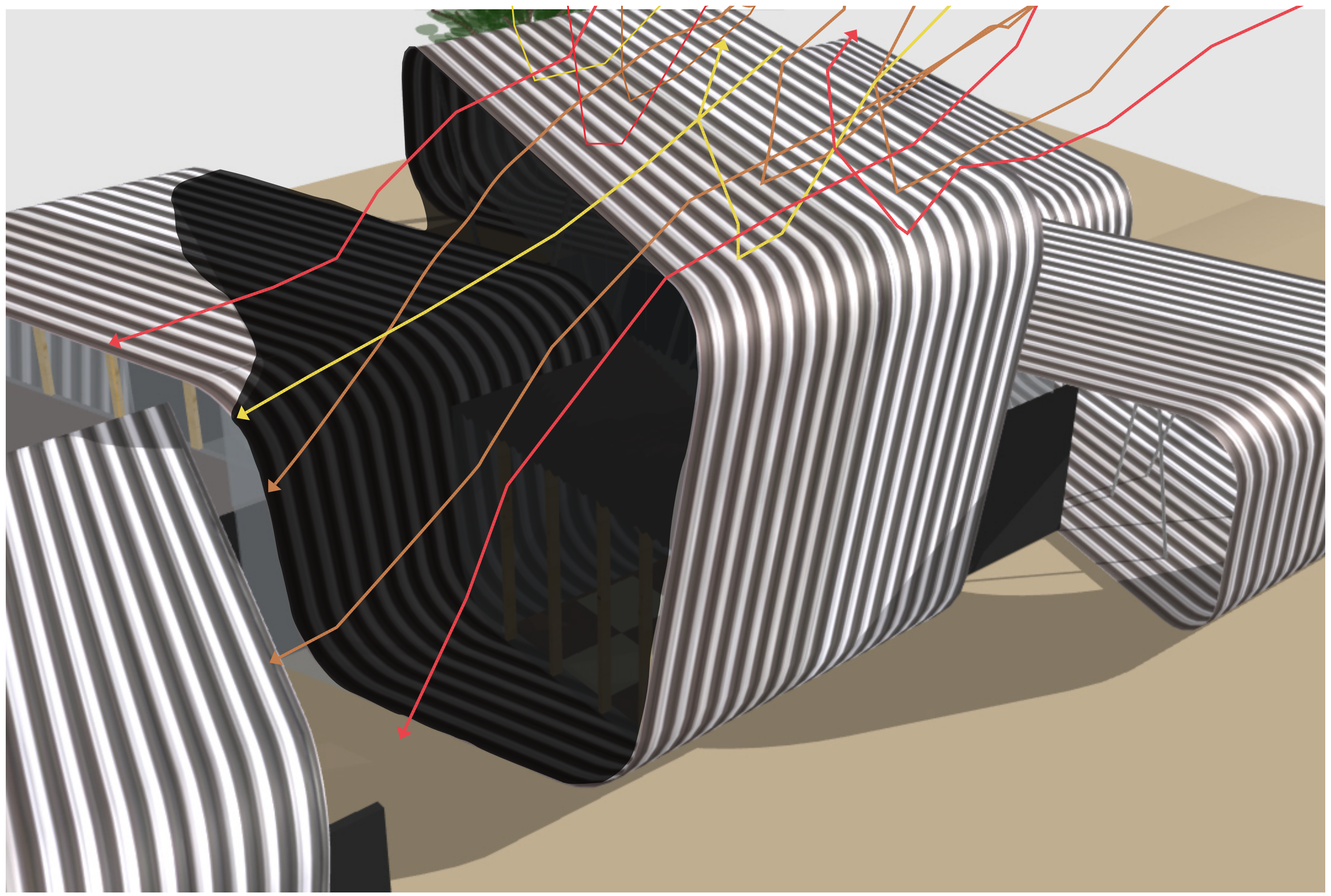


this diagram is showing the orientation of springtecture b. in passive design orientation of a building is critical to how it responds to its climate and can harvest elements of it to improve the comfort levels. in the case of springtecture b windows are kept to the east and west sides of the buidling to allow for large amounts of light to enter the structure. viewing the southern side of the buidling you are met with a solid facade to help protect from harsh sun rays.

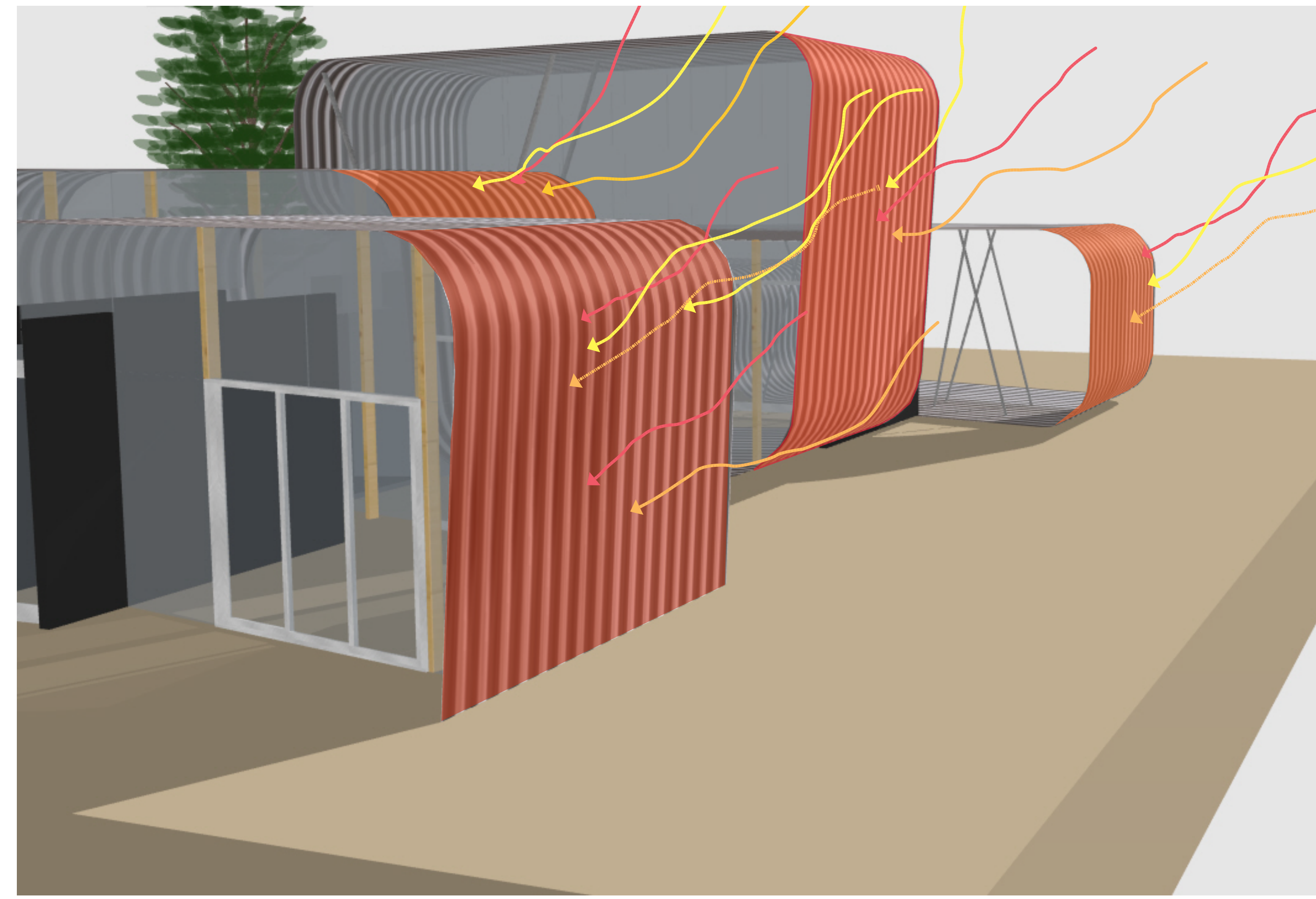


a passive design element that is present but not fullen taken advantage of is the concept of thermal massing. masonry walls run parallel to the east-west axis thus exposing one of their faces to the southern rays. this idea could be better taken advantage of it if a larger percentage of the walls could were exposed to the sun or if they had a larger mass. these walls could be used to help warm the entire space.

While these aspects of the project could be described as passive design elements, there are places where more cold of been included. Masonry walls run parallel to the east-west axis and are structural elements for the house, both formally and spatially. These masonry elements could have been placed so that a larger percentage of them would be exposed to the southern rays of the sun, and thus become thermal sinks that would keep the house warm during cold nights. Also by increasing their mass they could see improved performance. The building itself is also positioned along the east-west axis. This allows for all of the glass exterior surfaces to capture the light of the day as the sun passes through the sky. Along with this overhangs are located in the building, but the idea that these are placed for passive energy reasons is dubious and more likely positioned in order to assist with the creation of space inside the corrugated ribbon. The corrugated steel ribbon could be considered an element of passive design for the summer months. In these months it would heat up quickly during the day, but more importantly would cool down quickly during the night. This ability to heat up or cool down quickly is intrinsic to steel, and can be applied passively. Endo has stated though that he likes to use corrugated steel because it is a highly versatile material, cheap, easy to work with, but never because of its thermal properties. Overall Springtecture B is a space that contains several small microclimates based on good architectural design and not necessarily because the architect consciously wanted to incorporate passive design elements.



incorporated into the design of springtecture b are overhangs that create shade and protect areas from the rays of the sun and associated heat. this aspect of the design i believe was not added intentially with passive design as a goal but simply rose out of the shaping of the metal ribbon., and also with the need to create spaces of inhabitation.

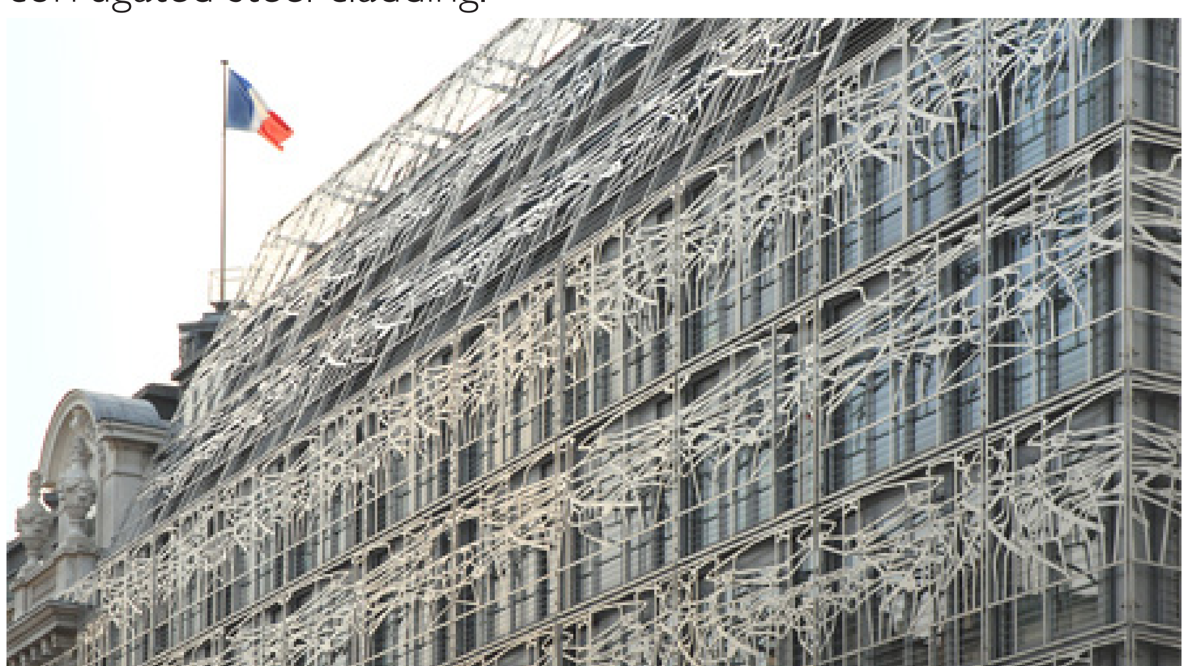


an aspect of the building that hampers the ability for passive design elements to perform well is the thermally light exterior skin. this skin is made up of simply a sheet of corrugated steel so that it any heat generated by the building is quickly lost through the buildings envelope and any outside temperatures quickly modify the interior temperature.

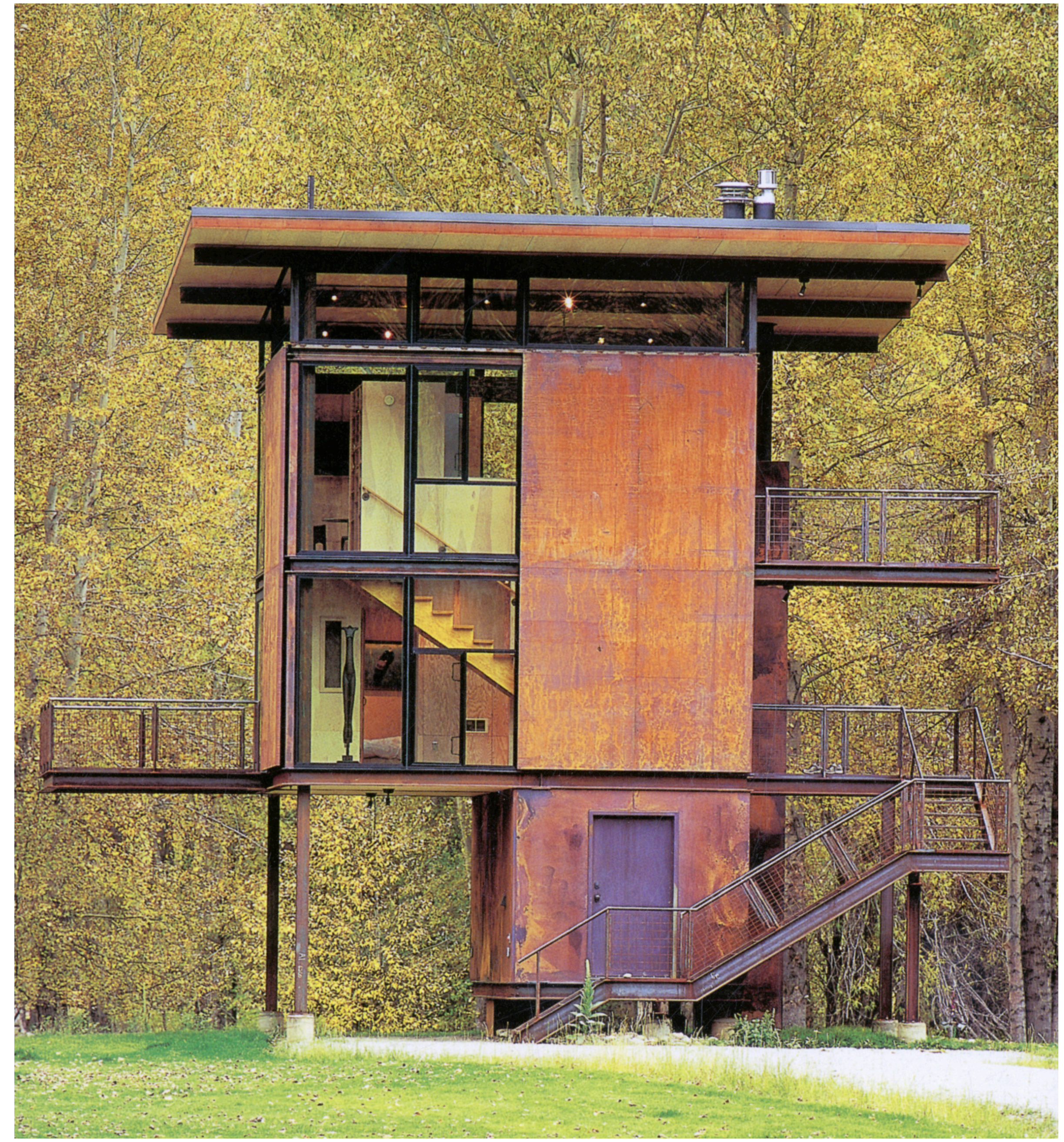
material assessment.

material assessment.examples.

rooftecture s. shuhei endo.
corrugated steel cladding.

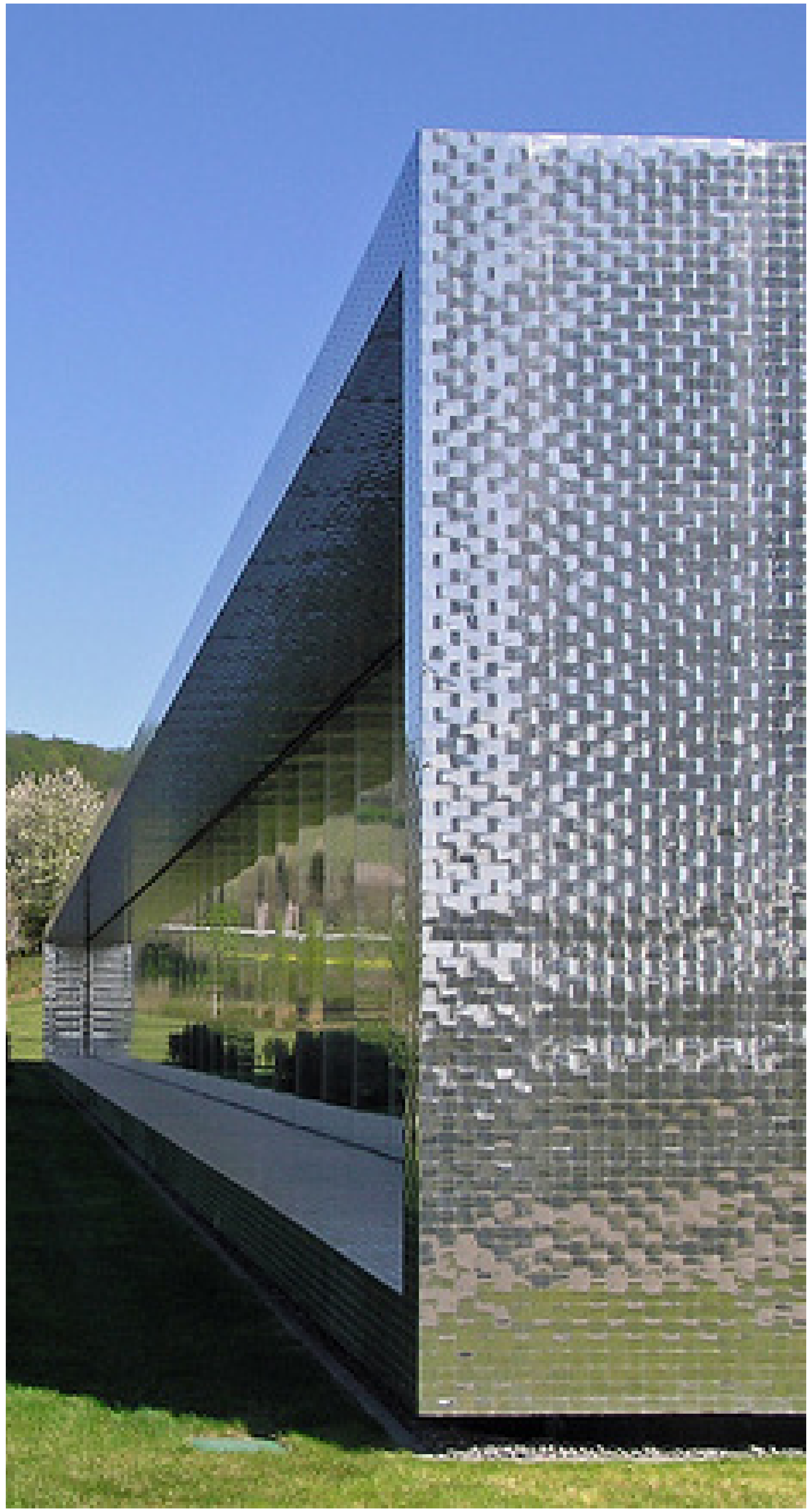


"les bons enfants". francis soler, frederic drout, michel desvigne.
steel latticework facade.



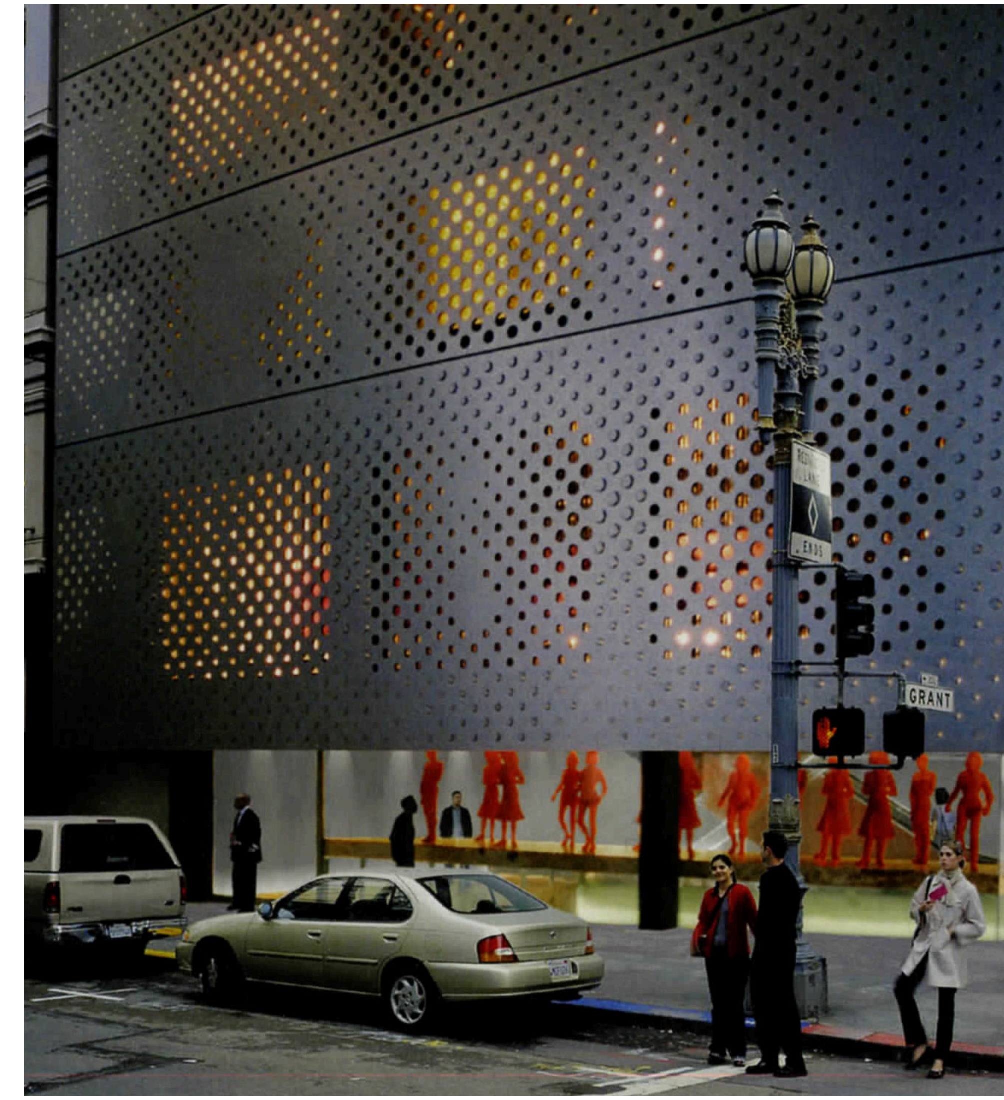
delta shelter. tom kundig.
cor-ten steel cladding.

these are three examples of fairly common implementations of a facde system devised from steel. corrugated steel panels, cor-ten (weathering steel), and artfully cut steel sheets are all represented. each of these were speficially choosen and show the flexability that is inherant with steel as a material.



sudwestmetall heilbronn branch office.
dominik dreiner architekt.
woven stainless steel facade.

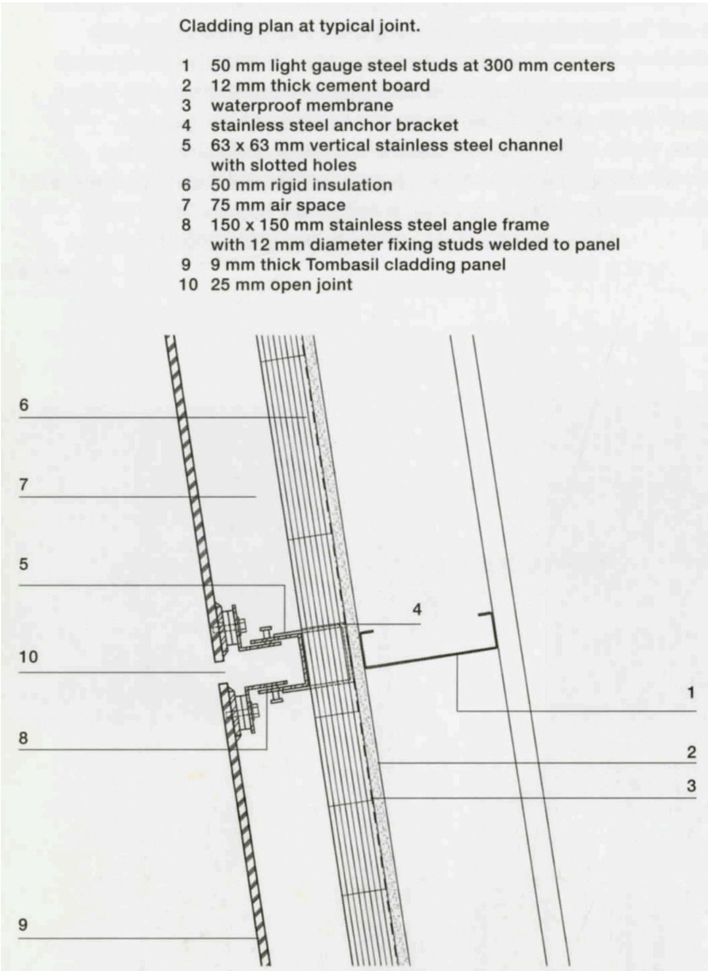
experience music project. frank gehry.
sculpted sheets of stainless steel.

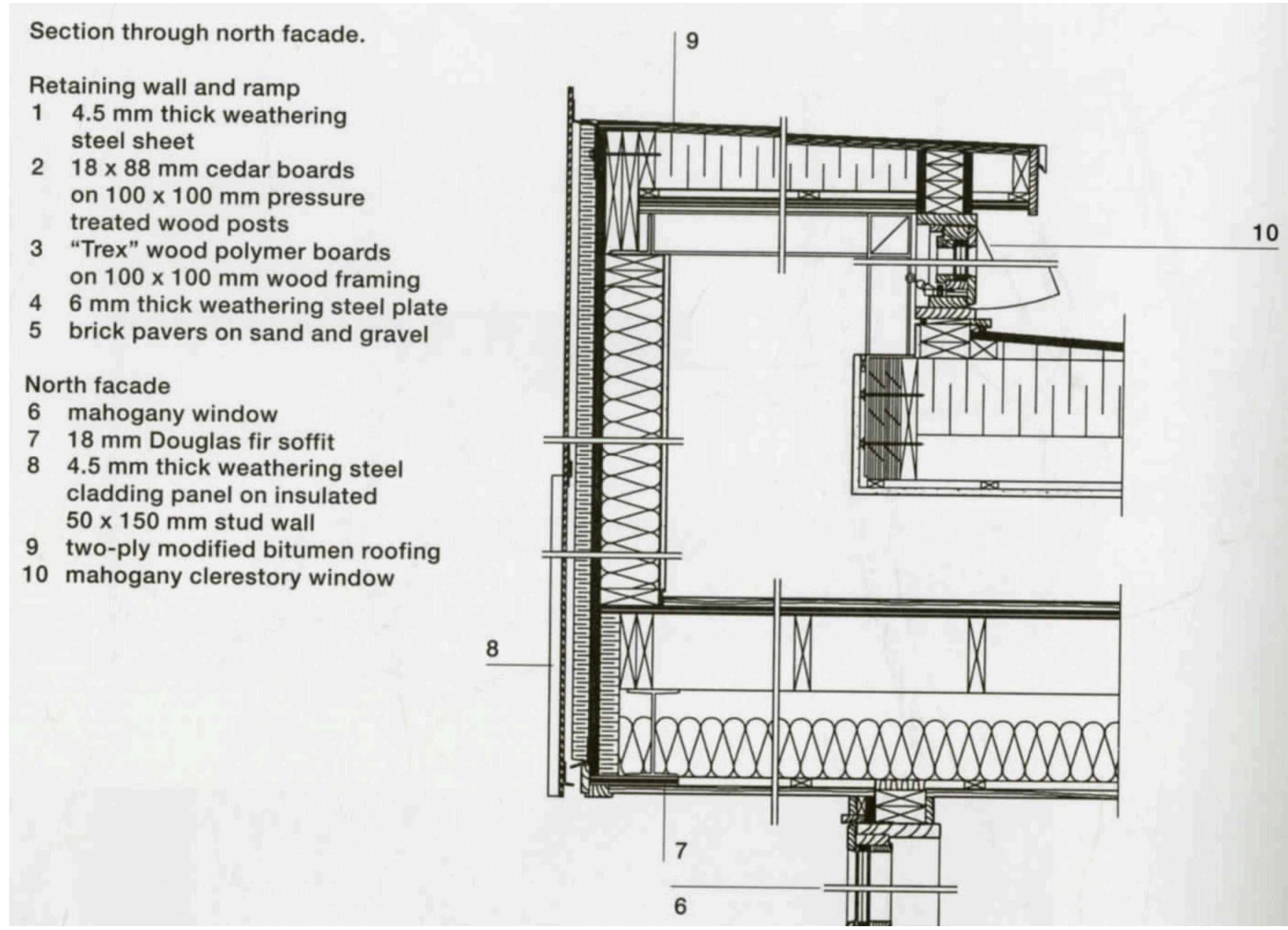


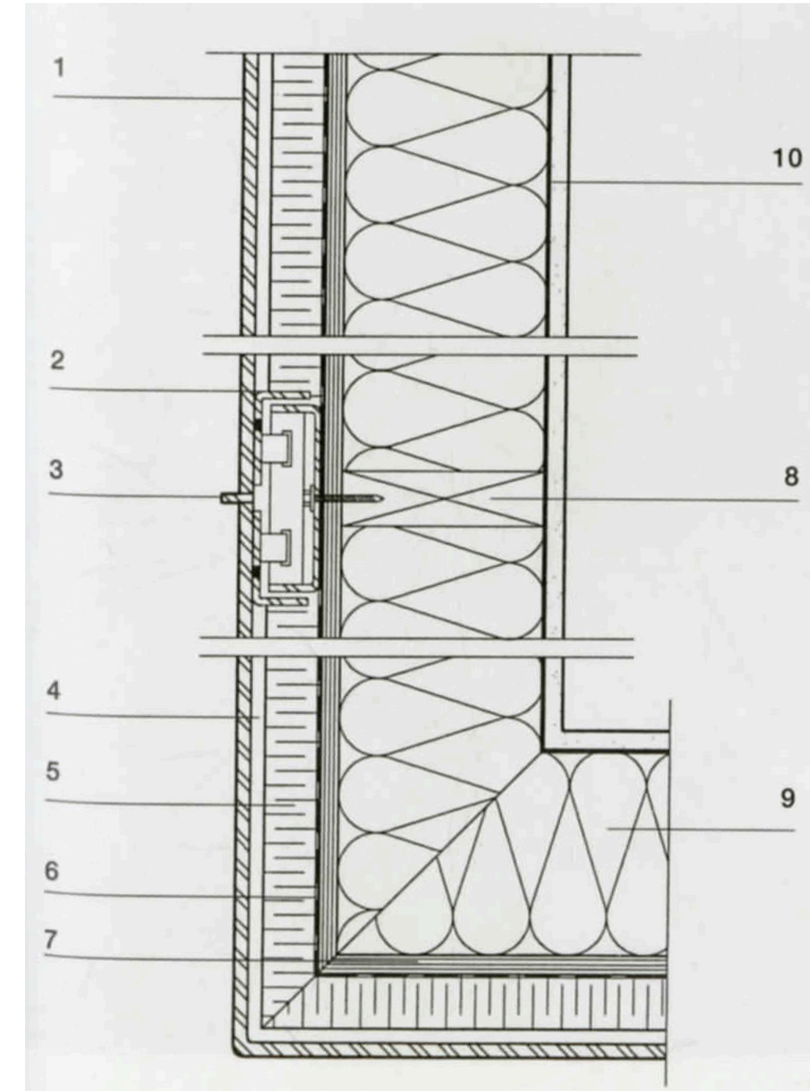
prada tower. office for metropolitan architecture.
punctured sheets of steel.

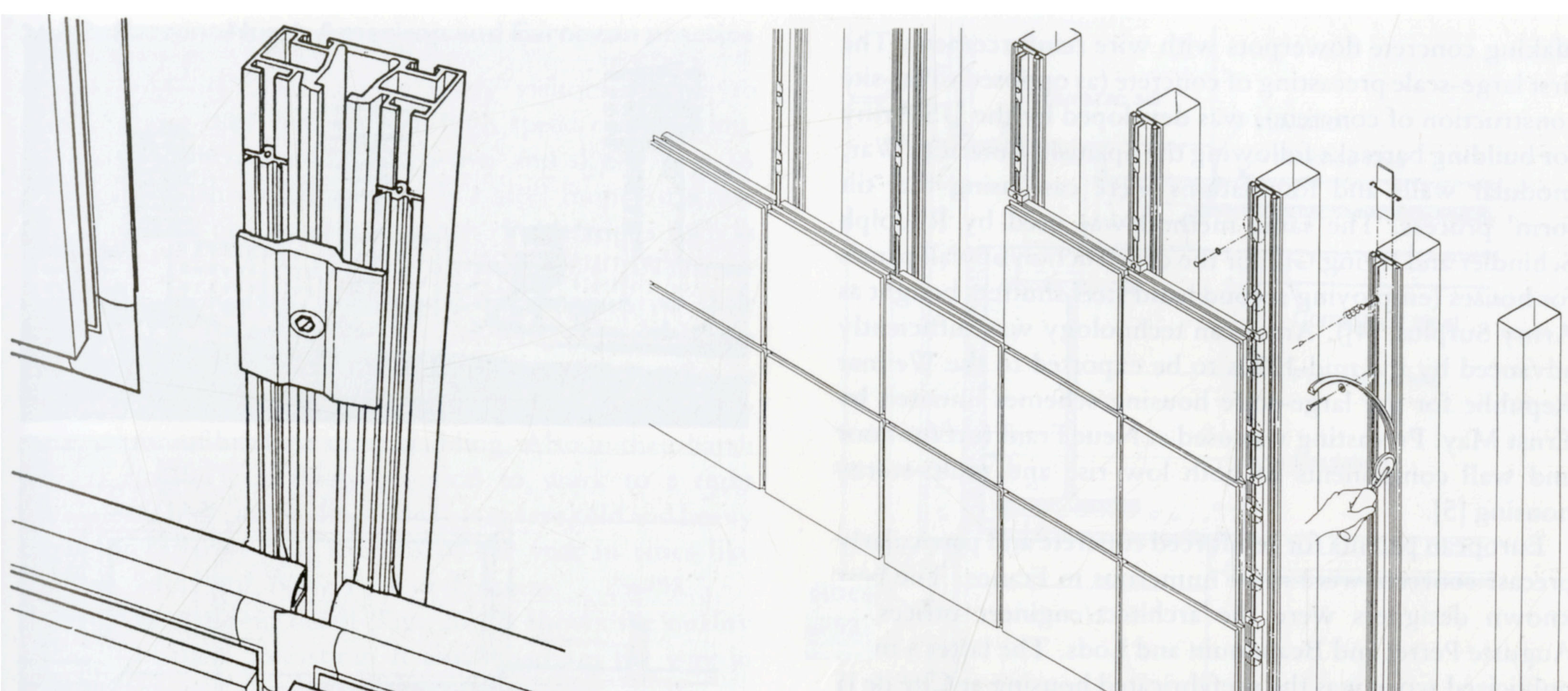
unlike the prior three buildings these examples push the boundaies of what is possible with a material like steel. not only do they push the boundaries but they also inspire those who come in contact with the buildings. anything from a facade of woven stainless steel strips to a sculpted facade of steel sheets is possible. even a material which is typically seen as stable and impervious can quickly be put into a state that challenges that assumption.

material assessment.details.fabrication.



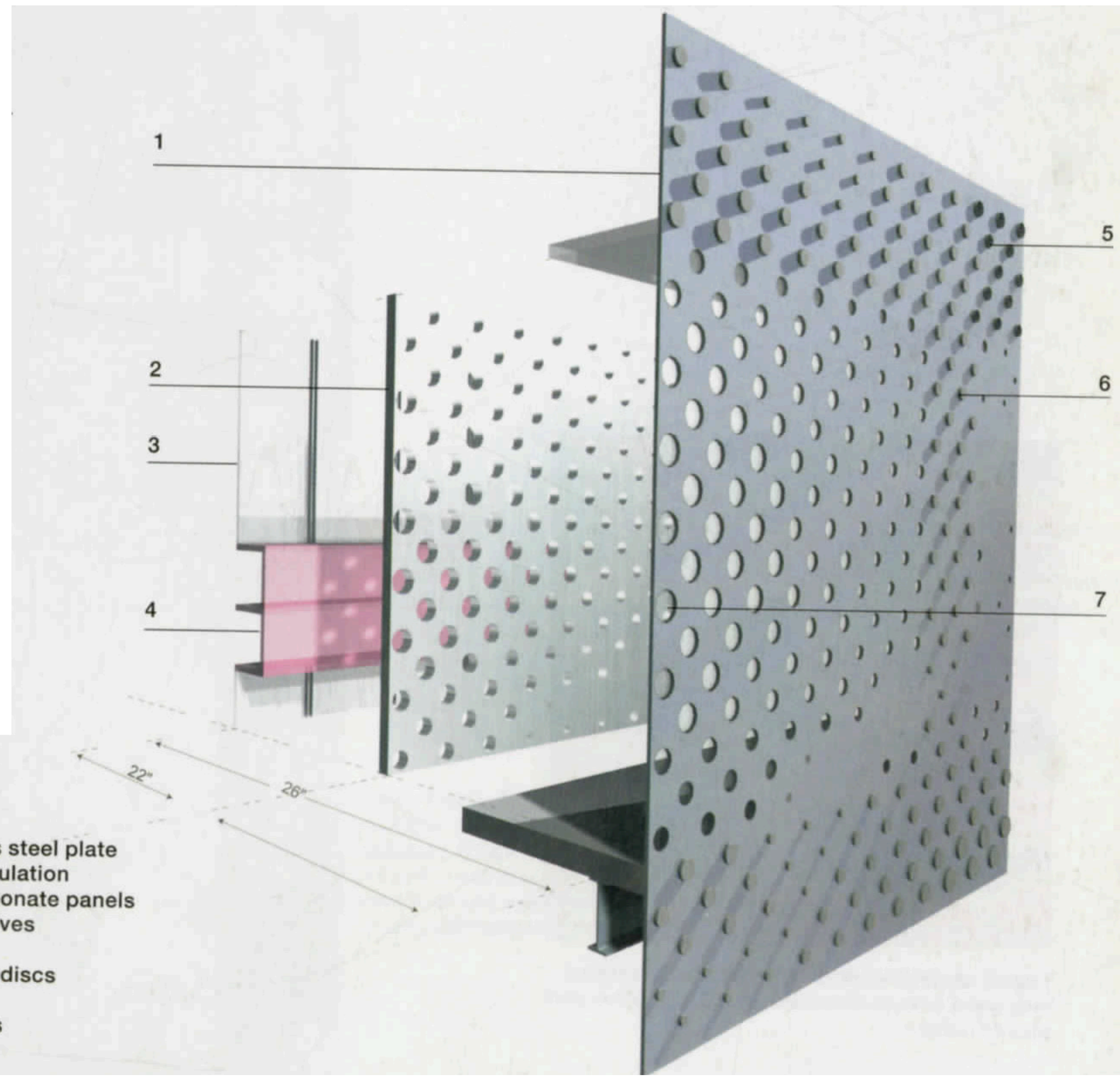






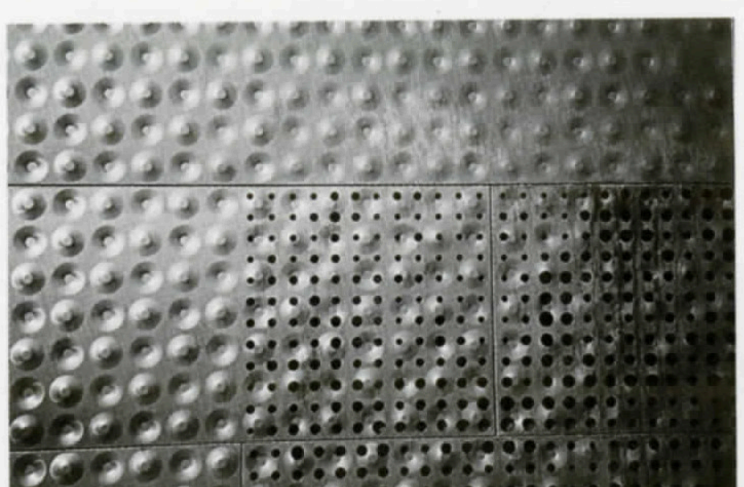
three common techniques for applying a steel facade to a building are being depicted here. the top left detail shows how a joint between two panels might be dealt with. the section in the top center along with the detail on the top right is showing how weathering steel might be ahered directly to the exterior of a building. in the bottom right the depiction of a track system is being shown. each of these systems pertain to a specific material, application, and desired look.

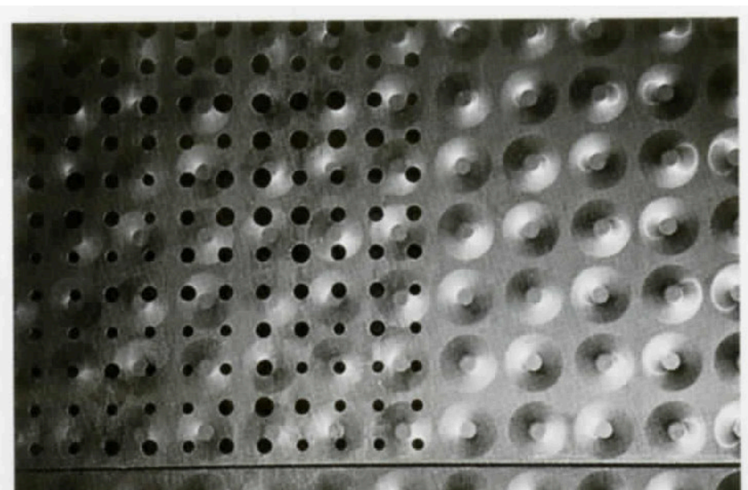
on this page are technique for how facade systems are constructed and also assembled. the panel on the right side shows the process that frank gehry took while designing the facade of the experience music project. while the form from the outside is highly imaginative the interior skeleton is far more typical of an average building. also, an exploded view of a wall assembly from the prada tower is being shown. finally, the method used in Springtecture B to adhere corrugated panels to the structures.

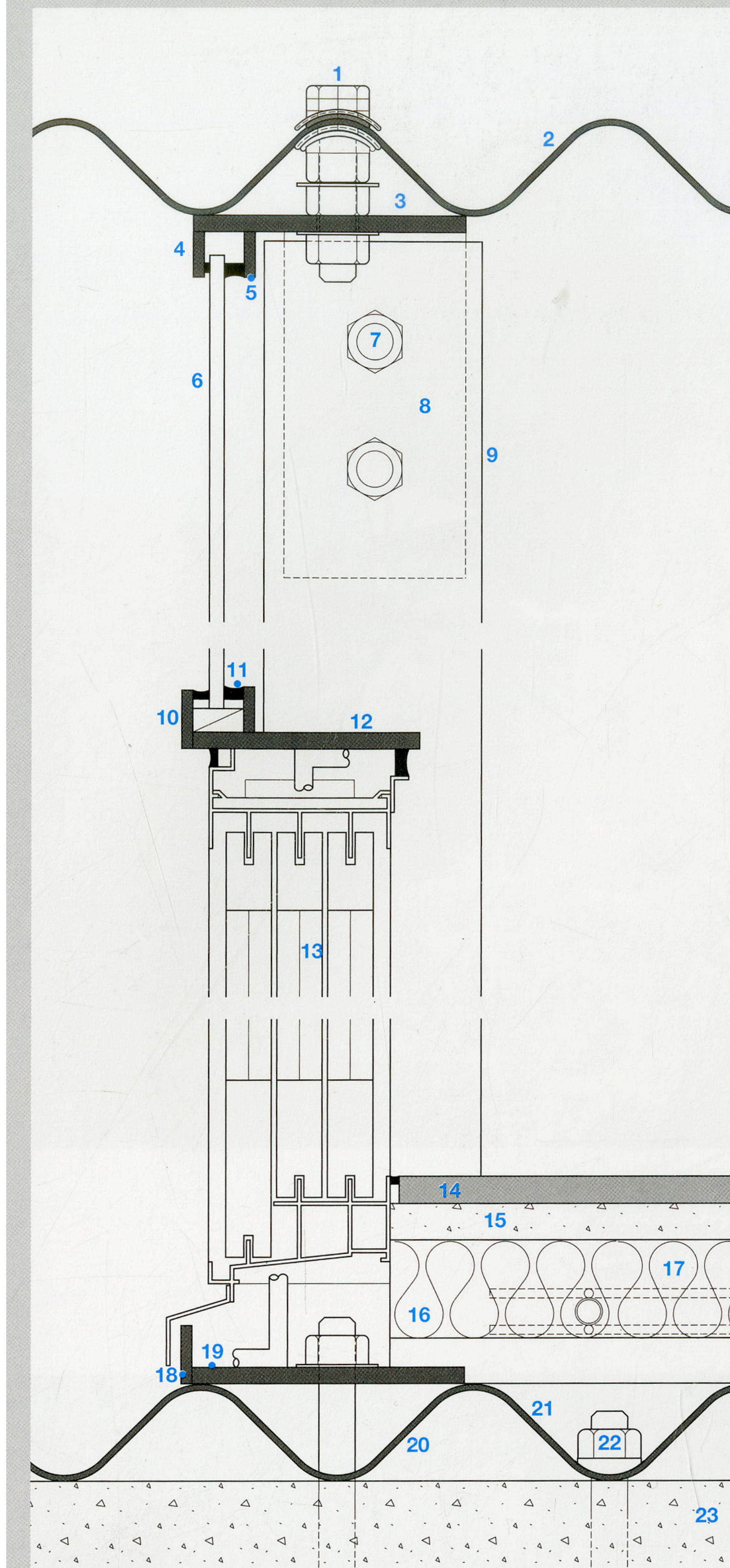


Facade layers.

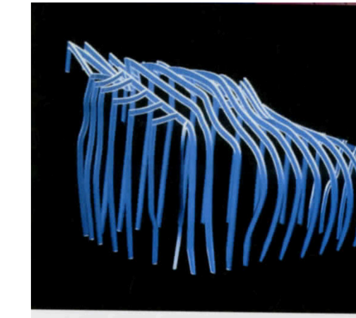
1 25 mm thick stainless steel plate
2 100 mm foil faced insulation
3 18 mm thick polycarbonate panels
4 translucent resin shelves
5 ventilation louvers
6 raised stainless steel discs at slabs and columns
7 ultra clear glass plugs

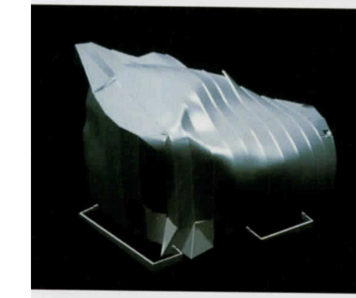


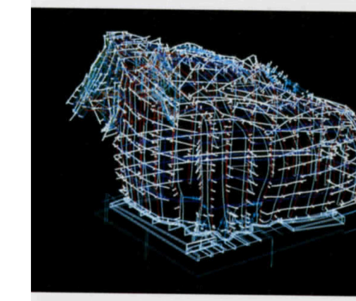


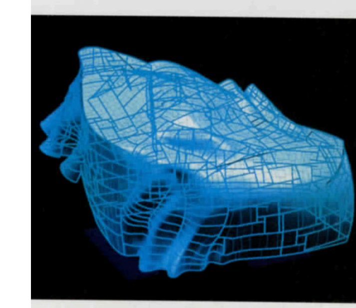


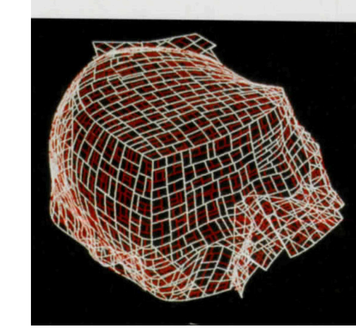
29.09
Sheet Metal Detail 5
1:5
1 Bolt and washer fixing to corrugated sheet roofing
2 Corrugated steel sheet with hot dip galvanized finish
3 Flat steel bar
4 Flat steel bar with hot dip galvanized finish
5 Flat steel bar with hot dip galvanized finish
6 Glass
7 Bolt fixing to gusset plate
8 Gusset steel plate with hot dip galvanized finish
9 Japanese cypress mullion
10 Flat steel bar with hot dip galvanized finish
11 Flat steel bar with hot dip galvanized finish
12 Flat steel bar with hot dip galvanized finish
13 Double sliding window assembly
14 Marble flooring
15 Setting mortar
16 Cinder concrete
17 Insulation
18 Flat steel bar with hot dip galvanized finish
19 Flat steel bar with hot dip galvanized finish
20 Corrugated steel sheet with hot dip galvanized finish
21 Mortar screed
22 Bolt and washer fixing to corrugated sheet roofing
23 Reinforced concrete slab









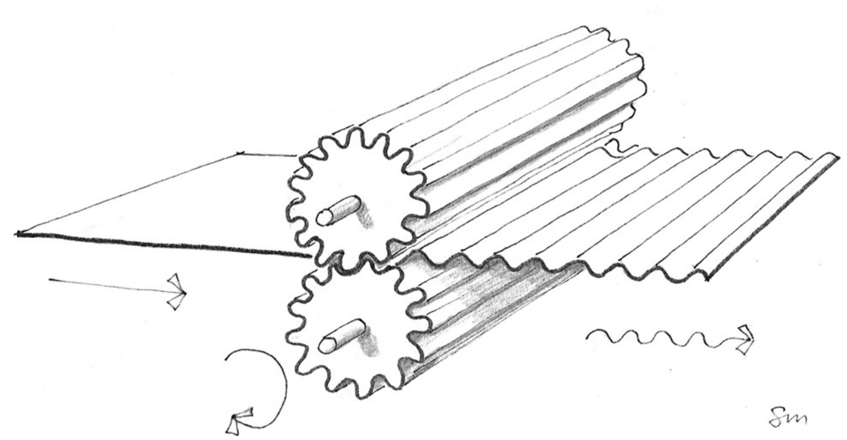


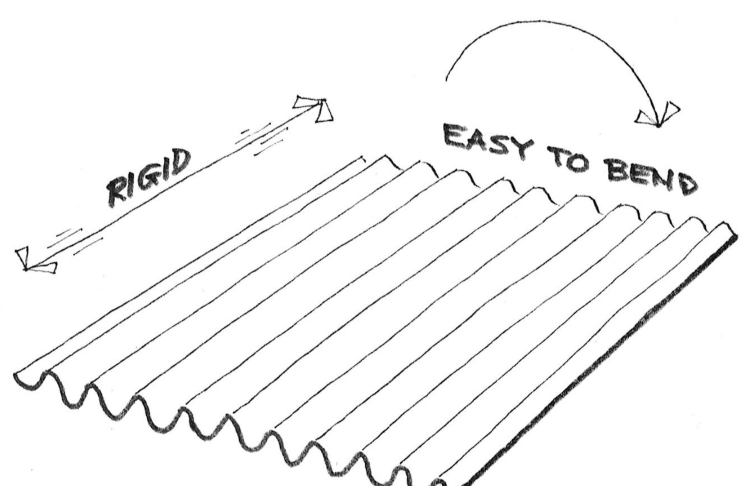
material assessment.details.fabrication.

shuhei endo predominantly used steel, in the form of corrugated sheets, to design springtecture b. unlike typical construction where steel beams and columns are used as the skeleton of the structure, shuhei endo employed steel to be the façade or outer skin of springtecture b. this practice of using various metallic materials, especially steel, as an outer facade has become far more popular recently and steel is one material that is leading the pack of façade materials. this category of steel cladding has many subsets and takes various forms and include: color-coated steel, cor-ten or weathering steels, enameled steels, stainless steel, and many other variations upon the same material (architecture and construction in steel, p.398). the most predominant forms of cladding used in architectural design were weathering steels, stainless steels, and corrugated steel sheets.

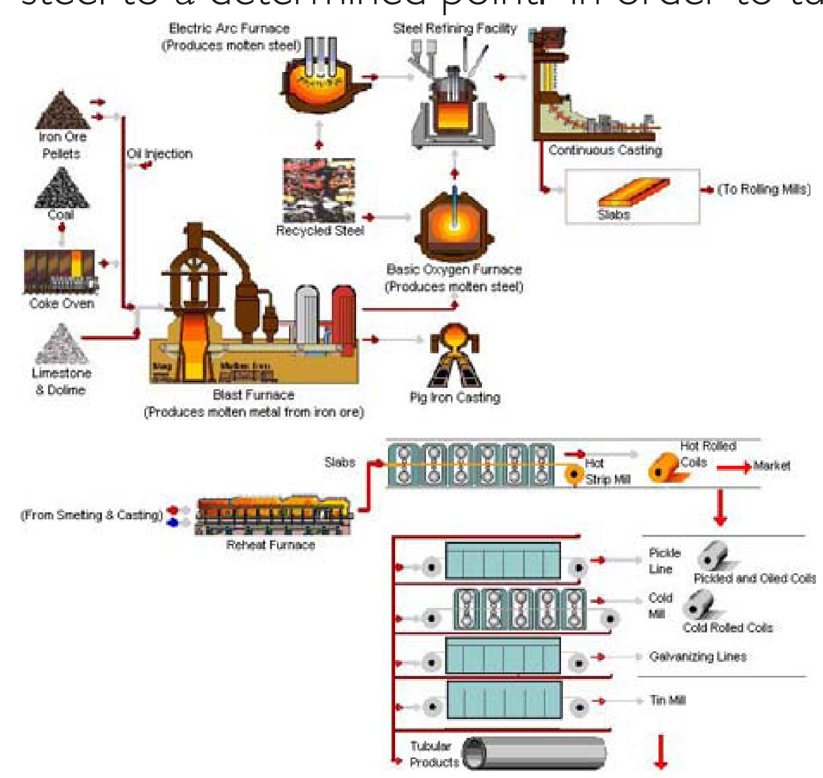
before delving into individual uses and examples of each of these materials there are properties that all of these forms of steel possess. when examining the thermal properties of steel it appears to be a material that neither insulates nor conducts heat extremely well, in comparison to other materials. in the case of attempting to use steel as an insolative material for the shell of a building one might be very disappointed. steel, on the order of per inch thickness, has an r-value between 0.0032 and 0.0055 (r-value chart). in comparison a single pane of glass has an r-value of roughly 240 times greater. in the case of using steel as a thermal mass it also fairs poorly. steel has a fairly low thermal conductivity value, 7-26 btu/hrfft (engineering toolbox). this means that the steel being used as a thermal mass would quickly loose or gain heat, depending on external conditions, and not be able to retain a constant internal temperature. one example of this phenomenon in action is when corrugated steel was originally seen as a great building material for tropical climates. this was believed because the corrugated panels used in hut construction would quickly cool down in the evenings after the hot days (steel construction, p.66).

production.





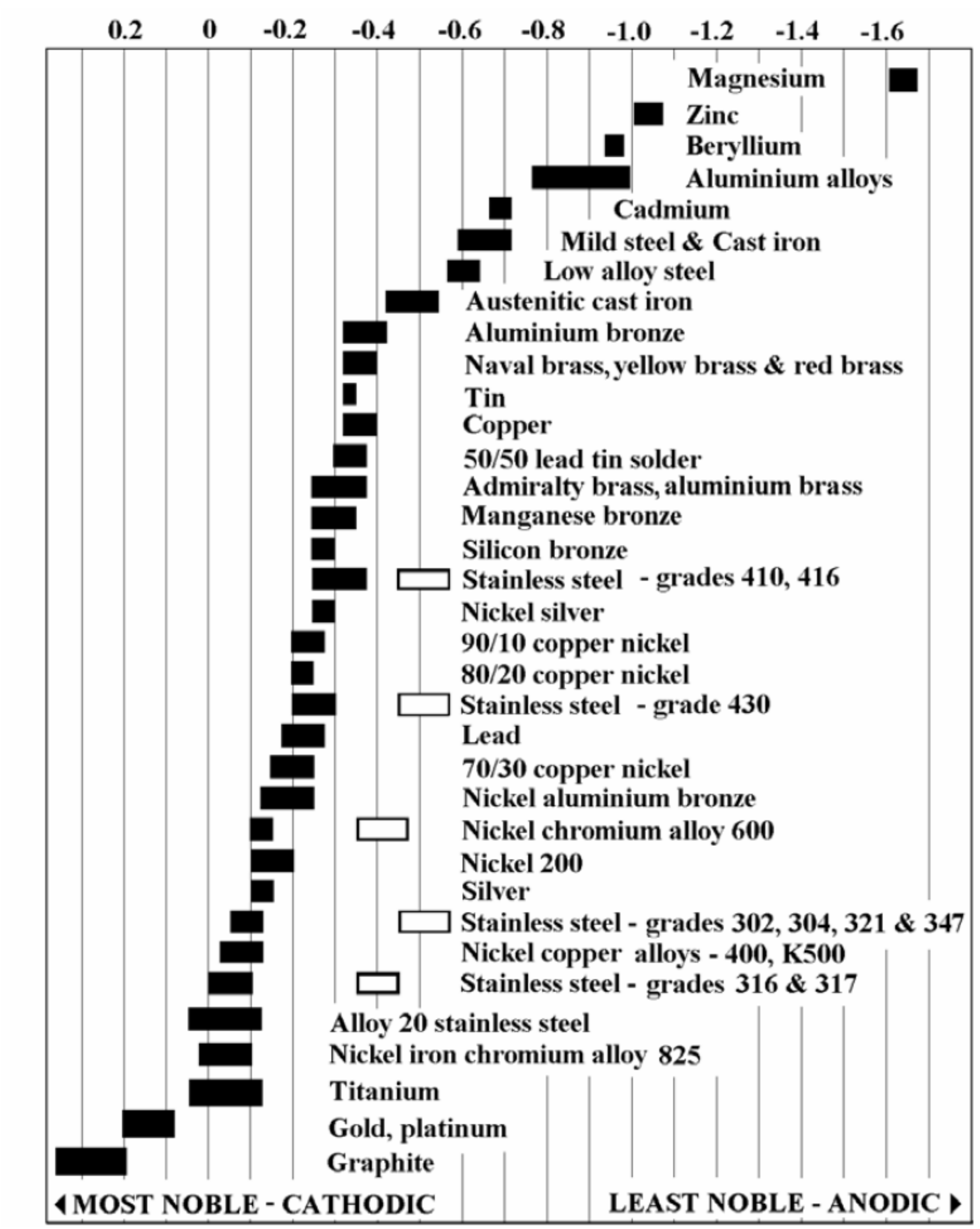
the process for creating sheets of steel starts with the smelting of materials to create molten steel, and its here where the grade of steel will be determined by the carbon content and inclusion of other alloying materials. this molten steel is then cast into ingots where it is then sent to a rolling machine. these rolling machines decrease the thickness of the steel to a determined point. in order to turn this into sheets of corrugated paneling is an easy process. the sheets are passed through another rolling machine, but instead smooth rollers the rollers are covered in teeth. these teeth match the corrugation. when the sheets come out of the machine they are corrugated and can either be transferred onto a roll or trimed to a determined length.



galvanic reaction.thermal properties.

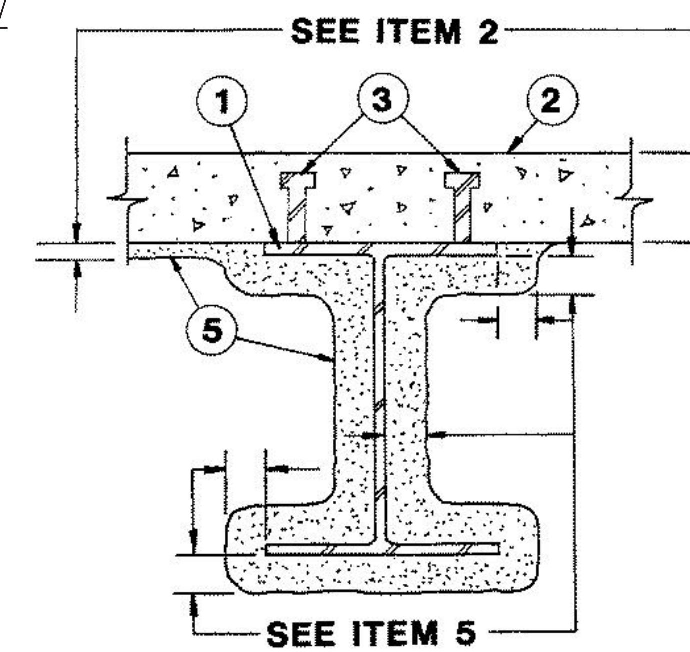
another property that one must keep in mind when using steel in design is the galvanic reaction. this reaction takes place when there is a difference in electrode potentials between materials that are in contact with each other. this difference in potentials sets up a situation where one material corrodes over another, and often at an accelerated rate. to prevent this from happening a physical barrier is often created in the form of a neoprene gasket (architecture and construction in steel,p.333).

when designing with a material like steel, the possibility of galvanic reactions taking place must be thought through. by keeping materials that are fall apart from each other on the galvanic chart physically seperated these corrosive reactions can be avoided.



heavily implementing steel in the design of buildings, both for cladding and structural elements, is because it has a high strength to weight ratio (architecture and construction in steel, p.391), meaning that in comparison to other materials steel has a high strength when compared to its weight, and this correlates to why steel is such a versatile material. other properties of steel are that it is a relatively fire resistant in comparison to other materials that are used in relatively the same way as steel. in comparison to aluminum, another material used for both cladding and framing, steel can resist temperatures up to 960f before it loses half of its structural integrity, and aluminum can only withstand temperatures of 330f before it reaches a similar level of structural integrity (architecture and construction in steel, p.391). in comparison to another building material, wood, the fire resistance of steel far exceeds that of wood. where these materials begin to differ is when one starts comparing the weathering effects, galvanic reactions, reasons for avoiding a material, or level of knowledge and detail need to successfully use these materials on a project.

Thermal Conductivity - k - (W/mK)	
Aluminum	250
Brick dense	1.31
Brick work	0.69
Concrete, light	0.42
Copper 401	400
Fiberglass	0.04
Fiber insulating board	0.048
Glass	1.05
Plaster, gypsum	0.48
Plywood	0.13
Steel, Carbon 1%	43
Stainless Steel	16



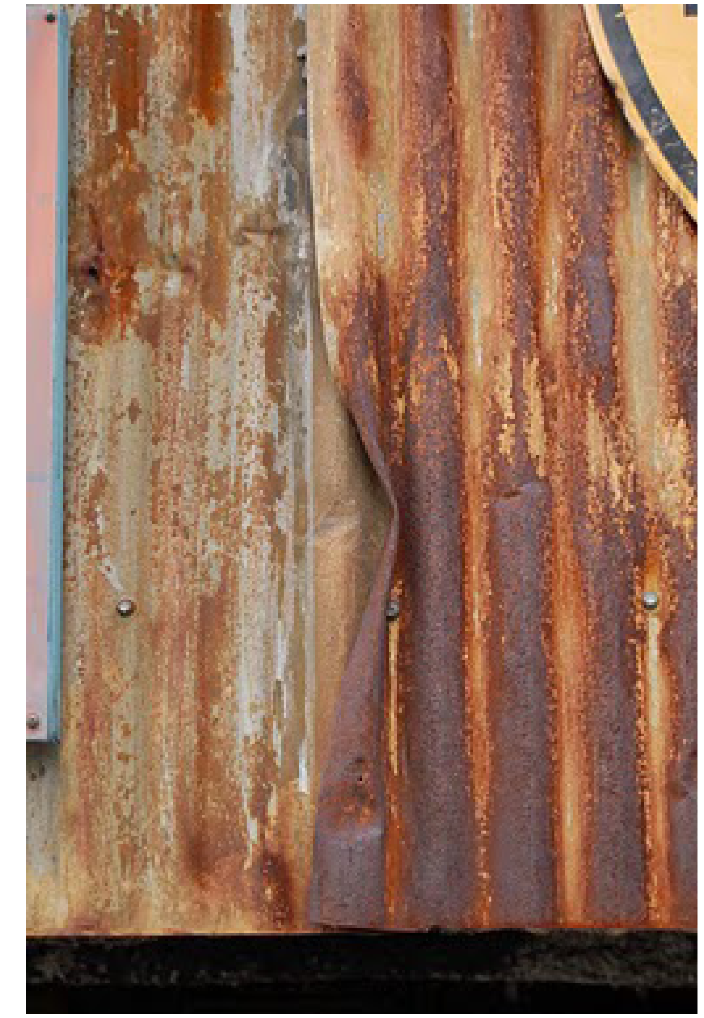
along with corrosion a designer must keep fire protection in mind. structural elements like steel beams require some for of fire protetions. often this is to not save the building, but to instead keep it stable long enough to ensure people are able to evacuate the building.

weathering processes.

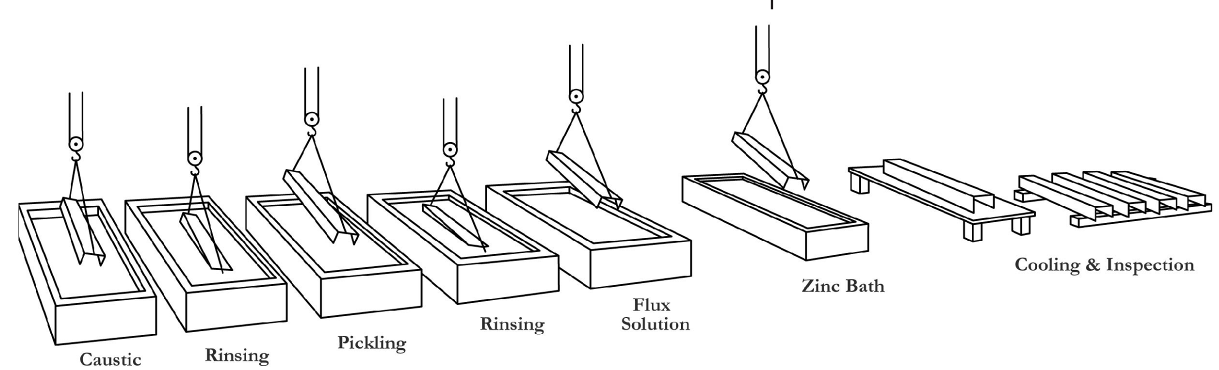
the family of materials classified as steel that are used in construction can be divided along a distinct dividing line, whether the material is protected against corrosion or not protected. these materials are either protected using a coating or alloyed with zinc, chromium, or molybdenum, as in the case of stainless steel. materials like cor-ten steel, or other weathering steels, are used because of this characteristic to corrode and thus encouraged to rust. two very different approaches to the problem of corrosion produce very different materials with diverse applications.

if one were looking for a steel cladding material that requires less long-term maintenance then a product like cor-ten steel would be a material that is highly desired (architecture and construction in steel, p.97). on the other hand the class of steel known as weathering steel carries many peculiarities with it that can create difficulties for the designer as well as the client. for weathering steels to be implemented properly prior knowledge of how the material reacts over time to different climates, along with knowledge of proper detailing procedures to ensure the material corrodes correctly is a necessity. weathering steels, if improperly positioned on a building or in the wrong climate, may take an abnormally long time to build up the protective coating of corrosion on its surface, develop unsightly streaks, corrode far too quickly, or take on an undesired coloring. (architecture and construction in steel, p.97&103). all of these aspects of the material are ones that a designer using weather steels should be acutely aware of and take into consideration.

the other family of materials is those that are not created to rust, whether due to alloying or protective coatings. corrugated steel, in particular galvanized corrugated steel like that in use springtecture b, falls into this category of a metallic material being protected by a protective coating. when it comes to the weathering of these materials in theory the protective layer or alloying material should suspend corrosion, but often due to imperfect alloying or coating this does not always prove true. material detailing in regards to flashing and trim to provide a barrier to moisture and the formation of rust is highly important to extend the life of the material (architecture and construction in steel, p.391). in conclusion steel is a material that has several very desirable traits and because of this it is no surprise that steel has ruled the construction domain for projects of all sizes, and looks to continue to be used heavily until a fundamental leap in construction practices takes place.

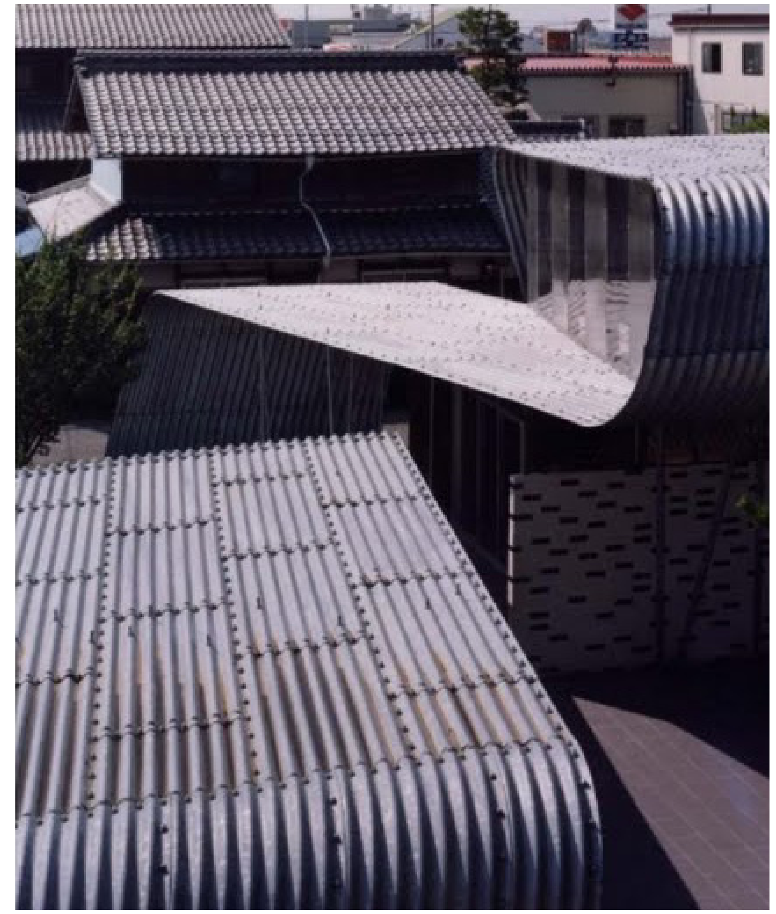


elements like moisture and oxygen are steel's worst enemies in many cases, except for weathering steels. this process of oxidation that takes place on steel is called rust and if left untreated can slowly eat away at the integrity of a steel beam or panel, again weathering steels are the exception to this rule a in that rust creates a barrier that protects the steel. to combat this virtually all steel pieces, especially those exposed to the elements, are galvanized. this process creates a barrier on the steel that protects the steel within from being corroded out by rust propogation. this this is done thorugh a process called hot dip galvanizing where a thin layer of zinc is applied to create that protective barrier. to the left are images that depict the process.



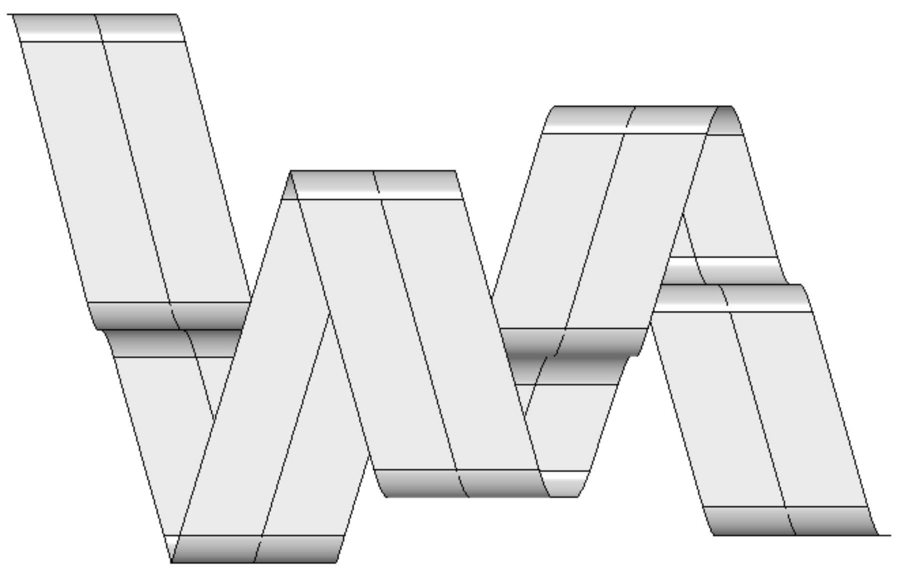
material assessment.springtecture b.

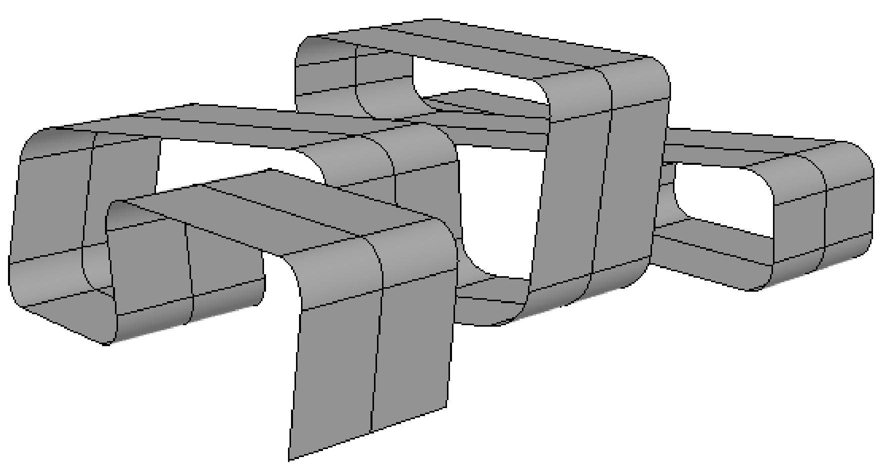
in order to achieve the graceful lines and curves of architect shuhei endo's springtecture b a material was needed that could be easily bent and shaped to a variety of forms. in the case of springtecture b, the material selected to act, as the skin of the building envelope was corrugated steel. this material comes in large sheets, and in pictures of the building the method used to join the hundreds of sheets together can be seen. the sheets, once joined together, form a single ribbon of steel that is 16 feet wide, 295 feet long, and 0.1 inches thick (takahasi, p.125). the ribbon is used to create not only interior spaces, through the creation of walls and ceilings, but also creates a series of exterior spaces that dot the building. the ability to create exterior and interior spaces that seamlessly flow into one another and link all aspects of the building to one another is one reason for why shuhei endo would choose this material. this idea of creating simply constructed buildings symbolizes shuhei endo's idea of using minimalist ideas and construction techniques that provide an open building system (takahasi, p.127). also the flexibility of using a building material that can easily be transformed, reused, moved, and constructed are all ideas held closely by endo.



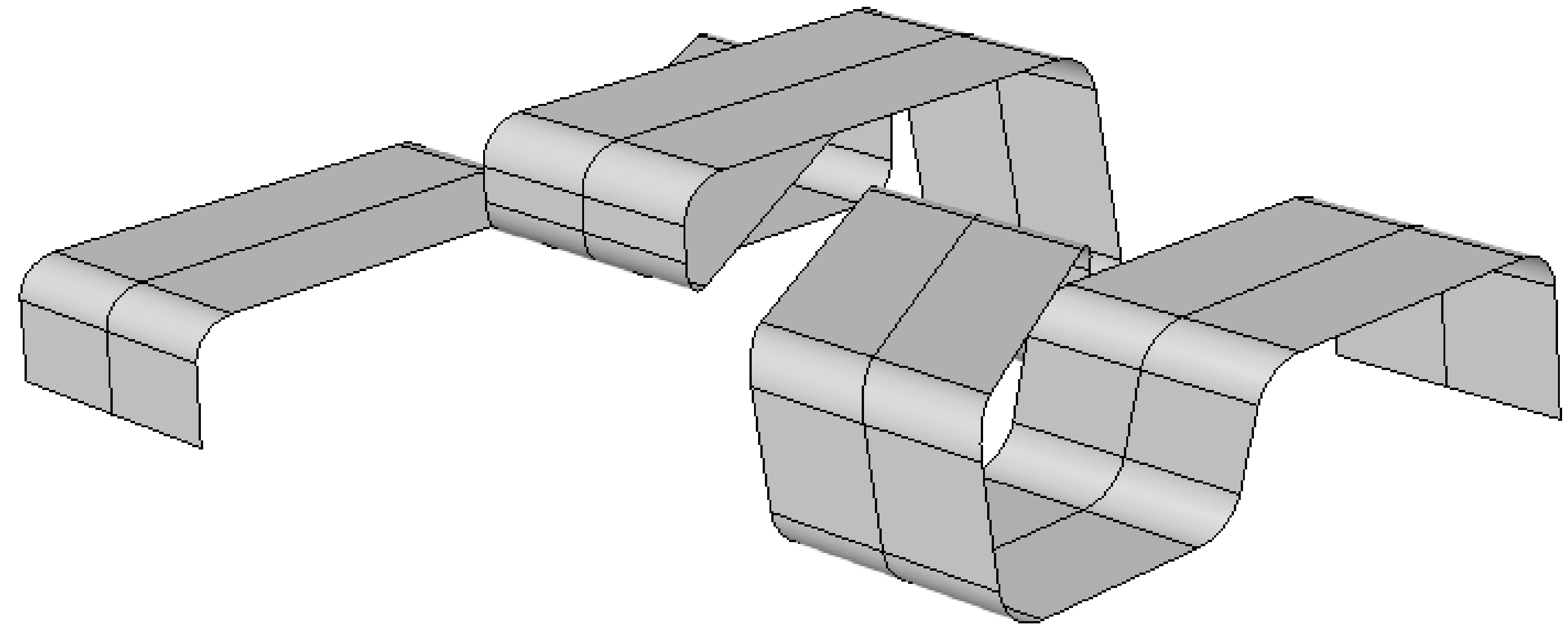
to the left are several pictures that try to depict how shuhei endo used corrugated steel to create the seamless blending of indoor and outdoor spaces. along with the corrugated steel steel pipes were also used to support the skins own weight, snow loads, and materials loads attached to the structure. this material while ideal for creating these forms, performs poorly when doing a thermal analysis.

Several fabrication and installation challenges probably confronted Shuhei Endo. For the building's design an abnormally large ribbon was needed, both length and width, and attempting to fabricate a single piece of corrugated steel would be near impossible. To confront this problem the ribbon was fabricated out of several smaller sheets of steel and then bolted together to create the illusion of a single sheet of steel that has organically sprung into place. Another challenge that faced the designer was how to deal with supporting the corrugated steel coil under its own weight along with the weigh of snow loads. In order to solve this issue steel support posts were strategically placed around the building, and brick masonry walls were inserted to provide added support.

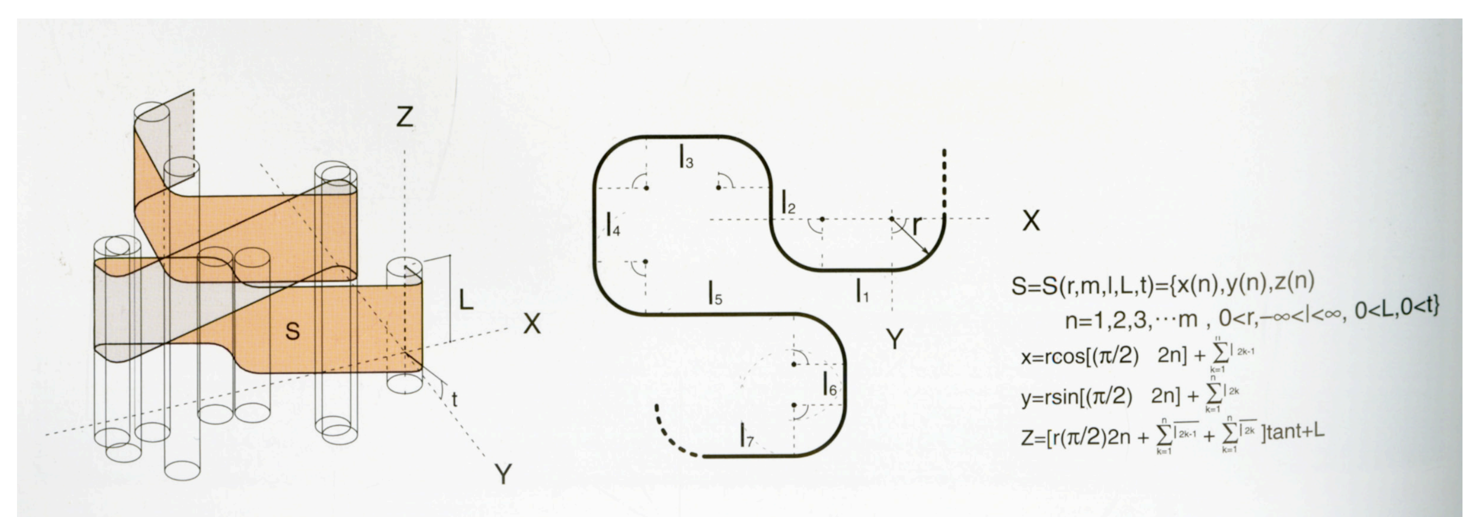




coil.perspective.



Temperatures in the Shiga Prefecture of Japan are typically fairly low, yearly average of 58 degrees F, the thermal properties of corrugated steel do not necessarily line up with typical comfort needs. The thermal resistance of steel is in the neighborhood of 0.0032R per inch (r-value chart) and, with a wall section that in most places only consists of a sheet of steel 0.1 inches thick one would assume the house tends to be fairly cold outside of the summer months. To combat and address this issue a layer of insulating paint, 0.03 inches thick, that had the insulating qualities equivalent of 1.2 inches of spray polyurethane foam were added to the bedroom. This boosted the R-value in this room to approximately an R-value of 7.2 (r-value chart). In conclusion, the use of corrugated steel is on of the defining features of Springtecture B, but with the artistic qualities of this material comes several fabrication difficulties and poor thermal performance.



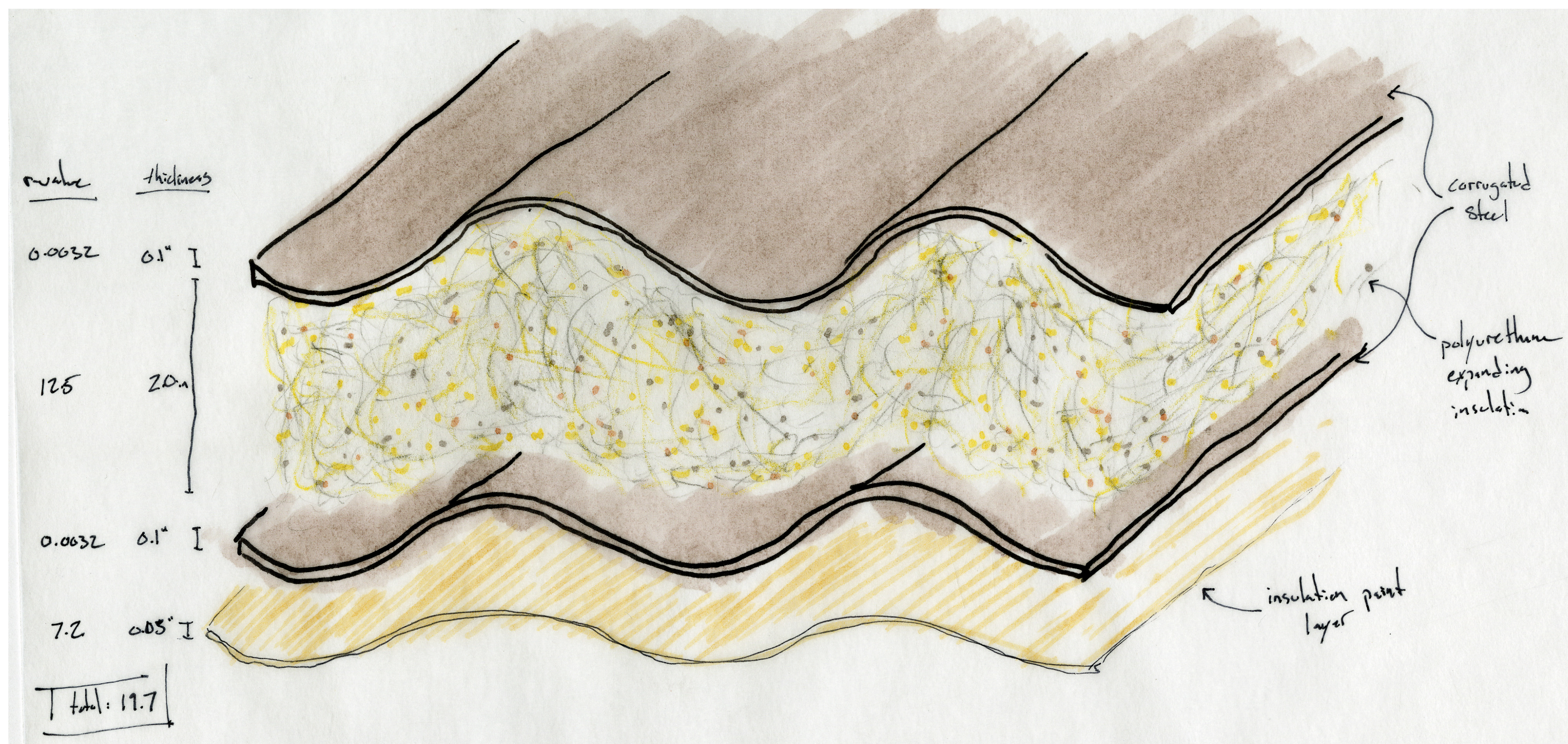
design intervention.

deisgn intervention.

Springtecture B is located in an area that experiences fairly low temperatures for much of the year, and the small amounts of insulation and low thermal mass of the skin does little to help keep the interior comfortable year round. If asked to make a design intervention I would choose to focus on improving the thermal properties of the steel skin through the addition of insulation. This insulation could take a few different forms. One option could be to sandwich a layer of expanding polyurethane foam between two layers of corrugated steel. This option would exponentially increase the thermal properties. If only 2 inches of foam were added the r-value would theoretically increase by a factor of nearly 40 to and r-value of approximately 12.5. While this value is still fairly low compared to many residential houses being built today it would greatly improve the thermal properties of the building while retaining the look originally desired by the architect. If by chance the aesthetics of the building could be sacrificed on the interior living areas, a layer of insulation paint, like that applied in the bedroom, could be added. Just 0.03 inches of insulation paint could be added to increase the r-value of the skin to a value of approximately 19.7. With an R-value of 19.7 the proposition of residing in this building year round quickly becomes a feasible proposition, but it would come at the cost of the aesthetics and core of what Shuhei Endo believes about his architecture.

current skin cross-section.

proposed skin cross-section.



a proposed modification that could be made to springtecture b if thermal comfort was critical and desired.

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