**Masters Thesis**

Clubhouse Facility at St Andrews Beach Golf Course, Fingal, Victoria, AUSTRALIA

completed for the course Masters of Architecture (MSc) under the supervision of

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*a huge thanks to my parents and family who have not only supported my studies in Austria, but have also coped with a reduced-size family over the last 5 years.*

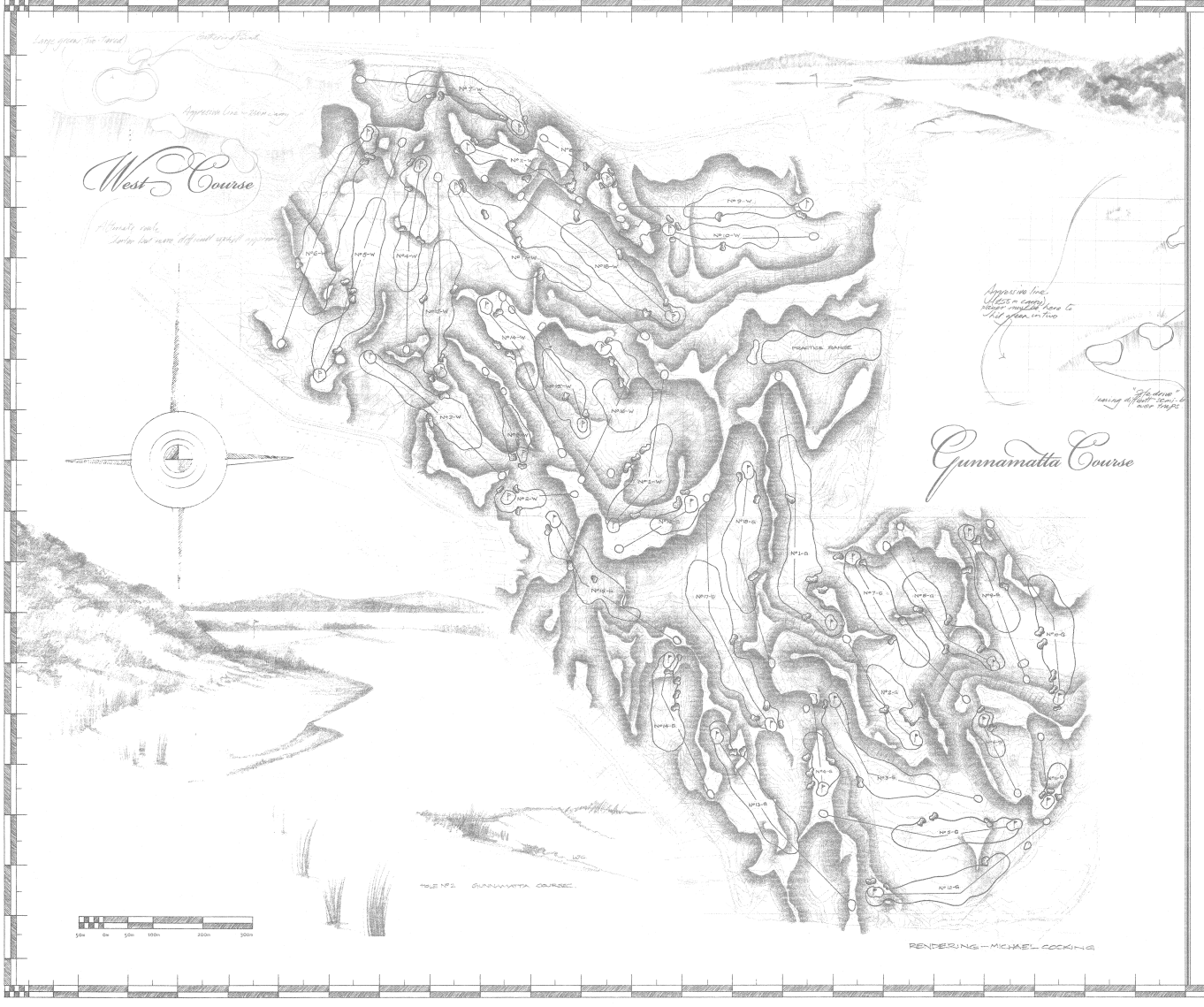
The Australian Sports Commission estimates that in 2008 ***1.18 million*** Australians played golf. This figure represents 6% of the total population and makes golf Australia's highest participation sport. A total of 450,000 people were registered members at one of Australia's 1530 golf clubs with more than ***1566 courses***. Another 475,000 or 51% of all golfers are social golfers with no official attachment to a golf club. The gender ratio is heavily weighted towards males at 4:1.

Victoria is home to 26% of the total Australian golf population who played an estimated ***30 million*** rounds of golf in 2008 - or 82,000 per day![1]

Golf in Australia is a true social sport offering something for everyone from the avid beginner to the tour professional.

[1] Golf Australia, http://www.golfaustralia.org.au/default.aspx?s=statisticsandquickfacts (08.03.2001)

# Introduction




## Gunnamatta Course

| HOLE | PAR | LENGTH | HOLE | PAR | LENGTH |
|---|---|---|---|---|---|
| 1 | 5 | 535m | 10 | 4 | 395m |
| 2 | 4 | 260m | 11 | 3 | 140m |
| 3 | 4 | 395m | 12 | 4 | 400m |
| 4 | 3 | 190m | 13 | 4 | 440m |
| 5 | 4 | 395m | 14 | 4 | 300m |
| 6 | 3 | 165m | 15 | 4 | 365m |
| 7 | 4 | 375m | 16 | 3 | 175m |
| 8 | 4 | 335m | 17 | 5 | 495m |
| 9 | 4 | 325m | 18 | 4 | 405m |
| OUT | 35 | 2975m | IN | 35 | 3115m |
| | | | OUT | 35 | 2975m |
| | | | TOT. | 70 | 6090m |

## Composite Course

| HOLE | COURSE | PAR | LENGTH | HOLE | COURSE | PAR | LENGTH |
|---|---|---|---|---|---|---|---|
| 1 | N°1-G | 5 | 535m | 10 | N°3-W | 4 | 365m |
| 2 | N°2-G | 4 | 260m | 11 | N°4-W | 4 | 380m |
| 3 | N°3-G | 4 | 395m | 12 | N°12-W | 4 | 400m |
| 4 | N°4-G | 3 | 190m | 13 | N°13-W | 3 | 185m |
| 5 | N°5-G | 4 | 395m | 14 | N°14-W | 4 | 340m |
| 6 | N°12-G | 4 | 400m | 15 | N°15-W | 3 | 220m |
| 7 | N°13-G | 4 | 440m | 16 | N°16-W | 4 | 310m |
| 8 | N°14-G | 4 | 300m | 17 | N°17-W | 5 | 500m |
| 9 | N°15-G | 4 | 365m | 18 | N°18-W | 4 | 470m |
| OUT | | 36 | 328om | IN | | 35 | 3170m |
| | | | | OUT | | 36 | 3280m |
| | | | | TOT. | | 71 | 6450m |

## West Course

| HOLE | PAR | LENGTH | HOLE | PAR | LENGTH |
|---|---|---|---|---|---|
| 1 | 4 | 340m | 10 | 4 | 300m |
| 2 | 3 | 140m | 11 | 4 | 350m |
| 3 | 4 | 365m | 12 | 4 | 400m |
| 4 | 4 | 380m | 13 | 3 | 185m |
| 5 | 5 | 500m | 14 | 4 | 340m |
| 6 | 5 | 465m | 15 | 4 | 320m |
| 7 | 4 | 355m | 16 | 4 | 310m |
| 8 | 3 | 155m | 17 | 5 | 500m |
| 9 | 4 | 375m | 18 | 4 | 395m |
| OUT | 36 | 3075m | IN | 36 | 3100m |
| | | | OUT | 36 | 3075m |
| | | | TOT. | 72 | 6175m |

## Legend

- GREEN
- TEEING AREA
- ALTERNATE / COMPOSITE COURSE TEE
- BUNKER
- SLOPES

THE GOLF CLUB
ST ANDREWS BEACH

001 course plan

Today Golf Courses are designed predominately by a special group of landscape architects, who have become known as Golf Course Architects - here we see a direct link between our profession and golf courses as well as an inherent connection between golf and design.

The history of golf course architecture is not the topic of this thesis but it is important to recognise that design has changed over time. Initially courses were almost entirely dependent upon the existing terrain. Only ploughs pulled by farm animals were available to form the land and thus formal 'shaping' was kept to a minimum. The natural lie of the land determined the character of the course. With the proliferation of machinery, especially bulldozers, landscapes could be shaped, formed and changed so much that they would no longer resemble the existing terrain. TPC Sawgrass is perhaps one of the best examples of this artificial approach. Its signature 17th hole with an island green shows how far machinery pushed the boundaries of design.

Modern architecture has also faced such challenges with the onset of computers and more recently parametric design. The modern movement in golf course design tries to retain the natural lie of the land with minimal impact to the environment. Today, as in the earlier days of golf, a great course is fitted into the terrain. The variety of topography around the world means that golf courses have developed regional characteristics, defining courses of particular regions.

*002 natural undulations, Old Course St Andrews, 16th C.*

*003 A bulldozer creates TPC Sawgrass, Peter Dye, 1980s*

*004 natural undulations at Moonah Links, 2003*

005 *Dubai Creek Clubhouse, Godwen Austen Johnson*

006 *Abu Dhabi Golf Club*

007 *Concept design for indoor golf, Zwarts + Jansma*

A clubhouse is simply the building attached to a golf club, usually providing at the least an area for members to socialise after a round of golf. However, depending upon the size of the club, the building may provide more facilities such as a restaurant, locker rooms, conference facilities as well as administration areas.

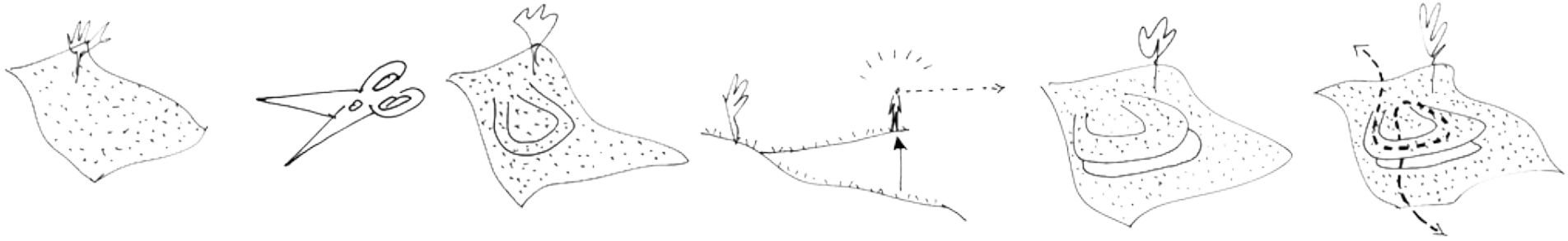
Traditionally golf club houses have not been built in contemporary style, but rather a more traditional style which might suggest grandness and position in society. Recently, however, as golf continues to appeal to younger people, architectures have broken from what is socially accepted and non traditional buildings with modern facilities are dotting the landscape.

Although the architecture is slowly changing the principles of clubhouse design remain. Large dining or bar areas with a view of the course, especially the 18th hole are standard; locker rooms with full amenities as well as golf club storage fill out a mid-sized building. More recently conference facilities, day spas and larger pro shops have become common at more established popular courses.

The clubhouse at Dubai Creek Golf and Yacht Club, with its roof inspired by a dhow sail has become a landmark in Dubai, whilst being a forerunner for formalistic modern clubhouse design. Further up the road in Abu Dhabi another club house takes the form of a falcon watching over the course.

In 2010 Saadiyat Beach Golf Club in Abu Dhabi announced thata Frank Gehry design had been chosen for its new clubhouse. This design is inspired by a khadori, the traditional dress worn by Arab men. Despite the formal nature it will be far cry from the traditional Victorian buildings one might immediately associate with golf.

Despite these examples of ‘anything goes’ modern Middle Eastern golf architecture, not all golf buildings are so whimsical in their formal search for form. In Upper Austria, X-architekten used the fluid nature of a golf swing to arrive at harmonious form, whilst the Dutch team Zwarts & Jansma were inspired by the flight of golf ball for their concept design - a design they, ironically, hope to build in Dubai.



008 *concept from x-architekten*

011 *floorplan*

009 *Clubhouse built into the terrain*

010 *Golf Club St. Oswald, X-architekten*

Location: Oswald, Upper Austria
Completion: 2004
Budget: €1 million
Usable area: 757m²

Although this clubhouse is relatively small it shows how a concept can be fully realised. The initial golf swing concept combined with the idea of cutting the clubhouse into the terrain was not discarded for a more pragmatic approach. The result is a successful small clubhouse with full amenities.

# *Project Description*

*012 view from 1st tee*

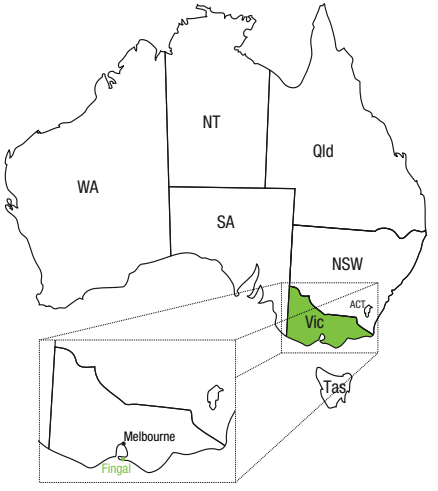
The Mornington Peninsula has been a popular golfing destination for many decades. Established private courses such as The National, Sorrento and Portsea have recently been challenged by new modern courses taking advantage of the favourable natural terrain and improved infrastructure connecting Melbourne. St Andrews Beach Golf Club opened in 2005 after a string of success stories from other new courses.

In Australia golf clubs can be categorised into three major groups; public, private and semi-private, although within the individual groups there is also much variation. The type of golf club changes the requirements of a clubhouse and other facilities. Public courses are open to everyone, regardless of skill level. Memberships are not offered and thus these clubs although very popular at a grass roots level do not have a core group of players. Correspondingly the facilities are often nothing more than a simple building with an office and desk where one pays for a round of golf. Food and drinks may be offered for the round but there would rarely be a sit down restaurant or bar.

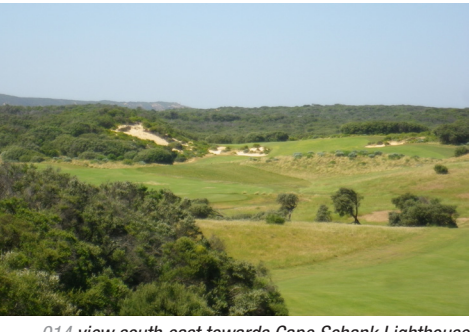
Private clubs are at the opposite extreme. Players must be members to play the course and use the facilities, which in this case would include full service restaurants and bar as well as a well-stocked pro shop. Furthermore locker rooms and club storage would be offered for members who wish to leave their gear at the course. Other features depending on the prestige of the club may include lounges, games rooms, spa and even a hotel area. Behind the scenes large administration areas with office, meeting rooms and secondary rooms are required for the day-to-day running of the club.

Finally, semi-private clubs do make memberships available but there is also general public access. St Andrews Beach is a semi-private club. In such clubs small locker rooms and club storage are required as well as a full service restaurant. However the more prestige rooms are not a necessity.

St Andrews Beach Golf Club is located about 60km due south of Melbourne on the Mornington Peninsula. The Mornington Peninsula developed as a beach side holiday destination for city dwellers during the start of the 20th century. Although



013 *view south from 1st tee*



014 *view south east towards Cape Schank Lighthouse*

015 *view from the top of the hill at the centre of the site*

tourism, driven by the local wineries, galleries and golf, is predominant on the Peninsula a few smaller towns are home to a permanent population.

Over the last 20 years the grassy undulating sand dunes of the Mornington Peninsula have become home to many world class golfing facilities and the home of professional golf tournaments. The traditional aboriginal name for the area is Moonah, meaning grassy plain – the name of another course only a few kilometres away. Within a 10 km radius there are 6 different golf clubs with a total of ten 18 hole golf courses. A drive of only 15 minutes will bring you to another 4: clearly the region is a vastly popular world class golfing destination.

The Golf Club at St Andrews Beach was opened in 2005 to a design byrenowned golf course architect Tom Doak.

Doak's design makes use of the natural terrain, using slopes and natural bowls to create an aesthetic golfing landscape. In 2007 the course was rated in the top 10 in Australia. However, before major facilities were built at the course the club unfortunately ran into financial difficulties. For many years the course lay dormant with only a few grounds keepers maintaining the multi-million dollar investment. Due to the financial trouble which plagued the club from the outset, facilities are today limited to a structure consisting of shipping containers and a marquee tent where players can get refreshments before or after the round.

In September 2010 new owners took over the club with a vision of developing the club into one of Australia's premier golfing destinations. Improved course

maintenance, completion of the accommodation unit, a hotel with day spa and of course a new clubhouse are to be funded through a major cash injection.

Tom Doak's design philosophy of using the natural contours to create a golf course resulted in a course which blends harmoniously with the surrounding grassy plains and dunes. The already built Gunnamatta course starts its route from one of the highest points on the property and has regular views out to the southern sea and Cape Schank lighthouse as well as back inland. A not yet built second course is to follow a more inland route starting at a similar high point.

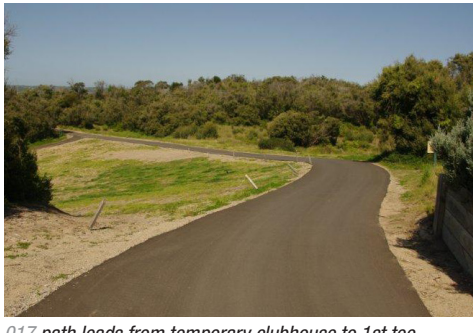
The master plan (Ill. 001) from Doak for the courses does not show any site for a clubhouse. However, in his book The Anatomy of a Golf Course, Doak describes his theory on modern golf course architecture, and tells the reader that 'access to the golf course and room for expansion of facilities' is the most important consideration in locating a clubhouse.

Furthermore, Doak believes that the best routing for a golf course might be 'overlooked because the clubhouse site was chosen in advance.'[1] Thus the decision to design a clubhouse facility after the establishment of the course as the topic for this thesis is in keeping with the course architect's original intention.

This thesis documents the development of a unique clubhouse for St Andrews Beach, which includes the necessary restaurant/ bar, administration areas and pro shop as well as locker rooms and golf club storage.

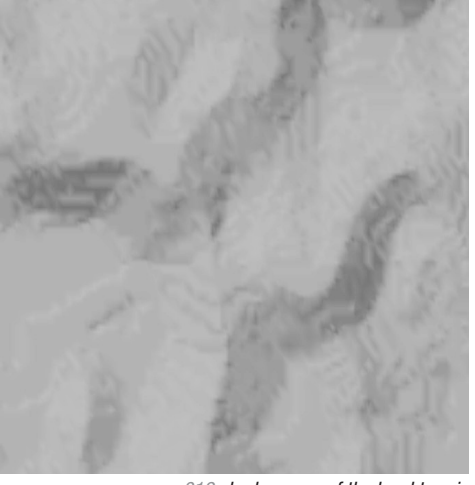
[1] Tom Doak, The Anatomy of a Golf Course, Ithaca, NY, Burford Books, 1992

*016 temporary clubhouse with marquee addition*



*017 path leads from temporary clubhouse to 1st tee*

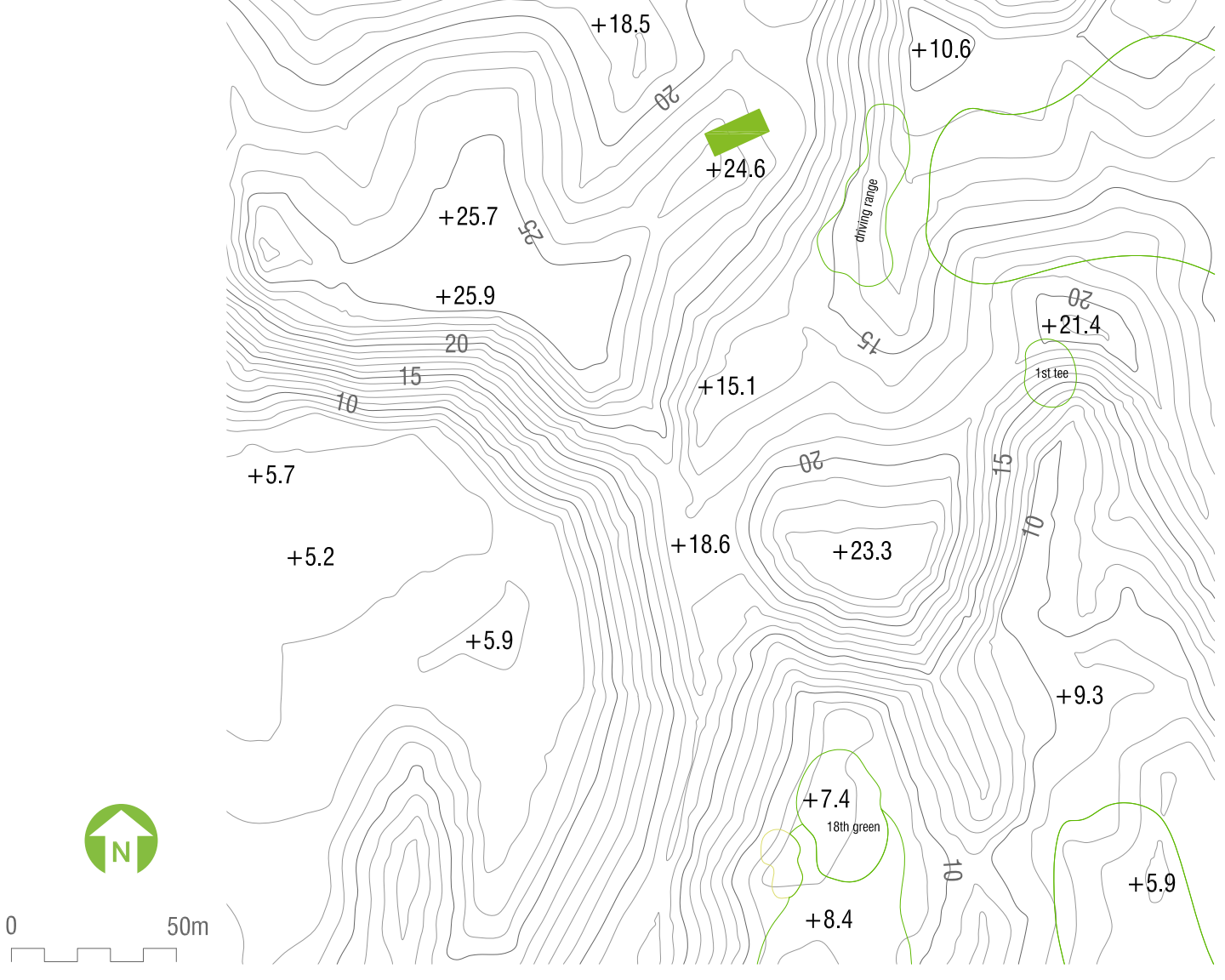
*018 thick natural vegetation cover the higher sand dunes*



*019 shadow map of the local terrain*

Access to the course is via a serpentine road from the north. This road passes a series of double houses built as onsite accommodation, but never finished. The road culminates at the large car park. The temporary clubhouse is visible to the south-west of the car park. On the southern side of the vegetation is the 1st tee and 18th green of the Gunnamatta course. The lighter grey areas in the west define the yet to be built second course.

*020 aerial view of the site*




The position of the current temporary clubhouse (shown in green) is practical only because of it proximity to the car park which could itself be better located.

The centre of the site is dominated by two large hills whose heights (23.3m and 25.9m) provide a platform for a view across the land and out to sea.

The higher of the two hills is the planned location for the 1st tee of the second course,the construction of which should also occur with the new cash injection. The current clubhouse does not take advantage of the terrain in the same way that Tom Doak's design of the course does.


021 aerial view of the site

N

existing infrastructure

planned infrastructure

access road

asphalt path

optimal area for clubhouse

The ideal location for a clubhouse must meet a few criteria. As we know access to the golf course is paramount. Equally important however is clear access to the clubhouse from the car park.

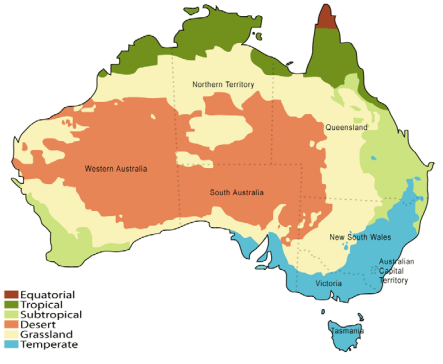
Assuming that the second course at St Andrews Beach is built, the new clubhouse must also give equal access to this course, but without dividing the landscape. The proposed Fingal course would have its starting and finishing holes to the west of the existing Gunnamatta course. The map on the opposite page shows the start and end of the current course marked with green dots whilst those of the proposed course are marked with white dots.

If one is to join the dots, the area within would be a suitable location for the clubhouse. The blue dashed line defines a general area whose location would be ideal. This region has interesting natural topography which would provide a view out over the course. This area would also be advantageous due to its proximity to the practice range. The final location of the design is indeed within this area.

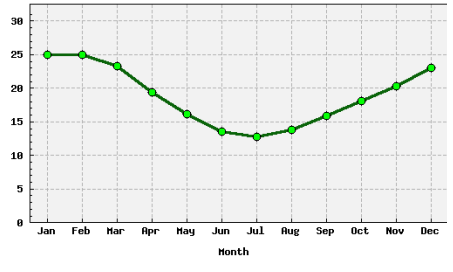
Vehicle access is also important. However, the decision was made to set the clubhouse away from the car park, creating a tranquil setting, rather than surrounding the clubhouse with bitumen. Existing paths would be used for players' access as well as deliveries. Given that golfers will walk up to 10 km in a round of golf, a short stroll from the car park is not too much to ask.

*022 existing path to and from the golf course*

*023 hill behind 18th green provides a view*




*024 Australian climatic regions*




*025 mean maximum temperature °C* [1]

Located at 38° south, Melbourne has a generally moderate oceanic climate which can be unstable leading to rapidly changing conditions. Melbourne is rightly labelled the city with 'four seasons in one day'. In European terms, Melbourne's climate is similar to that of southern Italy or areas of Croatia.

The average temperature in January is 29.9°C but the mercury often climbs above 40° for several days on end. July has the coolest mean maximum at just 13.4°C. This weather makes golf a year round sport.[2]

In the winter months the prevailing winds are strong southerlies bringing icy conditions to Victoria. Snow loading and frozen earth is obviously not a consideration, where soil temperatures range between 8 -15°C year round.[3]

Energy consumption is relatively high during summer months, when cooling systems try to cope with hot weather. This makes heat penetration into a building a consideration for building in this climate.

Due to the milder weather conditions ecological and sustainable building has been much slower to progress in Australia compared to Europe, where cold harsh winters demand it. Recently, however, with increases in energy prices and government rebates for insulation there is incentive to move towards sustainable building design and 5 star energy ratings. Despite this the physical demands on a building in Melbourne remain considerably lower than in central Europe.

[1] Australian Bureau of Meterology
[2] Ibid.
[3] Dirk Hindrichs, Klaus Daniel (eds), *plus minus 20°/40° latitude: Sustainable building in tropical and subtropical regions*, Axel Menges, Berlin, 2007

*026 13th Hole, St Andrews Beach*

# *Concept*

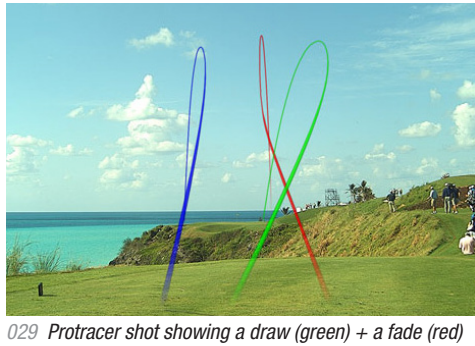
*027 Flight Curves*

After initial research and brainstorming it was decided to base the design on the flight of a golf ball. The flight of a golf ball follows the standard rules of ballistics such that a perfectly struck shot will follow a parabola with a function proportional to $1/kx^2$. However, on the golf course there are many different factors which affect the flight of the ball. Firstly the basic shot shapes should be recognised. For a right handed golfer, a ball which moves left to right in flight is known as a fade or cut, or in the extreme case a slice. Balls moving right to left are known as a draw or again in the extreme case a hook: very rarely does a golfer hit the ball dead straight.

The physics defining the movement of a golf ball are dependent upon many factors. Side spin causes lateral movement, whereas top and back spin cause the ball to rise or fall in flight due to the Magnus Effect. The final equation for the flight of a ball also takes into account the loft (i.e. angle) of the club, the force with which the ball is struck and of course external conditions such as humidity, air density and temperature as well as wind.

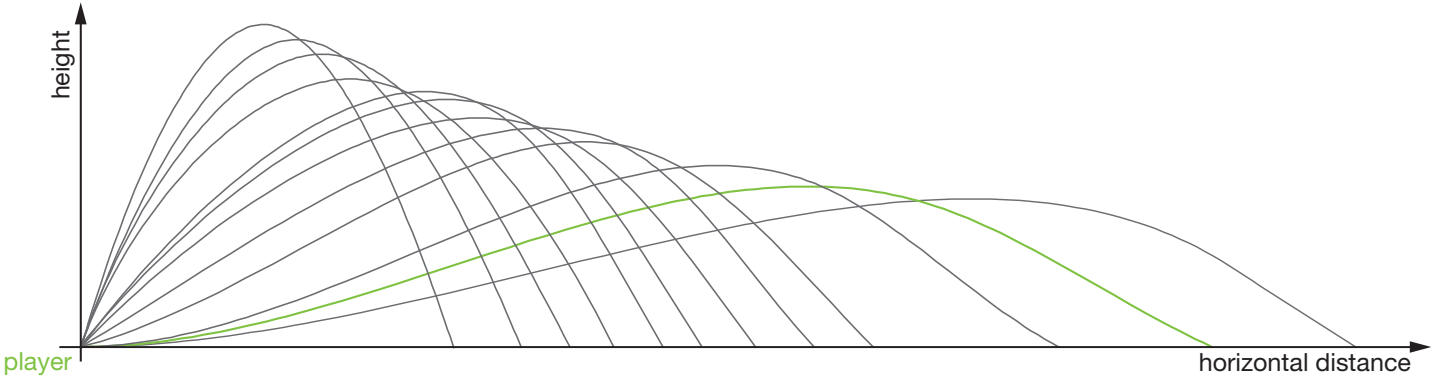
Most golfers will have standard shot shapes but a good golfer must be able to move the ball both ways in order to master various situations. Due to the side spin draws tend to have a longer lower flight with more roll out than a fade does.

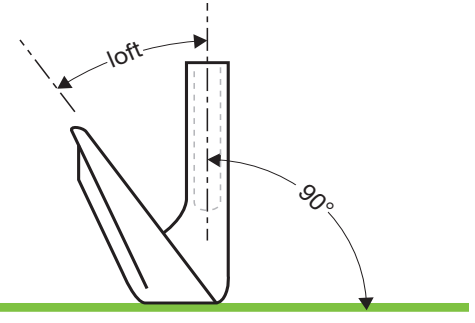
*028 a golfer's shot as seen with Protracer*



*029 Protracer shot showing a draw (green) + a fade (red)*


*main shot shapes in plan view*



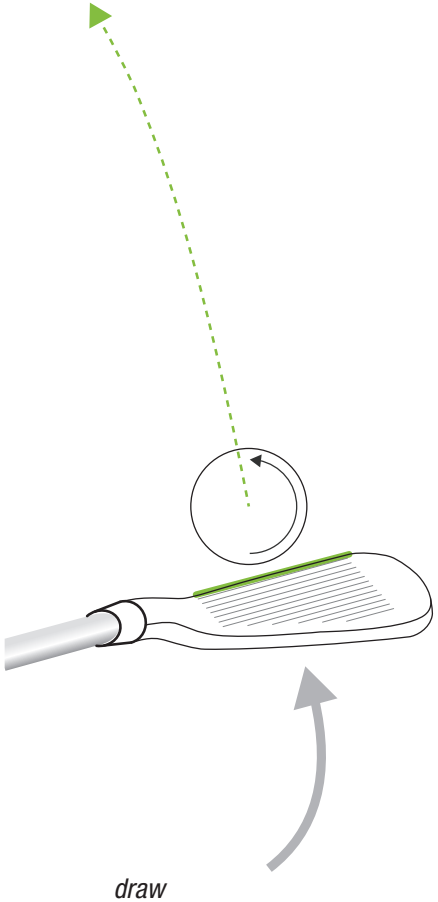




*club loft is intergral in determining launch angle*

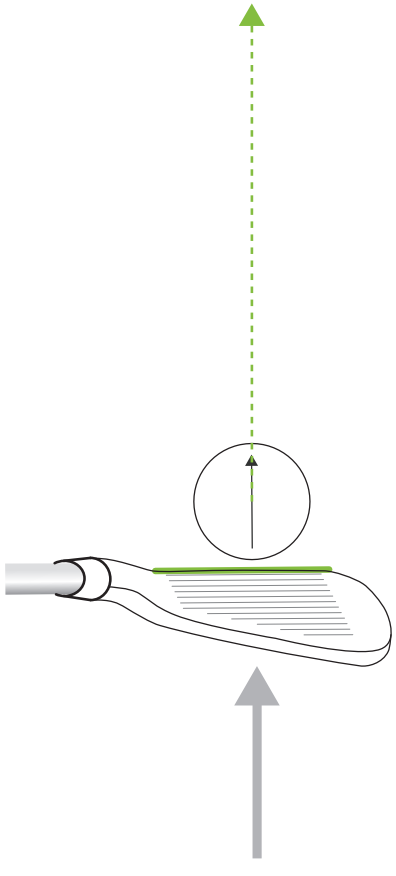
The distance that a golf ball travels is predominately a factor of the loft of the golf club used, this in turn determines the launch angle of the ball. Once the ball is in motion technical equations involving force, drag, Magnus Effect and side spin determine the ball's flight. In the diagram above we see approximations of the various parabolic curves created with the different lofted clubs.

In recent years technology such as Protracer has allowed the flight of balls to be studied in 3-dimensions.

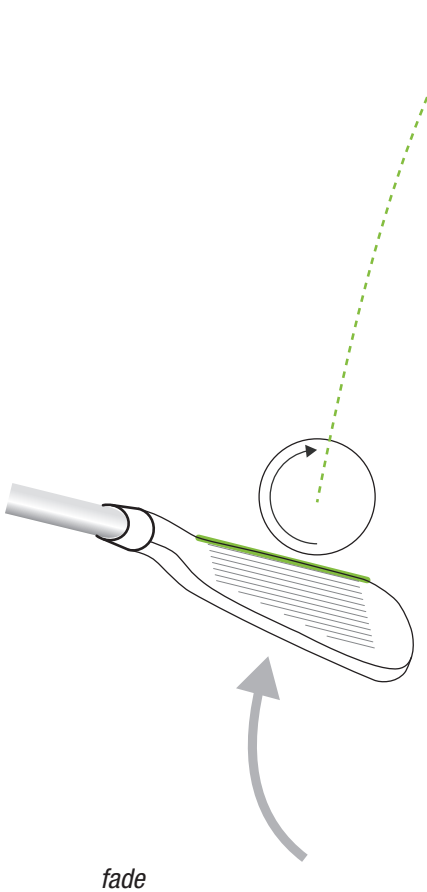
After deciding to use the flight of a golf ball to inspire the form, initial shell concepts were created. The first of these was a simple sweep between a long shot with low trajectory and a shorter shot with a much higher launch angle, the origin of which were constant. This immediately created a shell with an interesting internal space. After rotating and moving the second curve a new sweep formed a large shell, whose sides reveal two distinctly different ball flight curves.



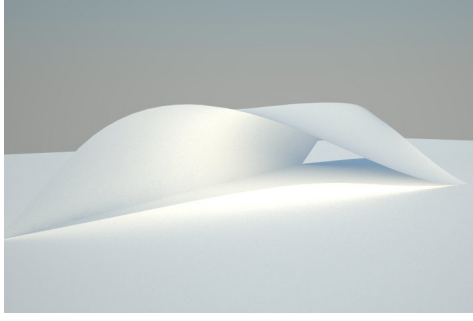
*draw*
clubface closed at impact and "wraps around the ball". Spin in an anti-clockwise direction is imparted and as a result the ball moves from right to left.



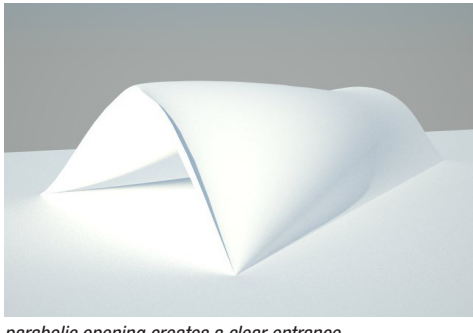
*pure*
clubface perpendicular to target line - no side spin, only top or back spin.



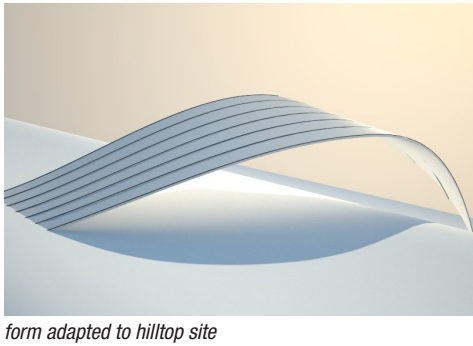
*fade*
clubface open at impact and cuts behind the ball. Spin in a clockwise direction is imparted and as a result the ball moves left to right.



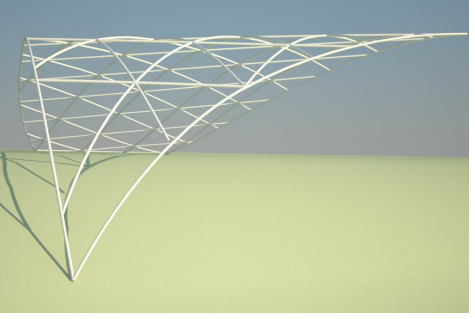
*initial concept model, October 2010*



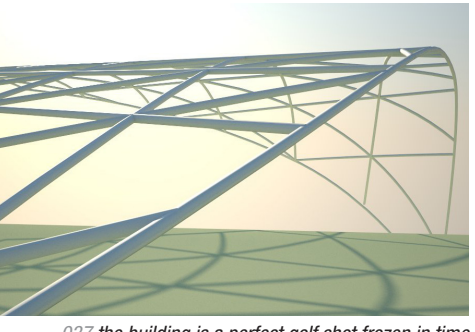
*parabolic opening creates a clear entrance*



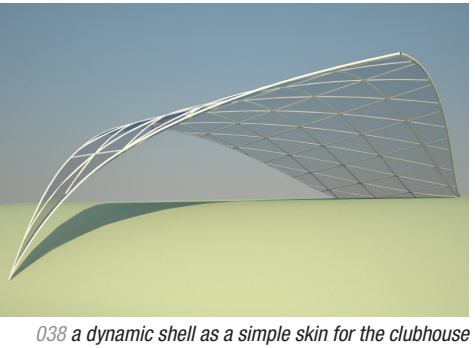
*form adapted to hilltop site*



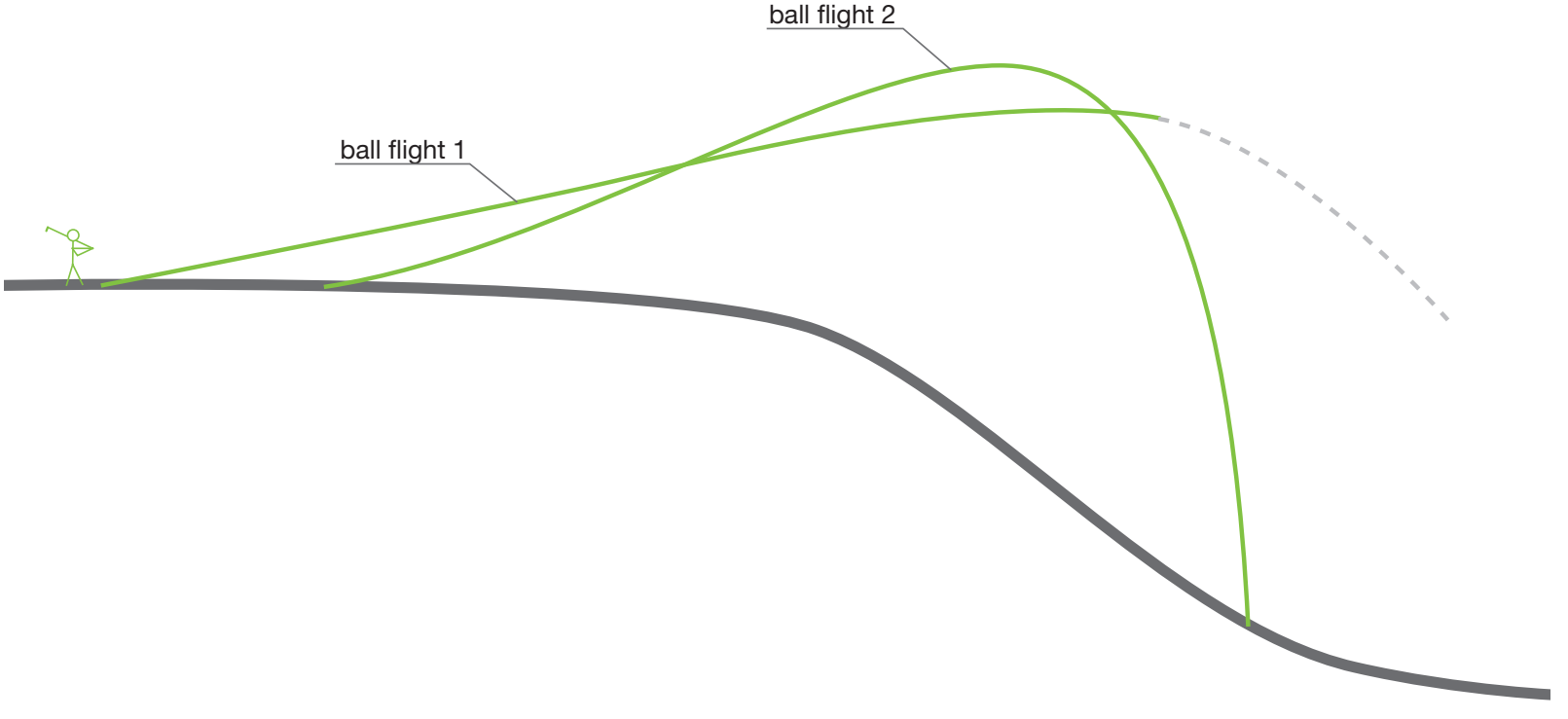
*036 framework developed from two flight curves*

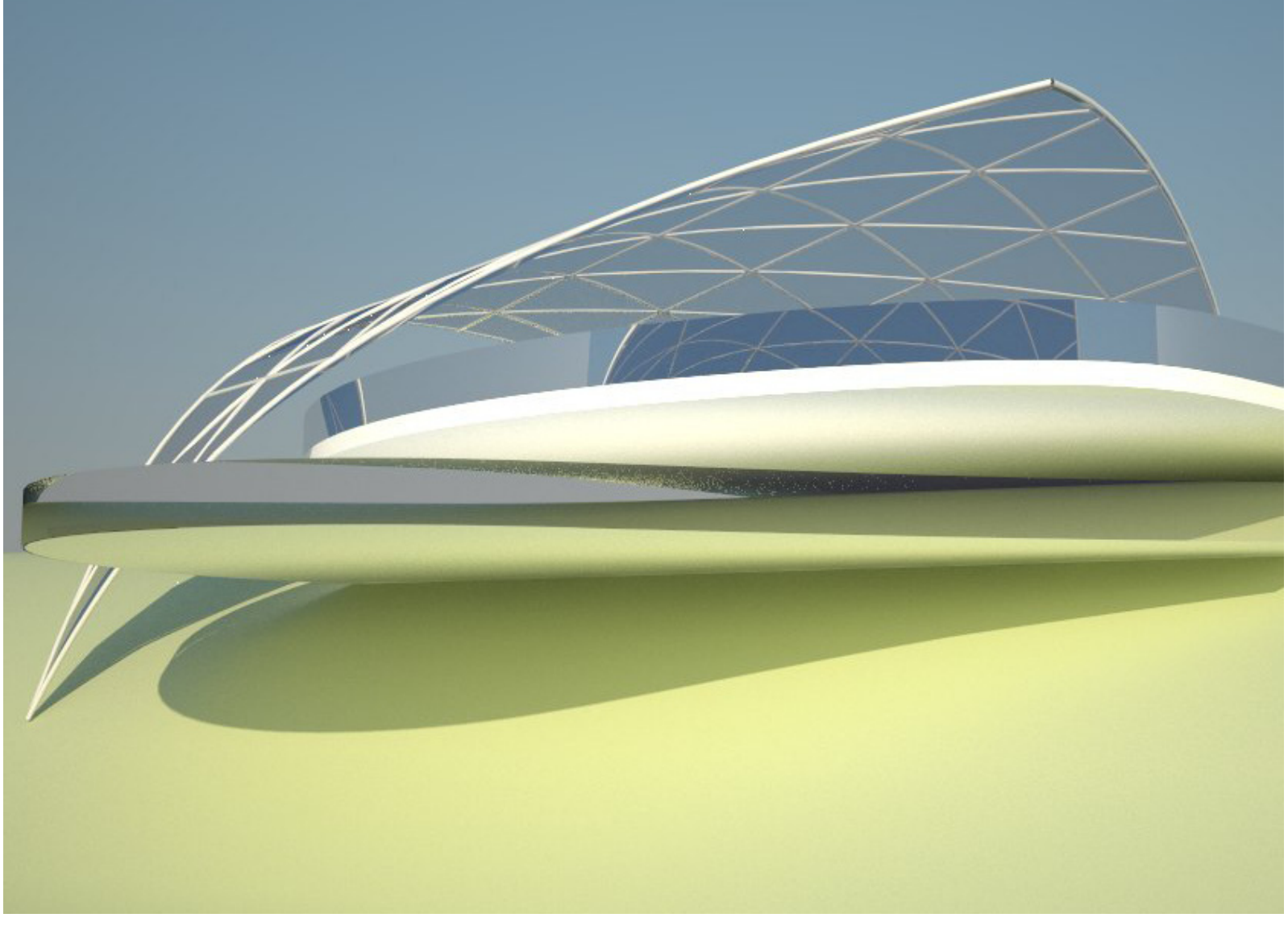


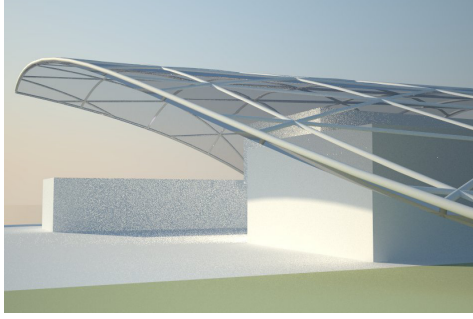
*037 the building is a perfect golf shot frozen in time*



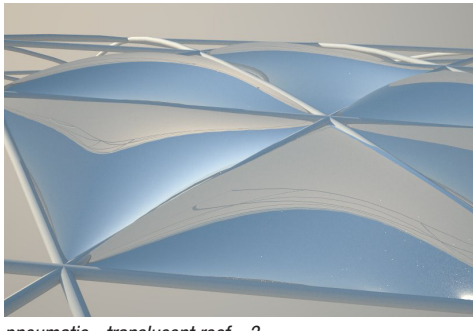
*038 a dynamic shell as a simple skin for the clubhouse*





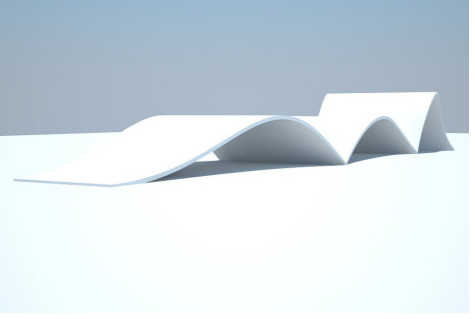


*boxes under the shell define space and rooms*

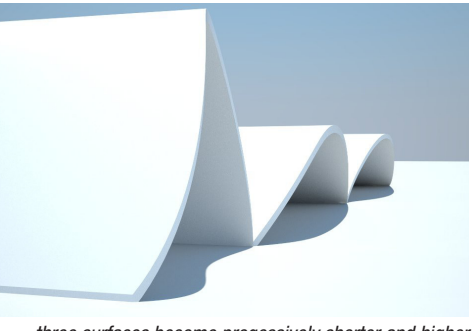


*pneumatic - translucent roof... ?*

This very aesthetic design revealed the way in which the lofted curves would open the sides of building whilst still forming a sheltering roof. The surface's open front also directed internal rooms and the atmosphere of the building towards the view. Although this concept design was deemed too simple, aspects are clearly present in the final design.



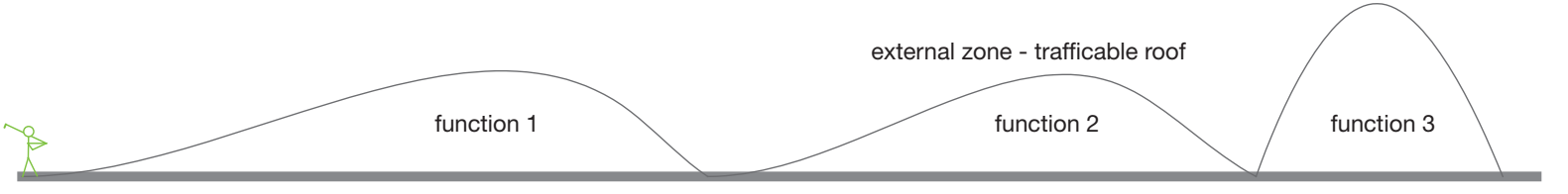
*concept design using a series of shots*



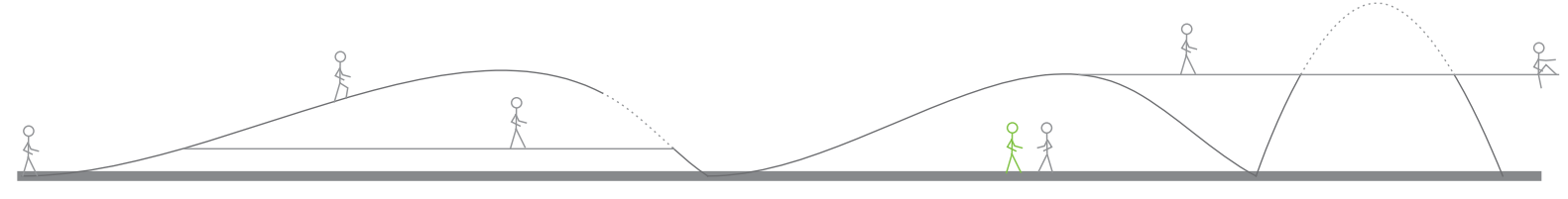
*three surfaces become progessively shorter and higher*

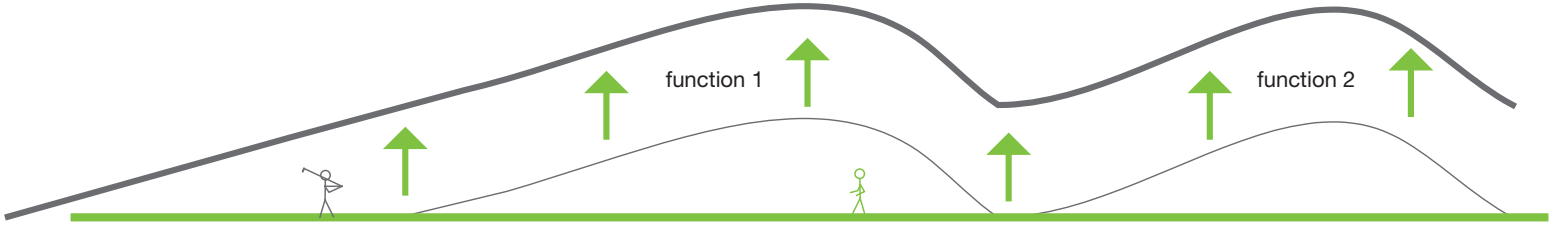
A game of golf actually consists of multiple shots played one after another, each from the point where the last shot finished. This concept was then explored and various situations for defining space were developed.

The initial design for this concept saw a series of surfaces defining space and separating functions. This also provided a few options; the building could be above, below or within the surfaces.

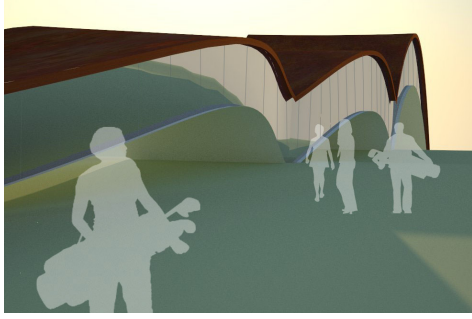



artificial landscape

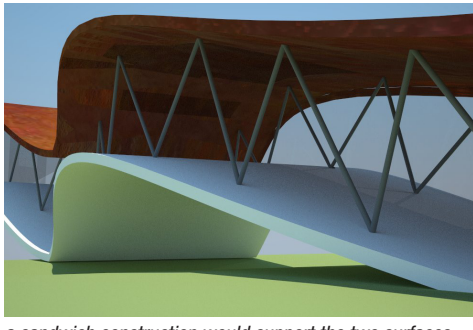




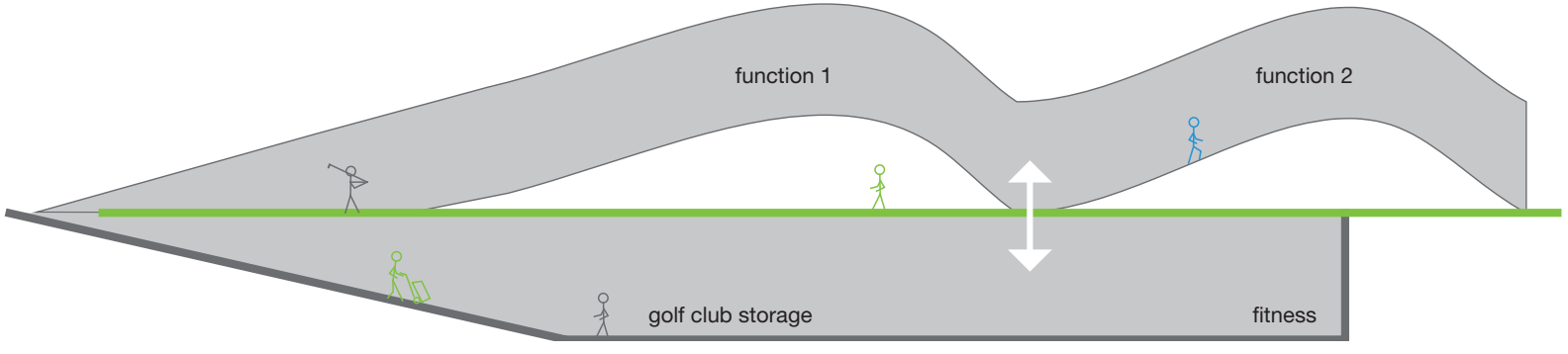

artificial landscape



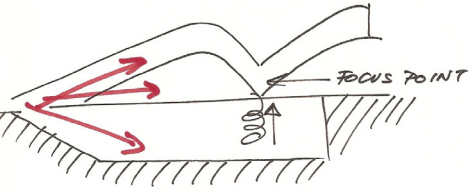
*area between surfaces defines internal space*



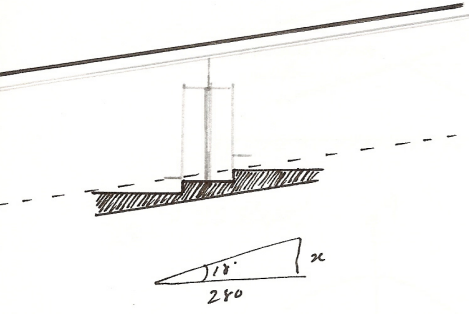
*a sandwich construction would support the two surfaces*



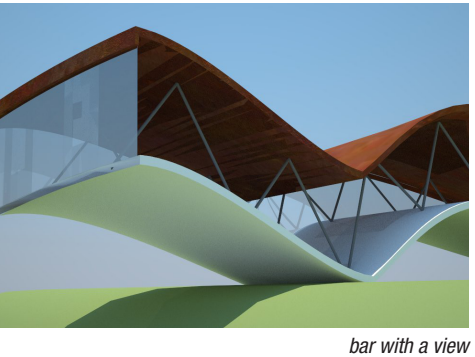

A further development of this final option saw the surfaces duplicated, creating rooms between the surfaces, which then became trafficable. The new concept immediately opened up the opportunity to create a series of circulation patterns. The end of the first shot could then become a vertical connection between above and below ground zones.




*vertical circulation concept*




*ideas for dissolving the surface into horizontal areas*



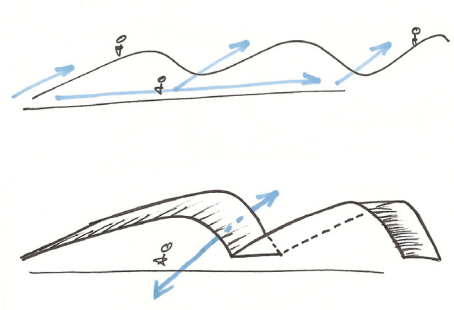
*bar with a view*

This multi-shot concept was advantageous for a few reasons. Firstly the building clearly defined separate areas, allowing for a practical distribution of functions. A bar and restaurant area could be accommodated towards the south, taking advantage of the view, whilst the northern end of the building would be conducive to office and club administration. Again here the north-south orientation would have suited. The possibility then arose for a ramp leading down into the earth to create space for golf club storage, change rooms and other necessary secondary rooms.

This idea would leave the present ground level free, preventing the building from dividing the landscape, whilst offering equal access to both courses.

Of course having a sloping floor was never going to be 100% practical. A series of small steps would have broken the ramp into manageable horizontal surfaces, whilst still maintaining an overall gradient. However, this solution was not efficient for larger areas, for example in the bar-restaurant.

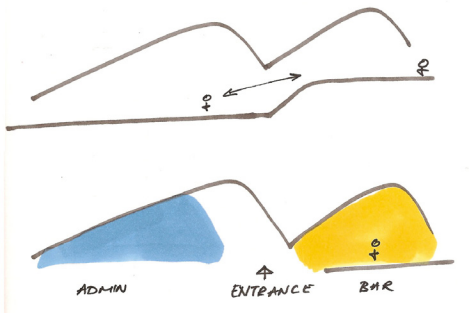
Another challenge with this concept was finding a suitable and efficient entrance. On the one side the parts of the building which touched the ground were an obvious choice. However the exact geometry was not conducive to a large scale foyer area and distribution zone, as the building only selectively made contact with the ground, before climbing steeply on both sides. The end of the building could have also functioned as an entrance; however, this would have led to long circulation patterns.



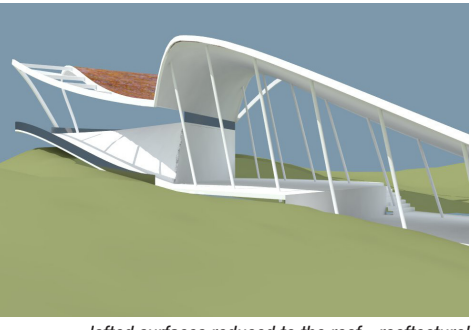
*flowing lateral and longitudinal circulation patterns*

Amongst other things a building of this size was not going to accommodate the required division of space, whilst still maintaining exciting rooms and creating suspense in the visitor. A successful design would have to achieve both, but also provide more usable space. A bar that isn't horizontal would not be practical and the sloping rear surface would need to sacrifice too much space for circulation.

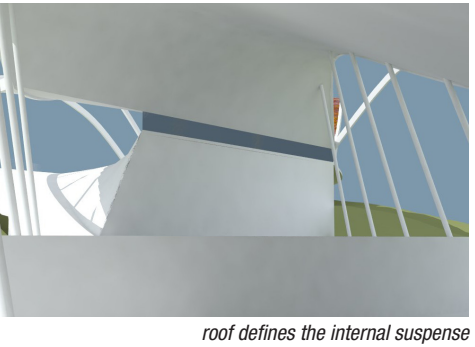
The next step would mean discarding this aesthetic design and working on a compromise.




*sketch of spatial relationships*



*lofted surfaces reduced to the roof - rooftecture!*

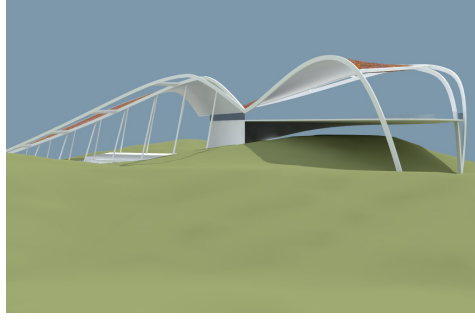


*roof defines the internal suspense*

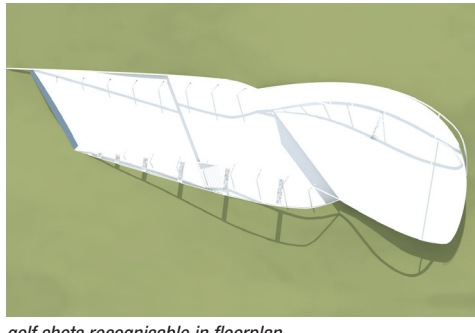
In order to create practical usable horizontal space the lower surface was removed as the starting point for the next concept. This left only the roof, which in the eye of the visitor inside would gradually rise, providing an ever changing environment. The entrance was left in the middle and a large flat area was designated as the foyer and distributor zone. From here visitors could head up a ramp into the bar-restaurant or in the opposite direction for club administration as well as change rooms etc, which were now conceived above ground.

This new minimised system allowed a bar area with a terrace to be developed. The fundamental ideas are still visible in the final design. A wide sweeping ramp leads up to the bar, reflecting the movement of a golf ball in flight. The concept needed to be adapted to the terrain, which made the shaping of the rear form difficult. From the foyer the ground slopes away to the north making the idea of a flat slab floor in this section redundant. The resulting design solved the problem of the bar and restaurant area, as well as defining a suitable entrance area. However, the weaknesses of the concept were too overwhelming. The rear section of the building lacked clear composition in that it did not draw heavily upon the initial flight curve concept.

Regardless of this shortfall the new system allowed a chance to study and develop a structural skeleton. The columns in this concept are also inspired by the flight of a golf ball; their angle changes progressively as the speed of the ball slows.

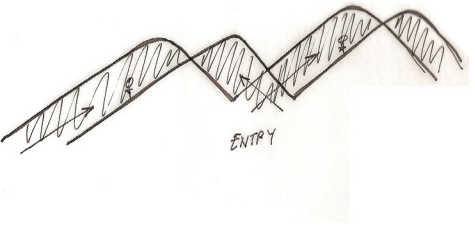


*western elevation*

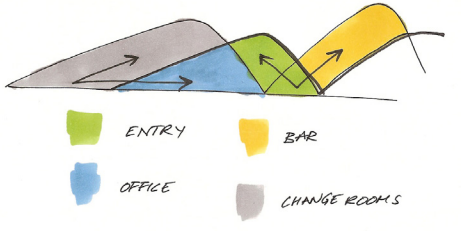


*golf shots recognisable in floorplan*

The most pleasing note to come out of the development of this concept was the terrace which looks out over the 18th green and south towards the ocean. However, the overall result was not successful in using an arbitrary concept to define space and divide functions.

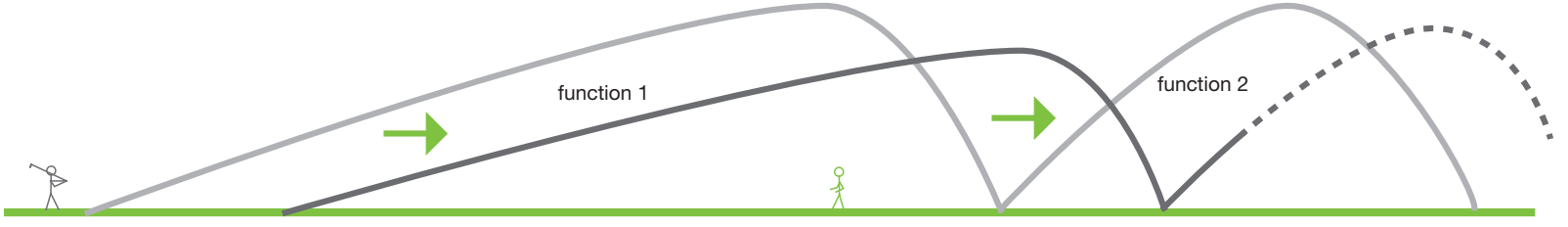


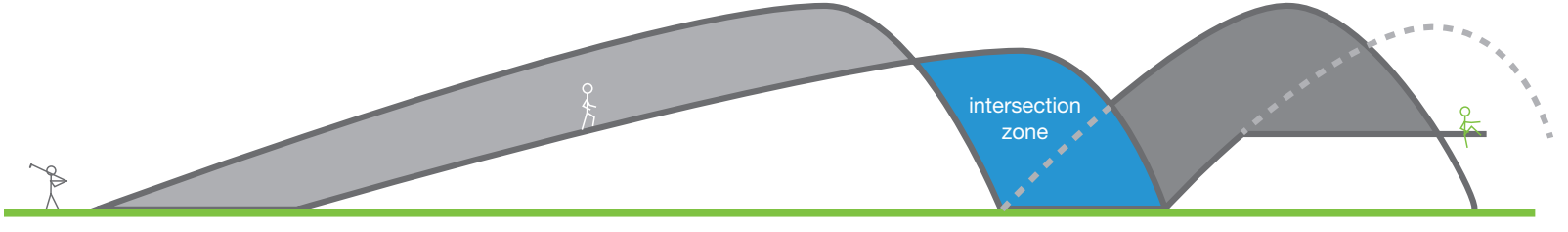

*concept sketch*

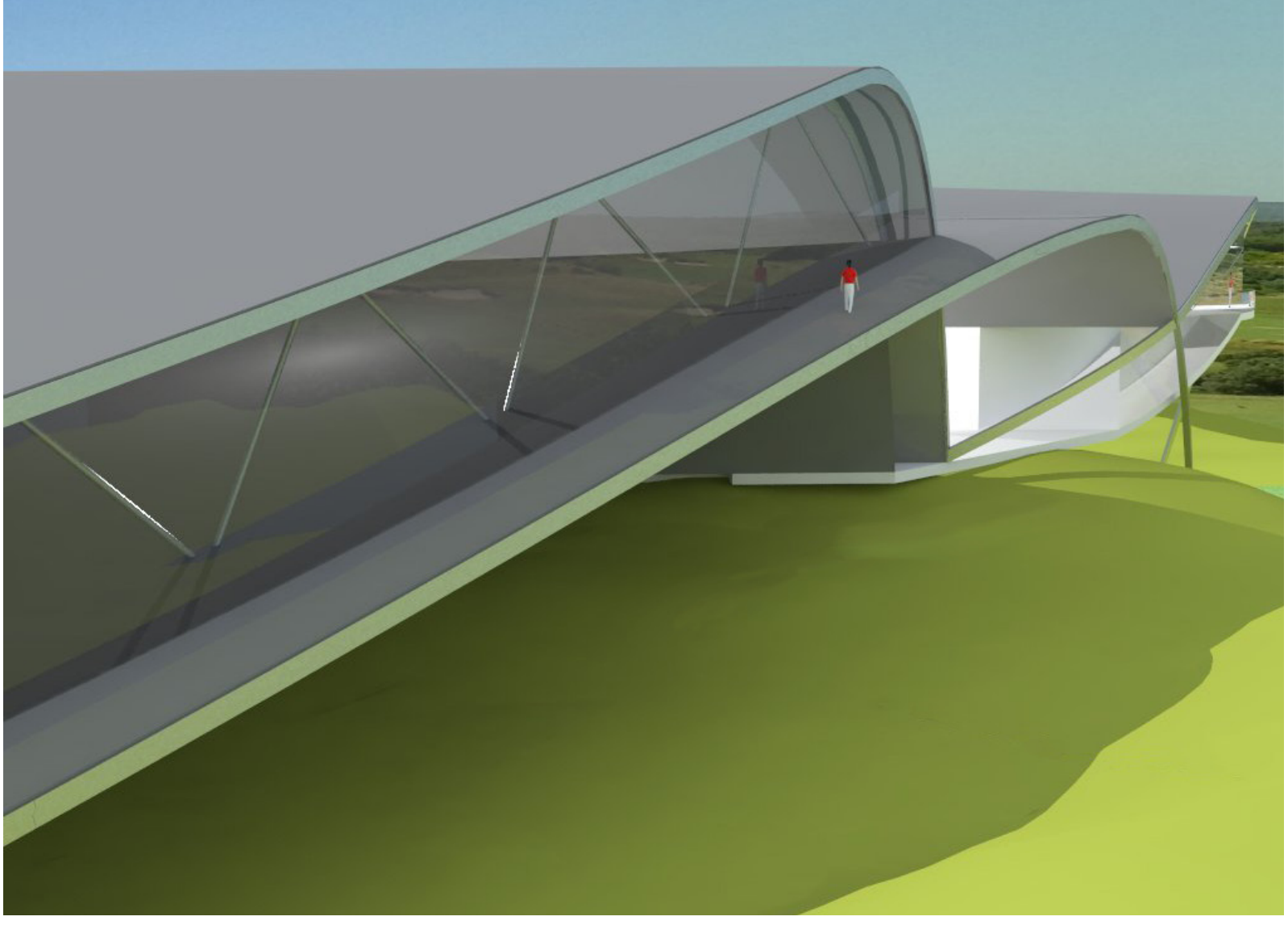


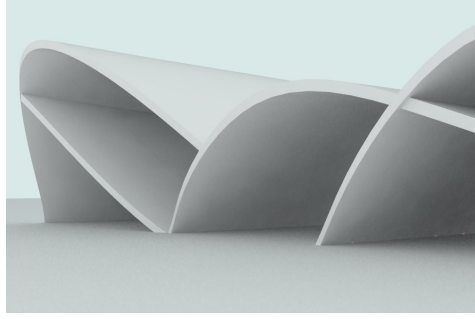

*initial devision of funtions*

A simple displacement of the second set of curves along the y-axis was the starting point for this concept; a concept which would ultimately define the final design. The way in which the surfaces intersect each other immediately defined space, above, below and also horizontally. A central intersection zone connects all areas, giving the building an inherent internal organisation.





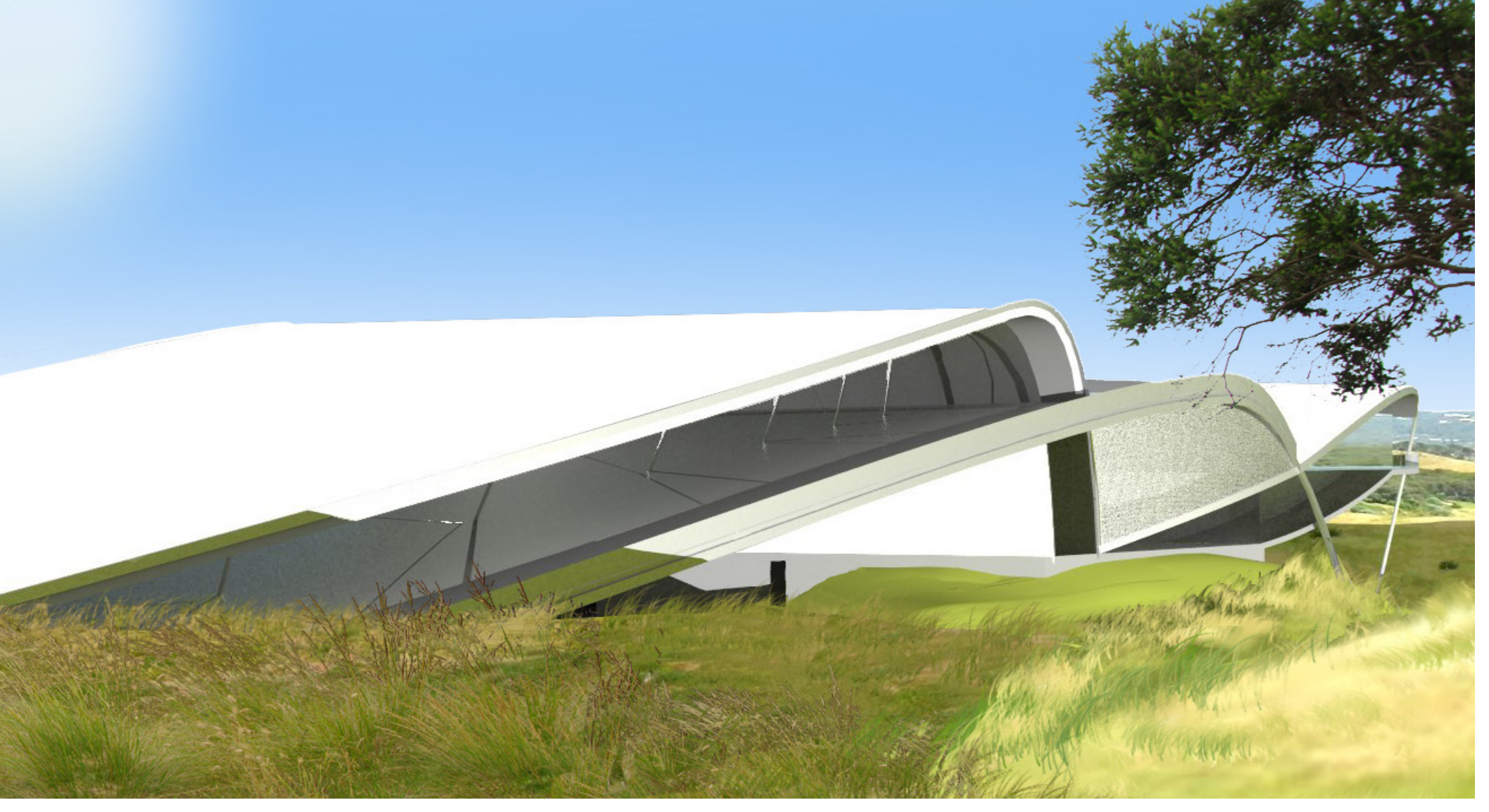


*concept model rendering*

This final concept contains aspects or inspiration from all previous concepts, whilst maintaining a unique aesthetic.

The resulting intersecting surfaces allow a straightforward ordering of functions, which are naturally arranged within the volume. Each function receives an inherent hierarchy, depending on its location in the building. The tilted surfaces allow for multiple levels to be connected from one point, whereas the central intersection of all curves provides a perfect focus point to enter the building. All functions must be connected to the foyer, meaning that all circulation patterns must pass through this area. Thus the foyer does not require any specifically prescribed function, it is the main distribution zone; stabilising the internal organisation.

# Design



The final design is based around three lofted surfaces, whose intersections and positions define space.

From the outside the flight curves are clearly visible. Viewed from the rear of the building, the trajectories seem to lift effortlessly into the air, with subtle horizontal movements. Parabolic beams and thick eaves highlight these flight curves.

The main surfaces rise towards the middle of the building where their maximum height signals the entrance to the clubhouse. The entrance is a large semi-open room where inside and outside blurr together. The foyer is the focus point of the building. Inside the foyer is the main golf desk, where players must report before the round. Additionally the market style pro shop will be a meeting point for guests.

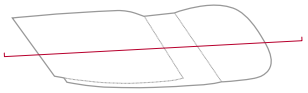
All major functions are directly connected to the foyer. Two long sweeping ramps lead up to the restaurant and bar area. In the opposite direction stairs lead down into the locker rooms. Regardless of where a guest wants to go, their path will lead through the foyer. The foyer is semi-public space which stabilises the internal circulation.

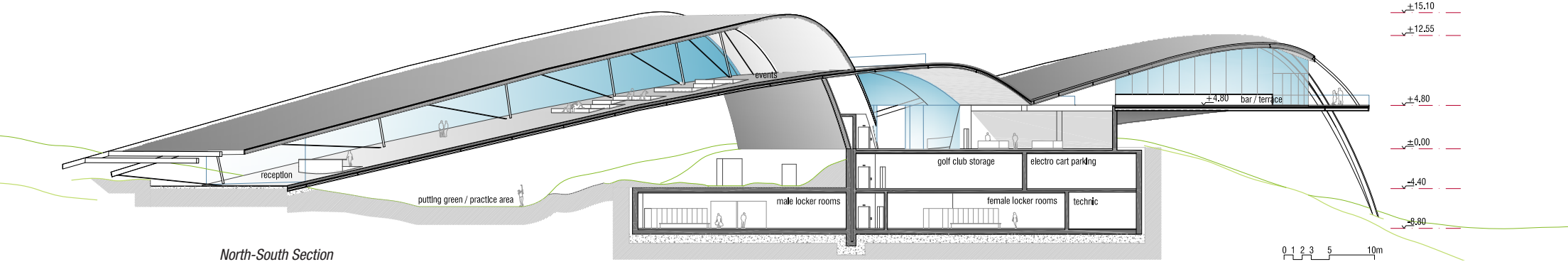
At the top of the ramp the resturant and terrace area provides stunning views southwards over the golf course and out to sea. This large zone has been deliberately left open with areas to be defined with furniture. Open on three sides the view is never far from mind. The rear of the bar offers a view back down to the foyer, linking these two elements

Locker rooms and club storage are located below ground, with direct access for carts and buggies offered from outside.

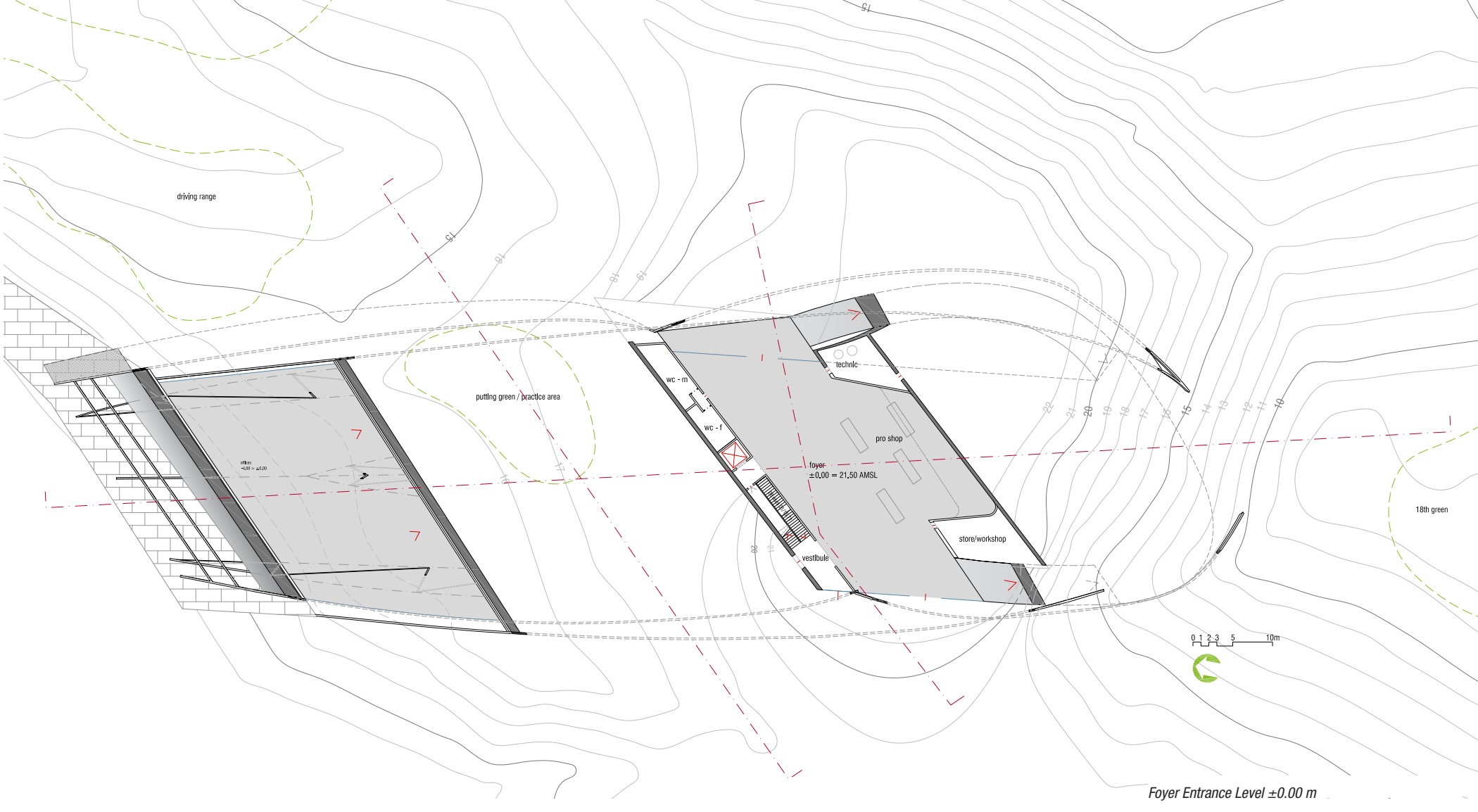
The large rear volume houses administration areas in the lower zone, tilting platforms offer flexibility and variation, without distracting from the original concept.

Overall the building is a consequent result of an arbitary concept idea. Throughout the process each design decision was made so that it would not detract from the original concept.

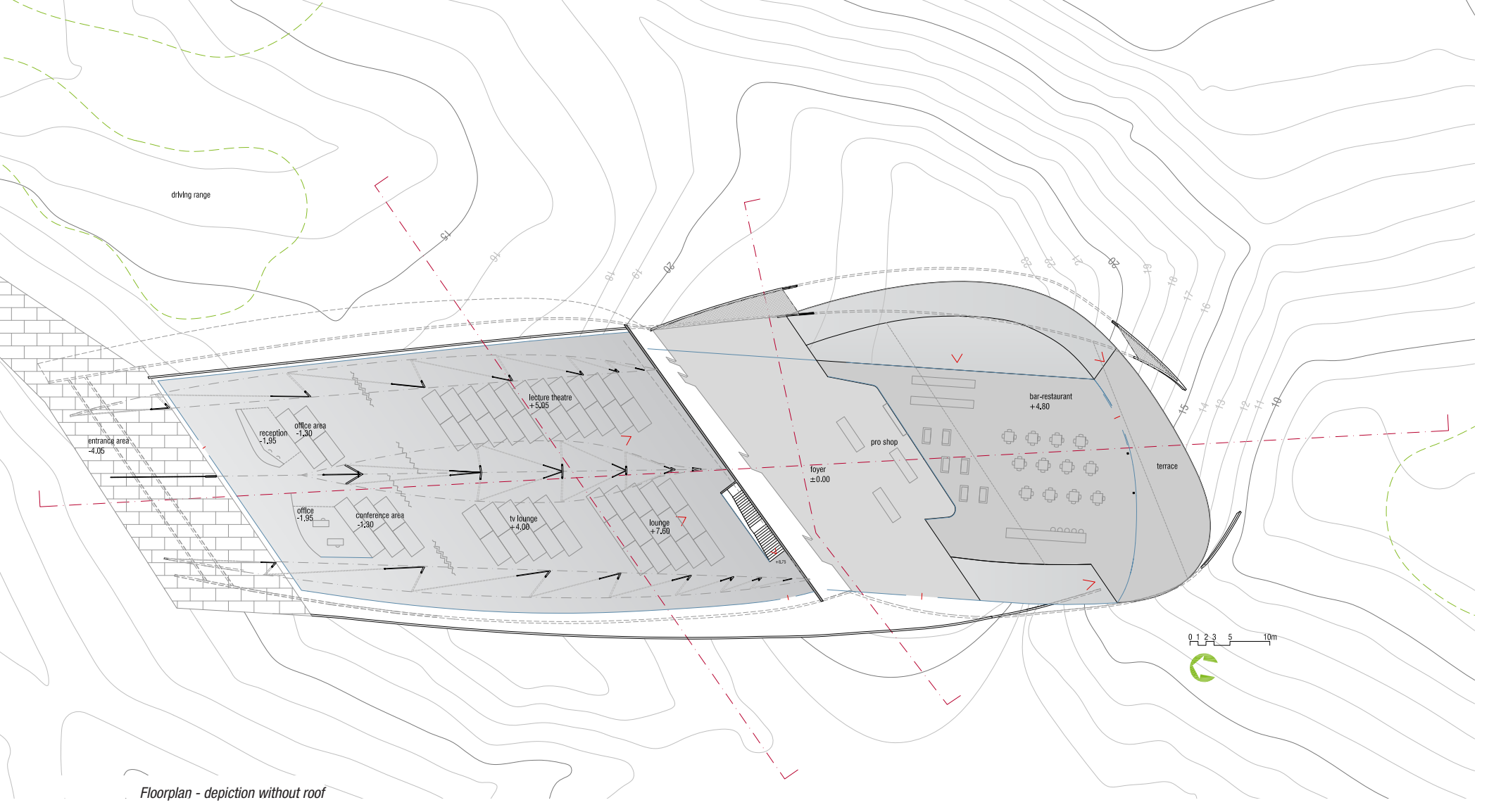




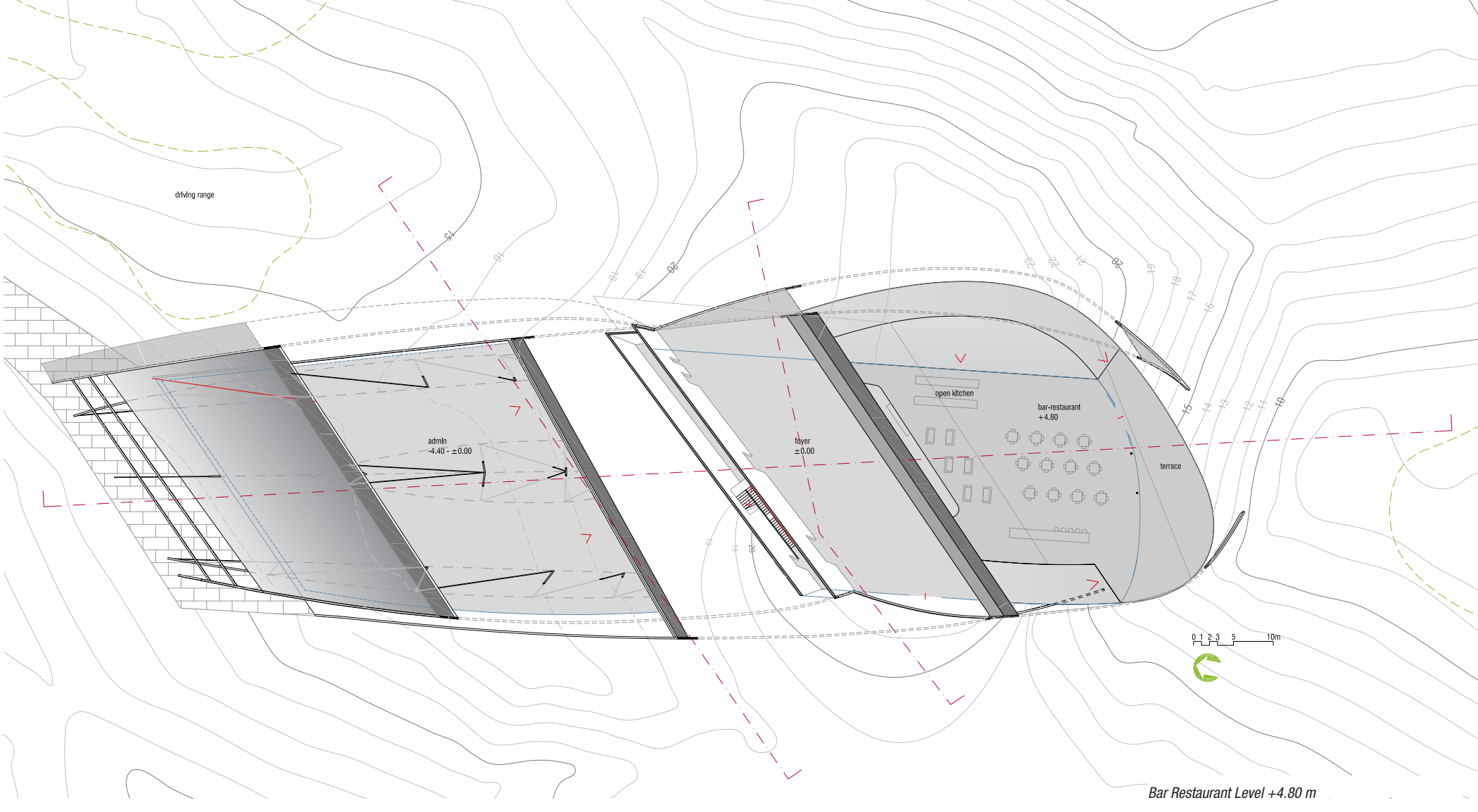

*North-South Section*



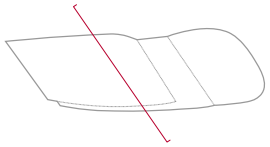

*Foyer Entrance Level ±0.00 m*

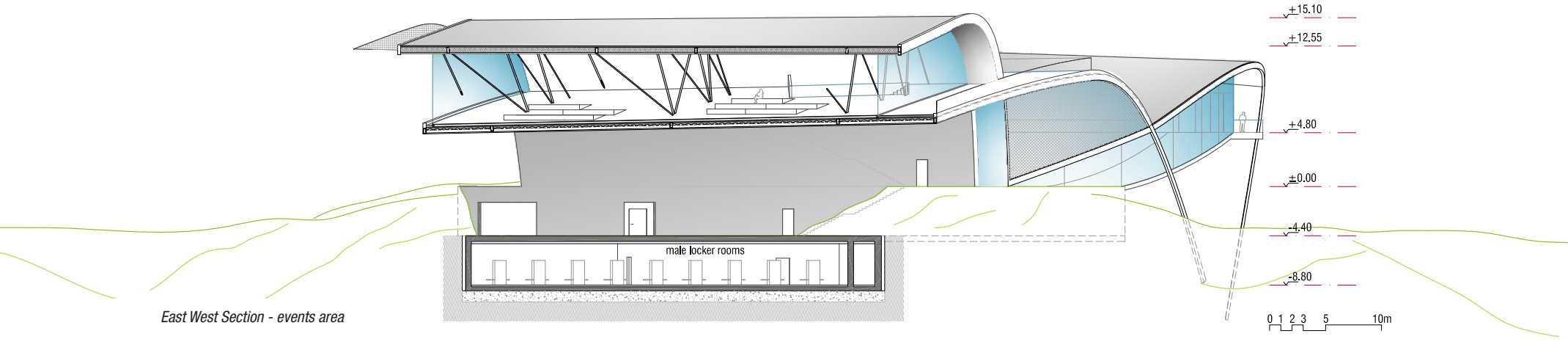



*Floorplan - depiction without roof*

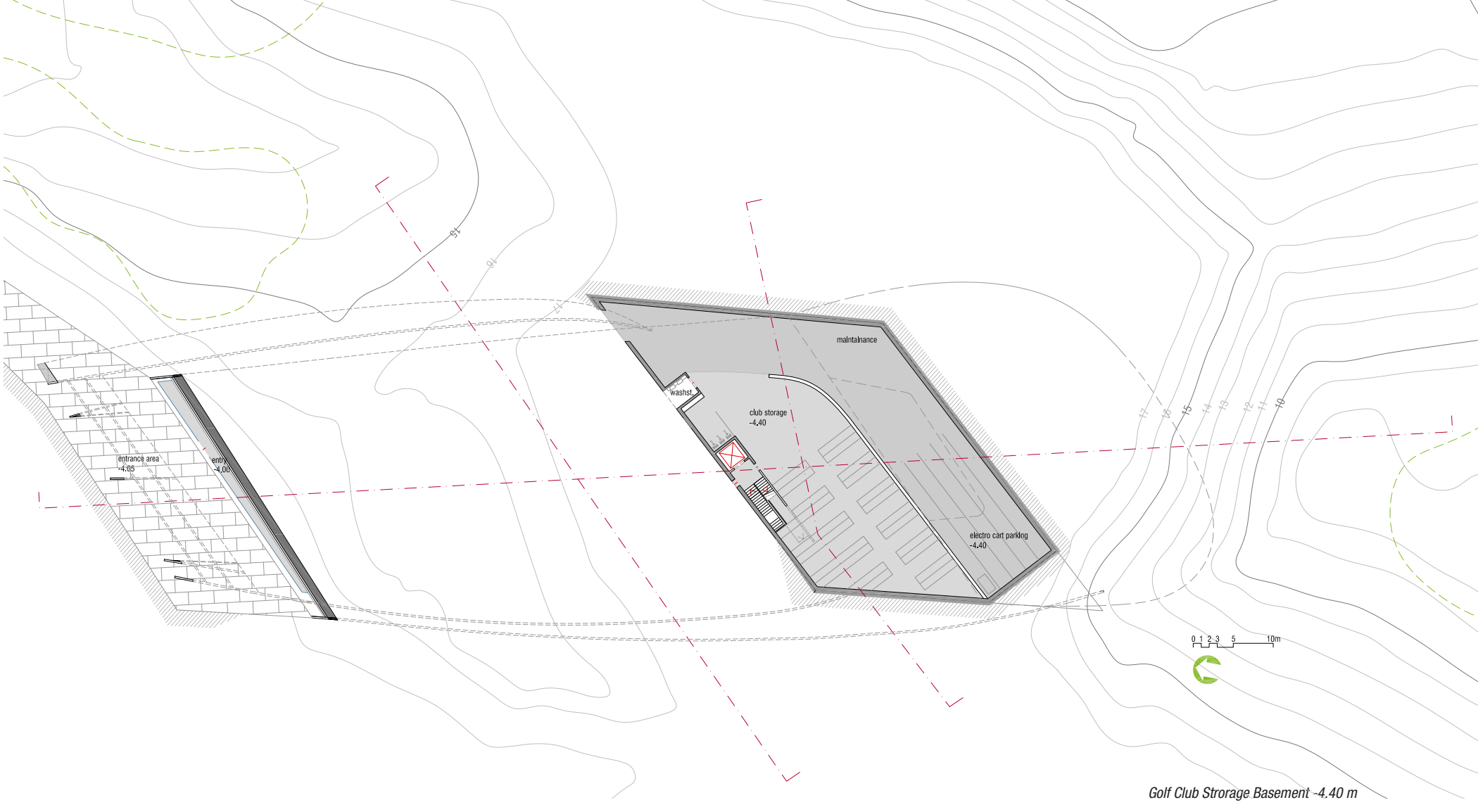



*Bar Restaurant Level +4.80 m*

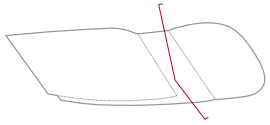


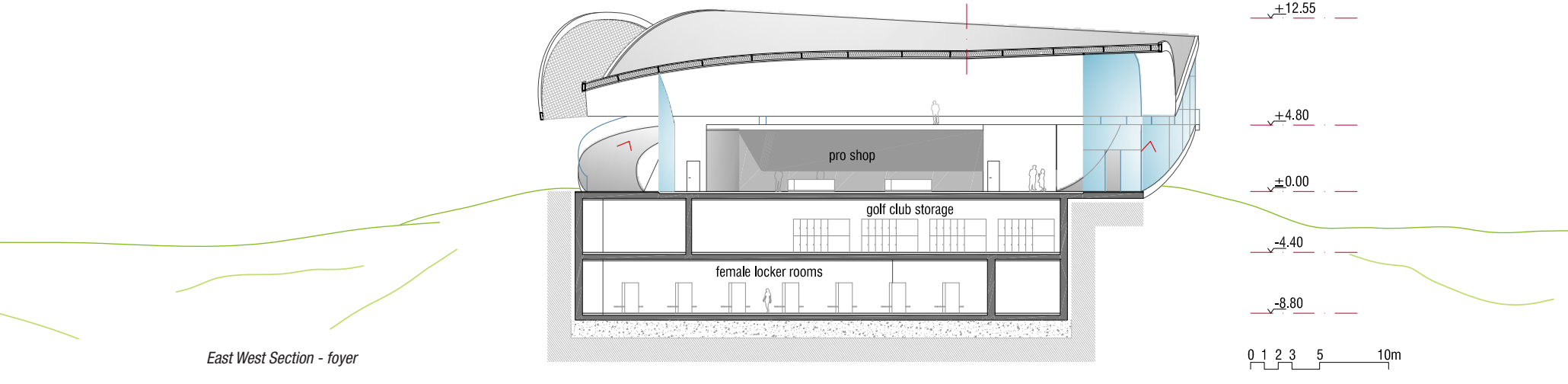



*East West Section - events area*

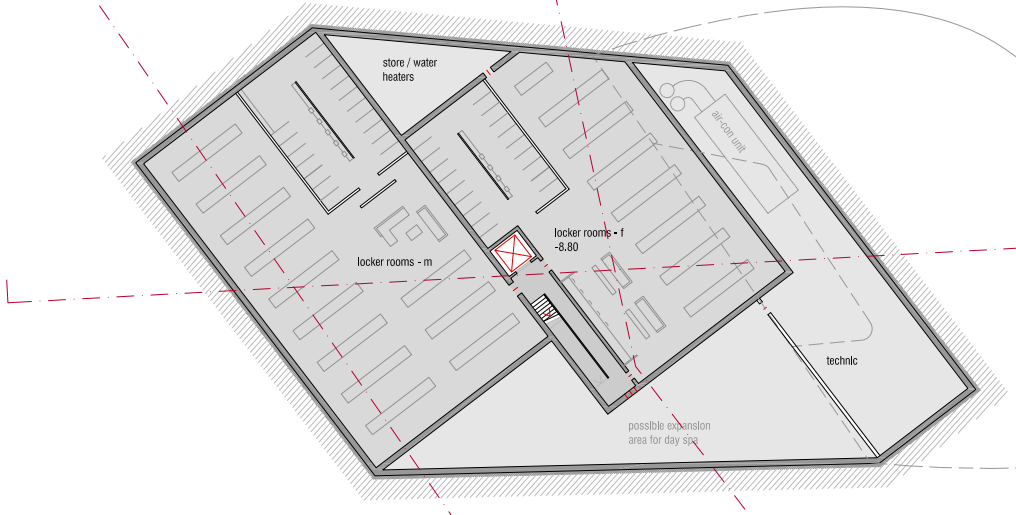



*Golf Club Strorage Basement -4.40 m*

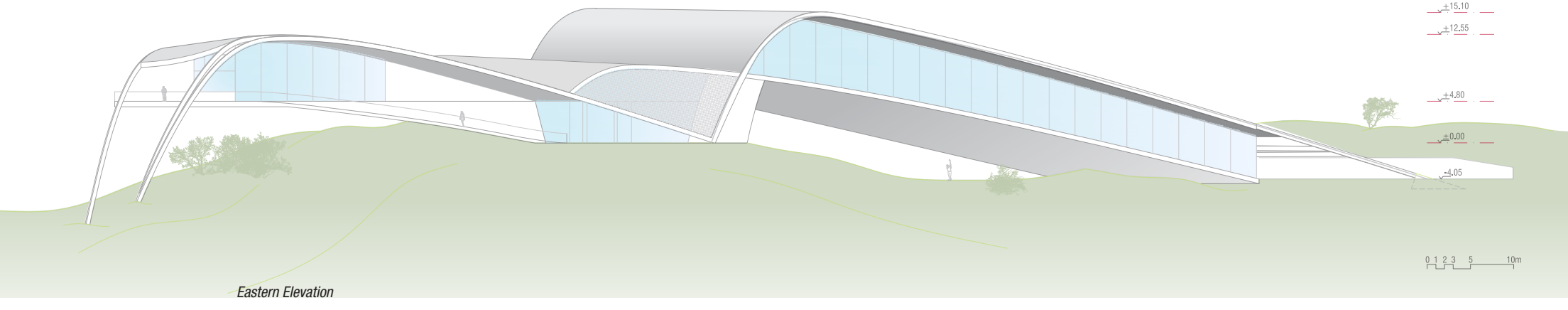




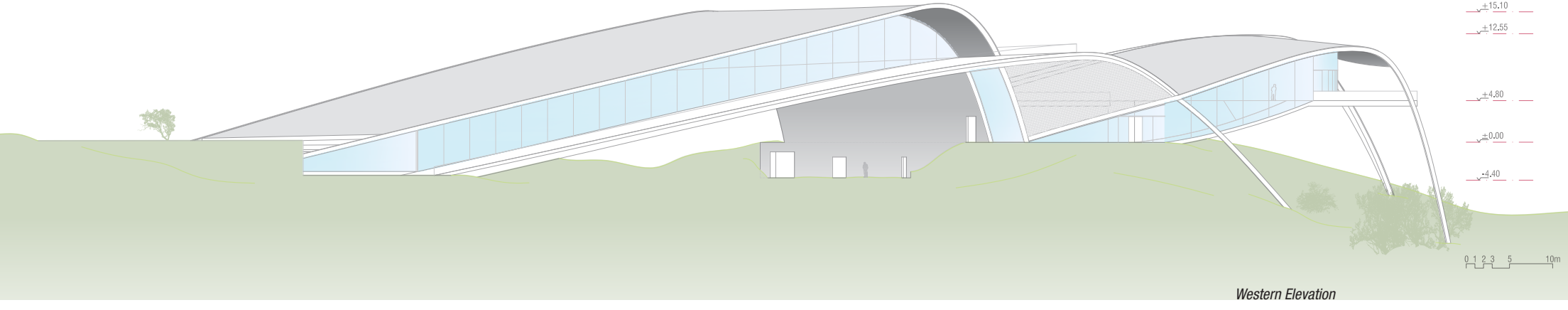

*East West Section - foyer*



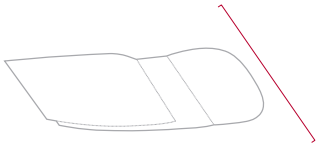

*Locker Rooms -8.80 m*

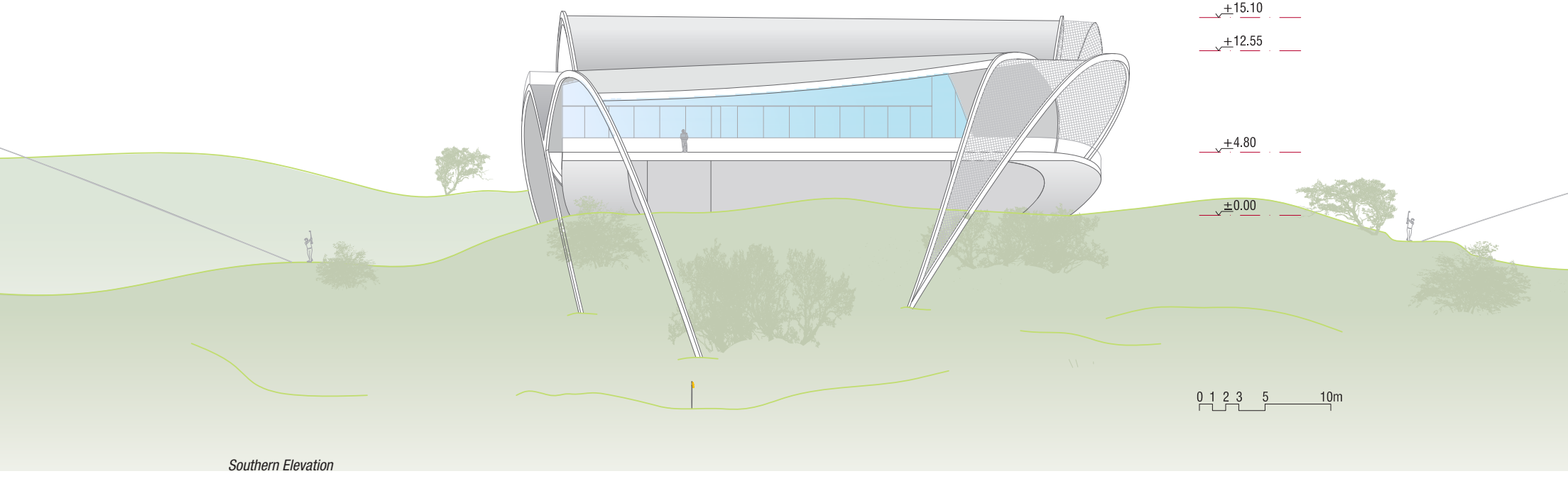



*Eastern Elevation*

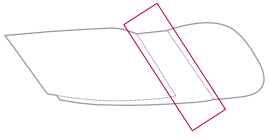



*Western Elevation*






*Southern Elevation*

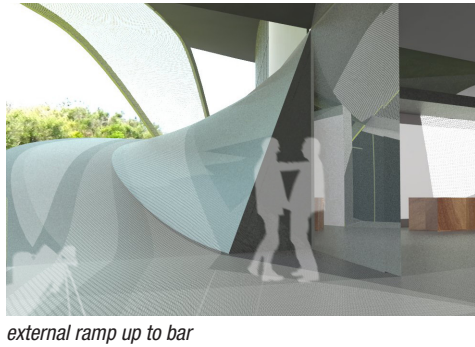


*vertical connection sandwiched between surfaces*

Attached to the foyer is the main vertical connection. This ‘sandwich zone’ was made possible through the addition of a surface below the events area. A lift connects the lower floors, whilst a set of stairs follows the contour of the surface from the events area to the foyer and then further to the club storage and locker rooms.

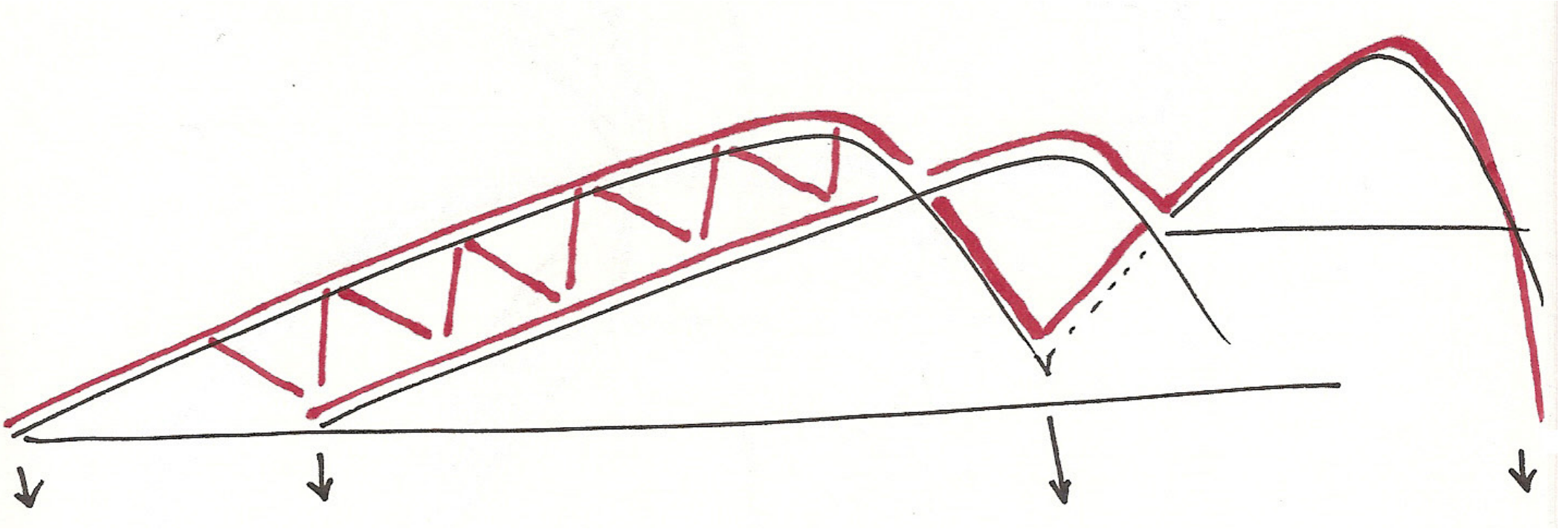
*all paths lead through the foyer*

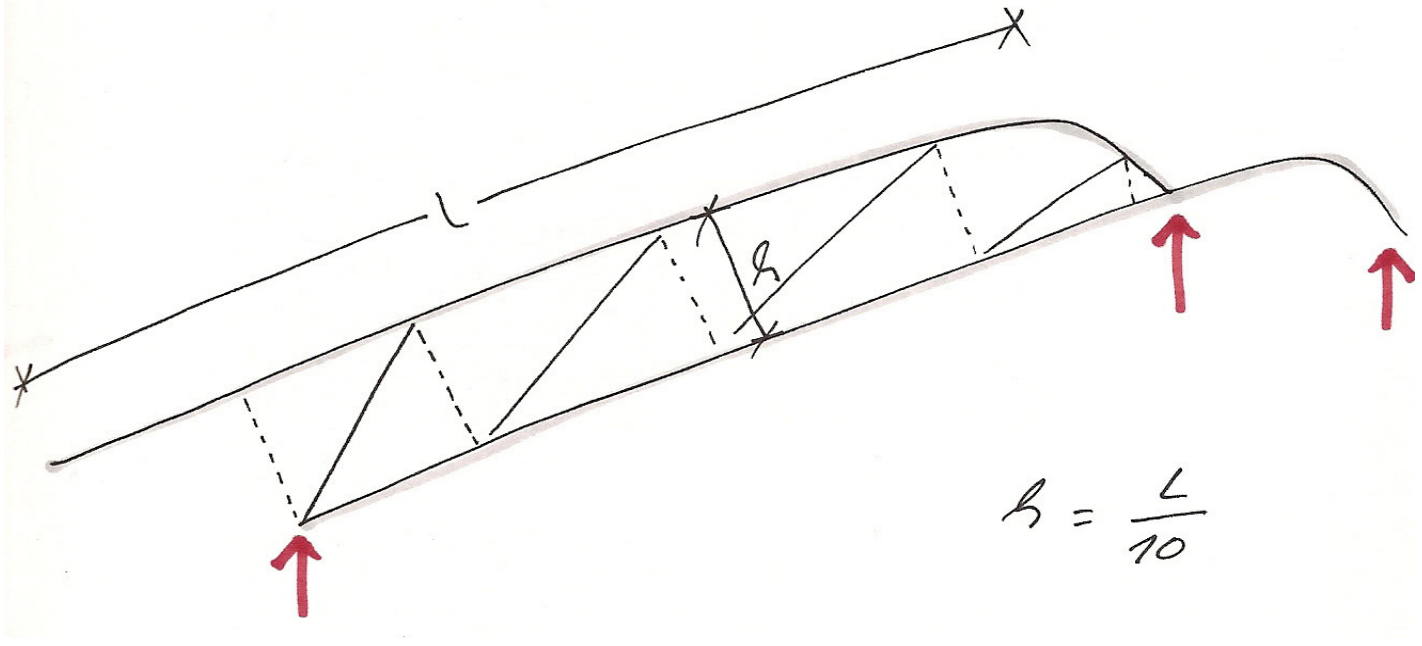
*foyer conceived as public space*

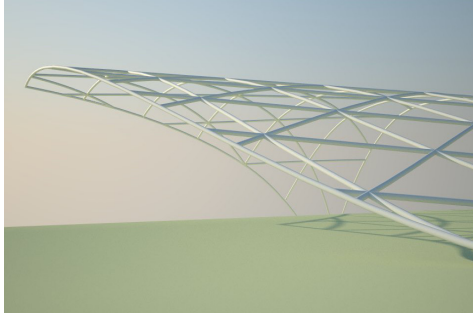


*external ramp up to bar*

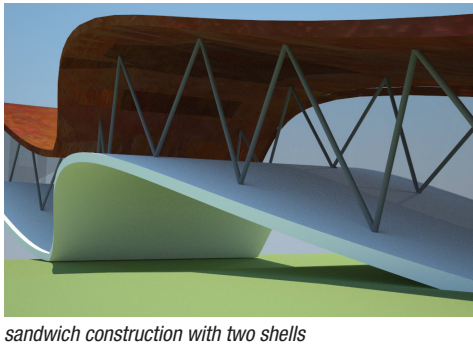
*Construction | Details*



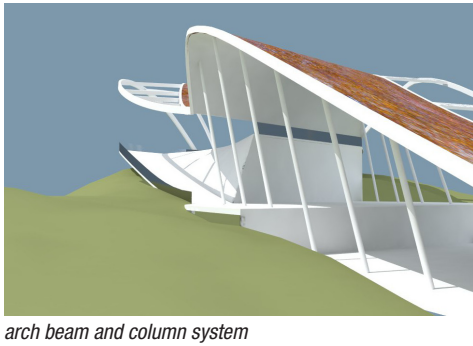


*gridshell system from an early concept*



*sandwich construction with two shells*



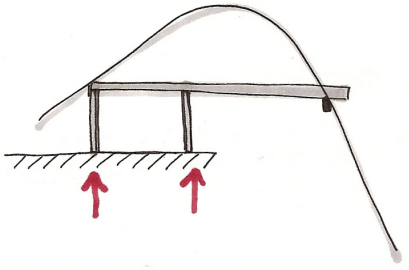
*arch beam and column system*

Structural systems were developed with each new concept design. This method allowed a level of pragmatism between a playful design and reality. The ball flight concept does not lead to an obvious construction method, however, the desire to have a building which is light and appears to fly were critical in defining the final construction.

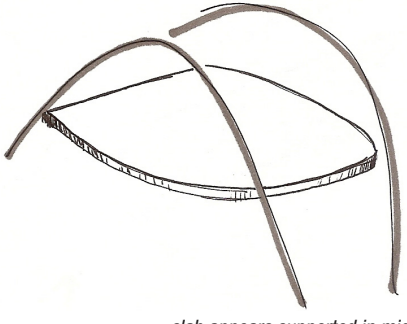
Early concepts explored the idea of a supporting mesh (gridshell), a system which was adopted for the column free bar area of the final design. The final concept for the supporting structure divides the whole building into two unique systems.

The double skinned rear section of the building has large non planar trusses which span the full length of the first surface. This large span leaves the area under the building free. The span of approximately 60 metres requires a construction height of 6m (h=l/10). The floor and roof composition is integrated within this 6 metres, delivering a final ceiling height of about 4.5 metres. Once again the flight of the ball is reflected in the way the sandwich structure seems to effortlessly fly through the air.

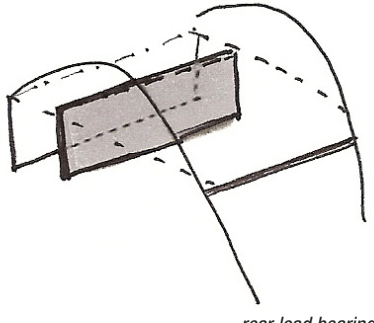
Internally the angles of the individual truss elements are also derived from the slowing motion of the ball. The distance between trusses is derived from a standard ballistic relationship $\mathbf{x^2/y}$.



*structural concept*



*slab appears supported in mid-air*



*rear load bearing walls*

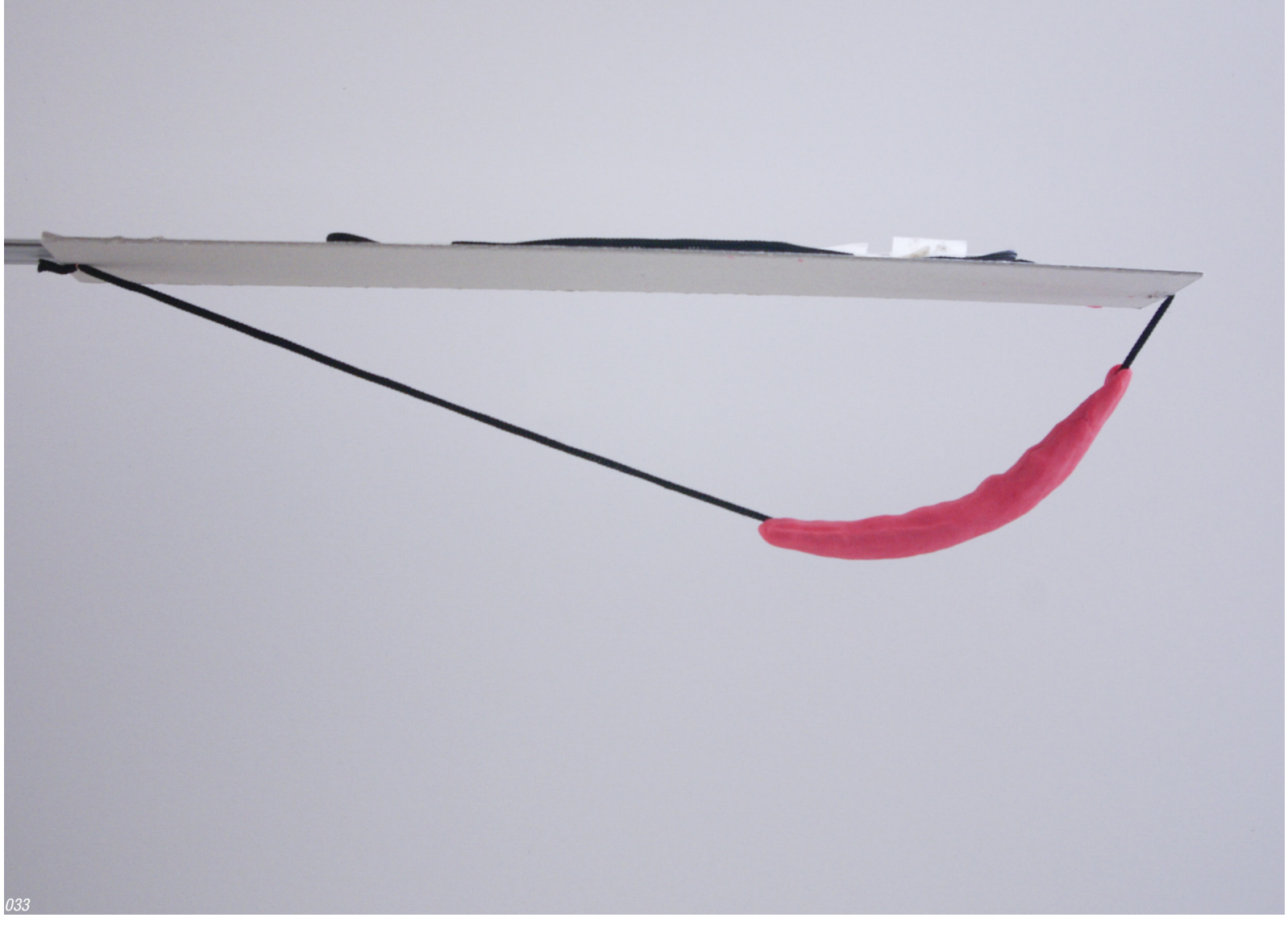
The foyer zone delineates the change from one construction method to another. Whilst still using a light-weight framework principle the desire for the bar area to be free of columns and supports leads to a different structural system. The roof is broken into a three-dimensional lattice or gridshell made of unique CNC cut steel profiles. This gridshell then provides a supporting framework onto which the roof can be constructed, whilst spanning the entire area. This system would not be appropriate for the whole building as the larger northern section does not have a significant double curvature.

Gridshells were first pioneered by Vladimir Shukhov at end of the 19th century. Recently Norman Foster amongst others has risen to prominence due partly to his use of this construction method. Gridshells derive strength from their double curvature. The lattice structure disperses weight outwards to the perimeter. From the perimeter the loading can either be directed straight into the foundation or through another structural system.[1]

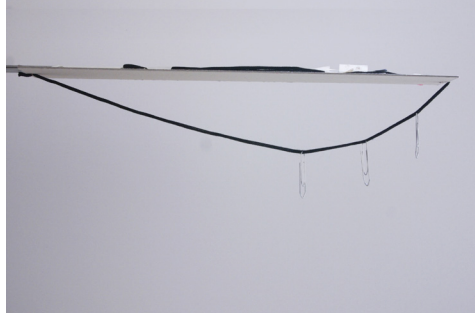
Gridshells provide a large support free area and have thus become popular for pavilions, exhibition halls and large forecourts.

The cantilevered floor is carried not only by load-bearing walls but also beams connecting the two prominent parabolic steel arches. The nature and form of these arches were studied using weighted hanging models.

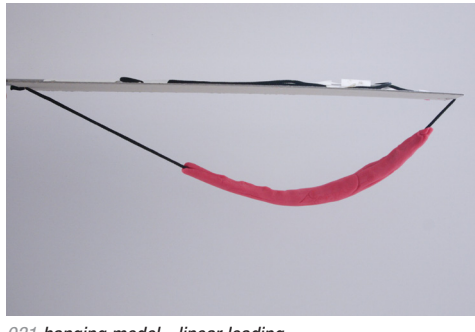
[1] en.wikipedia.org/wiki/Gridshell (23.02.2011)



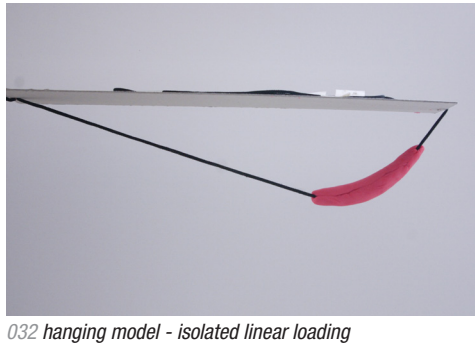
033



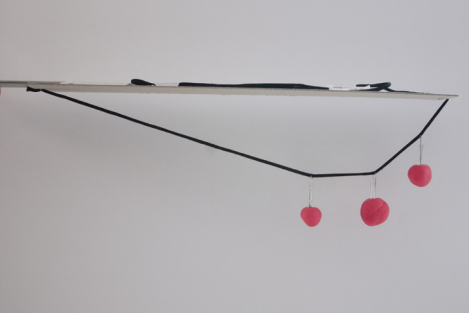
030 *minimal parabolic loading*



031 *hanging model - linear loading*



032 *hanging model - isolated linear loading*



034 *hanging model used to reconstruct a parabolic curve*

035 *small increase in weight*

036 *weight increases more dramatically along the x-axis*

$$\vec{\mathbf{F}} = -\alpha_\tau \frac{\pi}{12} p R^2 \sqrt{\frac{\pi m}{2 k_B T}} \chi \Re(z) \vec{\mathbf{v}} - \alpha_\tau \xi \frac{2}{3} \pi R^3 m n \vec{\omega} \times \vec{\mathbf{v}} - \alpha_\tau \frac{1}{3} \pi R^3 m n \chi \frac{\Im(z)}{|\vec{\omega}|} \vec{\omega} \times (\vec{\omega} \times \vec{\mathbf{v}}) \quad [1]$$

The flight of a golf ball generally follows the basic principles of ballistics and motion. However, a more technical equation which allows for wind, Magnus Effect, air temperature and pressure and spin rates was devised by Karl Borg and colleagues at Royal Institute of Technology in Stockholm.

In order to derive a structural system a much simpler version was used in which spin, temperature, wind etc… were neglected. This left gravity as the only acting force once the ball is in motion. The distance (s) a ball has travelled at time t can be calculated using:

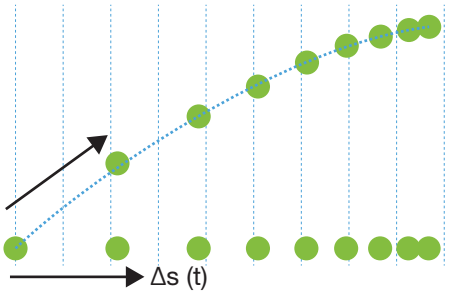
$$s = \tfrac{1}{2}at^2$$

As the ball has negative acceleration or deceleration it is clear to see that as time increases the distance (s) will decrease proportional to √t. However, to dissolve the trusses the distance the ball travelled per unit of time, e.g. 0-0.2s then 0.2-0.4s etc... needs to be calculated.

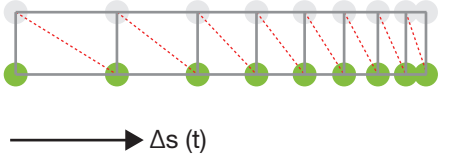
The velocity of the ball is not constant. This varying velocity (vx ) will thus result in difference distances travelled (s) for a constant unit of time (t). $s_x$ is proportion to t·vx

$$\Delta(s1\text{-}s2) = t' \,.\, \Delta(v1\text{-}v2)$$

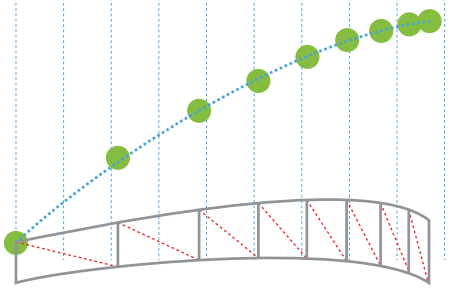
[1] James Barber III, Golf Ball Flight Dynamics, Cornell University




*position of a ball in flight at a constant time interval*




*horizontal extrapolation as a Pratt Truss*

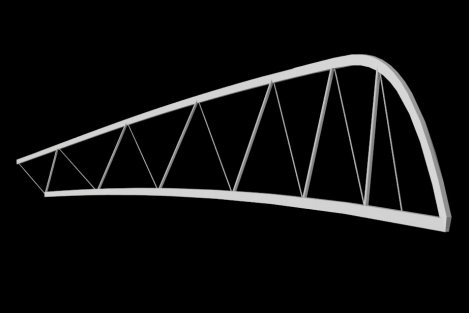


*translation into a parabolic truss*

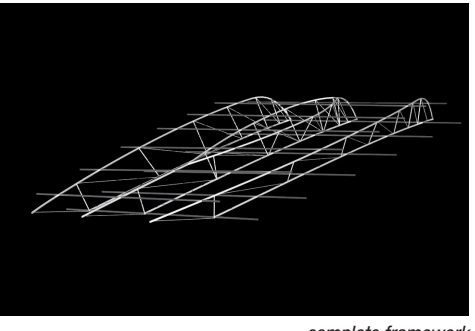
Thus the distance travelled per constant unit of time gradually reduces at a rate proportional to t2. This reduction of distances was then plotted along the x-axis of the truss. From these points vertical members connect to the upper and lower supports, further diagonal members complete the trusses making it a statically stable system.

As the angle of the truss members varies it is not easy to define tensile and compression members. The shorter 'vertical' members have been over dimensioned in order to highlight the decelerating ball - although these elements may not only experience compression. Three trusses, including a central truss which diverges in the middle would be connected with secondary beams to create the main rib-cage of the structure. The upper and lower beams will then be incorporated into the floor and ceiling construction, leaving only the internal members visible.

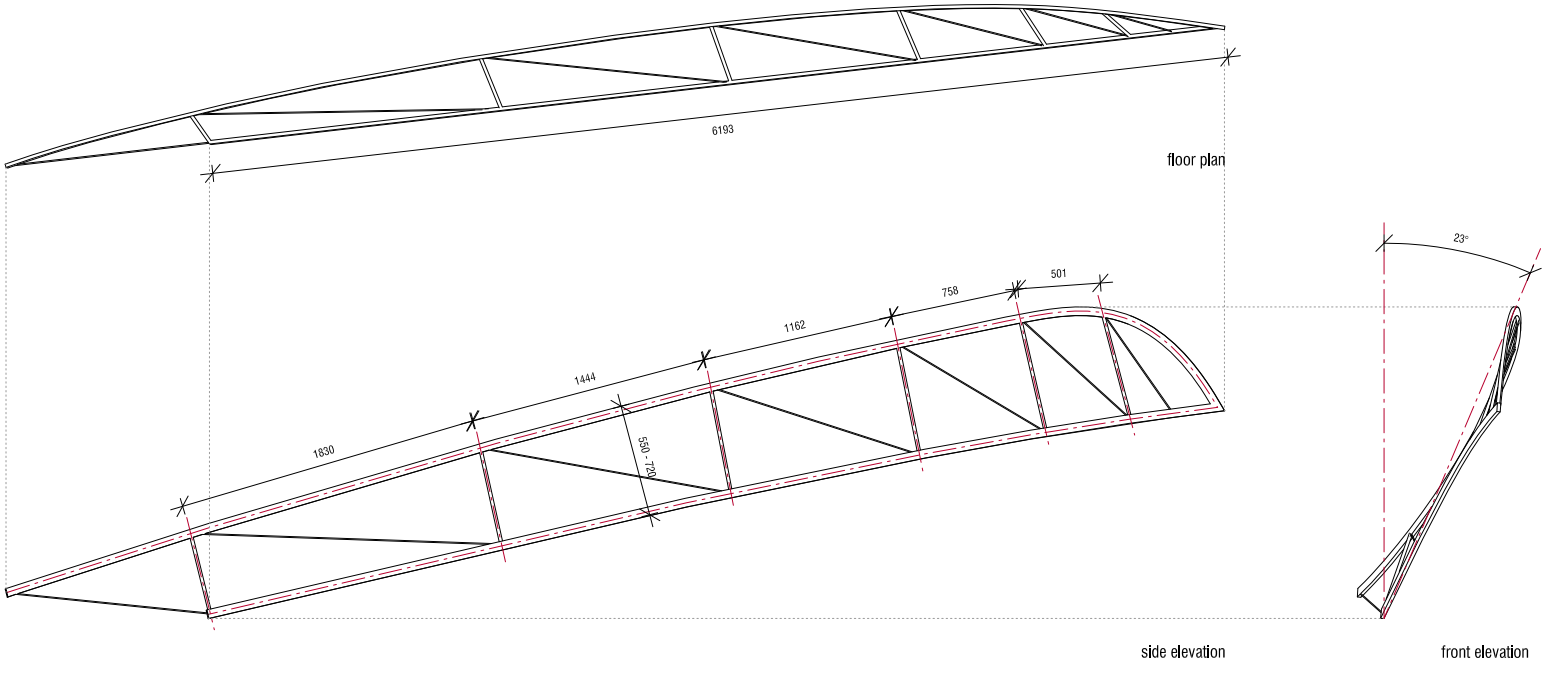
This system of derivation made it possible to create a statically correct system from an inherently dynamic movement. This frozen motion then remains visible within the building as only the angular truss members are left visible.

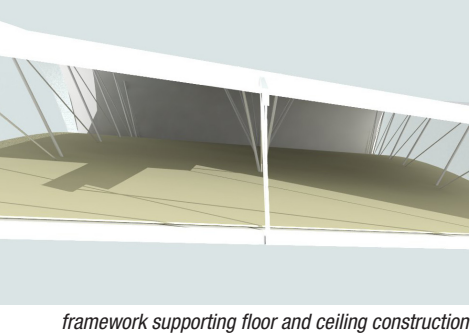


*non planar truss with double curvature*



*complete framework*



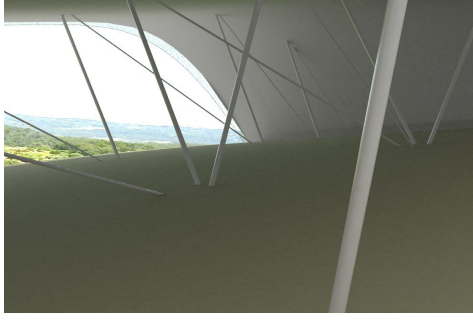



*framework supporting floor and ceiling construction*

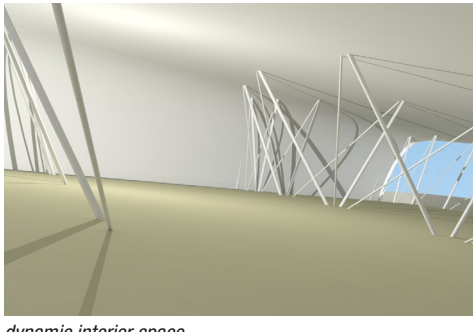
The resulting trusses are non-planar, but rather 3d dimensional trusses with a double curvature. The span of the level requires a truss where h=l/10. As the truss is tilted slightly outwards the actual length from top to bottom must be greater than l/10, so that the length in the z-axis or planar height achieves l/10. The geometry of the eastern truss is detailed in the orthogonal drawing above.

In total three trusses divide the width of the space creating a maximum span of 11m between trusses.

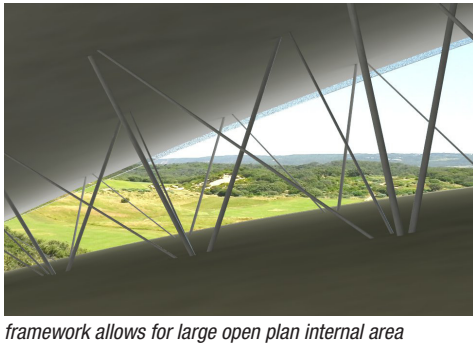
The trusses would be produced in smaller manageable pieces and then transported to the site for construction. Once the connecting beams are in place, a secondary system would allow for the floor and ceiling construction. Furthermore these trusses would serve as a base onto which the facade, terrace and sun-shade could be mounted. A final parabolic beam forms the outer edge of the walkway-terrace and is tied back onto the main framework. This parabolic beam provides a base to assemble the balustrade and terrace.



*ball flight translated into a structural concept*

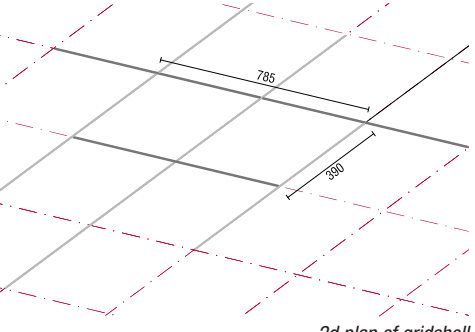


*dynamic interior space*

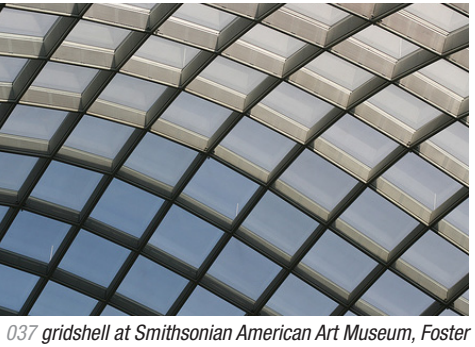


*framework allows for large open plan internal area*

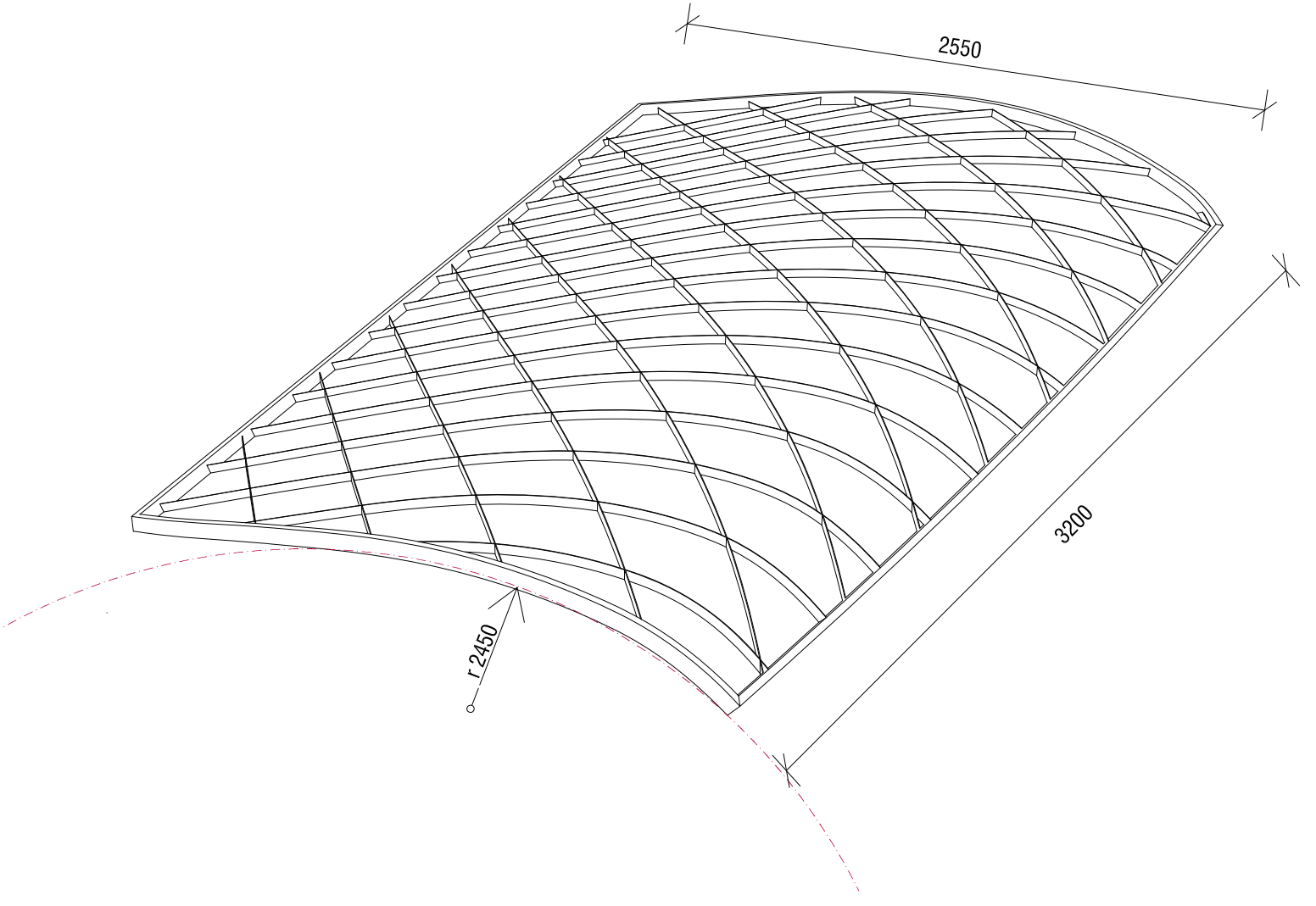
*detail location*

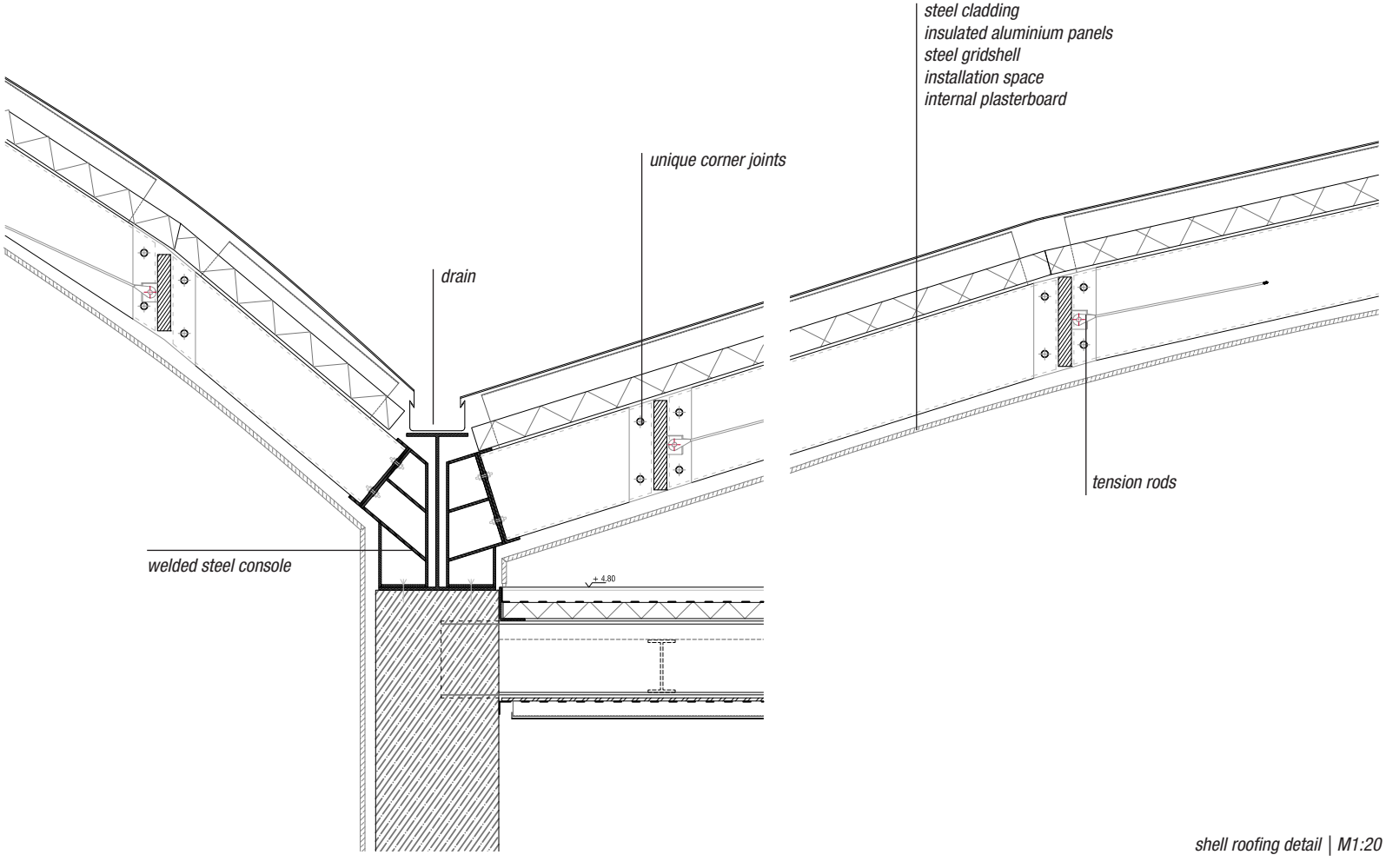



*2d plan of gridshell*

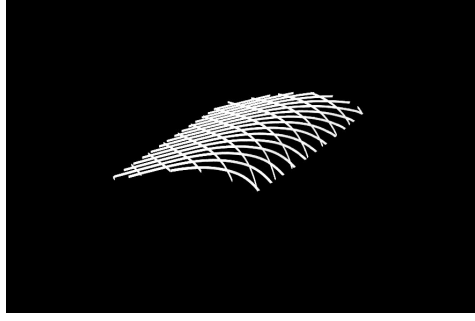


*037 gridshell at Smithsonian American Art Museum, Foster*

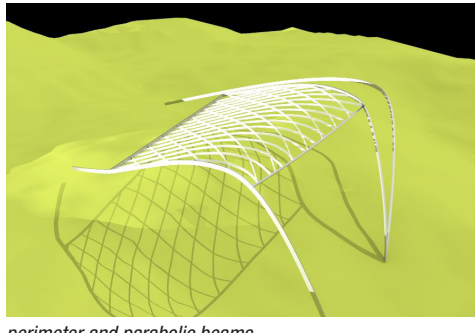




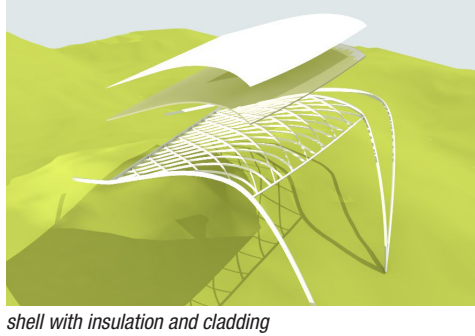

*shell roofing detail | M1:20*



*dissolved gridshell*

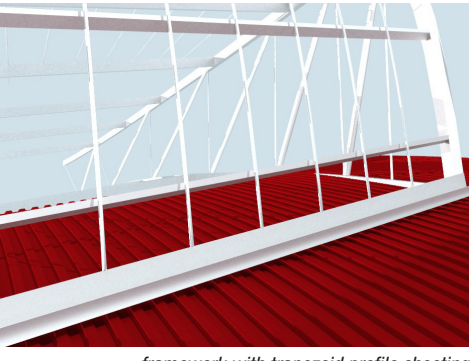


*perimeter and parabolic beams*

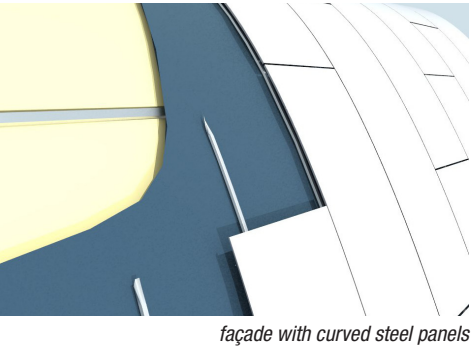


*shell with insulation and cladding*

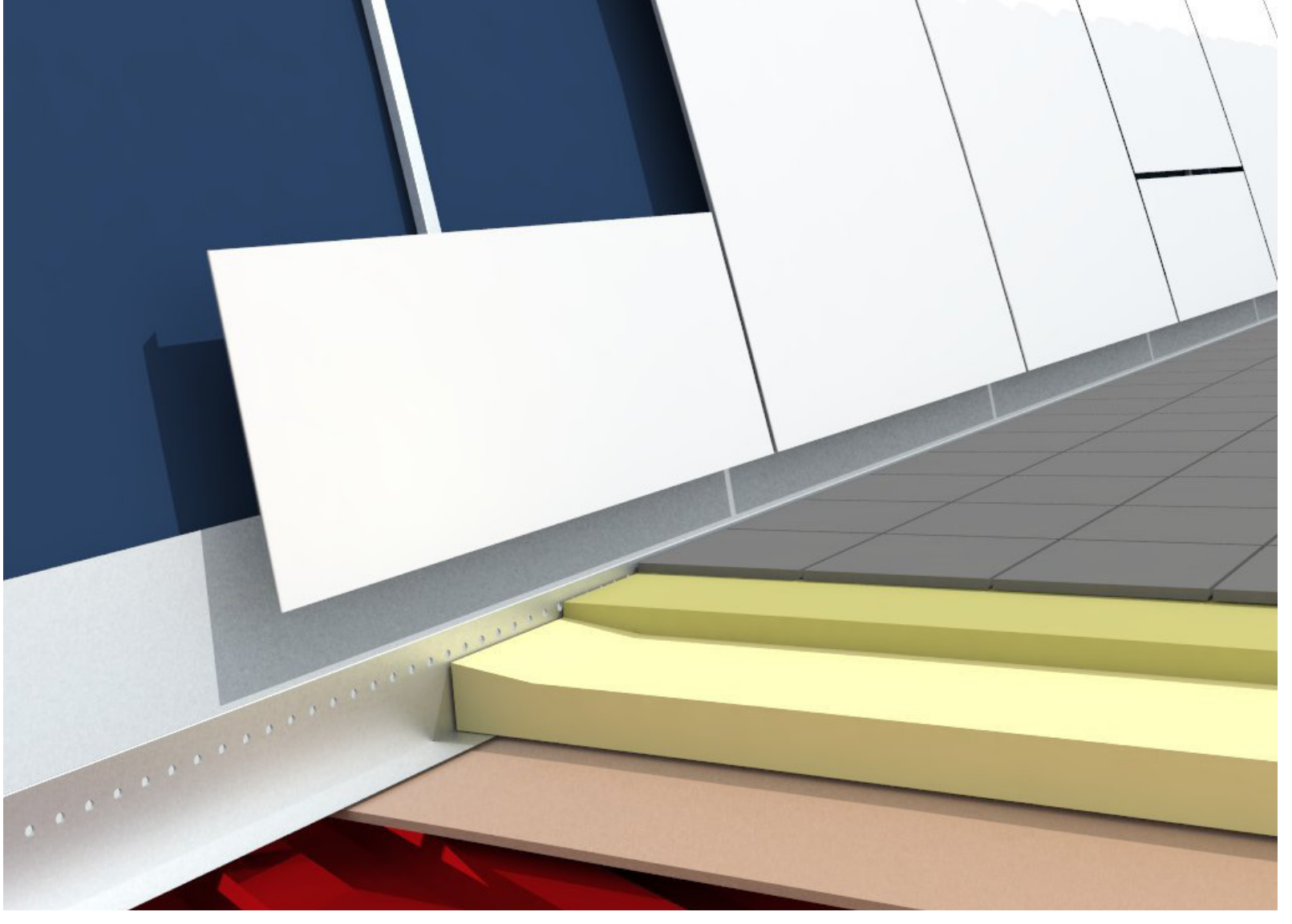
*detail location*

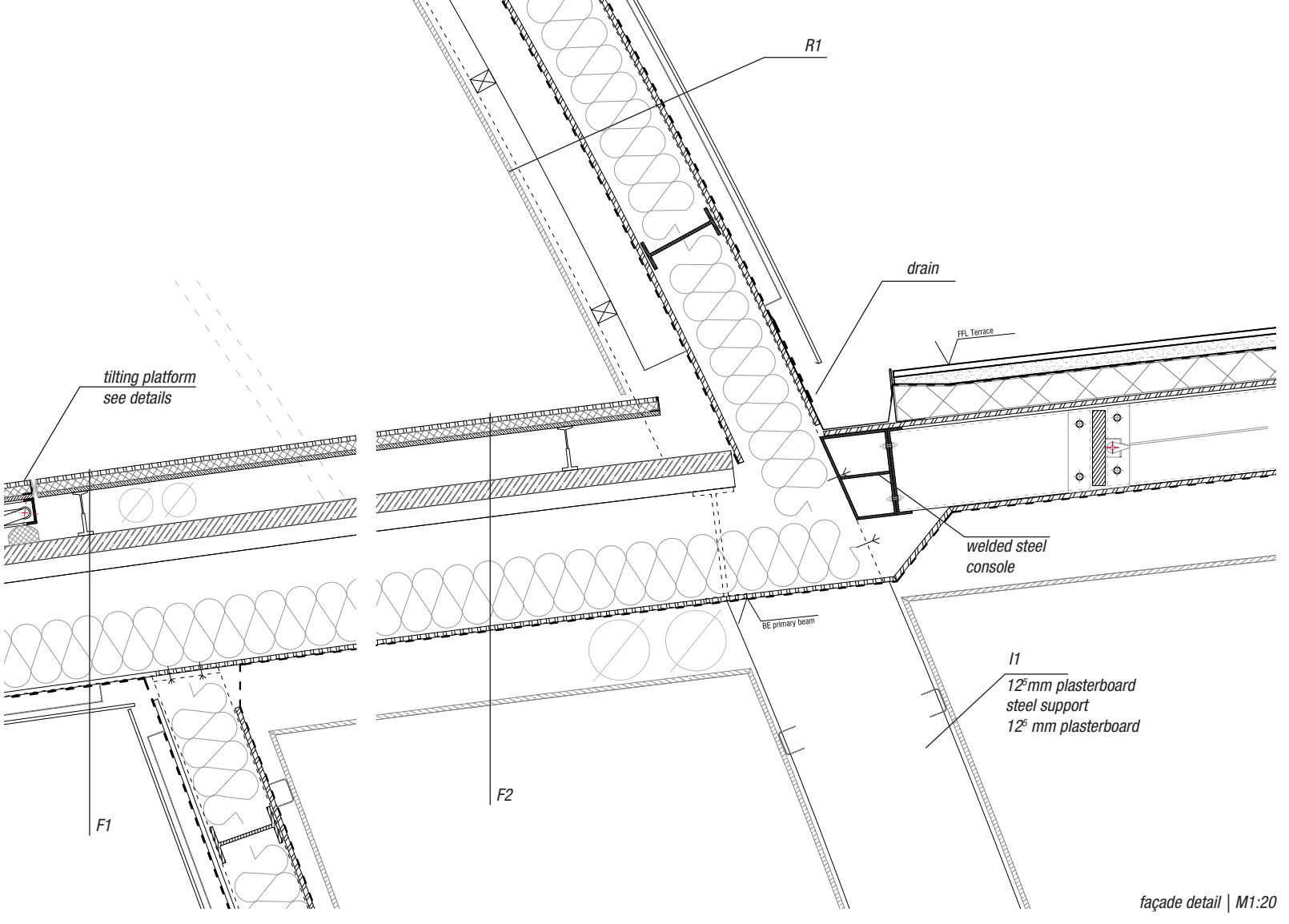


*framework with trapezoid profile sheeting*



*façade with curved steel panels*






façade detail | M1:20

*R1*

| | |
|---|---|
| 12⁵ mm | plasterboard |
| 40 mm | timber battens |
| (100 mm | air cavity) |
| | vapour barrier |
| 2 x 10 mm | particle board |
| 100 mm | thermal insulation |
| 2 x 10 mm | particle board |
| | air tight barrier |
| | water barrier |
| 40 mm | aluminium rail |
| 1⁵ mm | steel cladding |

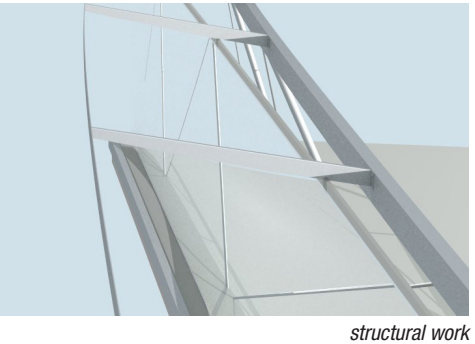
*F1*

| | |
|---|---|
| 25mm | hardwood timber floor |
| 30 mm | footfall underlay |
| | vapour barrier |
| 2x10 mm | particle board |
| | spacers |
| 120 mm | concrete on corrugated steel sheet |
| 200 mm | thermal insulation |
| 10 mm | particle board |
| | air tight barrier |
| | water barrier |
| 40 mm | aluminium rail |
| 1⁵ mm | steel cladding |

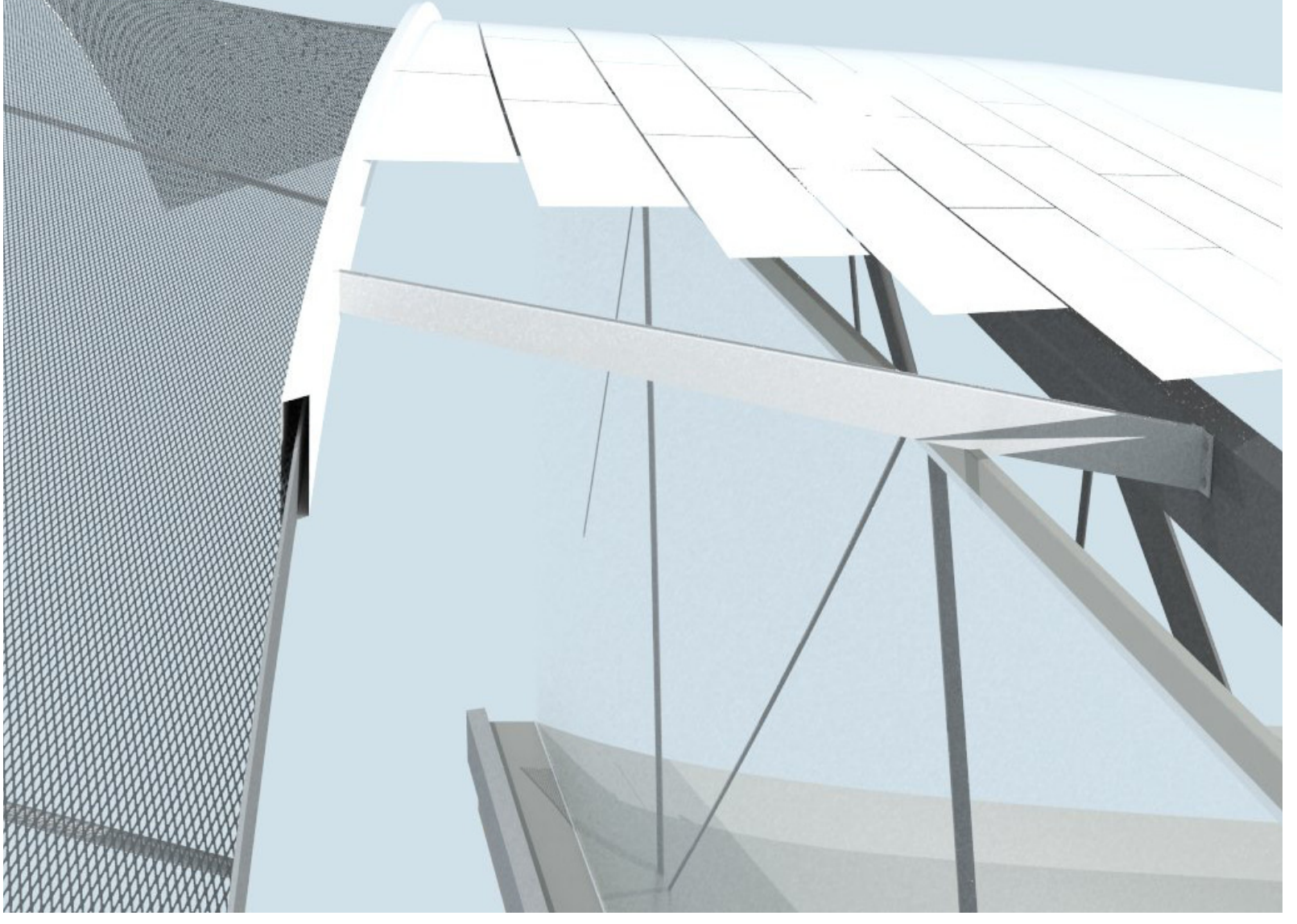
*F2*

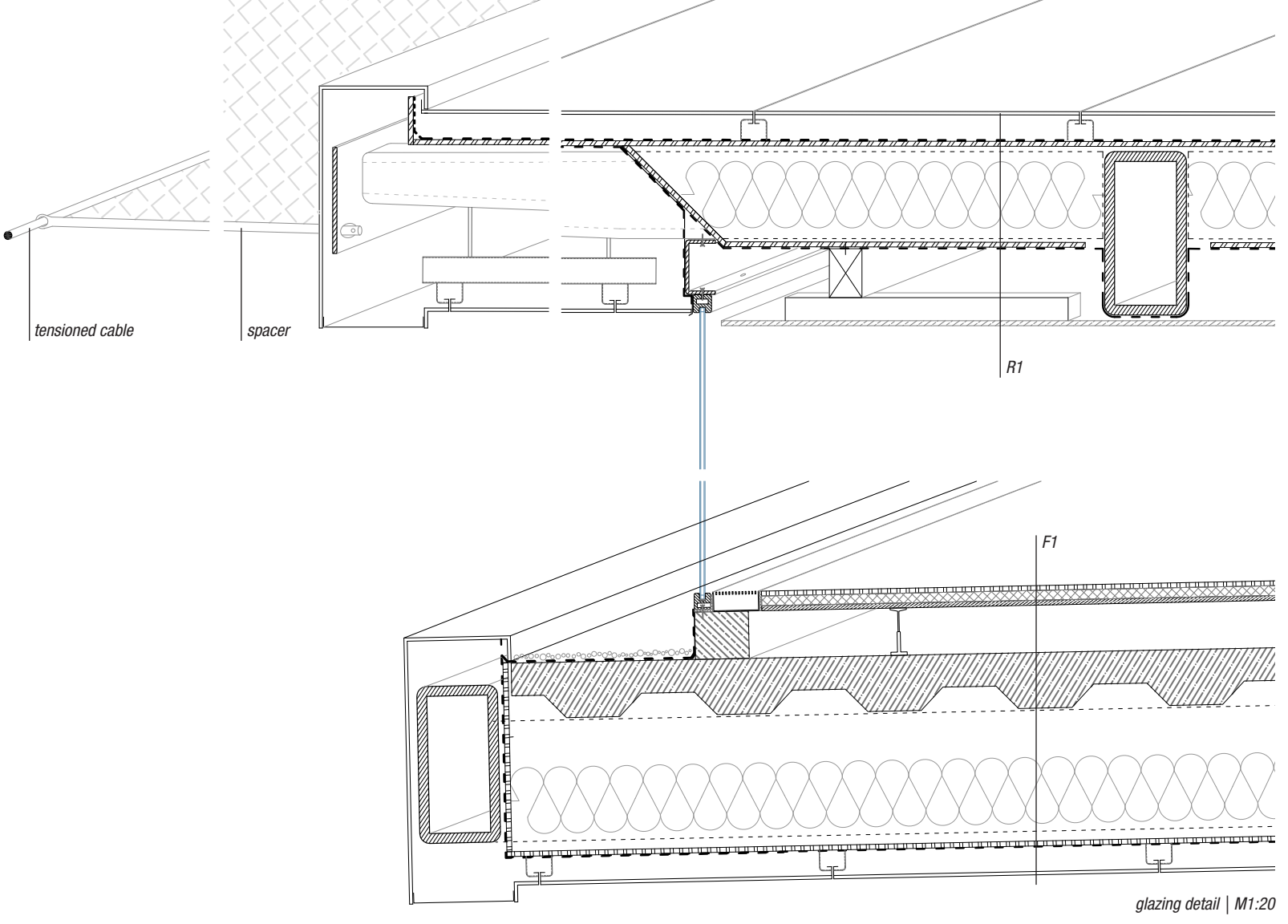
installation space
12⁵ mm plasterboard

*detail location*

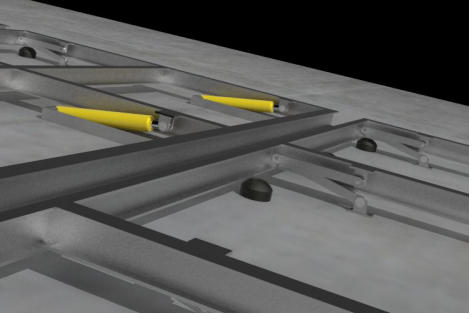


*structural work*

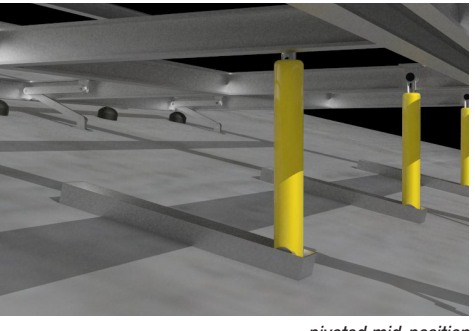




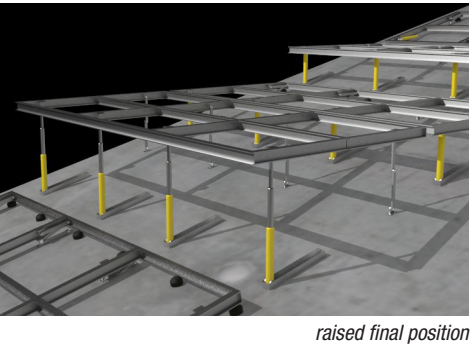

*glazing detail | M1:20*



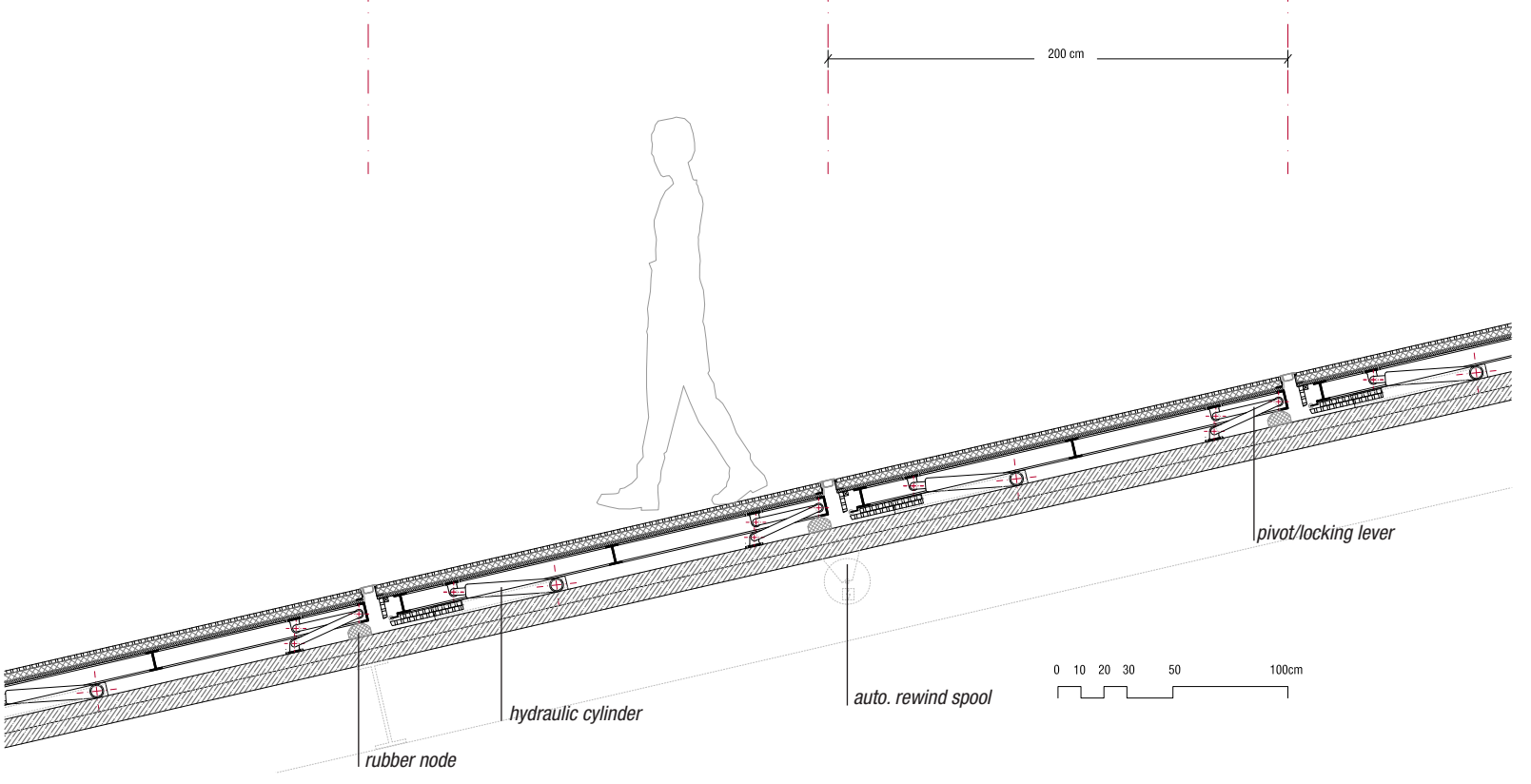
*folded position*



*pivoted mid-position*



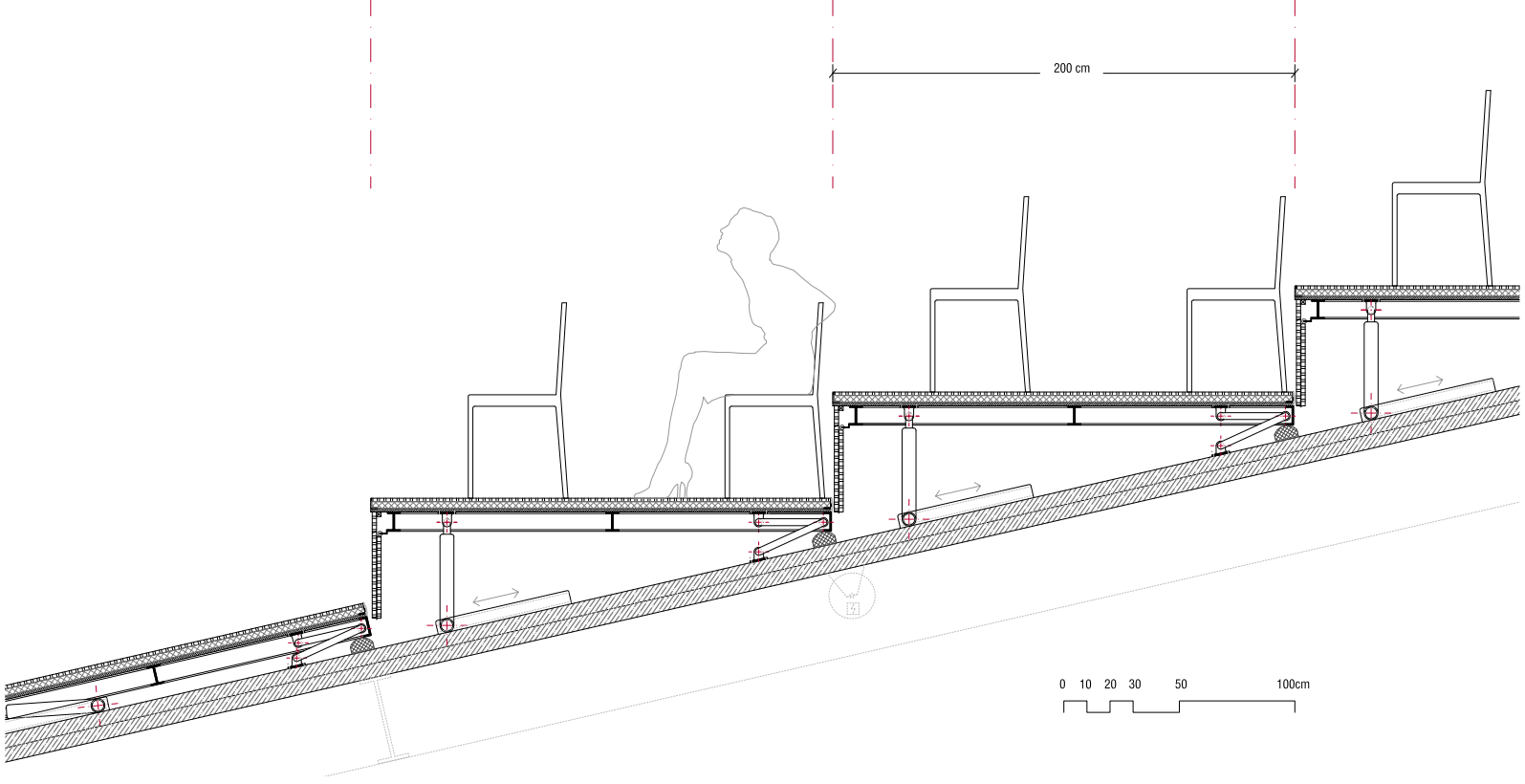
*raised final position*

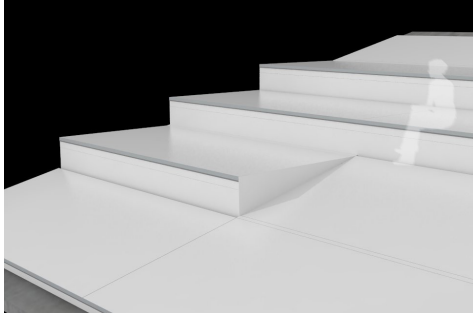



In order to create usable area and space within the large rear section of the building sections of the floor have been designed as tilting platforms. These individual elements and their mechanics were developed with the assistance of a mechanical engineer and should provide a large level of functionality to the already atmospheric room. Each field is 2 x 4 metres. (w x l) and can be moved and fixed into one of three positions.

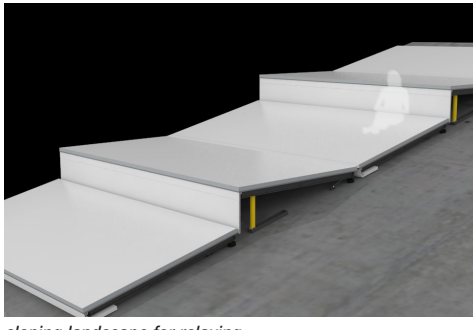
Two main problems were encountered with the mechanical system. Firstly there are two main movements, the inital pivot then the vertical rise. This meant that a combination of levers and pivots would be needed. A simple scissor lift would not be suitable as this principle requires base and table to be parallel surfaces.

In its folded position the platform is parallel to the slope of the construction. A first movement sees the platform pivot

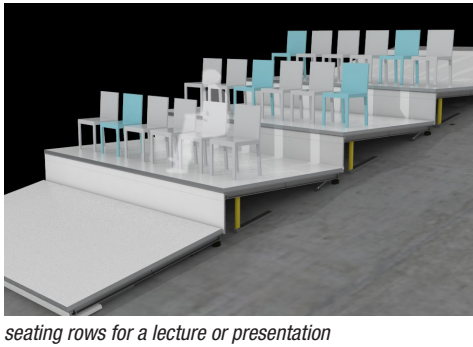


*grandstand style seating*



*sloping landscape for relaxing*

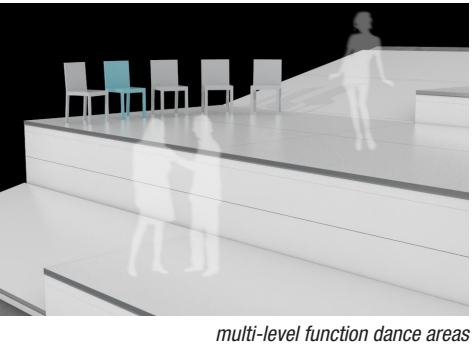


*seating rows for a lecture or presentation*

around a rear locking hinge to make a level area. The second movement uses hydraulic lifts to push the now hirzontal platform up vertically so that two flat areas are at the same level. With this system a variety of landscapes can be created to accommodate for different functions.

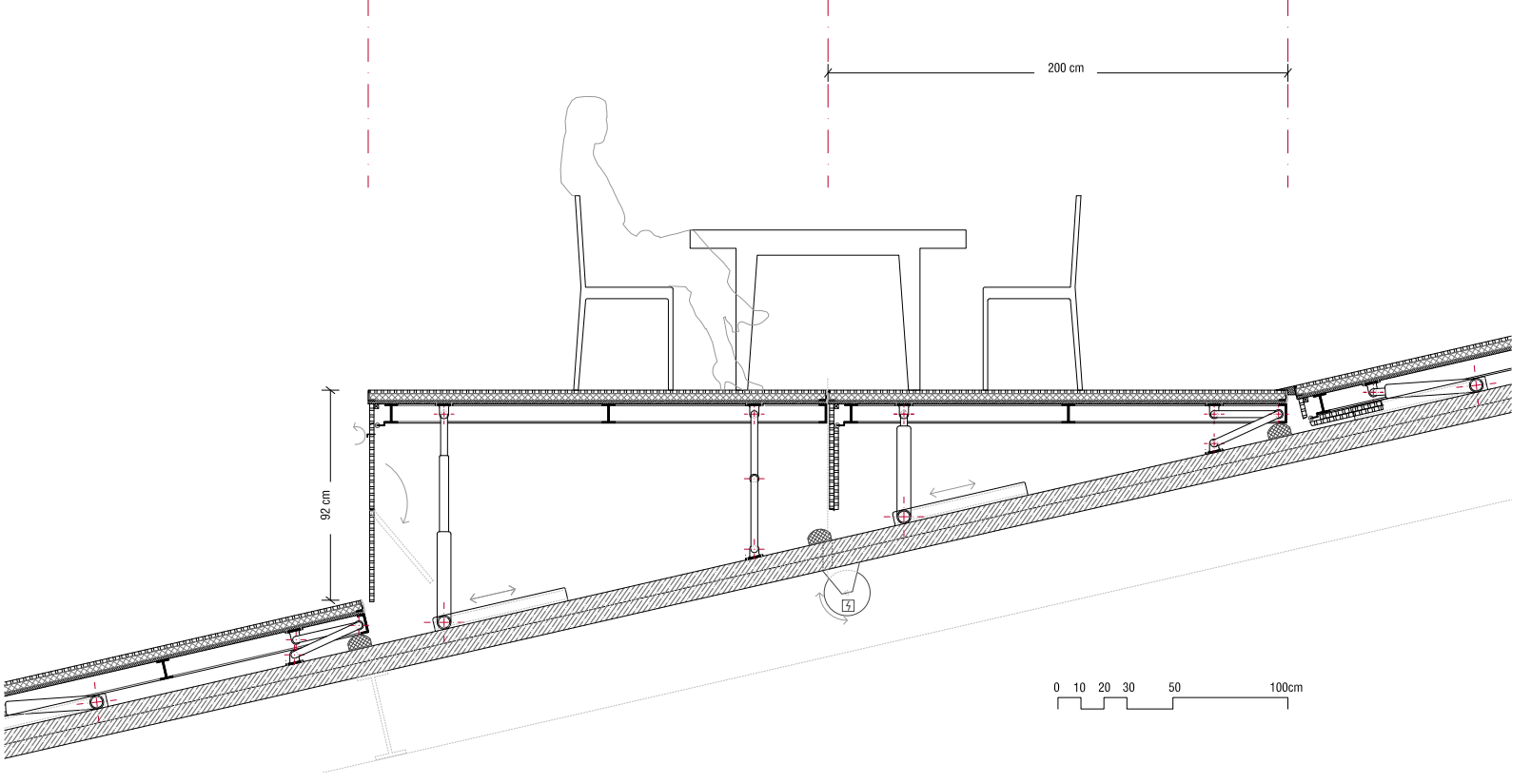
When all the platforms are folded down the room has a maximum amount of open space, without changes in floor level. When each or a series of platforms are pivoted into the mid-position an area of seating rows suitable for a lecture, conference or presentation is achieved. If platforms are selectively pivoted into this position a flowing landscape combining sitting and reclining areas can be formed, suitable for relaxing or perhaps watching sport with the projector. When pivoted up a timber panel will fold down from under the platform to athestically hide the mechanics. On the side individual panels must be inserted conceal hydraulics.

*detail location*



*multi-level function dance areas*

*meeting area*

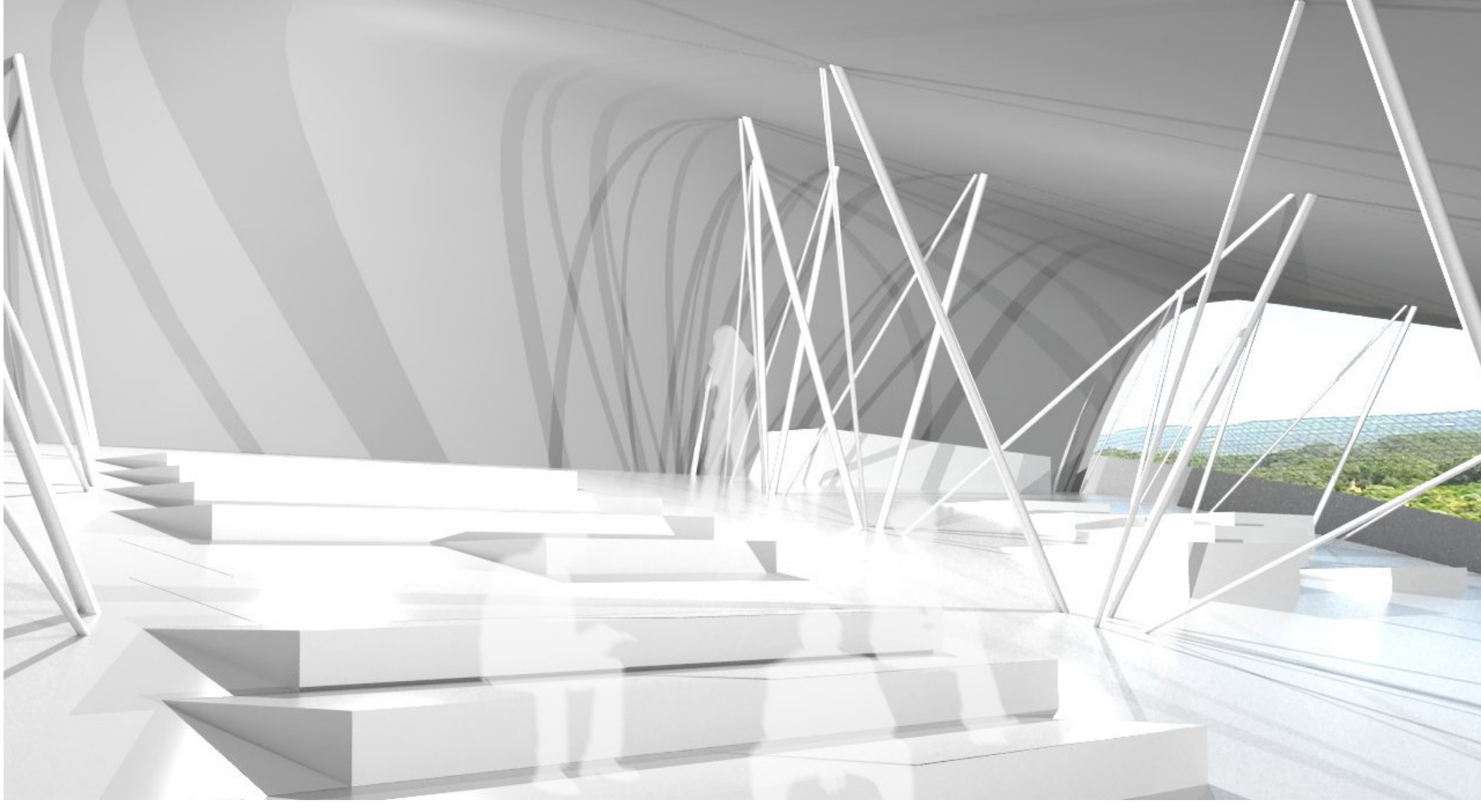



Beneath the floor construction are automatic rewind spools providing power and other cables for conference tables when required.

The Building Code of Australia specifies that a fall barrier is required where '*people could fall 1m or more... due to a sudden change in floor level.*'[1] This regulation helped in determining the size of each platform. The maximum incline in the floor is 12° which over a length of 2metres gives a rise of 46 cm. When a platform is jacked into the raised position, the maximum fall is only 92 cm, thus eliminating the need for a barrier.

Furthermore when the floor level is raised by 92 cm, the ceiling height is correspondingly reduced. With an average ceiling height of 4.5 metres in the main room, the raised floors still offer a comfortable environment.

[1]Building Code of Australia, Volume 1, DP3



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> James Barber III, *Golf Ball Flight Dynamics*, Cornell University
viewed online at www.fysik.org/WebSite/fragelada/resurser/GolfBallDynamics.pdf (29.01.2011)

> Dirk Hindrichs, Klaus Daniel (eds), *plus minus 20°/40° latitude: Sustainable building in tropical and subtropical regions*, Axel Menges, Berlin, 2007

> Tom Doak, *The Anatomy of a Golf Course*, Ithaca, NY , Burford Books, 1992

> C. Douthe, O. Baverel, J.-F. Caron, "Form Finding of a Grid-Shell in Composite Materials", *Journal of International Association for Shell and Spatial Structures IASS*, Vol 47 , 2006
viewed online at navier.enpc.fr/structures/pdf/article%202-%20SH.pdf (23.02.2011)

> Burkhard Fröhlich, Sonja SChulenburg (ed.), *Metal Architecture and Design Construction*, Berlin, Birkhäuser, 2003

> Rainer Zerbst, *Antoni Gaudi: The Complete Buildings*, Colonge, Taschen, 2002

> http://en.wikipedia.org/wiki/Gridshell (23.02.2011)

> Building Code of Australia, Volume 1

> Australian Bureau of Statistics
viewed online at, *Golf Australia*, http://www.golfaustralia.org.au/default.aspx?s=statisticsandquickfacts (08.03.2011)