The OPEN AIR CLASS at the Gardens on Spring Creek, a Geometrical Design and 21st century Scribe Workshop

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FRONT COVER PHOTOGRAPH
The Open Air Class at the Gardens on Spring Creek

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FOREWORD

This text records the design and construction of the Open Air Class at The Gardens on Spring Creek in Fort Collins, Colorado, USA. The project was run by the Timber Framers Guild and the timber conversion was carried out at Adrian Jones' Frameworks Timber framing shop in Fort Collins. The project was run as a geo-scribe workshop: the frame designed geometrically by Laurie Smith and the sophisticated timber conversion directed by scriber Glenn Dodge. Most of the timber for the project was supplied by Fort Collins City Council who were felling large numbers of beetle-kill Lodgepole pines in order to halt the spread of the contagion.

The function of the Open Air Class was to provide a positive visual focus and teaching base for educational projects encouraging children to plant seeds, nurture them to fruition, harvest them, prepare them for cooking, cooking and, finally, eating them. The purpose of the project was to make children aware of nutrition and to give them control over their future diets.

This record of the project is in four sections, covering the research and design, fabrication at Frameworks Timber, the test assembly in Old Town Square in Fort Collins city centre and final construction on site at the Gardens on Spring Creek.

CONTENTS

An introduction to daisy wheel geometry

The Open Air Class timber frame was designed using the daisy wheel, a simple, compass geometry that a child can draw. I have a vivid memory of drawing it myself as a schoolboy: each child in the class was given a small brass compass and instructed to draw the wheel, colour in the sectors with waxy crayons and pin the finished work up on the classroom wall. The gaudy colourways hung there for months like peeling wallpaper but, although I had a sense of pride when I looked at my wheel, I had no idea it was geometry and no idea why I had drawn it. In retrospect, we had learned how to use the wheel for two-dimensional pattern making but we had learned absolutely nothing about how to use it as a three dimensional design tool. In this text I aim to remedy this deficit by first setting out the construction, properties and development of the daisy wheel and, second, showing how it functions as a geometrical design tool in the development of the Open Air Class.

If a daisy wheel is drawn on paper it gives two elements of information, the pin point axis of the circle and its circumference. However, the axis is sometimes hard to relocate after drawing so it is better to commence the drawing from a point on a straight line and for the point to be marked. When the drawing commences from a marked point on a line, the line automatically determines the circle's diameter. This is beneficial because the drawing has greater precision, with a known axis, specific diameter and circumference, and with the diameter cutting the circumference at diametrically opposite poles.

The traditional and complete way to draw the daisy wheel is to commence with the boundary circle and then draw six further identical radius circles around its circumference, figure 1. Drawing the outer circles would commence at the north or south pole to give the configuration shown in figure 2 and from the east or west pole to give the configuration in figure 3. The drawing automatically generates the familiar pattern of six petals within the central circle. If the requirement is for the six-petalled wheel alone then the perimeter circles can be drawn as shorthand arcs within the boundary circle as in figures 2 and 3.

The daisy wheel can be drawn in two orien-

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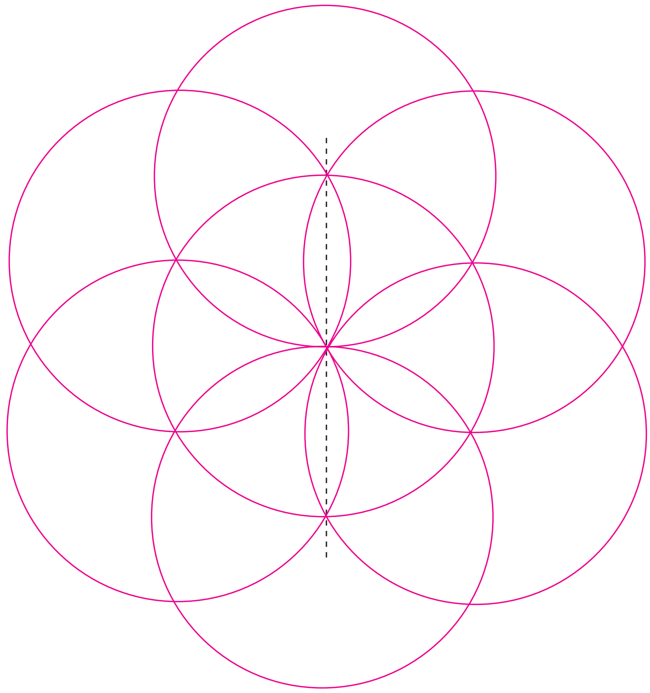

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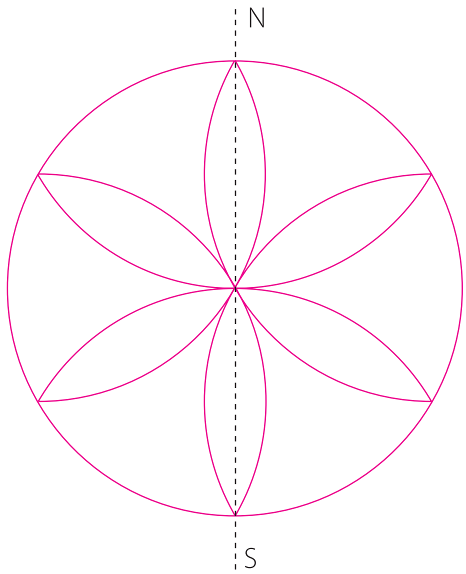

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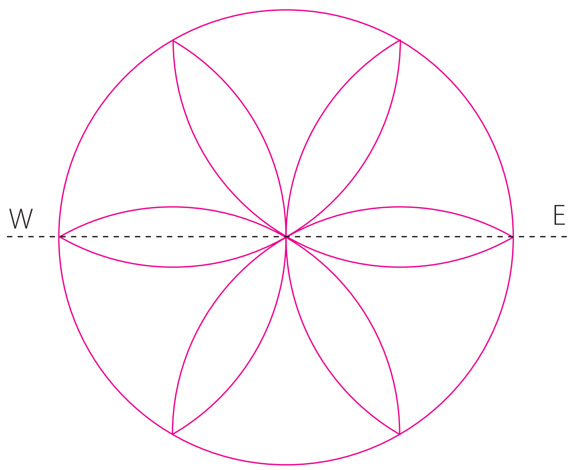

tations: north-south (vertical), figure 2, or east-west (horizontal), figure 3, each orientation being perpendicular to the other. It follows that the line from which the wheel is drawn must be drawn first in the orientation required. The orientations have relevance in the design process, particularly if a frame design is being undertaken, a point I will return to later.

The daisy wheel is the geometrical source of numerous angles, equilateral triangles, hexagons, rectangles and the square. Figure 4 shows that alignments drawn between the circles' intersections divide the wheel into regular 30° and 60° angles. Adding these angles generates a 90° right angle and division of 30° into two 15° angles allows the product of 45° to be made. Further divisions and additions of angles can be made.

Figure 5 shows how two large equilateral triangles, constructed by linking every second petal tip, overlap each other to form the star of David, with a ring of six small equilaterals around its perimeter and a central hexagon.

Figure 6 shows that two harmonically related rectangles can be generated from the daisy wheel. The 6 point rectangle (in pale blue tone) is drawn through all six petal tips on the wheel's circumference. The four point rectangle (in black line) is drawn through four petal tips. The larger rectangle is exactly twice the area of the smaller. The four point rectangle's diagonal (in dashed magenta line) divides it into two equal right angled triangles with 30° 60° and 90° angles, each a perfect set square.

Figure 7 shows that tangents to the daisy wheel's N, S E and W poles form a square (in pale blue tone) and extending the four point rectangle to the wheel's N and S poles generates a double square (in black line).

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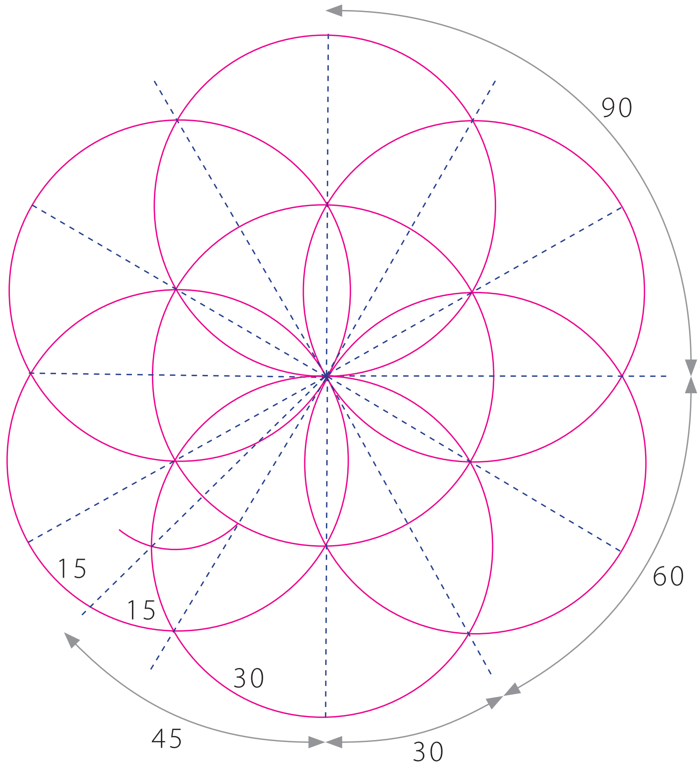

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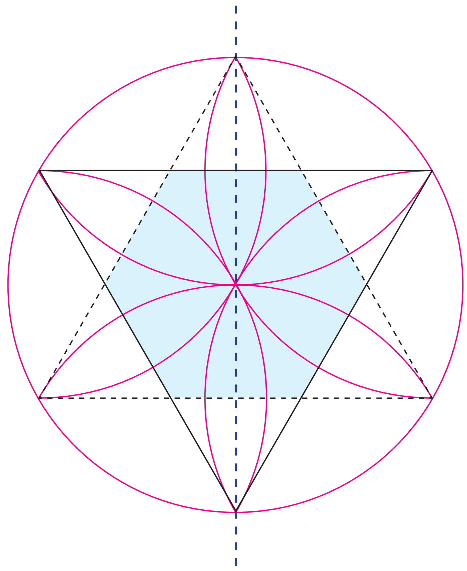

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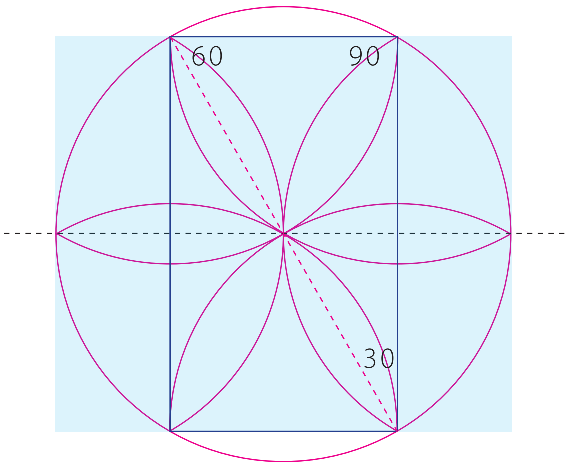

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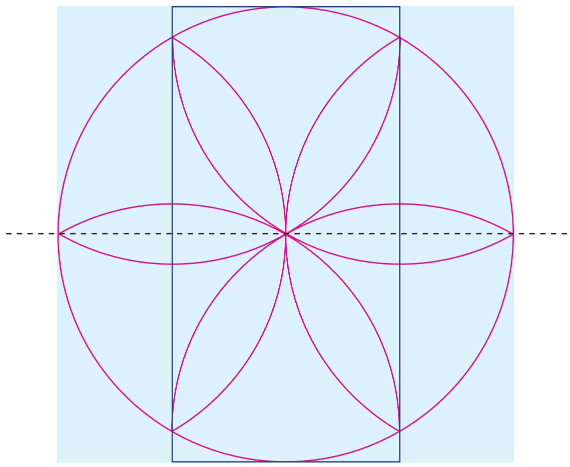

The four and six point rectangles both embody proportional characteristics that are useful in the design of buildings. At Cressing Temple in Essex, England, the section of the 13th century Knights Templar barn, dendrochronologically dated to 1220AD, is designed within the six point rectangle. Figure 8 shows the rectangle, in blue tone, and four diagonal alignments drawn in dashed magenta line. The diagonals all rise from the base of the rectangle, which is simultaneously the building's ground level, and travel to the wheel's east and west poles and the rectangle's top centre, which is simultaneously the building's ridge. A further alignment, in heavy black line, passes through the intersections of the diagonals to give the level of the building's wall plate. Figure 9 shows the Barley Barn's section derived from the geometrical constructions. The full size section is 3 medieval Rods wide, a Rod being 16½ feet in length, and the building therefore 49 feet 6 inches in width. The east west orientation of the daisy wheel is used because this gives the 6 point rectangle's maximum length on the ground, a necessity for a barn designed to store large amounts of agricultural produce.

In contrast, the Gardener's Shelter, built in the walled Elizabethan garden at Cressing Temple in 2008, uses the daisy wheel's north-south orientation. This orientation was chosen because the building's site was small, constrained at its back by the garden's wall, on one side by ancient apple trees and on the other an old walnut tree, necessitating a small footprint. The orientation also allowed relatively higher tie beams on the wheel's diameter and a roof pitch that is similar to that of the Barley Barn. The frame is 15 feet from ground to ridge, 7½ feet from ground to tie beam and just over 13 feet wide, a small shelter for the team of gardeners whenever rain starts to fall.

Figure 11 shows the scale relationship between the Barley Barn, on the left, and the Gardener's Shelter. It should be remembered that geometry generates proportional designs and that proportions remain constant whatever the scale. Scales are chosen to resolve the design requirements of specific buildings so that a large building like the Barley Barn might be designed at 1:48 scale while the diminutive Gardener's Shelter might be designed at 1:12 scale. The design scale is determined by the radius or diameter of the first circle.

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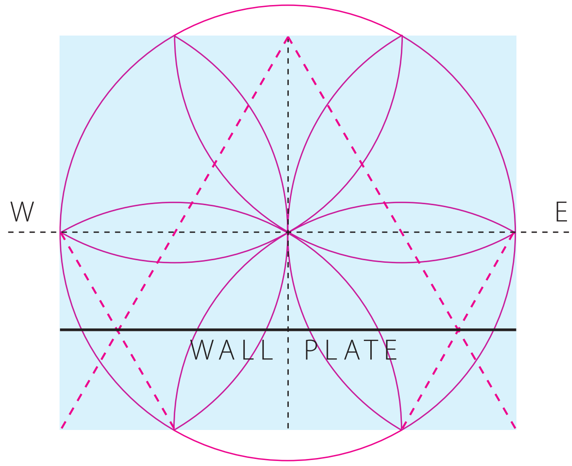

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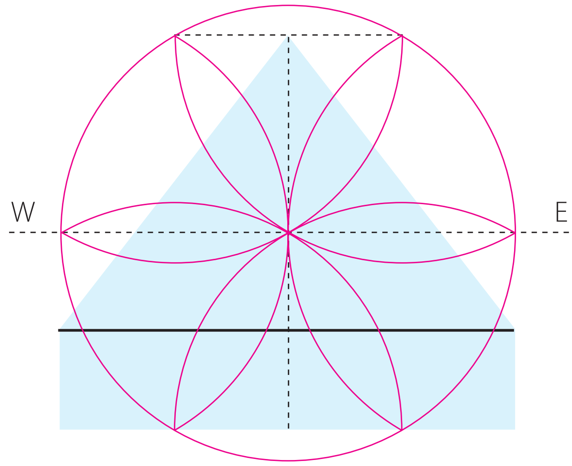

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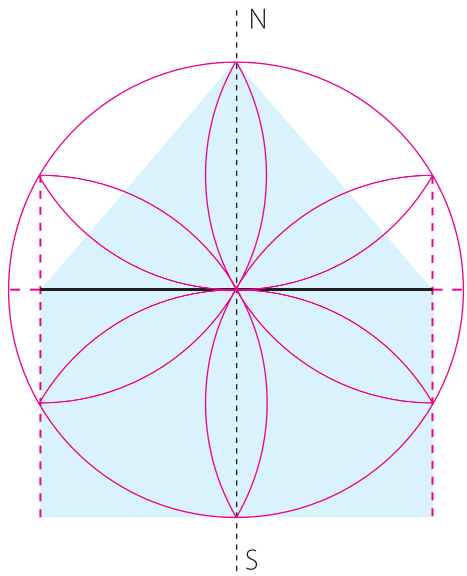

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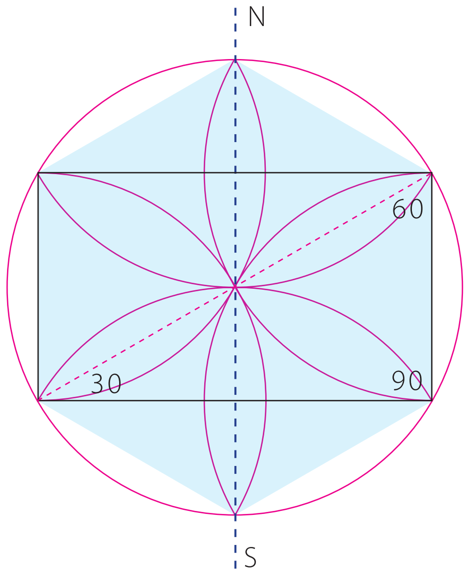
There are further developments that can be made using the daisy wheel and the hexagon is next on the list. Connecting all six petal tips around the wheel's circumference generates a hexagon, figure 12. Linking four of the hexagon's angles gives the same four point rectangle previously shown in figure 6. However, the east-west orientation of figure 6 gives a vertical rectangle while the north-south orientation of figure 12 gives a horizontal rectangle. As in figure 6, the rectangle's diagonal divides it into two right angled triangles with 30º 60º and 90º angles.

The relationship between the daisy wheel, hexagon and rectangle can be used to construct smaller rectangles of the same proportion with a different orientation, figure 13. If alignments (in dashed magenta line) are drawn to connect the large rectangle's base line to the north pole and top line to the south pole, the lines cut the rectangle at four points, A B C and D. Connecting AB and CD divides the rectangle into three equal sectors, with the central sector shown in darker blue tone. The three small rectangles have north-south orientation within the large parent rectangle's east-west orientation. The rectangles demonstrate an intrinsic characteristic of many geometrical constructions, that links between points of intersection often generate identical proportions at different scales and in different orientations.

Once the hexagon is drawn it is possible to draw a second circle (in dashed magenta line) inside and parallel to the initial circle to kiss the hexagon's sides, figure 14. The two circles and the hexagon share a harmonic relationship that makes the perimeter space between the hexagon and initial circle equal to half a daisy wheel petal. The drawing shows the six perimeter spaces duplicated and placed in half daisy wheel petals, colour coded for pairs facing in parallel alignments. Because the daisy wheel has six petals it is a logical deduction that the areas between the hexagon and the initial circle are equal in total to the area of three petals. It can be seen that on the wheel's north-south axis the vertical centre line dividing the petals into equal mirror-imaged halves cuts the inner dashed circle to give two additional points of intersection, indicated by the black arrows (there are four others in the remaining petals). The north-south points of intersection are relevant to the design of the Open Air Class.



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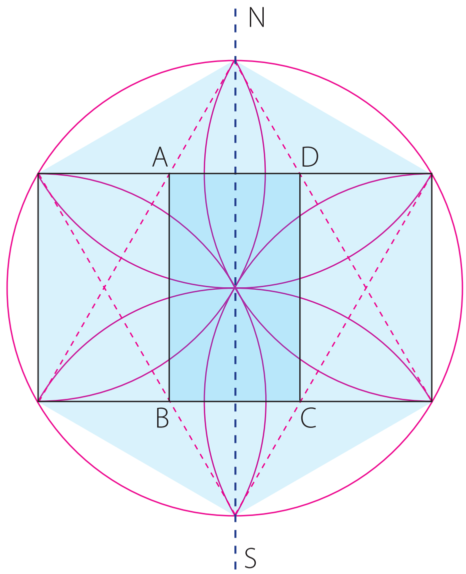

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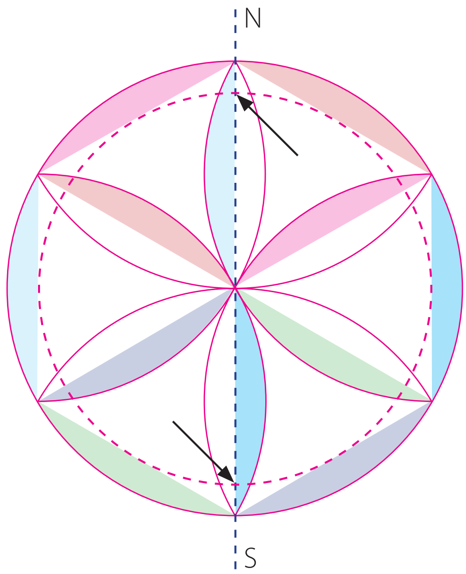

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Designing the Open Air Class

Traditional drawing board design techniques generate three related drawings: the building's plan, facade and side elevation. Geometrical design methods differ from this convention in that the plan and elevations are combined in a single drawing and, if daisy wheel geometry is being used, the drawing commences from a single radius. The other major difference is that geometry automatically generates harmonically proportioned space, a characteristic not automatically embodied in dimensions. Of course, a building's dimensions are essential but a geometrical design considers proportion first and the drawing is then scaled appropriately to the building's final size.

It can be seen in the preceeding drawings that lines can be drawn either by compass or along a straight edge and that further alignments can be drawn between points of intersection. It follows logically that all interconnections within the geometry are related and that, as more interconnections are drawn, the grid of related lines will slowly increase in complexity. A geometrical design therefore moves gradually from an initial simplicity governed by the limited choice of interconnections to a greater choice as more interconections are made. In reality, the grid of interconnections is a self-drawn graph paper that can be used to design, in this case, the Open Air Class. The geometrical graph paper differs from conventional modern graph papers in that it is not a monotonously repetitive grid of miniature squares or triangles but is an open grid embodying variable straight and curved line lengths with different areas in between them. Beyond this the drawing principles are the same, that lines are drawn between points of intersection to establish the building's form.

It is logical to start at the beginning with the daisy wheel's six point rectangle defining the floor plan. Because the floor length is equal to the daisy wheel's vertical diameter it is easy to draw the wheel at a scale that can be converted to full scale. If the wheel's drawn radius is 6 inches (diameter 12 inches), the diameter can be stepped out with dividers along a chalk lined timber to full size. As 12 inches = 1 foot, ten steps will give a ten foot floor, fifteen steps will give a fifteen foot floor, twenty steps will give a twenty foot floor and so on.

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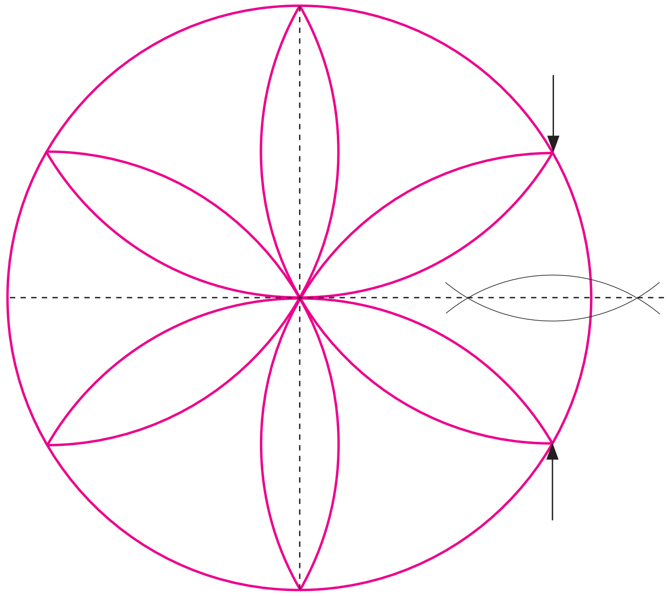

Figure 15 shows the initial development of the geometrical grid: the daisy wheel's vertical diameter is drawn between the north and south poles and the horizontal diameter through the intersections of two equal radius arcs drawn from the two right hand petal tips and the wheel's axis though, optimally, two further arcs would be drawn from the left hand petal tips. These small arcs are obsolete once the diameter is drawn and can be eliminated.

Figure 16 shows the floor plan, determined by the six point rectangle, shown as grey tone.

Figure 17 shows a second, harmonic circle drawn parallel to and inside the wheel's circumference. The radius of the circle is governed by the width of the six point rectangle where it cuts the wheel's horizontal diameter. With the floor plan and parallel circle in place there are several options for the building's section, all of which are exactly the floor plan's width.

Figure 18 shows a section determined by the full height of the wheel's vertical diameter, shown as a darker grey tone. It gives a high roof pitch but also, because the tie beam is placed on the horizontal diameter, high side walls.

Figure 19 shows a section determined within the inner, parallel circle. Like the section in figure 18, it has its tie beam on the horizontal diameter but has a lower roof pitch and lower side walls.

Figure 20 shows a compromise between the previous two figures. The tie beam remains in

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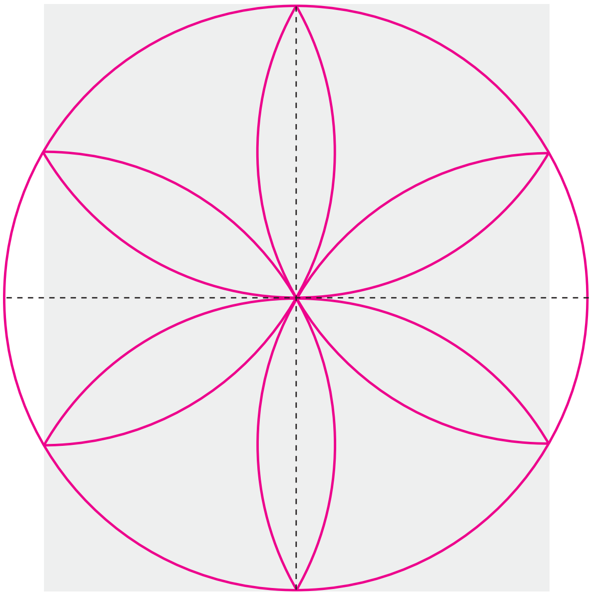

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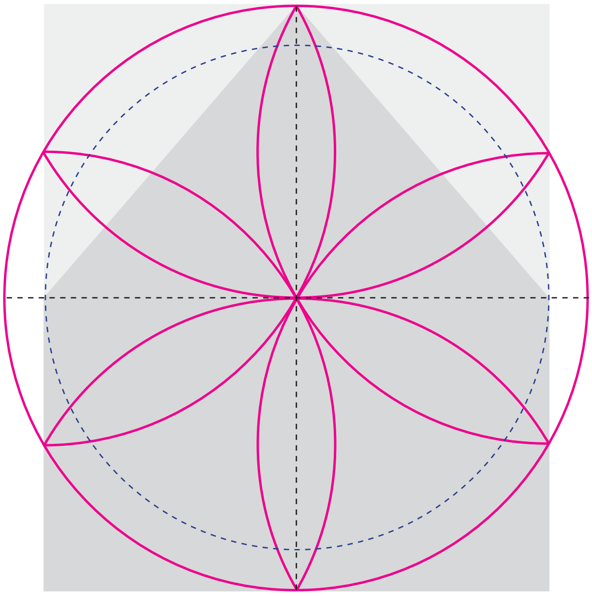

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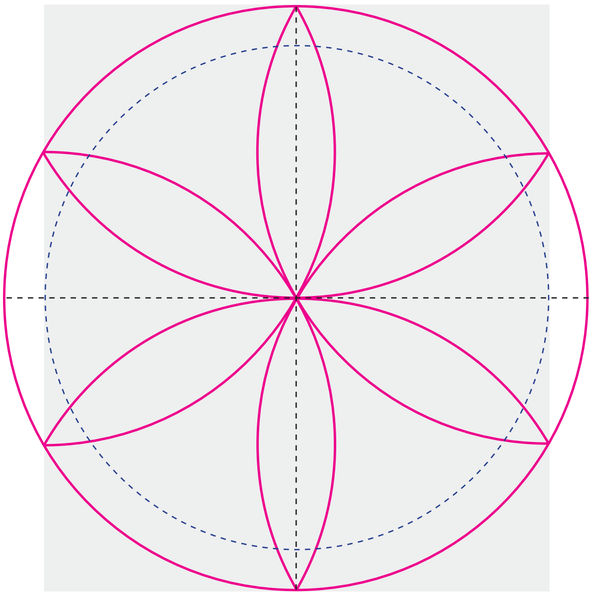

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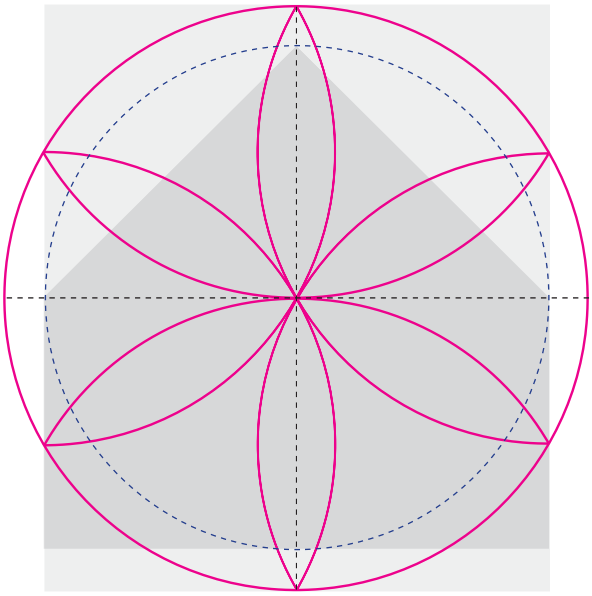

the same location on the horizontal diameter but, while the roof pitch runs high to the full daisy wheel north pole circumference, the wall height is governed by the inner parallel circle. This configuration gives a greater roof pitch in relation to the building's wall height. This choice was made as the result of correspondence between Adrian Jones of Frameworks Timber in Fort Collins who said that a steep roof pitch was a necessity for shedding the sudden heavy snow loads that fell there in the winter. He also mentioned that there was a high level of solar radiation and that the building would need overhangs all round to shield against the power of the sun, so the lower walls were a first step towards providing some protective shade inside the building.

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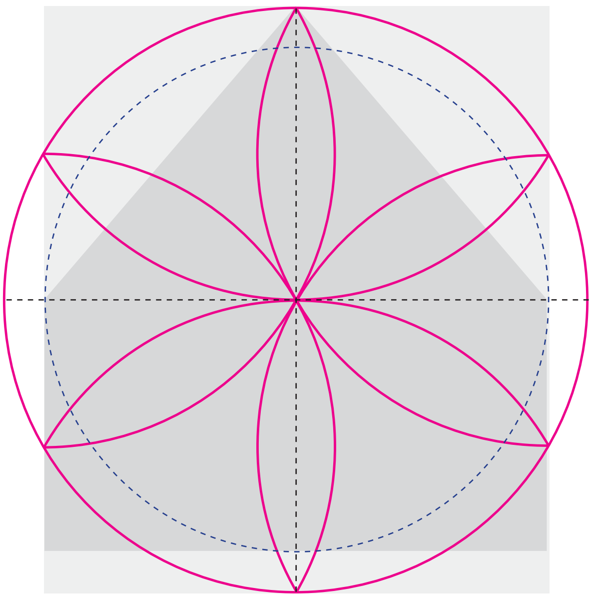

Introducing dimensions

It should be remembered that geometry is a proportional rather than dimensional design system so the drawings thus far are free from dimensions and could exist at any number of scales. For example, the floor plan and section could be the design for a doghouse, a garden shed or a barn, all identical in proportion but different in scale. So, when Adrian emailed again with some general dimensions to aim at (which were dictated by factors such as the available site, the available timber, the time scale of the project, etc) it was time to check the proportions against some dimensions. On computer this was simple. I have some rulers that can be expanded or contracted in scale so that they can be tested against proportional drawings. Adrian suggested an approximate building width of 20 feet and a wall height of 10 feet so I could set my ruler to the width and then test it against other aspects of the plan and section.

Figure 21 shows the ruler set to 20 feet building width (at the base of the section) and then tested against the building's height (on the right). The wall height is 10 feet from ground level, the ridge 21 feet 6 inches from ground level and the principal rafter just over 15 feet from wall plate to ridge. Adrian's suggested length for the building was around 24 feet. Using the same ruler and testing against the floor plan's long side, gave a length of just over 23 feet, close to Adrian's suggested length.

Solar protection (floor plan)

Adrian's email of 28 June 2010 had warned, *big overhangs are essential here for solar protection, 2 feet is a minimum*). So, with the frame's general proportions in place it was time to consider shelter from the sun's rays. Obviously, the overhangs could be attained by projecting the roof pitch down beyond the floor plan (or wall plate) but it was essential that any projection should follow the proportional control of the initial daisy wheel geometry so that all elements of the frame were visually unified. In historic buildings from the medieval period the building's diagonals are often an important element of the design so I chose to follow suit and apply diagonals to the floor plan and to

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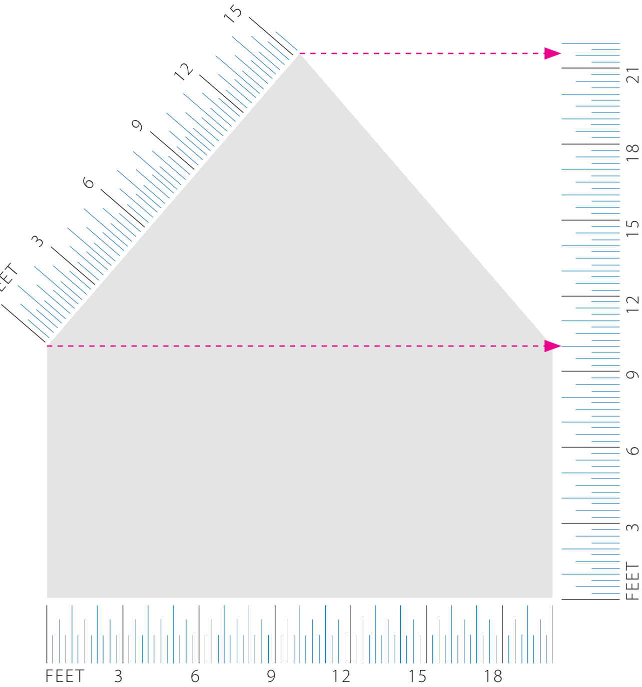
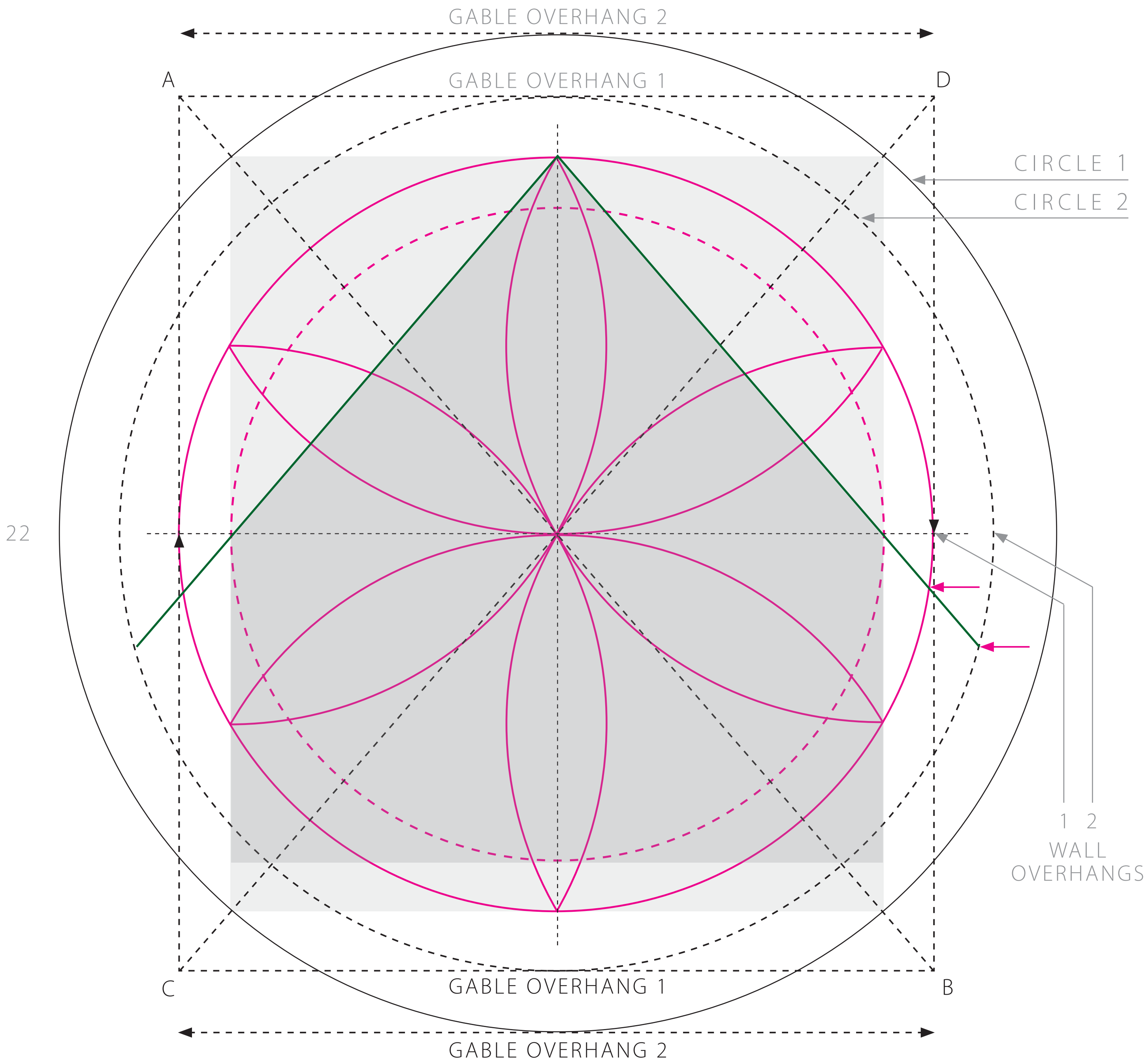


project them beyond its corners as a way of gaining the overhangs. I also needed a way of deciding how far the diagonals should extend and chose concentric circles, parallel to the daisy wheel, as my method. The diameters of the concentric circles, the diagonals and the degree of overhang are all interconnected as the following diagrams will show.

Figure 22 is enlarged for clarity but remember that, being a geometrical construction, the proportions remain constant. The diagonals AB and CD are drawn first to pass through the corners of the floor plan (the six point rectangle in grey tone). The alignments AC and DB are drawn next as tangents to the daisy wheel's circumference (kissing the wheel at the black arrows). Where AC and DB intersect the diagonals (at A B C and D) they give the horizontal alignments for the gable overhangs AD and CB (gable overhangs 1) at either end of the floor. Because the floor is a rectangle the diagonals automatically generate a rectangular overhang, narrower along the side walls but deeper at the gables where, the gable being higher, greater shelter from the sun is needed.

To increase the choice of gable overhang, two additional, concentric circles are drawn from the wheel's axis. Circle 1 (in solid black line) passes through the four corners of the floor's six point rectangle and, on its vertical



diameter, defines the horizontal locations of the second pair of gable overhangs (gable overhang 2). Circle 2 (in dashed black line) has its vertical diameter defined between the first pair of gable overhangs (gable overhang 1) at either end of the floor. The two new circles, which are an evolutionary development from the proportional values of the original daisy wheel geometry, give two deeper choices of location for the gable overhangs. In the diagram, gable overhang 2 is shown with the same width as gable overhang 1 on the side walls but the circles also generate wider choices of overhang at the side of the plan, see wall overhangs 1 and 2 (indicated in grey tone at the daisy wheel's horizontal diameter).

However, although this is the case on plan, it is necessary to consider the geometry in section to see the effect of the overhangs on the side walls. The crucial factor is the overhang's height above ground level as this determines whether the structure can be entered through the side walls with adequate head clearance. The roof pitch (shown in dark green solid line) projects down to cut the circles at two potential levels (indicated by magenta arrows). The heights can be tested against the ruler and this is shown in the following figure 22, overleaf.

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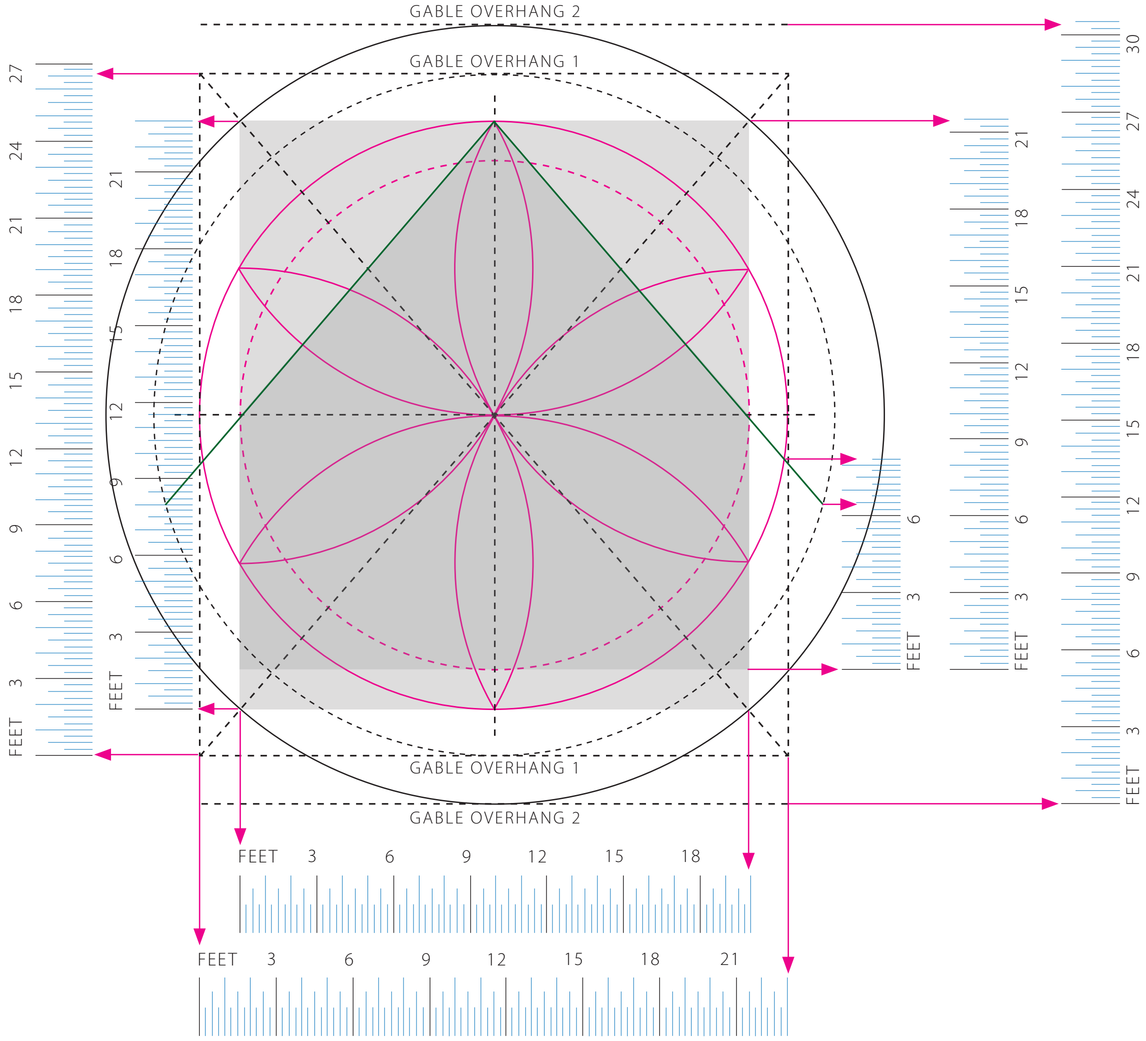
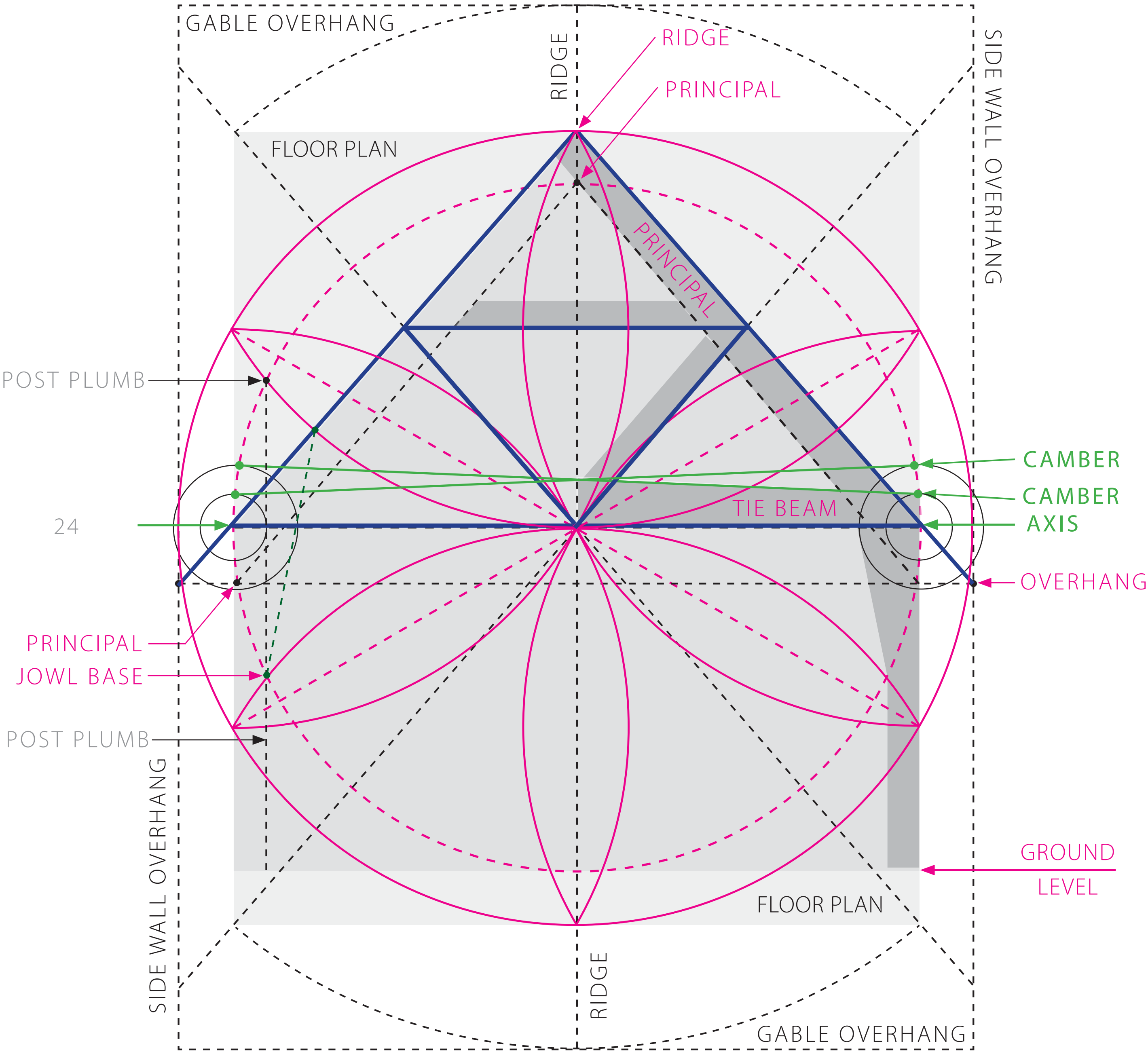


With the rulers in place the section overhangs can be assessed for height: the overhang to the dashed black line being 6 feet 6 inches and too low; the overhang to the Daisy wheel's circumference being a viable 8 feet 3 inches.

A single drawing 1 proportions - dimensions

It must be emphasised that Figure 23 represents a single drawing and a single ruler. The drawing is being repeated in incremental stages so that each development can be understood in its own right. In reality, everything drawn so far would be drawn as a single drawing to a specific scale and dimensions checked against a single ruler using dividers. However, the drawing above records all the dimensional tests for different elements of the design: the floor plan's length and width, gable overhang 1's length and width, gable overhang 2's length and width, the sectional height from ground level to ridge and the two eaves level overhang heights on the side walls. The important emphasis, again and again, is that the geometrical drawing has proportional resonance between all of the elements drawn so far. The rulers allow translation from geometry's spatial language into a numerical language that is comprehensible to the modern mind. The translation can be attained just as easily by taking divider readings from the scale geometry and stepping out along chalk-lined timbers at full scale. What our modern minds can learn from the rulers is that the floor is 20 feet by 23 feet, overhang 1 is 22 feet by 26½ feet, gable overhang 2 is 22 feet by 30 feet 4½ inches and the optimum side overhang gives 8 feet 3 inches vertical clearance. The distance between the frame gables and the gable 2 overhangs totals 7 feet 4 inches or 3 feet 8 inches at either gable. The daisy wheel has a 23 feet diameter or, alternatively, an 11 feet 6 inch radius.



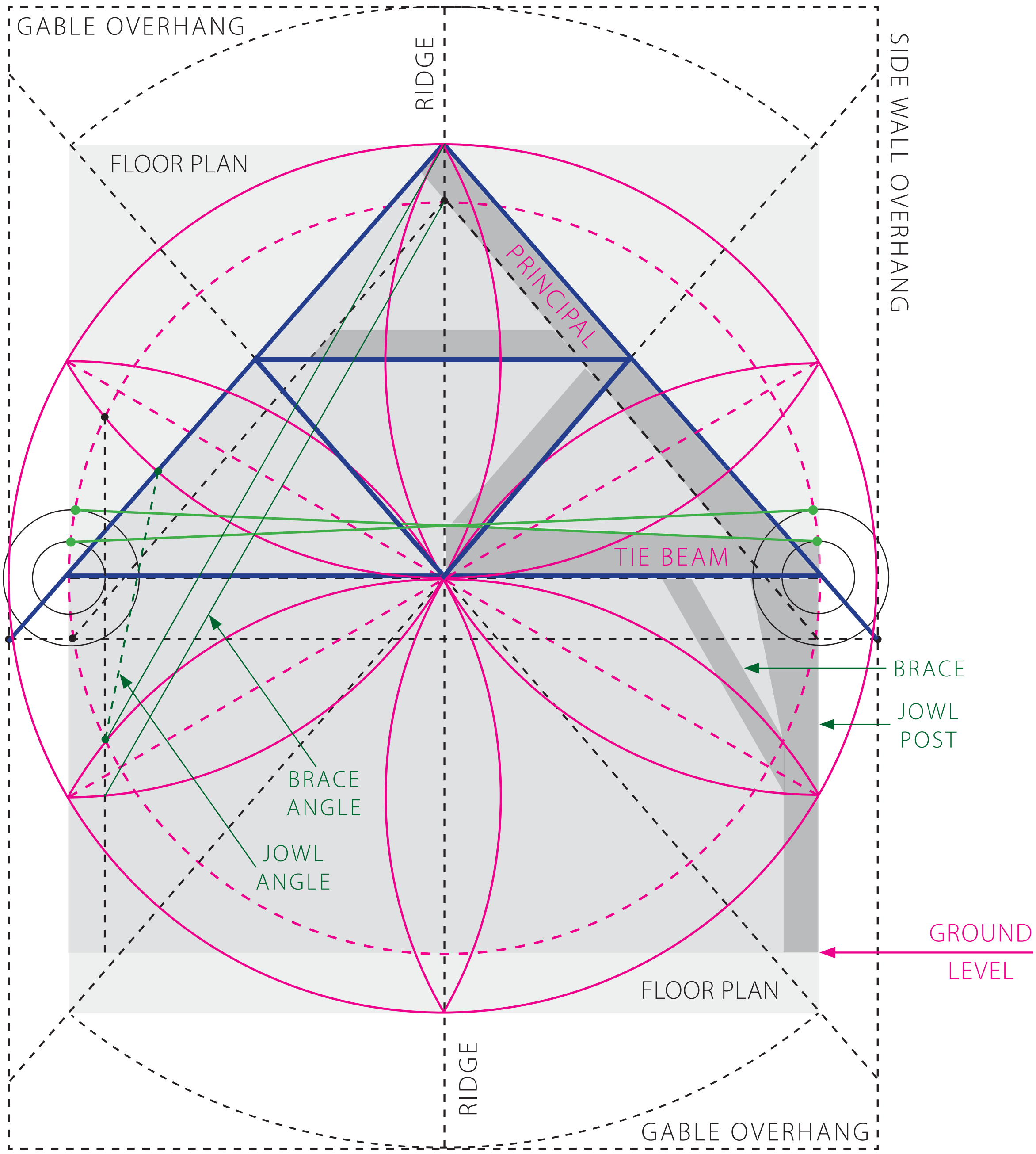
A single drawing 2 frame alignments

Adrian's email of 24th June 2010 had mentioned, *for what it's worth, I love English tying joints, cambered bottom chords on trusses, and tapered members in the frame. I would love to see those details included in this design. All traditional English details I believe.*

Figure 24 shows the introduction of Adrian's requests, shown as links between points of intersection on the left and as tonal infills on the right. On the left, the post's inner face follows a vertical dashed black plumb, from where the wheel's petals intersect the inner, dashed circle, down to ground level. The jowl links the jowl head intersection of roof pitch with the wheel's petal and the jowl base intersection of the vertical post plumb and the dashed magenta line bisecting the wheel's lower left petal.

Two additional concentric circles, drawn from an axes at the tie beam - roof pitch junctions as far as the post and jowl at either side of the frame, allow the shallow camber angles of the tie beam to be drawn.

The triangulation of the braces follows the floor plan diagonals and, where these cut the roof pitch, the collar links the principles, shown in heavy blue line. These timbers are shown in tone on the right hand side of the drawing.



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A single drawing 3 jowl posts and braces

Figure 25 shows the geometry of the jowl posts and braces, as alignments on the left and as solid tones on the right. The alignments show the post inner face as a dashed black plumbline and the brace as solid green angles. The important factor in these alignments is that the jowl and brace both spring from the same geometrical point and both are formed from straight timbers. The reason for this is to eliminate the traditional dog-leg jowl and to therefore give the frame a cleaner, simpler aesthetic. This, in turn, allows the eye to see the triangle between the post and brace as a single shape, growing in length and width as it rises towards the tie beam, and to comprehend the angle of the brace as an alignment that leads to the ridge. This gives the track of the brace a visual reason for being rather than as a timber fixed across the angle at random. The chosen alignment is derived from the geometry of the floor plan and section and is therefore harmonically related to everything that has gone before. However, this decision came into conflict with the availability of some natural curve timbers that Adrian was keen to use in the frame and we will return to this later.

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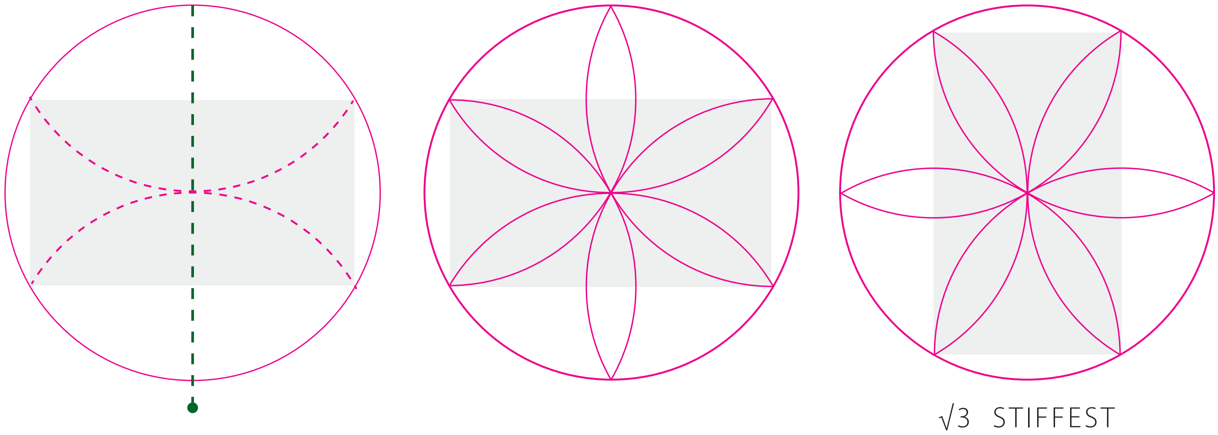

√3 STIFFEST

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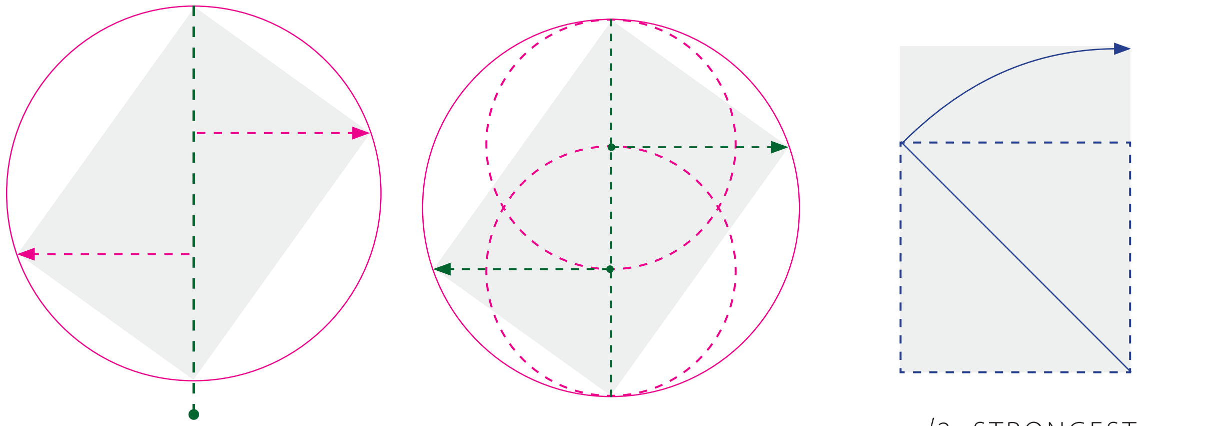


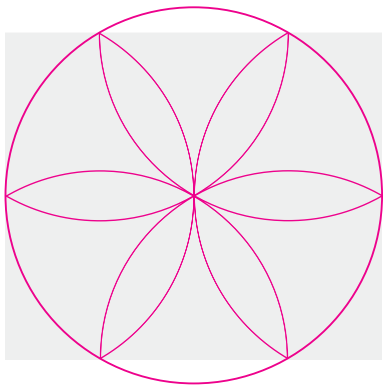
√2 STRONGEST

Timber sections strength and rigidity

In advance of the project's start, Adrian and I had trans-Atlantic email discussions about timber availability, species, natural curves, sections, strength, engineering and so on. The Encyclopedia of Architecture by Joseph Gwilt (the classic 1867 edition with 1364 pages and 1400 drawings) threw some light on these issues and gives, on page 433, two geometrical methods for finding the best proportion of a beam to be cut from a round section tree.

The **stiffest** beam has a section in the ratio √3:1 and the **strongest** beam has a section in the ratio √2:1, root 3 and root 2 rectangles respectively. Both of these rectangles can be found quickly and easily within a circle and, therefore, in the section of a tree. To find the root 3, two arcs of circle are scribed from either end of a vertical plumb bob held on the log end, figure 26, left. Figure 26 centre shows that this rectangle is also the four point rectangle found by linking four of the daisy wheel's six petal tips. Figure 26 right shows the wheel, or log, spun through 90º, the position in which the timber is stiffest and the maximum section at the centre of the cambered tie beams.

28



JOWL POST

The root 2, strongest beam section, figure 27 left, shows a vertical plumb divided into three equal sectors with right angles projected to the log's circumference. Figure 27 centre shows an alternative compass method for the same proportion and figure 27 right shows how the same section can be drawn using square geometry, with the square's diagonal equal to the rectangle's long side. Figure 28 shows the daisy wheel's six point rectangle, already selected for the Open Air Class floor plan, used at a smaller harmonic scale for the jowl post footprints.

Timber sections natural curves

Working on the geometry of the frame alone in Wales, remote from Adrian's shop and the building's ultimate site, it was useful to have his regular email updates about the state of play regarding the availability of timber and the impact that it might have on the design. I discovered that Adrian and his team had been working at weekends sawing timber, that the design had been submitted for its engineering review (for buildings above a certain size, engineering was mandatory in Colorado) and some minimums had been suggested for certain timbers, the braces requiring a minimum length of two feet six inches. It was a simple matter to test this aspect of the design against the ruler, ascertain that the brace as designed exceeded the minimum dimension (which it did), and email back.

Adrian again: *First, about the materials. This frame will be cut from a mix of species and most of the major members are locally harvested beetle kill pine.* And: *The second source for materials is urban logging. The City of Fort Collins Forestry Department has been dropping off logs for the last couple months. Some are useless, others are quite nice. There's the right amount of material to make the collars, struts, and braces out of the City's hardwood, and we've sawn them accordingly. One deviation that we've pursued here is the struts in the trusses. They're drawn as straight, but the city brought us some beautifully curved material that I can't bear to cut strait.* ***We have the perfect amount to put three matched pairs of curved hardwood struts in this building. Can you bear to consider this as an alternative?*** *If not, we'll save that stuff for some other project and cut straight struts out of remaining pine logs.*

I have always admired the American use of non-standard timbers in timber frames. I could see Adrian's vision of paired natural curve struts clearly in my own mind's eye and, to be honest, I liked the look of it but it cut right across the development of the frame's geometry and it was a geometrical design that I had been asked by TFG to produce. It was time to down tools, go for a walk and clear the mind.

On reflection I thought that a frame with deep solar gable overhangs would conceal more of the struts than it would reveal, in fact only the pairs in each gable would be clearly visible and even then only from the viewer's end of the building. I decided not to go along with Adrian's wishes and to keep the strict triangulation of the trusses intact but another thought had formed, that the natural curve timbers could brace the long side walls where they would be more clearly visible. With six braces per side this meant we would need more but, if they could be found, the visual benefit would be doubled. So I resolved the building's geometrical grammar around the juxta-position of straight triangulation within the cross walls and natural curve timbers as braces in the side walls. This juxta-position followed medieval and Islamic architectural thought where opposite characteristics became the positive and negative or male and female elements within the design. This manifests itself in the basic interchange of solid and space that constitutes a building, the solid acting as the vessel containing the space. The arcades in English cathedral naves are constructed with alternating cylindrical and angular piers, expressing the two opposing geometrical characteristics of circularity, found in the organic world of living things, and angularity, found in the static world of crystal formations. Felling a living tree reveals the circularity of the trunk. Walking on the Giant's Causeway on Northern Ireland's Antrim coast reveals a geological formation of cooled volcanic basalt hexagons that rise the full height of the cliffs.

A further thought came, that with the natural curve timbers acting as braces to the truss posts in the long side walls, their positions would be closer to what they had been when they were alive and growing in trees. And walking past might be more like walking through a wood. So this was my reply to Adrian's email and this was how we actually built the frame.

The length of the natural curve timbers meant that it was easy to exceed the engineering demands for timber lengths. The length also meant that it was possible to take the same triangulation as that of the truss braces from jowl post to tie beam and place the natural curve timbers in a similar relationship between the jowl post sides and the side-wall plates. In the event, just the start and finish points of the angles were defined and the natural curves followed their own paths between the two points, allowing the geometrical design and the growth of the curves to be brought together in a visually harmonic way.

The Gardens on Spring Creek

After a long flight I was back on terra firma on the American side of the pond. I met Adrian and he showed me round Fort Collins: to his workshop where we would layout and cut the frame, Old Town Square in the historic centre of the city where we would do a promotional test raising and out to the Gardens on Spring Creek where the frame would be permanently erected as an educational venue where young children would be taught how to plant and nurture seeds to full growth, reap and prepare them for cooking, and eat them. The programme was run by Fort Collins City council to combat juvenile obesity and to give children nutritional knowledge and control over their lives. On the day Adrian and I visited there were around thirty children, all wearing miniature white chef's hats, cleaning and cutting vegetables for cooking. The project radiated an inspirational atmosphere and I felt honoured to be playing a small part in it. It was heart warming to witness a challenge to the marketing of junk food to the next generation and to recognise that, in sound minds and enlightened places, ethics and values were more important than making a fast buck selling junk food at someone else's expense.

Compass, straight edge and **Autocad**

Back in the workshop I was introduced to Glenn Dodge, the carpenter who would teach the scribe aspects of the project. Together, we investigated Adrian's workshop, my wall screen for projecting geometrical information and horizontal blackboard for large scale compass chalk drawings, and the equipment Glenn would use for converting timber and setting out the geometry on the shop floor. I had arrived with a drawing of the frame geometry and had a slight concern about its accuracy in relation to the specified 20 feet width of the frame. Though drawn to scale I felt that, if we stepped out the drawing to full scale on the floor, the full size geometry might be a quarter of an inch under or over the precise dimension due to the original compass line thickness being enlarged. Glenn suggested that we could use his laptop to redraw the geometry in Autocad and then tell Autocad that the building's width was 20 feet. If we did this then everything else would be in its correct proportional relationship. The only problems were that Glenn couldn't draw the geometry and I had never used Autocad. So we sat down together and I instructed Glenn from the centre line onwards until we had the geometry in Autocad. We were like co-pilots: I knew where we were heading for but didn't have a joystick, Glenn had a joystick but no idea where we were heading and, as in so many things in life, two heads proved better than one. This was an exciting moment for me because we had fuelled Autocad, which normally runs on a humdrum diet of dimensions, with a gourmet set of proportions and it followed, as it does with computers, that the quality of the output is in direct relation to the quality of the input. The moment was also exciting because, as a researcher of historic building design looking back through time into the proportional methodologies of the past, it was suddenly possible to bring them right up to the minute so that cutting edge 13th century aesthetic skills could be re-applied in a 21st century computer design context.

However, although the translation of a compass and Indian ink geometry into the + – electronic language of the computer enabled the geometrical proportions to be read as specific dimensions and translated into timber it also caused a problem as the project got underway. After the first timbers had been dimensioned and cut some of the participants expressed concern that the geometrical aspects of the project were being bypassed and this, after all, is what they had come for. Thankfully there was a simple answer to the problem: we could run Autocad and trammelled geometrical layouts side by side in Adrian's spacious workshop. So the two methods, manual and electronic, ran in harmony and, when we came to do the test assemblies, everything fitted perfectly. In retrospect, the two methods of layout validated each other and it was useful to be able to make comparisons between adjacent assemblies, checking the dimensional frame against the geometrical frame and vice versa. Once we had established this way of working the team built up steam, working steadily through the blazing heat of the Colorado days and, after a well earned break for our evening meal, on into the cool, dark evenings under the starry Fort Collins sky.

Master and Slave

Traditional English scribe carpentry follows a logical series of steps: a timber is first levelled and scribed with a level mark on the timber's upper face to indicate its original position when moved into different positions or configurations, the timber's length is marked and a two foot mark is scribed below its top end so that, if adjustments are made to the top joint (and the original top scribing lost), further measurements can be taken from the two foot line. Once the first timbers are levelled a second layer of timbers can be placed above them and their relationship defined using a plumb bob and dividers. In this layup system it is possible to scribe the uneven edge of one of the first timbers onto the precut surface of second layer timber so that, as an extreme example, a square section stud can be scribed to a cylindrical sill. Setting the layups in place was attained by the use of a range of timber wedges that held all the timbers level, parallel to the ground and to each other and small wedges were often cut specifically in mid layup to fit the carpenter's specific needs. The layups were either on blocks of wood placed on the ground or, with more sophistication, on trestles. It was a simple and time honoured system that had worked for centuries.

Enter 21st century scribe carpenter Glenn Dodge. Glenn had re-appraised the system of wedges and designed a 21st century alternative that he used extensively in his own work. The alternative was a small engineered framework incorporating threaded bolts that could be rotated backwards, forwards or side to side by cordless drills and, at the centre, a wooden block with a non-slip surface offering support for the timber placed upon it during the layup. The frameworks were in pairs, one for each end of each timber in the layup, the Master controlled by the cordless drill and the Slave which moved in response to the master, figure 29.

There were clearly some plus and minus factors to the Masters and Slaves. On the minus side there were the engineering costs, the need for a battery driven drill, storage and maintenance which, in total, was a significant inrease in cost over simple timber wedges. On the plus side there was the fact that neither Masters nor Slaves would slip and both brought precision control to the layup. Of course, the proof of the pudding is in the eating and Glenn's system gave a precision frame that was absolutely true to the geometry.

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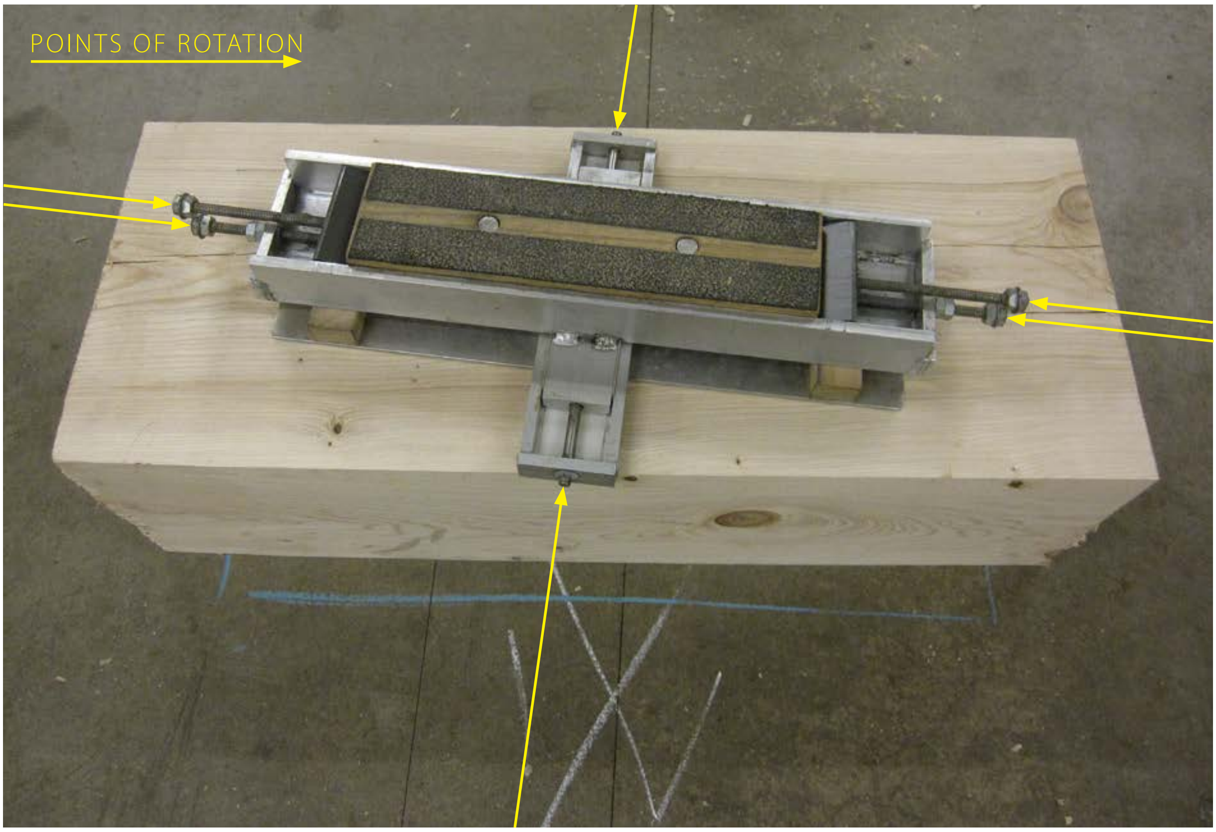

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Lodgepole Pine conversion

At the time the Open Air Class project was being planned, lodge pole pine within the environs of the city of Fort Collins and the landscape around it came under beetle attack. The city had a felling programme to halt the spread of the beetles by removing the food source of those that had already invaded trees. The trees were easy to identify because their leaves died and turned brown at a time when the woodlands along the foothills of the Rocky Mountains were normally in their prime. This was bad news for the lodgepole pines but good news for the Open Air Class as Adrian was offered a free supply of large timber for the project. Figures 30 and 31 show the soft, dove grey discolouration of the sap wood that is characteristic of lodgepole pine that has suffered beetle attack. I noted that, like wood-worm attack in English oak, which is confined to the sapwood, the American beetles were similarly unable to penetrate the heartwood of lodgepole pine. Inevitably, as the timber was converted and the full impact of the staining was revealed, there was some debate about the aesthetic impact of the sap wood stain but the more important fact was that the physical strength of the timber was unaffected and this meant that we had a sound supply of large timber for the project. Figure 32 shows one of the logs being converted from round to square on the TimberKing 1220, a fine piece of historic 13th century carpenter's kit still in use today!

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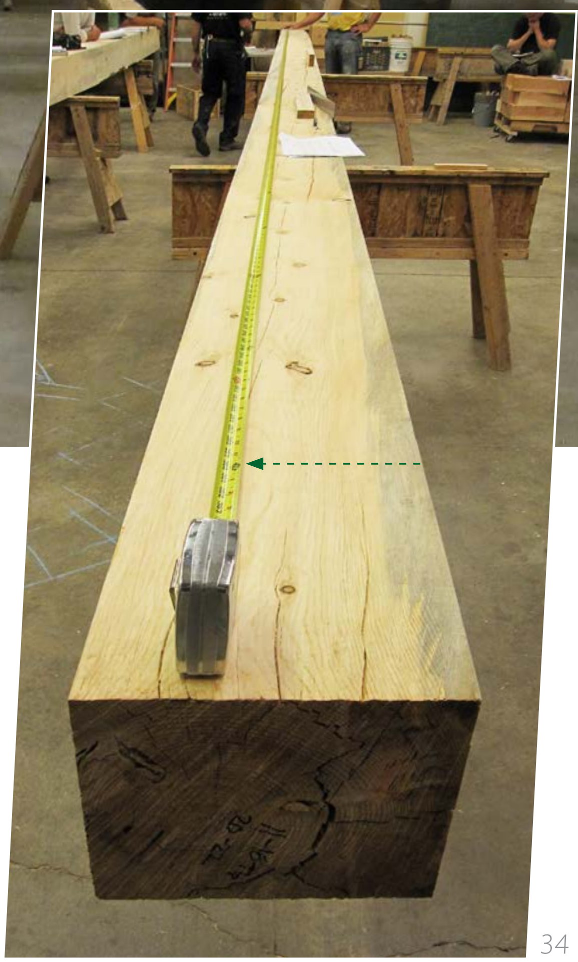
In *Frameworks Timber* workshop

After conversion the timbers were brought into Adrian Jones' spacious and well organised *Framework Timber* workshops. The size of the timbers allowed them to have geometrical proportions all round so that, for example, the jowl posts were defined between their conventional outer face geometries, which also defined the building's outer face, and inner face geometries, which meant that the section of the posts related harmonically with the overall proportions of the full building section. This resulted in larger than normal sections but we had the timber there to do it. The timber lengths were also in propoortion to the sections so that we had extremely long timbers for wall plates, purlins and ridge beam. In fact there were no scarf joints in any of the long timbers. The length and scale of the timbers can be appreciated in figure 33 where Glenn Dodge, in the pink baseball cap, introduces the team to the principles of scribe and in figure 34 where the arrow marks 30 feet on the tape.



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Levelling and scribing timbers using plumbobs, small trammel and dividers. In figure 35 visual judgements are made by observing squares or rules placed on the timber surface. The drawing shows how twists in the timber register as mis-alignments and how these can be adjusted to equalise the difference either side of the true level. Figure 36 shows the use of a trammel to transfer measurements between timbers along the plumb line. In figure 37 dividers are used to transfer measurements between timbers for marking joint locations.

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Two views of the gable layup. Figure 38 shows the tie beam and collar being scribed with Glenn's masters and slaves clearly visible beneath the tie beam, principal rafter and collar.

Figure 39 shows the principal rafters, collar, braces and tie beam assembled on blocks and winched together to test their fit. The jowl post and tie brace on the left are being inserted.

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Figure 40 shows the assembly of the principal rafter, tie beam and jowl post (with the English tying joint that Adrian had expressed a preference for), and jowl post to tie beam brace. The principal rafter, in addition to its mortice and tenon into the tie beam, is housed into the full width of the beam to resist any tendency towards outward spread. Many traditional English jowl posts rise to the tie beam through a curvature or zigzag that widens to allow for the wall plate joint. My choice was for a simpler form where the post widens gradually at a constant angle, from a lower level to its maximum width at the tie beam's lower face. I decided that the jowl post to tie beam brace would spring from the same level, a choice that results in a clearer aesthetic where the space between post, tie beam and brace is a pure triangle. Figure 41 shows the assembly of two natural curve braces connecting a jowl post to the wall plate. These timbers, of lodgepole pine, Russian olive, elm and maple were chosen by Adrian for the beauty of their curvatures and used in the frame's long walls in contrast to the straight bracing of the cross walls with posts of lodgepole pine, ash and spruce.

Figure 42 shows two of the natural curves being planed prior to scribing and cutting.

42

Invisible details

There are a number of aspects of the frame's construction that are invisible once the frame is assembled, staging posts en route to the finished frame. One of the most important of these is draw-boring, the technique of drilling peg holes on different alignments through mortice and tenon joints: to be precise, drilling a common hole through the two adjacent flanks of the mortice and a hole on a different alignment through the tenon. The hole through the tenon is drilled slightly closer to the tenon's shoulder so that when the mortice and tenon are finally pegged together during the frame's raising the tension in the peg draws the two elements of the joint tighter together. As the timbers shrink over time the peg will pull even tighter, ensuring there is no movement in the joint.

Draw-boring was once done by eye, drilling through the flanks of the mortice, then inserting the tenon and letting the drill kiss its surface, withdrawing the tenon and off-setting the drill slightly from the kiss mark, towards the tenon's shoulder, before drilling through. Figures 43 and 44 show the modern technique using drill, hammer and prick (the inevitable focus of workshop humour). The flanks of the mortice are drilled through, the tenon is inserted in the mortice, the prick is inserted in the drill hole and hit with the hammer so that it marks a ring and pinpoint on the tenon. The pinpoint marks the centre for drilling the tenon's different alignment. The prick has a mark on its outer surface so that it is inserted correctly for the pinpoint to be marked towards the tenon's shoulder. The pinpoint is indicated by a white arrow in the upper photograph and green arrows in the lower the photograph.

In figure 45 end grain is brushed with Land Ark oil to hinder moisture loss from the timber under the relentless heat of the Colorado sun.

Visible details

Figure 46 shows the logo for the frame's front gable tie beam being cut with the large daisy wheel design icon, the visual link to the frame's design, at the tie beam's centre. Figure 47 shows Framework Timber's logo, left, and figure 48 the logo for the Timber Framer's Guild, who organised the project, on the right.

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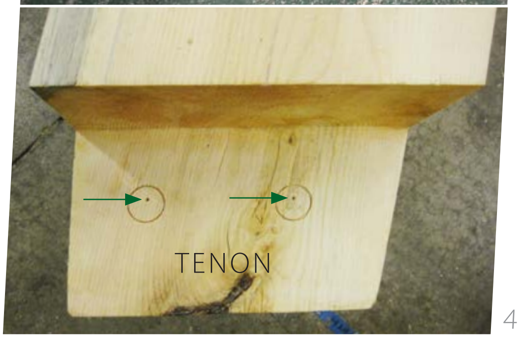

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The Test Assembly in Old Town Square

As the fabrication of the frame's components approached a conclusion, Adrian was arranging a test assembly in Old Town Square in the historic heart of the city of Fort Collins. The idea of raising the frame in such a public, pedestrianised area of the city centre was really positive publicity for the project, for Adrian's local Frameworks Timber business, for the TFG and, not least, for the Gardens on Spring Creek where the frame would be erected permanently. However, while the city authorities were supportive of the scheme, they were not able to give Adrian any parking priority when it came to delivering the timbers and equipment to site. So, on the day, everyone was out of bed extra early and we were first at the parking meters in Old Town Square!

The previous day, Adrian had asked me to help him check the specific site and site levels. In reality Adrian did it all (my role was simply holding a surveyor's pole upright while he took Transit theodolite readings). Then we chalk lined the site ready for the raising, at the end of the square in front of the elegant historic F. Miller Block, built in 1888. Then a quick tour around the city to several specialist hire companies where we hired extendable winches, like manual versions of the fork lift truck, for the raising the trusses and purlins.

Elements of the frame were assembled on the ground, ready for lifting into place. Figure 49 shows the principals, collar and braces of a roof truss pre-assembled, on the upper left of the photograph, and a jowl post and two natural curve timbers connected to a wall plate, on the lower right. Figure 50 shows the two long side walls assembled ready for raising with parallel wall plates and jowl posts and natural curve braces to their left and right.

Figure 51 shows three roof trusses assembled, the front gable tie beam embellished with the project's design icon daisy wheel and the year. The collar of this truss (not visible in this photograph) carries the remaining three logos for Frameworks Timber, the Timber Framers Guild and The Gardens on Spring Creek. The middle truss shows the precision equilateral triangulation of the collar and braces. The principals of the third truss can be seen in the background against the clear Colorado sky.

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Figure 52 shows the frame during assembly in Old Town Square in front of the 1888 F. Miller Block. Nailed laths shore the trusses temporarily while the purlins are unloaded from the truck and lifted into place. In figures 53 and 54 the ridge purlin is raised on winches and finally eased manually into place. The remaining purlins follow: upper purlins first and the lower purlins last to complete the frame. Figure 55 shows the cambered daisy wheel tie beam on wheels on its way to the frame for assembly.

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Job done

On the morning of the test assembly I was up at 5am for a lift into central Fort Collins and an early breakfast in the Silver Grill, eggs and bacon on toast, just like home. Adrian's truck and trailer had already arrived at Old Town Square and was being unloaded and Glenn was specifying where timbers should be placed ready for assembly. The work began and by mid-day the pegs were knocked into place, the whole raising having run like clockwork. We broke for some food and then spent a relaxing afternoon in the sunshine, hanging around by the frame talking among ourselves and responding to members of the public who were interested in the building, its design, method of construction and, eventually, its purpose at The Gardens on Spring Creek. The public reaction to the frame was considerable with a constant flow of people making their way towards the new tempoaray focal point in Old Town Square and quite a few commented that they would like the frame to become a permanent fixture. We now had a small crowd and, as with all crowds, they magnetise even more inquisitive people, eager to know what's going on. One joung man, who gave his name as Scott, said that he lived five blocks down and was planning to rebuild his property in the near future. He was so impressed by the frame that he wanted to meet Adrian and discuss the possibility of a similar building!

Michelle Provasnick, manager of the Gardens on Spring Creek project, was there for the raising and was amazed by the scale of the frame. Thinking back to the tiny structures that Adrian and I had seen when we visited there before work began on the frame her reaction came as no surprise. It was heartwarming to know thta we had a satisfied client and that some wonderful courses would be run wihtin this frame, teaching young children how to plant vegetable and other edible plant seeds, water and nurture them, harvest them when ready, prepare them for cooking, cook them and eat them, and in the process learning about nutrition and the body's requirements for healthy eating and a healthy life.

At the end of the afternoon as the Fort Collins pubs beckoned we embarked on a tour of local breweries. There had been some talk of touring the alcohol venues on bikes but in the event we were on foot and, after the first batch of samples, this seemed the safest and wisest option. After some rigorous liquid trials and a lot of lively conversation we finally settled down to the consumption of food, the whole team cramming into a great city centre pub with an equally great menu. It was a perfect finale to the project and yet we couldn't drag ourselves away from the frame. We made our way slowly back along the city's tree lined streets, figure 56, to Old Town Square for another look and there was the frame, lit up against the night sky, figure 57. Figure 58 shows a few of the team, from left to right, Glenn Dodge (lead scribe tutor), Laurie Smith (geometrical design), Adrian Jones (owner Frameworks Timber, Fort Collins) and Chris Kates (scribe tutor from Frameworks Timber).

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At the Gardens on Spring Creek

On the morning after the test assembly the team began to say it's goodbyes, split up and go it's various ways. Higgs Murphy stayed on for a further week to help Adrian and his Frameworks Timber team dismantle the frame and transport it for re-erection on it's dedicated site at The Gardens on Spring Creek. I was heading back to Denver on the Shuttle bus to start my flight back to the UK. On the flight home I had plenty of time to think back over what had been an inspirational project in every way and feel glad to have been part of it. Most of all I visualised the frame in it's final resting place among the giant watering cans, figure 59, and the meandering water courses, figure 60, that were filled from them when children operated a big, old fashioned well pump. I could picture the little allotments, guarded by a fence of gardening tools, figure 61, the scarecrows with flower pot heads, figure 62, and all the children watering their own plants, weeding around them and growing in confidence as their gardening knowledge and skill grew in tune with their produce. And then the excitement of harvesting their very own vegetables and fruits and preparing and cooking their very own food. Looking back to my own childhood I wished that I had been lucky enough to attend such an enlightened, public spirited, nurturing and literally productive place. Amazing!

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Enter *Harper Point*

Although it was my task to take photographs during the project I had none of the completed frame in it's place at The Gardens on Spring Creek. I emailed Adrian to see if he had some images and he replied that professional photographers ***Harper Point*** of Fort Collins and Denver were recording the building. This and the next few pages are devoted to their stunning images of the completed Open Air Class.

Figure 63 shows the building in the wider

context of the gardens. The flat roofed structure on the left was the original teaching area where Adrian and I had seen a group of children in miniature chef's hats preparing vegetables for cooking. Some of the children's allotments are on the right with their fruit bushes guarded by a group of scarecrows. The siting of the frame as a focal point in the surrounding landscaping, the sinuous path on the left and flights of steps rising to the floor level are all visually delightful. The low sunlight, dark cloudscape and foreground add dramatic effect.

64

Head On

The gables of the frame are identical but the facade shown in figure 64 is embellished with the project logos on the collar and tie beam. On the left of the collar is Adrian's Frameworks Timber company logo, at the centre and right, the Gardens on Spring Creek and the Timber Framers Guild logos. The project daisy wheel design icon and logo is at the centre of the tie beam with the build year 2010. The tables and chairs await the next class of children.

65

Figure 65 shows the opposite gable of the frame standing high above a flight of rising steps with the low, flat roof of the original teaching facility straight ahead through the building. The intended final environment of the frame is clear: once the planting has reached maturity the world of nature will come to the very edge of the children's new learning area. Could there be any better way to learn about the natural world and its nutritional pleasures than to do so in an open air class surrounded by plants growing in your own allotment?

66

A roof over your head

After the test assembly in Old Town Square we could look up through the purlins and see the sun burning in an azure sky or, after dark, the pale light of distant stars. Now the frame was erected and the roof was complete, with sarking boards spanning the purlins, the building was serving its intended purpose: protecting the children from the sun's dangerous rays as they were taught about plants and nutrition. The truth is that they were sheltered in their

outdoor classroom mainly by another, larger plant, Colorado's beetle killed lodgepole pine.

Figure 66 shows the interior of the roof and close inspection of the gable framing to the left and right of the photograph reveals that the collars and braces are slightly narrower than the principal rafters and are scribed to each gable's outer face. The central bent, invisible above the tie beam at the centre of the photograph, is scribed to a centre-line so that it is visually identical from either side. The solar overhangs are visible through the end gables.

67

Frame details

Figure 67 gives a close up of the solar over-hang at the entrance gable and the roof trian-gulation from the tie beam to the ridge. The post to tie braces are just visible in the lower corners of the photograph which also shows clearly the precision of Glenn's scribe method-ology following the geometrical design. Once the timbers were scribed and cut but prior to the test assembly it became apparent that the purlins ended in uncompromisingly flat sur-

faces that were visually heavier than necessary. My solution was to chamfer the purlin ends but only on the three sides that could be seen clearly by viewers from ground level. The edges supporting the roof edge rafters were left plain and flush with the rafter edges for maximum support. The ridge purlin, which is parallelogrammic to follow the angle of the pitch, has the same treatment, in this case chamfered on its two visible sides. These small details reward the eye of the spectator who makes the visual effort to analyse the building's structure.

68

For the record

Very little is achieved without co-operation and this project was no exception. There were many organisations and individuals who played a part in keeping the project on the rails and guiding it to fruition. I have listed as many as my memory allows below and figure 68 records the year. I have added Adrian's timber list and the local press release for interest and information.

Adrian's Team at Frameworks Timber
Dave Kaplan
Ethan Smith
Chris Kates
Steve Meyer
Chad Lanker

Timber Framers Guild
Joel McCarty

Photographers
Harper Point

Scribe Tutors
Glenn Dodge
Chris Kates

Workshop Nutrition
Jeannie's Snacks

Geometrical Design
Laurie Smith

The Carpenters Team
Todd Bellio
Dave de Leeuw
Matt Doner
Jackson DuBois
Erin Evans
Ellen Gibson
Jim Holzknecht
Paul Jensen
Isaac McCoy-Sulentic
Andrew McFadden
Ryan Misiolek
Higgs Murphy
Mark Olson
David Schanzenbaker
L. Don Seela
Lon Tyler
Trey Warren
Adam Zgola

Fort Collins Partners
The Timber Framers Guild
Frameworks Timber

Fort Collins Donors
Barton Supply
CTL Thompson
Friends of the Gardens on Spring Creek
GRK Fasteners
Hilti NA
Lafarge Concrete
Land Ark Northwest
Odell Brewing Company
Partners Roofing
Quality Traffic Control
Rotary Clubs of Fort Collins & Windsor
Timberlinx
Vogel Concrete

The Gardens on Spring Creek
Michelle Provasnick

TIMBER LIST	COUNT	WIDTH	DEPTH	LENGTH	GRACE
Bent Principal posts	6	9	17	12	beetle kill
Plates	2	12	8	32	beetle kill
Plates (Alternate)	2	10	9	32	beetle kill
Plates (Alternate)	2	9.5	9.5	32	beetle kill
Ties	3	9	17	22	beetle kill
Principal Rafters	6	9	14	16	beetle kill
Collars	3	8	8	8	mixed hardwoods
Struts	6	8	8	8	mixed hardwoods
Purlins	4	8	9	32	beetle kill
Ridge	1	9	9	32	beetle kill
Bent Braces	6	4	6	6	mixed hardwoods
Wall Braces	12	4	6	6	mixed hardwoods
Common Rafters	20	6	5	20	beetle kill
TIMBER TOTALS	73				

Press Releases

Timber Frame Building to be donated to the Gardens on Spring Creek
Released on Monday, October 11th, 2010
Contact Information The Gardens on Spring Creek 970-416-2486
Timber Framers Guild to construct a Timber Frame Building in Old Town Square.
The building will be donated and relocated to the Gardens on Spring Creek.

The Timber Framers Guild, a national non-profit organization, is holding a training workshop in Fort Collins for professional timber framers from across the country. As part of the workshop, participants will complete a 20' x 23' timber frame building, made of beetle-killed pine, that will be donated to the Gardens on Spring Creek to be an Outdoor Classroom.

The public is invited to view this one-of-a-kind building as it is assembled in Old Town Square on October 16th and 17th. Frameworks Timber, a Fort Collins company, will install the building at the Gardens on Spring Creek on October 18th.

The Gardens on Spring Creek is grateful to those who have donated to this project ~ Frameworks Timber, Partners Roofing, CTL Thompson, Vogel Concrete, Lafarge Concrete, Fort Collins and Windsor Rotary Clubs, Odell Brewing Company, and the Friends of the Gardens on Spring Creek.

Workshop participants will learn about math-free design and fabrication from Welsh artist and historian, Laurie Smith, who will discuss medieval geometric design principles. Master scriber Glenn Dodge of New Hampshire will teach scribing techniques.

The Gardens on Spring Creek is located at 2145 Centre Avenue, Fort Collins.

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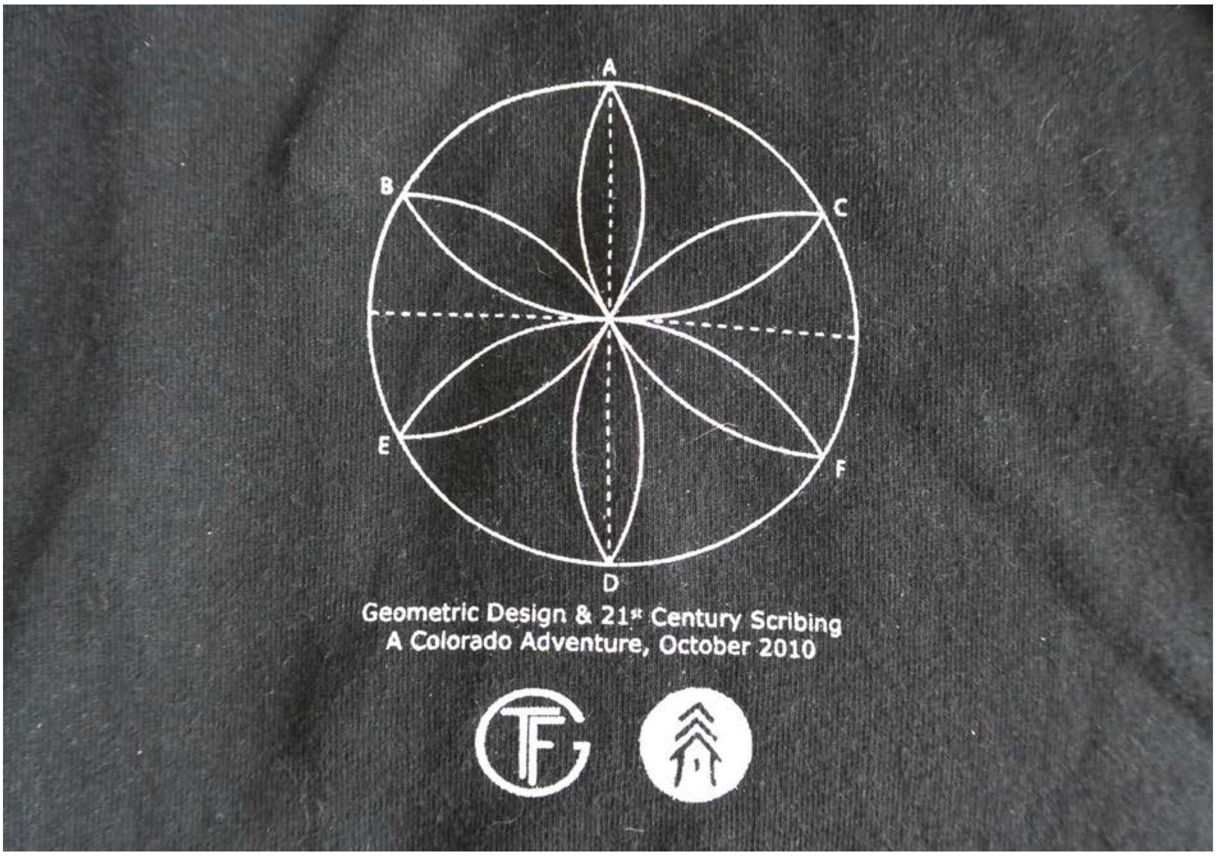

Got the T shirt

The TFG printed the project T shirts, figure 69, with the almost obligatory daisy wheel drawn from the intersection of two 90° perpendiculars: the basic compass geometry from which the frame's design was developed. The geometry is an eternal and international language that is constant wherever you are geographically and at any scale from micro to macroscopic. Conversely, the American and English languages have drifted slightly apart on the shirt, the American *Geometric* Design would have been *Geometrical* Design in England. But there is no dispute about the fact that it really was a Colorado Adventure in October 2010.

Thanks

I have a lot of people to thank for a variety of kindnesses while I was in Fort Collins. I was scheduled to give two geometrical introductions to the project, first a one and a half day workshop for the carpentry team who would work on the Open Air Class and, a few days later, to a group who aimed to attend a single day geometrical design workshop. The second event was cancelled at short notice when I completely lost my voice. Joel McCarty gave me a bottle of monastic honey liqueur to ease my throat and drove me to a pharmacy to find homeopathic remedies. Dave Kaplan's girlfriend bought me some Chinese medicine, slightly hairy nuts that I had to infuse in boiling water which I then had to sip slowly. It turned out the lady on hotel reception was a voice therapist and she advised me not to speak until my voice returned naturally so I did silent written question and drawn answer geometry on the 8 x 4 feet greenboard. This worked really well for a few days and slowly but surely the voice returned. My gratitude to Jim Holzknecht and Lon Tyler who were my breakfast companions every day and to Jim additionally for being my chauffeur absolutely everywhere. Ellen Gibson and Erin Evans are due some thanks for cutting the frame logos. The angel of Old Town Square was Ethan Smith's mother who took batteries from her own camera to go in mine. On my last day in Colorado, Higgs Murphy drove me out into the Cache la Poudre valley to witness the wonderful landscapes there. Finally my thanks to Adrian for his welcome and great hospitality during my time in Fort Collins.

BACK COVER PHOTOGRAPH
The Open Air Class at the Gardens on Spring Creek

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