Elements Available in PSSFSS

This Jupyter notebook illustrates the styles of Frequency Selective Surface (FSS) and Polarization Selective Surface (PSS) elements that are available in the `PSSFSS` package. Because the package includes a `Plots` recipe, the `Plots.plot` function automatically knows how to plot a variable of type `RWGSheet` that is returned by any of the constructor functions illustrated beow. As shown below, additional keywords are supported by the `plot` function that allow control of edge and/or face colors, inclusion of the unit cell boundary in the plot, and repetition of the unit cell to visualize the element in its arrayed environment.

In [1]:

```
using PSSFSS
using Plots
default(framestyle=:box)
```

```
┌ Info: Precompiling PSSFSS [6b20a5d4-3c6c-44cd-883b-1480592d72be]
└ @ Base loading.jl:1260
```

Help is available for any of the element types shown below, by typing, e.g.

```
?rectstrip
```

at the Julia prompt.

RECTSTRIP: Rectangular Strip

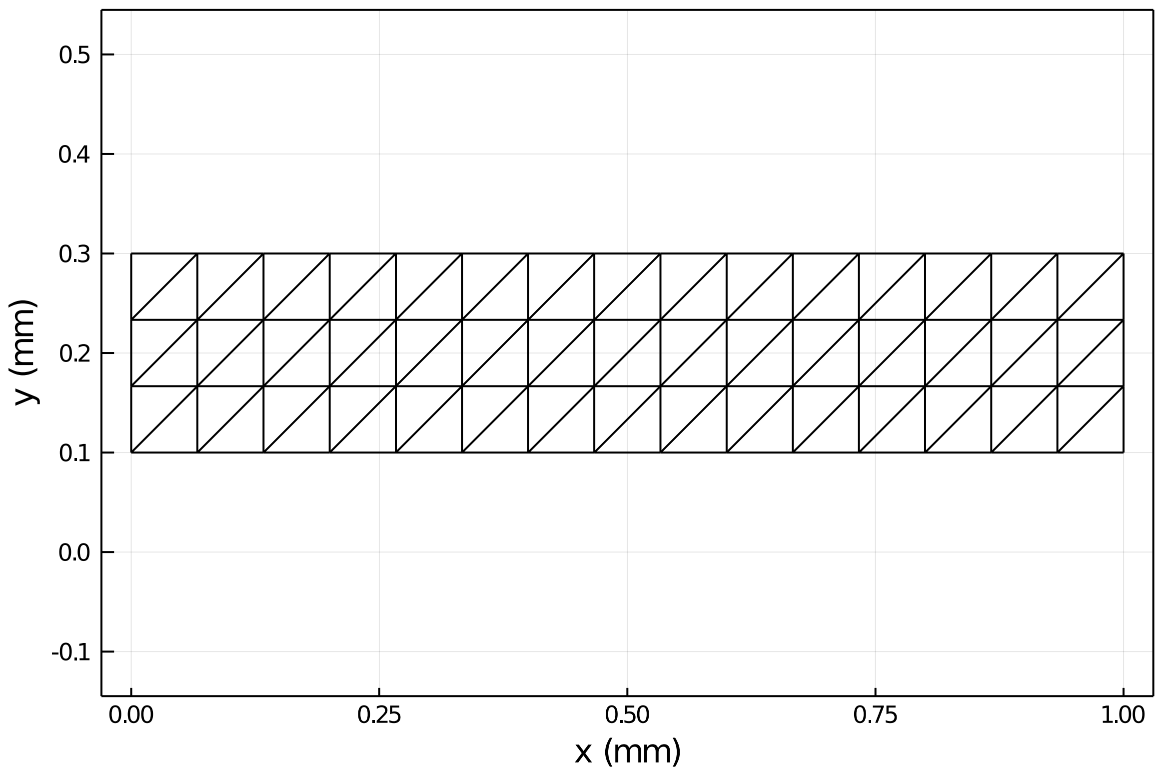
This element is typically used to model polarization grids, but it can also be used for rectangular or square FSS elements. It uses a structured mesh so `fufp` defaults to `true`.

In [2]:

```
sheet = rectstrip(Lx=1, Ly=0.2, Px=1, Py=0.4, Nx=15, Ny=3, units=mm)
println("$(size(sheet.fv,2)) triangles")
plot(sheet)
```

```
90 triangles
```

Out[2]:

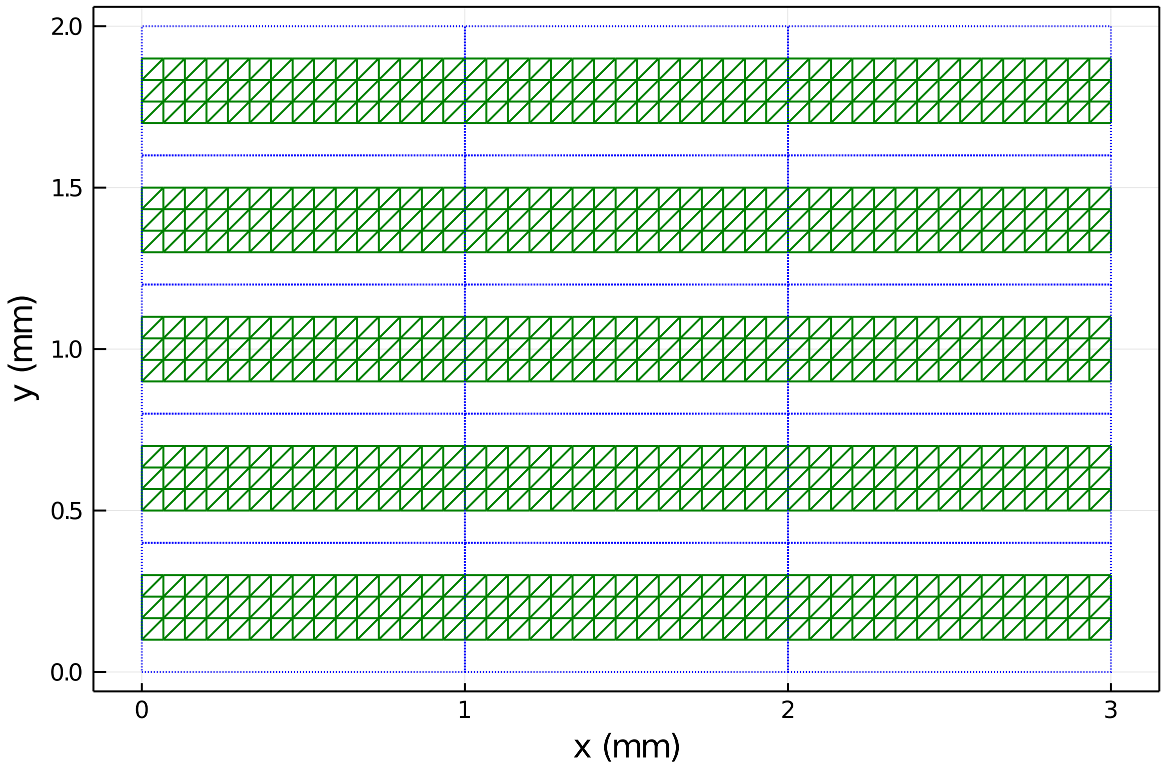


The above plot of the triangulation edges is useful, but a better visualation includes the unit cell boundary, adds color to the edges, and displays multiple adjacent unit cells:

In [3]:

```
plot(sheet, linecolor=:green, unitcell=true, rep=(3,5))
```

Out[3]:



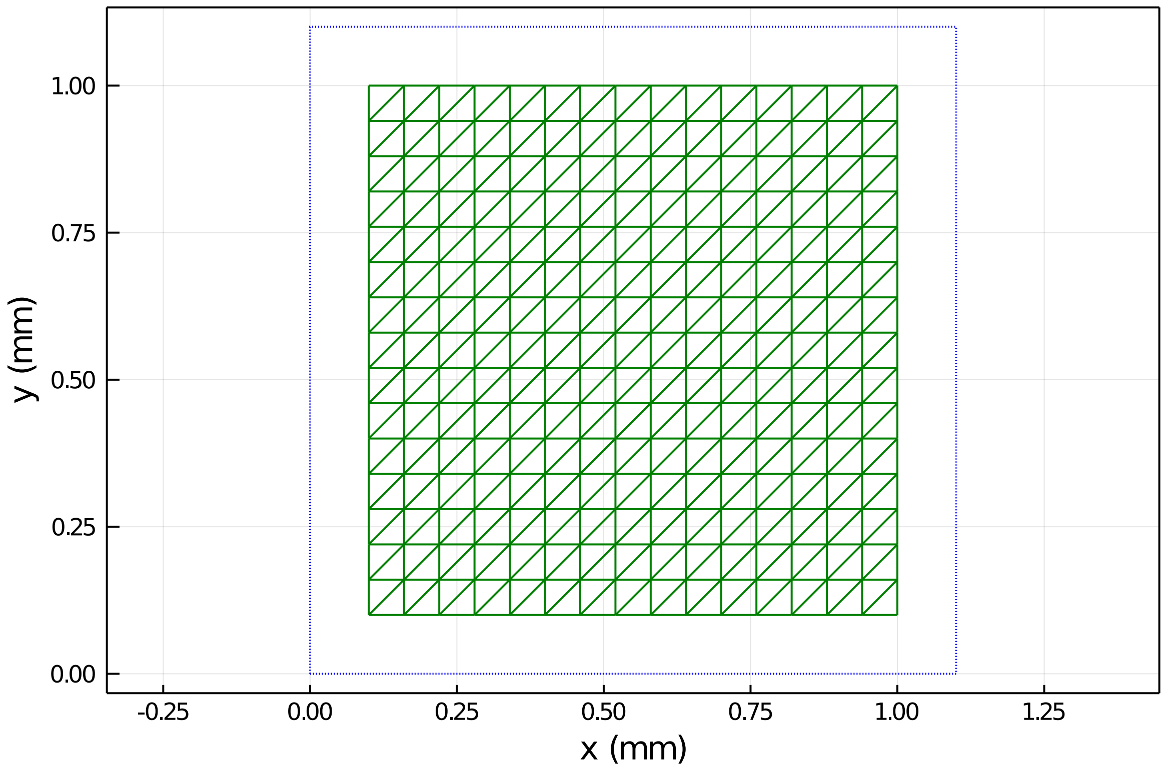
Below, we show how a `rectstrip` can be used to model a square FSS element:

In [4]:

```
sheet = rectstrip(Lx=0.9, Ly=0.9, Px=1.1, Py=1.1, Nx=15, Ny=15, units=mm)
println("$(size(sheet.fv,2)) triangles")
plot(sheet, linecolor=:green, unitcell=true)
```

```
450 triangles
```

Out[4]:



POLYRING: A Very Versatile Element

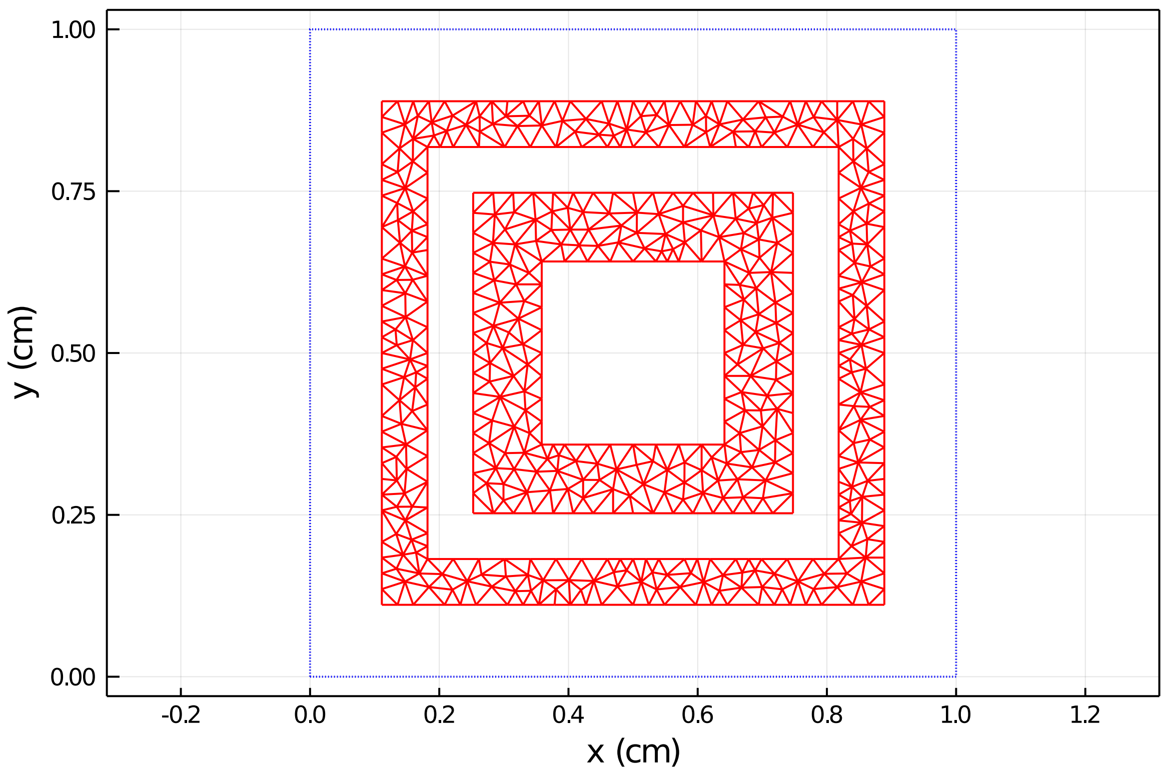
The first example shows how to model concentric square loops.

In [5]:

```
ntri=800
sheet = polyring(s1=[1,0], s2=[0,1], a=[0.2, 0.45], b=[0.35, 0.55], sides=4, orien
t=45,
                 units=cm, ntri=ntri)
println("$(size(sheet.fv,2)) triangles")
plot(sheet, linecolor=:red, unitcell=true)
```

```
876 triangles
```

Out[5]:



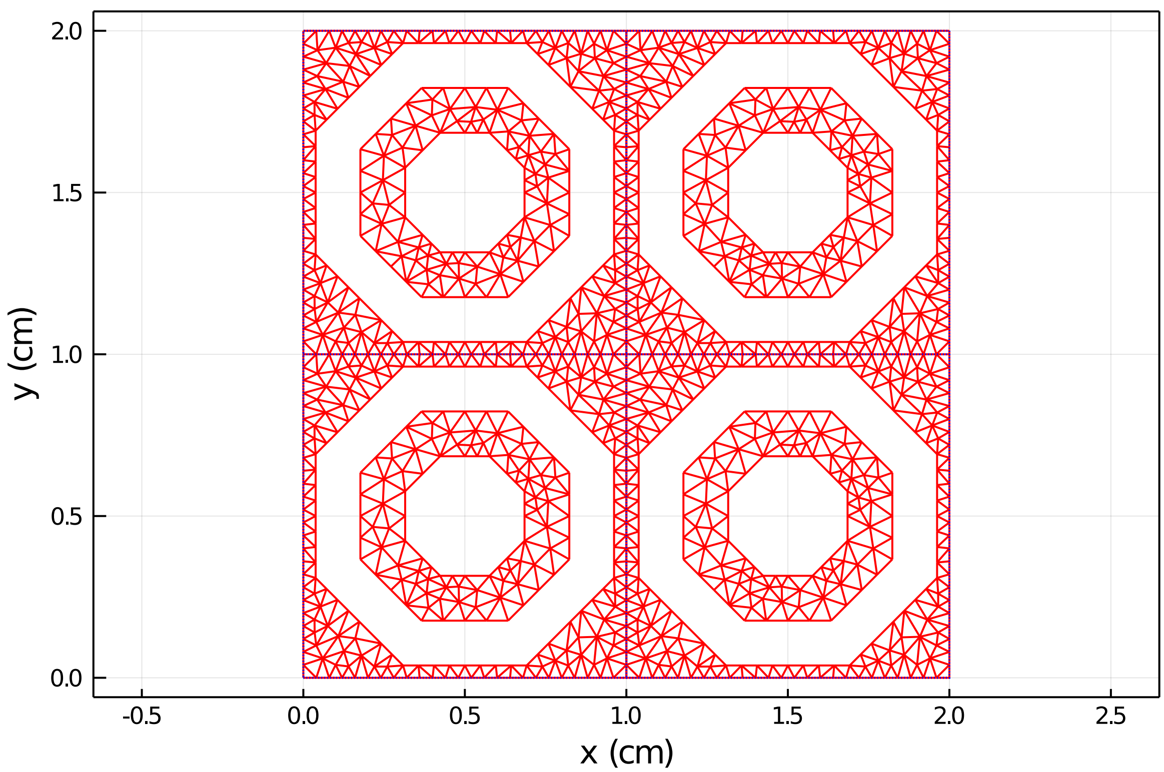
Next, we have an octagonal hole, and an octagonal, annular slot. Such a geometry could be more efficiently modeled by making use of a sheet of class `M`, and triangulating the complementary (smaller in area) region to that shown below. However, if one needs to model this type of inductive element while including the surface resistance of the sheet, this can only be done using a sheet of class `J` (the default)

In [6]:

```
ntri=400
sheet = polyring(s1=[1,0], s2=[0,1], a=[0.2, 0.5], b=[0.35, -25], sides=8, orient=
22.5,
                 units=cm, ntri=ntri)
println("$(size(sheet.fv,2)) triangles")
plot(sheet, linecolor=:red, rep=(2,2), unitcell=true)
```

```
426 triangles
```

Out[6]:



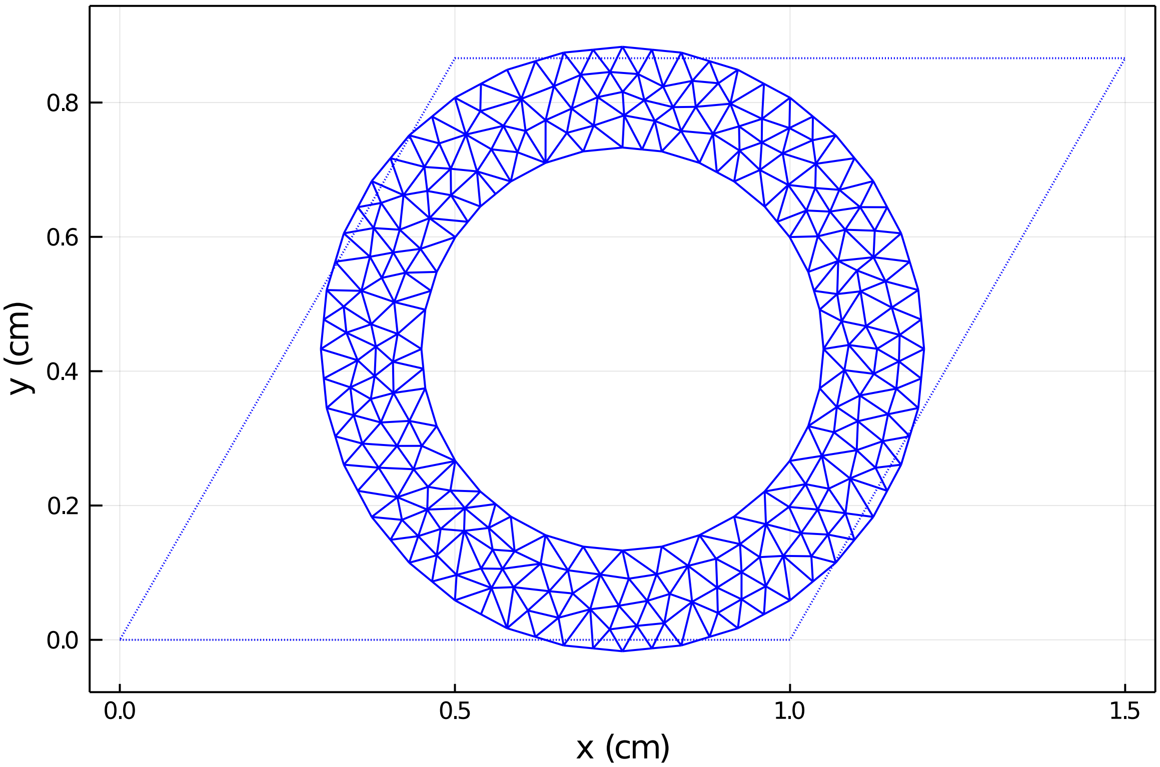
Below we approximate a circular loop using a 32-sided polygonal annulus. The lattice vectors are chosen to represent a close-packed (hexagonal) arrangement.

In [7]:

```
sheet = polyring(s1=[1, 0], s2=[0.5, √3/2], a=[0.3], b=[0.45], sides=32,
                 units=cm, ntri=400)
println("$(size(sheet.fv,2)) triangles")
plot(sheet, unitcell=true, linecolor=:blue)
```

431 triangles

Out[7]:

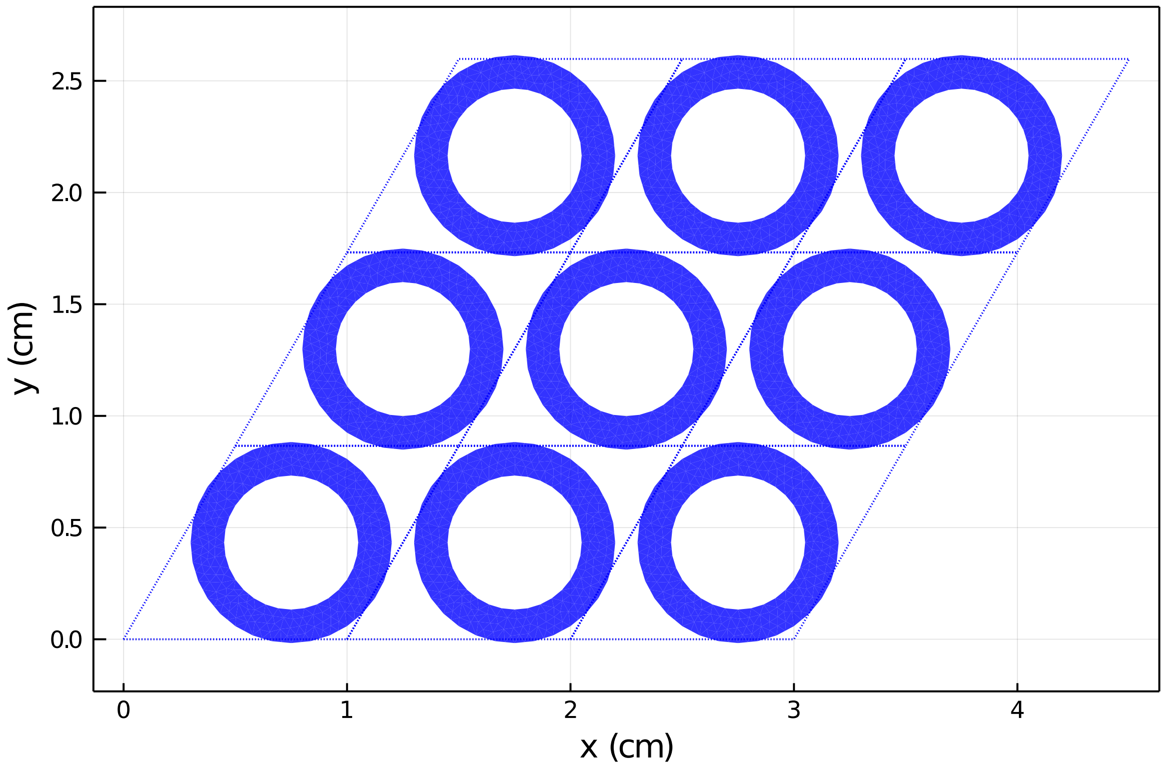


We illustrate the hexagonal arrangement by replicating 3 unit cells in each principal direction.

In [8]:

```
plot(sheet, edges=false, faces=true, rep=(3,3), unitcell=true)
```

Out[8]:



MEANDER: Used to model meanderline polarizers.

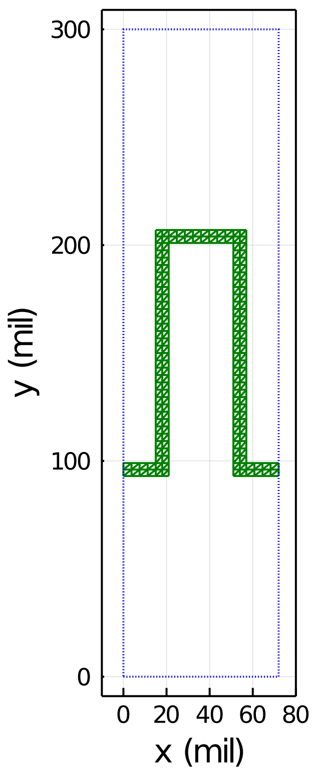
This is another element that employs a structured mesh, so that `fufp` defaults to `true` for this element style.

In [9]:

```
sheet = meander(a=72, b=300, h=114, w1=6, w2=6, units=mil, ntri=300)
println("$(size(sheet.fv,2)) triangles")
plot(sheet, linecolor=:green, unitcell=true, xlim=(-10,80))
```

```
336 triangles
```

Out[9]:



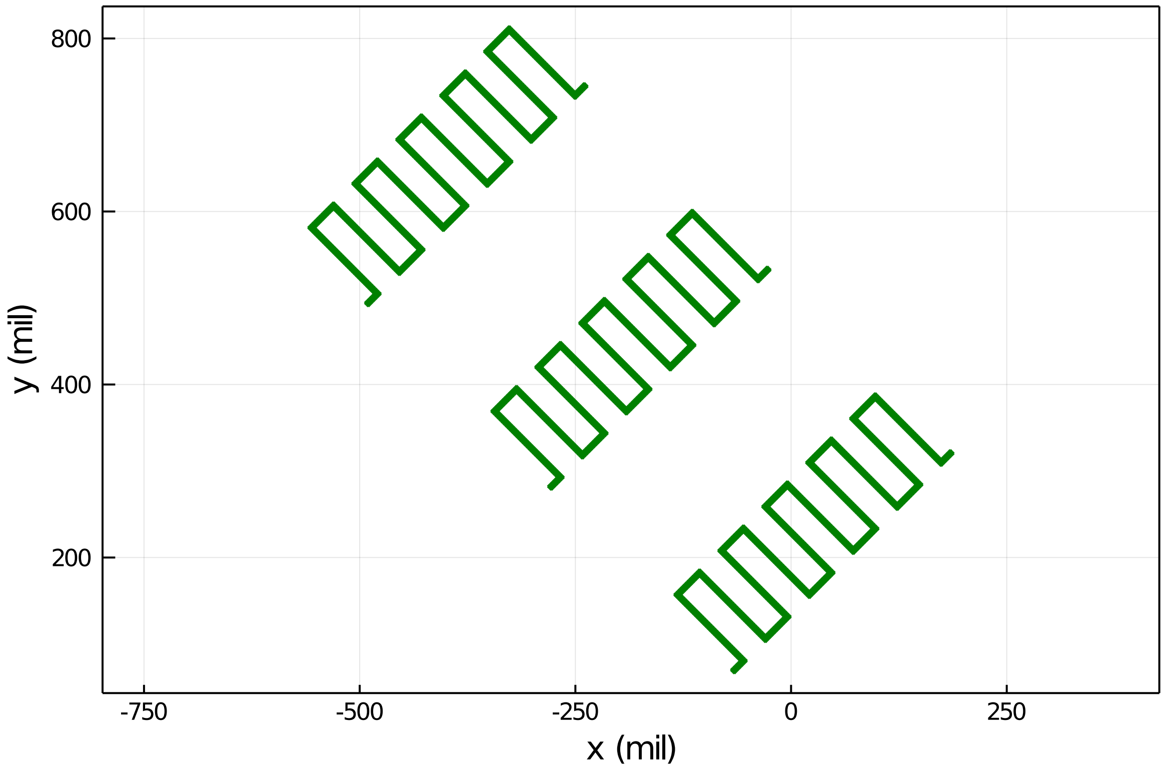
The meanderline is typically rotated 45° as shown below.

In [10]:

```
sheet = meander(a=72, b=300, h=114, w1=6, w2=6, units=mil, ntri=300, rot=45)
println("$(size(sheet.fv,2)) triangles")
p=plot(sheet, linecolor=:green, rep=(5,3))
savefig("meanderlines.png")
p
```

```
336 triangles
```

Out[10]:



Another useful element, shown in the next few figures, is the `loadedcross` , which as you can see in the first figure, does not actually have to be loaded.

LOADEDCROSS

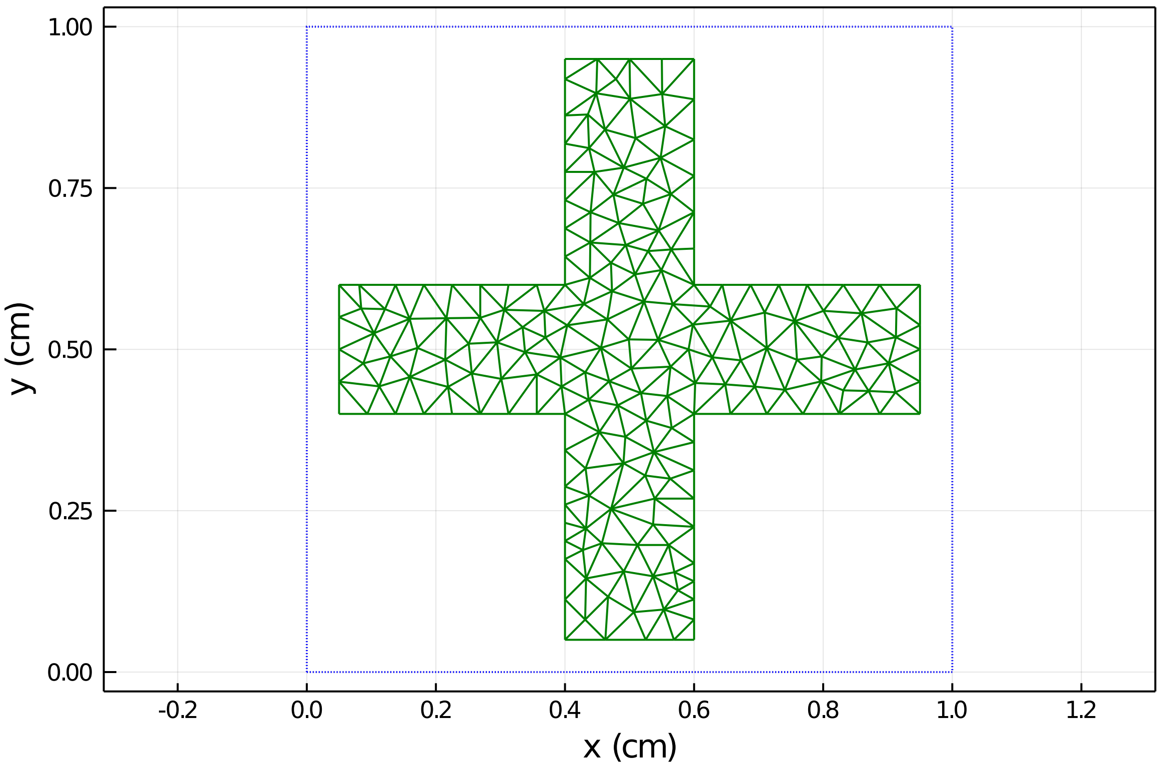
First, we shown an "unloaded" cross.

In [11]:

```
sheet = loadedcross(s1=[1,0], s2=[0,1], L1=0.9, L2=0.2, w=0.35, units=cm, ntri=300
)
println("$(size(sheet.fv,2)) triangles")
plot(sheet, linecolor=:green, unitcell=true)
```

```
320 triangles
```

Out[11]:



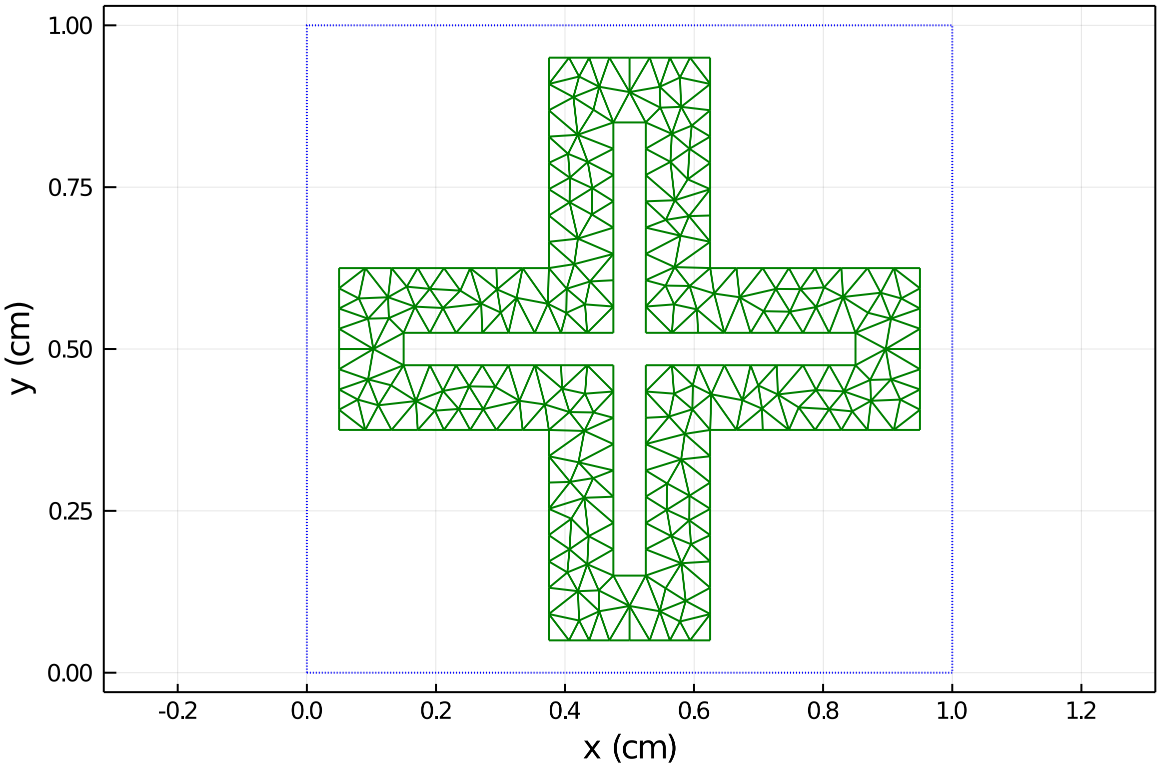
Proper choice of the geometrical parameters `w` and `L2` exposes the "loaded" area.

In [12]:

```
sheet = loadedcross(s1=[1,0], s2=[0,1], L1=0.9, L2=0.25, w=0.1, units=cm, ntri=400
)
println("$(size(sheet.fv,2)) triangles")
plot(sheet, linecolor=:green, unitcell=true)
```

```
420 triangles
```

Out[12]:



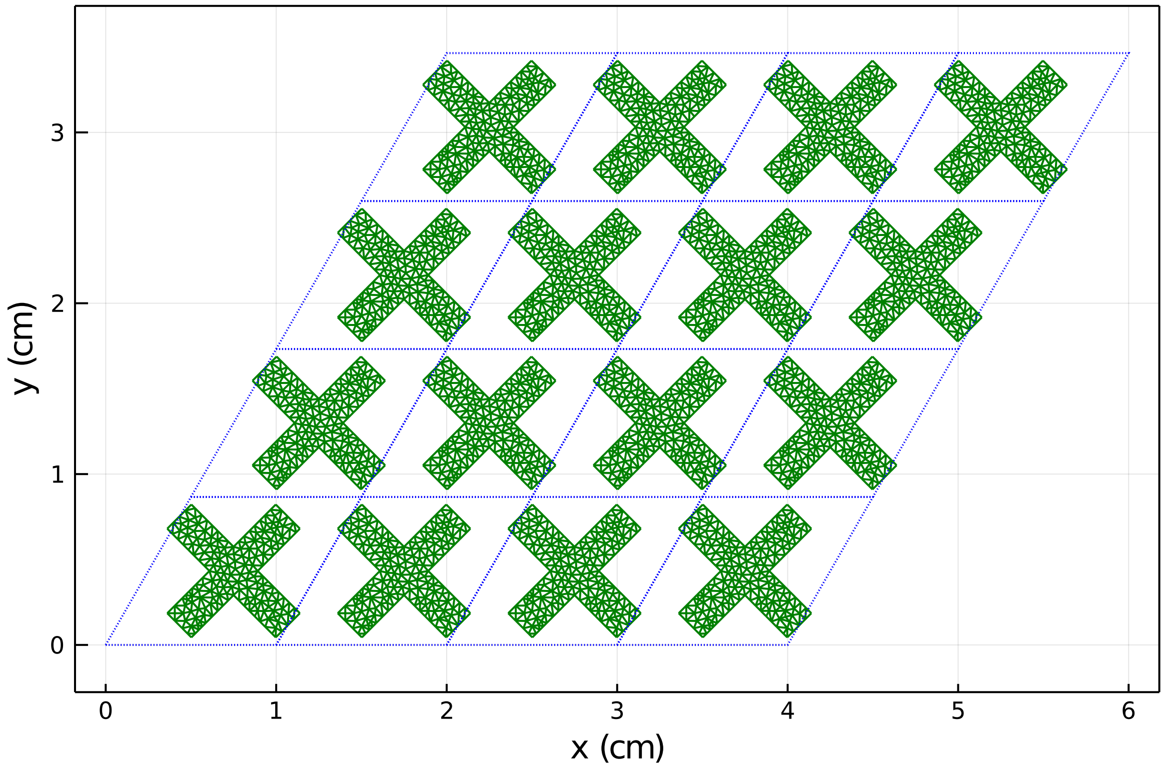
The plot below shows how this element can be used to model crosses in a hexagonal arrangement.

In [13]:

```
sheet = loadedcross(s1=[1,0], s2=[0.5,sqrt(3)/2], L1=0.9, L2=0.2, w=0.35, units=cm
, ntri=300, orient=45)
println("$(size(sheet.fv,2)) triangles")
plot(sheet, linecolor=:green, unitcell=true, rep=(4,4))
```

```
321 triangles
```

Out[13]:



JERUSALEMCROSS

The final element type is `jerusalemcross` , the Jerusalem cross. It can also be "loaded" or "unloaded" as shown in the next few plots.

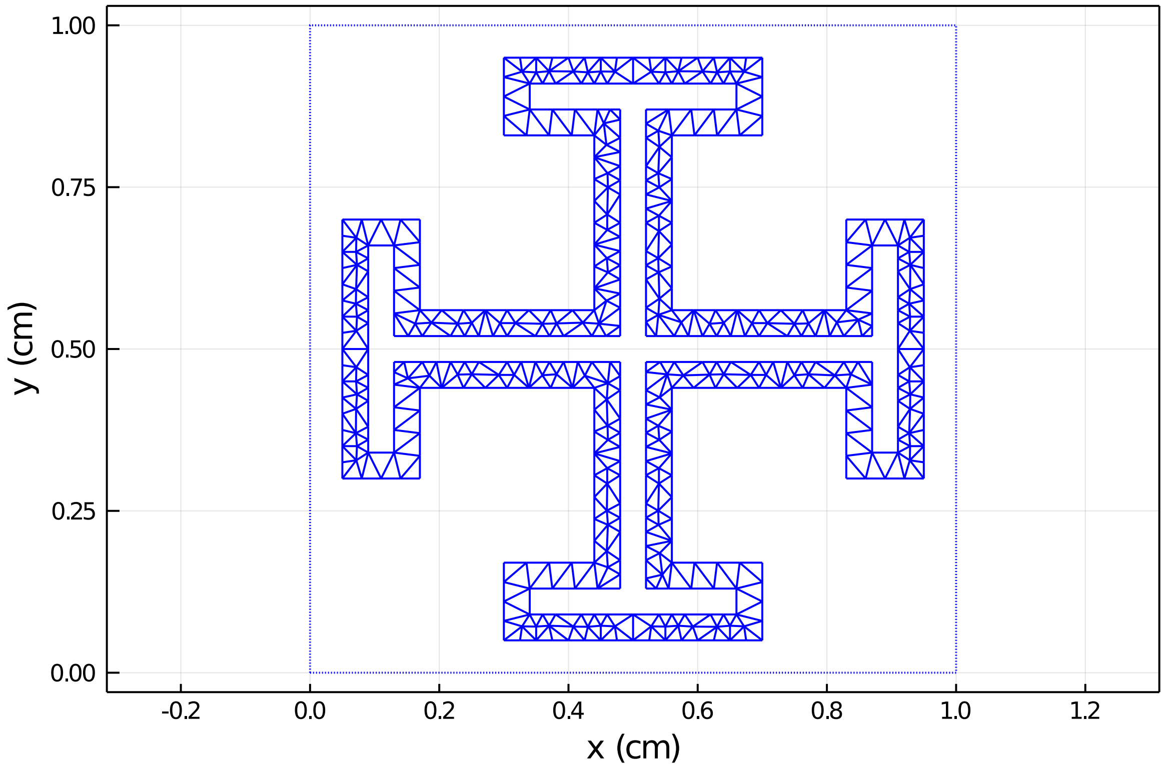
First, fully loaded:

In [14]:

```
sheet = jerusalemcross(P=1, L1=0.9, L2=0.12, w=0.04, A = 0.4, B = 0.12, units=cm,
ntri=600)
println("$(size(sheet.fv,2)) triangles")
plot(sheet, linecolor=:blue, unitcell=true)
```

```
660 triangles
```

Out[14]:



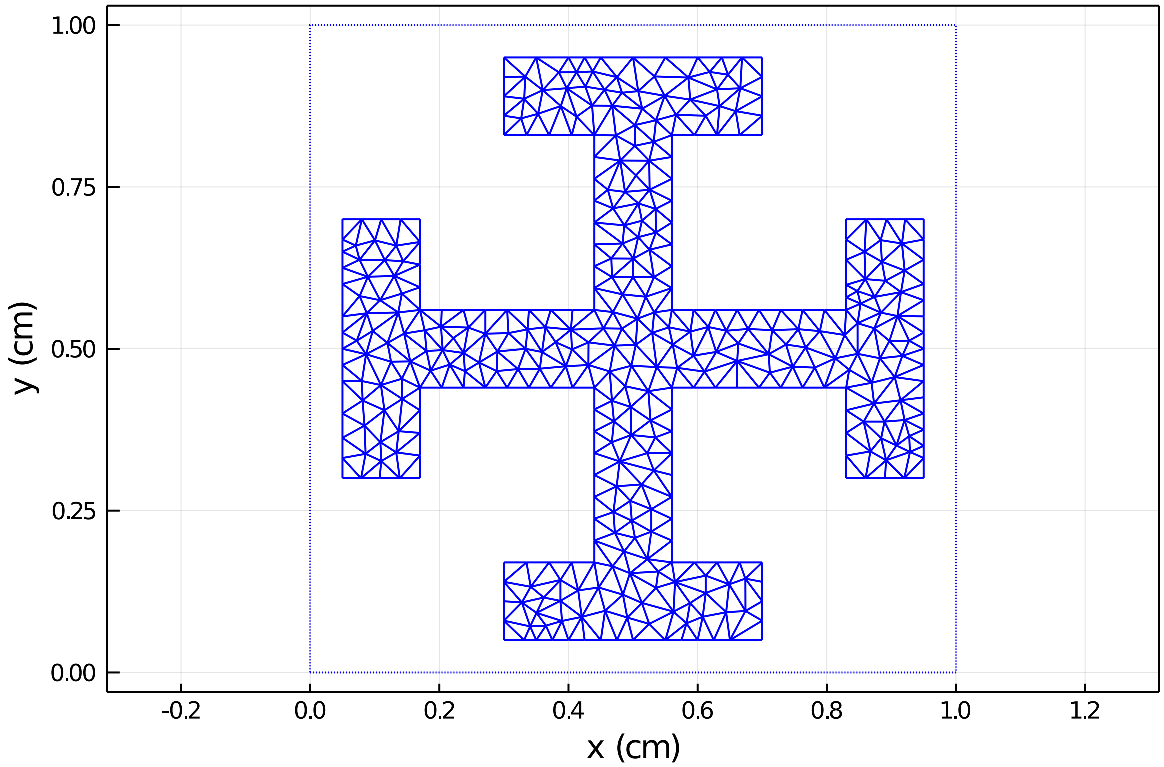
Next, unloaded (i.e., solid).

In [15]:

```
sheet = jerusalemcross(P=1, L1=0.9, L2=0.12, w=0.5, A = 0.4, B = 0.12, units=cm, n
tri=600)
println("$(size(sheet.fv,2)) triangles")
plot(sheet, linecolor=:blue, unitcell=true)
```

```
659 triangles
```

Out[15]:



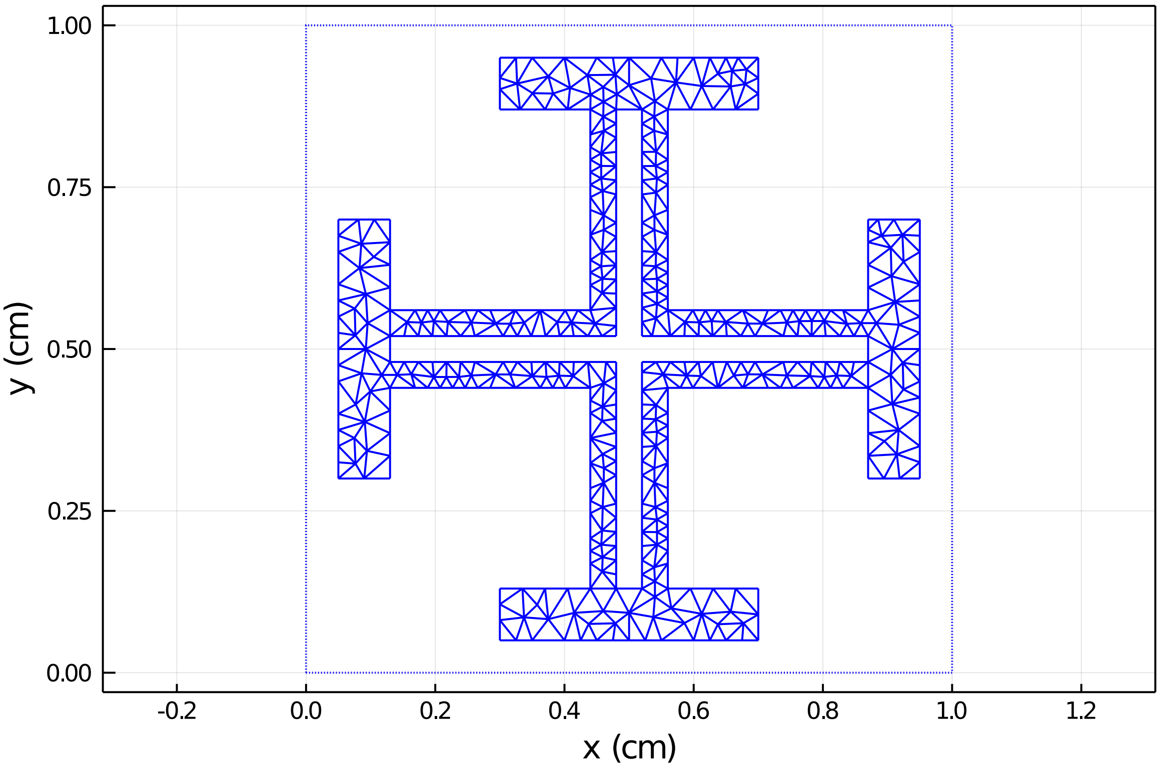
The next two plots show how the element may be partially loaded, on only its arms, or on the capacitive endcaps.

In [16]:

```
sheet = jerusalemcross(P=1, L1=0.9, L2=0.12, w=0.04, A = 0.4, B = 0.08, units=cm,
ntri=600)
println("$(size(sheet.fv,2)) triangles")
plot(sheet, linecolor=:blue, unitcell=true)
```

```
654 triangles
```

Out[16]:

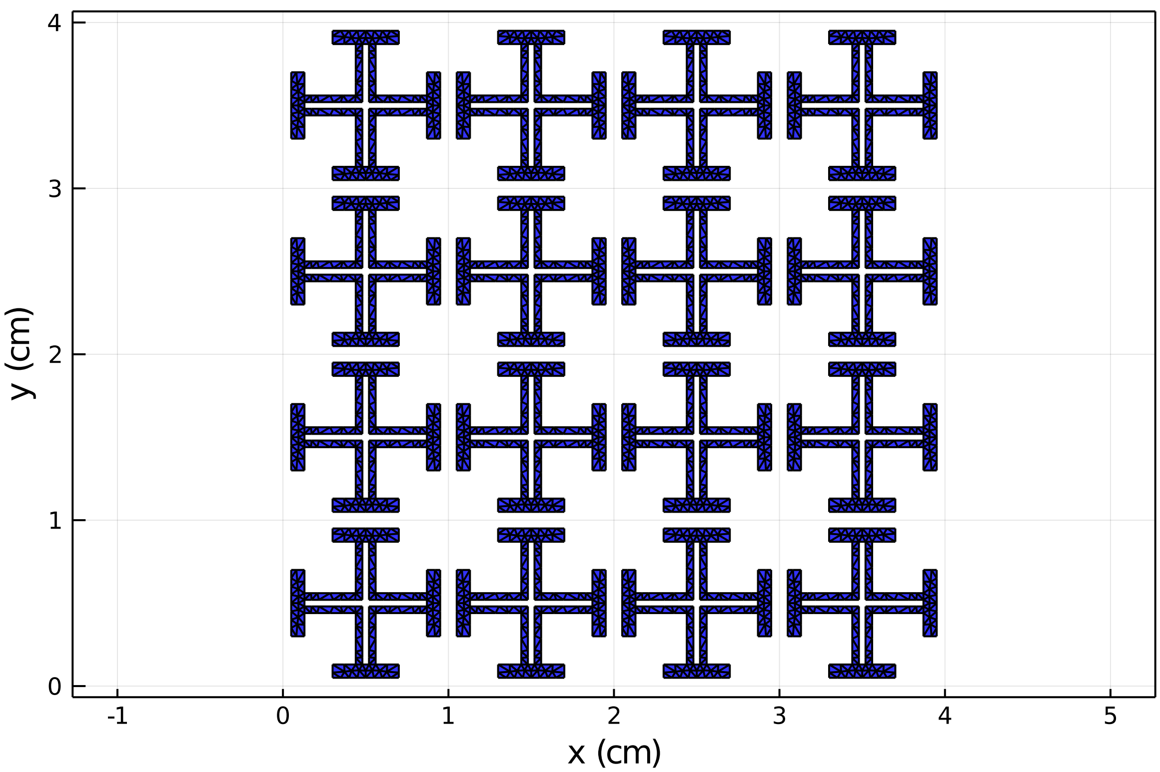


In [17]:

```
sheet = jerusalemcross(P=1, L1=0.9, L2=0.12, w=0.04, A = 0.4, B = 0.08, units=cm,
ntri=200)
println("$(size(sheet.fv,2)) triangles")
p=plot(sheet, edgecolor=:blue, faces=true, facecolor=:blue, rep=(4,4))
savefig("jcrossarray.png")
p
```

```
220 triangles
```

Out[17]:

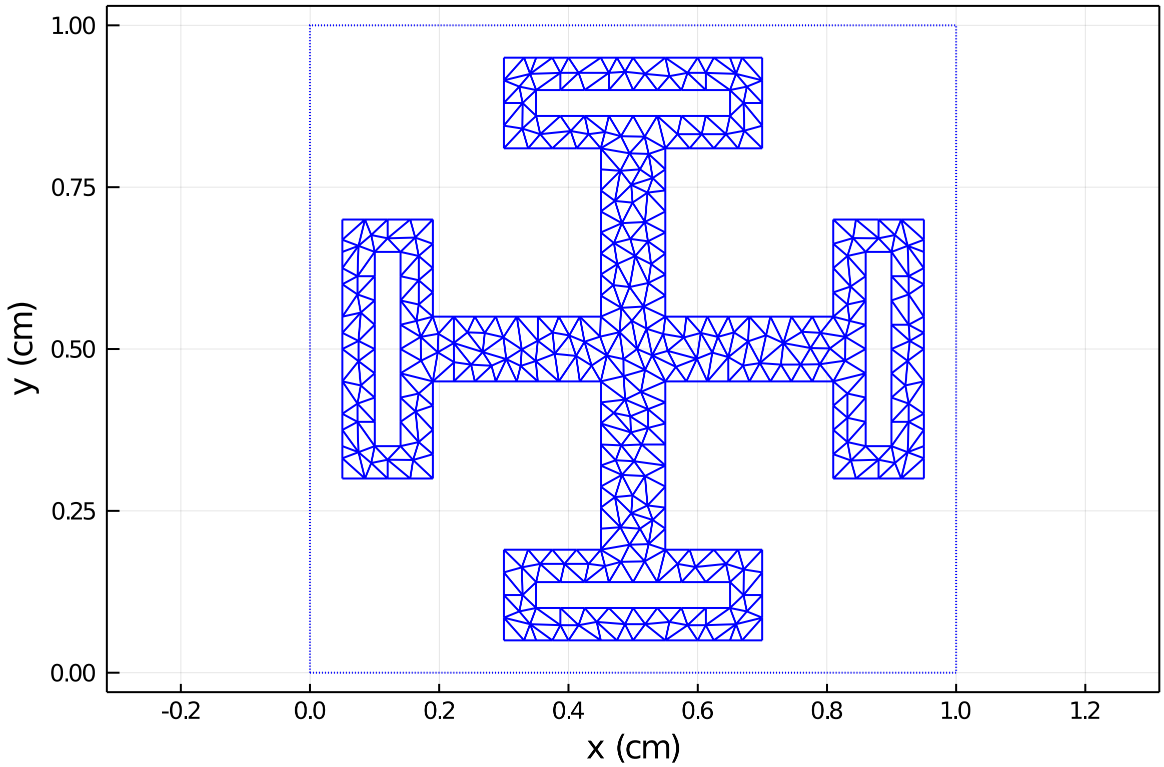


In [18]:

```
sheet = jerusalemcross(P=1, L1=0.9, L2=0.1, w=0.05, A = 0.4, B = 0.14, units=cm, n
tri=600)
println("$(size(sheet.fv,2)) triangles")
plot(sheet, linecolor=:blue, unitcell=true)
```

```
652 triangles
```

Out[18]:



Below, we show the help information provided for the `jerusalemcross`. Analogous information is available for the other element styles.

In [19]:

```
?jerusalemcross
```

search: **jerusalemcross**

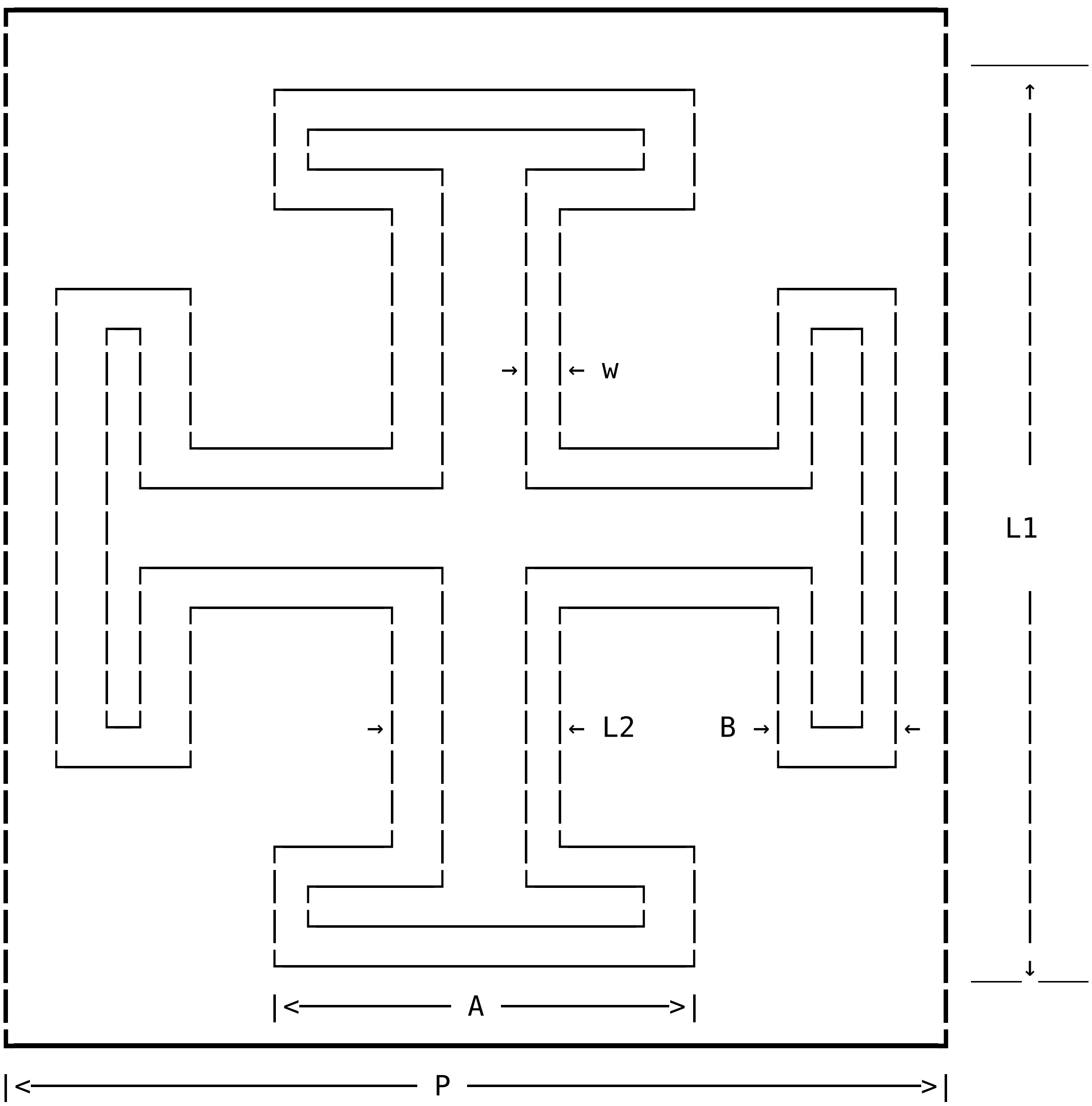
Out[19]:

```
jerusalemcross(;P::Real, L1::Real, L2::Real, A::Real, B::Real, w::Rea
l,
              ntri::Int, units::PSSFSSLength, kwargs...)
```

Description:

Create a variable of type `RWGSheet` that contains the triangulation for a "loaded cross" type of geometry. The returned value has fields `s₁`, `s₂`, `β₁`, `β₂`, `ρ`, `e1`, `e2`, `fv`, `fe`, and `fr` properly initialized.

The following "ascii art" attempts to show the definitions of the geometrical parameters `P`, `L1`, `L2`, `A`, `B`, and `w`. Note that the structure is supposed to be symmetrical wrt reflections about its horizontal and vertical centerlines, and wrt reflections through a line oriented at a 45 degree angle wrt the x-axis.



Arguments:

All arguments are keyword arguments which can be entered in any order.

Required arguments:

- `P` : The period, i.e. the side length of the square unit cell.
- `L1` , `L2` , `A` , `B` , `w` : Geometrical parameters as defined above. Note that it is permissible to specify `w ≥ L2/2` and/or `w ≥ B/2` in which case the respective region will be filled in solidly with triangles. If both conditions hold, then the entire structure will be filled in (i.e., singly-connected). In that case the `L2` and `B` dimensions will be used for the respective widths of the arms, and `w` will not be used.
- `units` : Length units (`mm` , `cm` , `inch` , or `mil`)
- `ntri` : The desired total number of triangles. This is a guide/request, the actual number will likely be different.

Optional arguments:

- `class::String='J'` Specify the class, either `'J'` or `'M'` .. If `'J'` , the unknowns are electric surface currents, as used to model a wire or metallic patch-type FSS. If `'M'` , the unknowns are magnetic surface currents, as used to model a slot or aperture in a perfectly conducting plane.
- `dx::Real=0.0` , `dy::Real=0.0` : These specify the offsets in the x and y directions applied to the entire unit cell and its contents. Length units are as specified in the `units` keyword.
- `rot::Real=0.0` : Counterclockwise rotation angle in degrees applied to the entire unit cell and its contents. This rotation is applied prior to any offsets specified in `dx` and `dy` .
- `Rsheet::Real=0.0` : The surface resistance of the FSS conductor in units of Ohm per square. This is only meaningful for a sheet of class `"J"` .
- `fufp::Bool` : This keyword is not usually required. `fufp` is mnemonic for "Find Unique Face Pairs". If true, the code will search the triangulation for classes of triangle pairs that are the equivalent in the toeplitz sense. I.e., if triangle pairs (A,B) and (C,D) belong to the same equivalence class, the six vertices in the pair (A,B) can be made to coincide with those of pair (C,D) by a simple translation. If there are many such equivalent pairs, a significant decrease in matrix fill time ensues by exploiting the equivalence. The tradeoff is the time needed to identify them. The default value is `true` for the `strip` and `meander` styles (those employing structured meshes) and `false` for the remaining styles (those employing unstructured meshes).
- `save::String=""` Specifies a file name to which the sheet triangulation and unit cell data is to be written, typically to be plotted later.