Finite Elemente für Plattentragwerke

Anna Paganetty

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1 Näherungslösungen mit Finiten Elementen

1.1 Implementierung des nichtkonformen Ansatzes bei JULIA

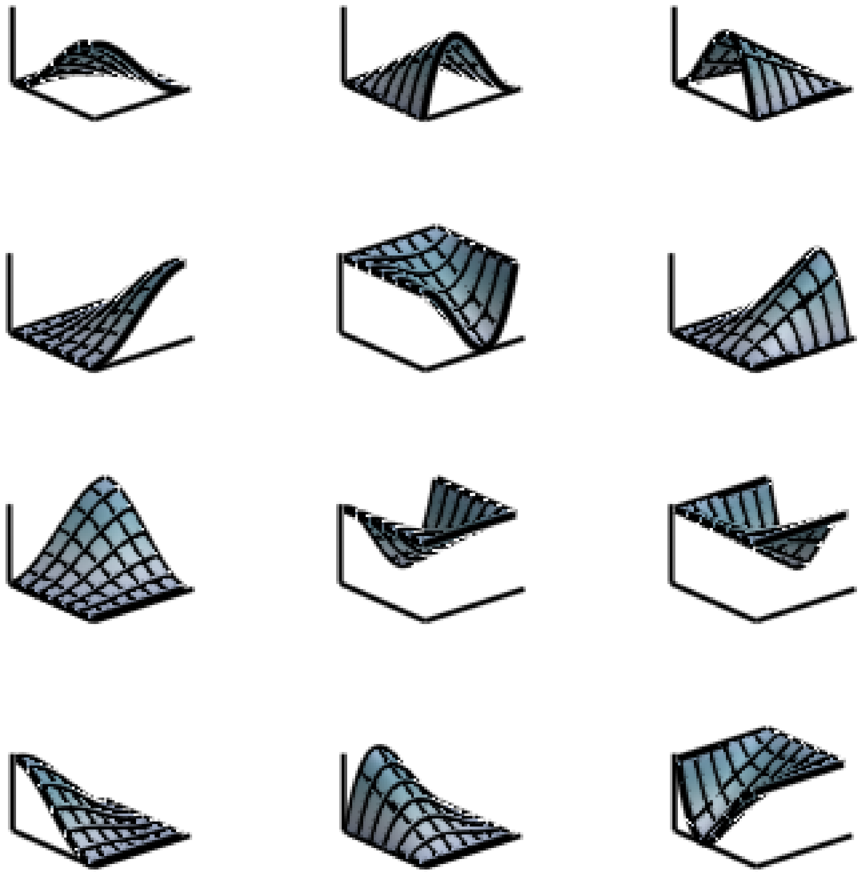
Wiederholung: *nichtkonformer Ansatz*

1.2 Shape functions der unkonformen Lösung

```julia
include("setup.jl")
GLMakie.activate!()
f1 =Figure(size=(200, 200))
display(H4)
fplot3d(H4, fig=f1)
```

```
WARNING: using Plots.Plots in module Main conflicts with an existing identifier.
WARNING: using Topologies.entities in module Main conflicts with an existing identifier.
```

```
12-element Vector{AbstractMapping{StaticArraysCore.SVector{2, <:Real}, Real}}:
 -0.125x₁³x₂-0.125x₁x₂³+0.125x₁³+-0.0x₁x₂²+0.125x₂³+0.5x₁x₂+-0.0x₂²-0.375x₁-0.375x₂+0.25
 -0.125x₁³x₂+0.125x₁³+0.125x₁²x₂-0.125x₁²+0.125x₁x₂-0.125x₁-0.125x₂+0.125
 -0.0x₁³x₂-0.125x₁x₂³+-0.0x₁³+0.125x₁x₂²+0.125x₂³+0.125x₁x₂-0.125x₂²-0.125x₁-0.125x₂+0.125
 0.125x₁³x₂+0.125x₁x₂³-0.125x₁³+0.125x₂³-0.5x₁x₂+0.375x₁-0.375x₂+0.25
 -0.125x₁³x₂+-0.0x₁x₂³+0.125x₁³-0.125x₁²x₂+-0.0x₁x₂²+-0.0x₂³+0.125x₁²+0.125x₁x₂+-0.0x₂²-0.125x₁+0.125
 -0.0x₁³x₂+0.125x₁x₂³+-0.0x₁³+-0.0x₁²x₂-0.125x₁x₂²+0.125x₂³-0.125x₁x₂-0.125x₂²+0.125x₁-0.125x₂+0.125
 -0.125x₁³x₂-0.125x₁x₂³-0.125x₁³+-0.0x₁x₂²-0.125x₂³+0.5x₁x₂+-0.0x₂²+0.375x₁+0.375x₂+0.25
 0.125x₁³x₂+-0.0x₁x₂³+0.125x₁³+0.125x₁²x₂+0.125x₁²-0.125x₁x₂-0.125x₁-0.125x₂-0.125
 -0.0x₁³x₂+0.125x₁x₂³+-0.0x₁³+0.125x₁x₂²+0.125x₂³-0.125x₁x₂+0.125x₂²-0.125x₁-0.125x₂-0.125
 0.125x₁³x₂+0.125x₁x₂³+0.125x₁³-0.125x₂³-0.5x₁x₂-0.375x₁+0.375x₂+0.25
 0.125x₁³x₂+-0.0x₁x₂³+0.125x₁³-0.125x₁²x₂+-0.0x₁x₂²+-0.0x₂³-0.125x₁²-0.125x₁x₂+-0.0x₂²-0.125x₁+0.125x
 -0.0x₁³x₂-0.125x₁x₂³+-0.0x₁³+-0.0x₁²x₂-0.125x₁x₂²+0.125x₂³+-0.0x₁²+0.125x₁x₂+0.125x₂²+0.125x₁-0.125x
```



```
m, w = plate(p, 3);
NN = 4 * nnodes(m)
nb = collect(m.groups[:boundarynodes])
ni = [i for i in 1:nnodes(m) if i ∉ nb]
adofs = idxDOFs(ni, 4)
NNa = length(adofs);

idxDOFs(nodeindices(face(m,1)),3)
```

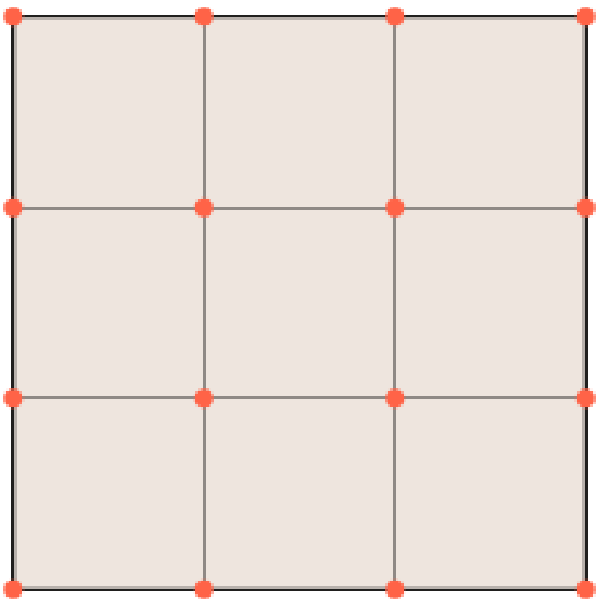
```
12-element Vector{Int64}:
  1
  2
  3
  4
  5
  6
 16
 17
 18
 13
 14
 15
```

1.3 Anwendungsbeispiel

- Deckenplatte 8m $\times$ 8m
- Allseitig eingespannt gelagert
- $E = 31000 \frac{\mathrm{N}}{\mathrm{mm}^2}$ und $\nu = 0$
- Dicke $d = 20\mathrm{cm}$,
- Belastung $q = 5 \frac{\mathrm{kN}}{\mathrm{m}^2}$
- Kirchhoff-Plattentheorie

$\nu = 0$ für Vergleich mit Czerny-Tafeln

```
f2 = mkfig(a3d=false, w=150, h=150)
mplot!(m, edgesvisible=true, nodesvisible=true,edgelinewidth =
0.2,featureedgelinewidth=0.5, nodesize=5)
f2
```



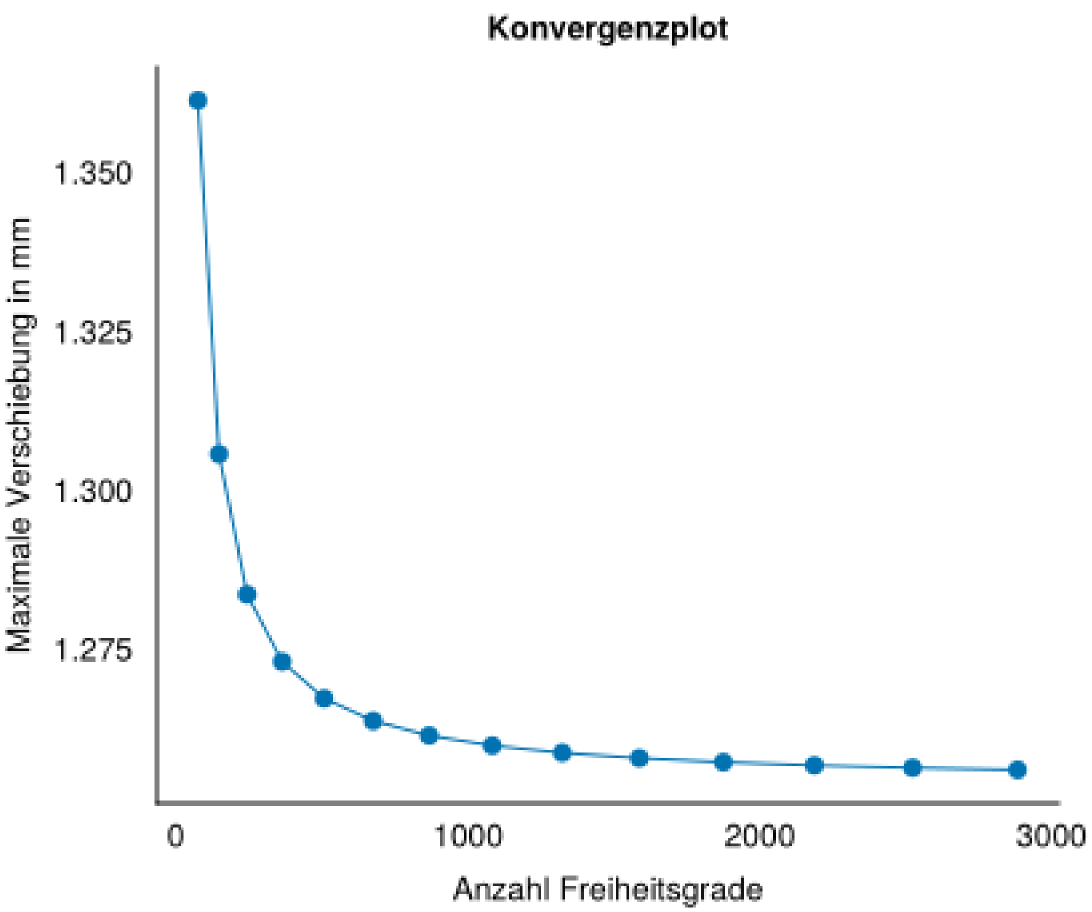
1.4 Konvergenzplot

Zusammenhang zwischen der Anzahl an Freiheitsgraden und der maximalen Verschiebung. Es ist erkennbar, dass mit steigender Anzahl an Freiheitsgraden, also einem feineren Netz, die maximale Verschiebung immer weiter angenähert wird.

```
CairoMakie.activate!()
l = 8
nn = zeros(0);
ww = zeros(0);
for n = 4:2:30
    mn, wn = plate(p, n)
    push!(nn, 3 * nnodes(mn))
    push!(ww, maximum(abs.(wn[1:3:end])))
```

```
end
w_fe = ww[end];
```

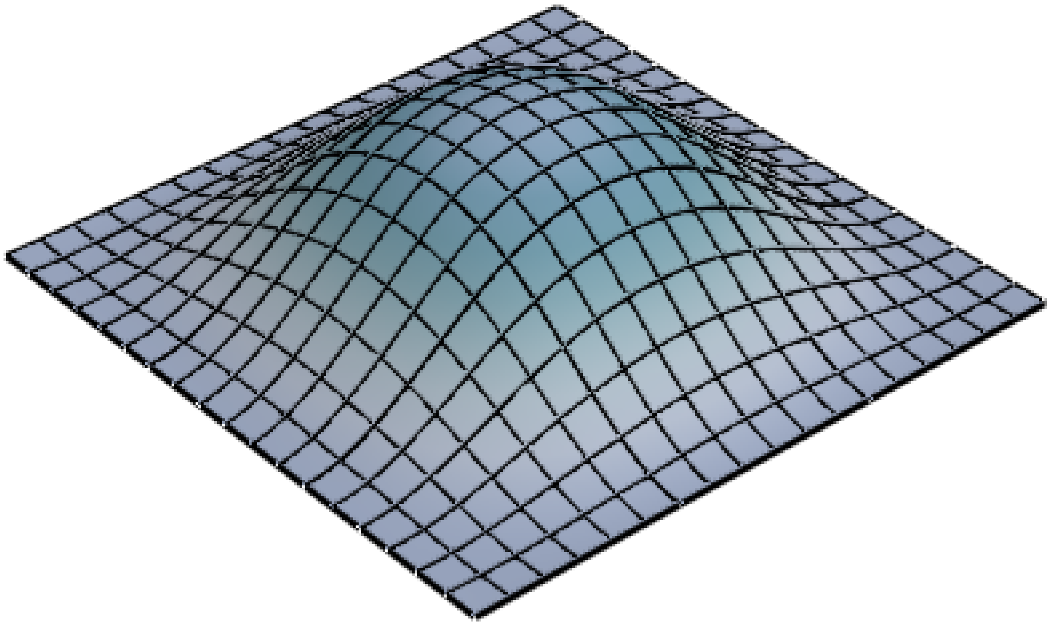
```
fig = Figure(size = (230, 200),fontsize = 6, linewidth = 0.5)
Axis(fig[1, 1], title = "Konvergenzplot",xlabel="Anzahl Freiheitsgrade", ylabel="Maximale Verschiebung in mm",spinewidth= 0.5)
scatterlines!(nn, ww*1000,markersize = 5)
fig
```



1.5 Ergebnisse der Verformung

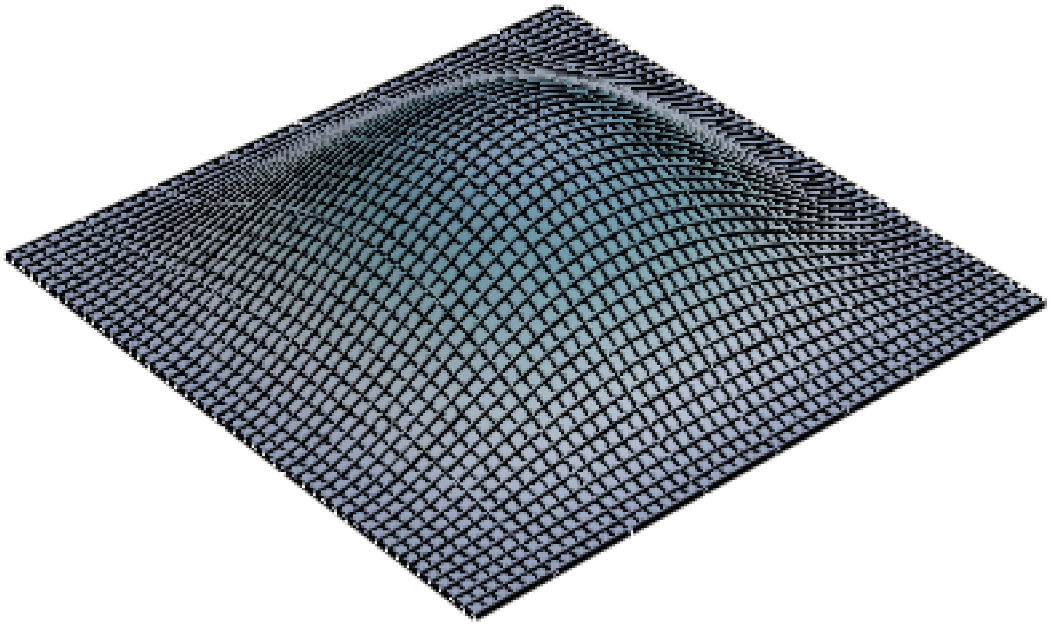
Plot der Verformung mit 9 Elementen

```
plotsol(p,3)
```



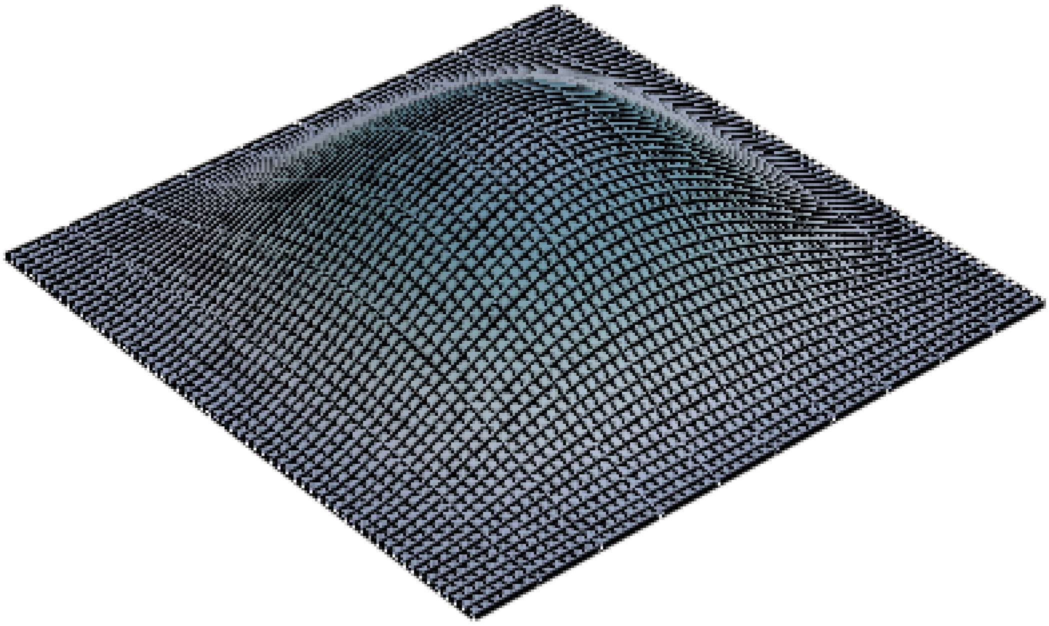
Plot der Verformung mit 64 Elementen

```
plotsol(p,8)
```



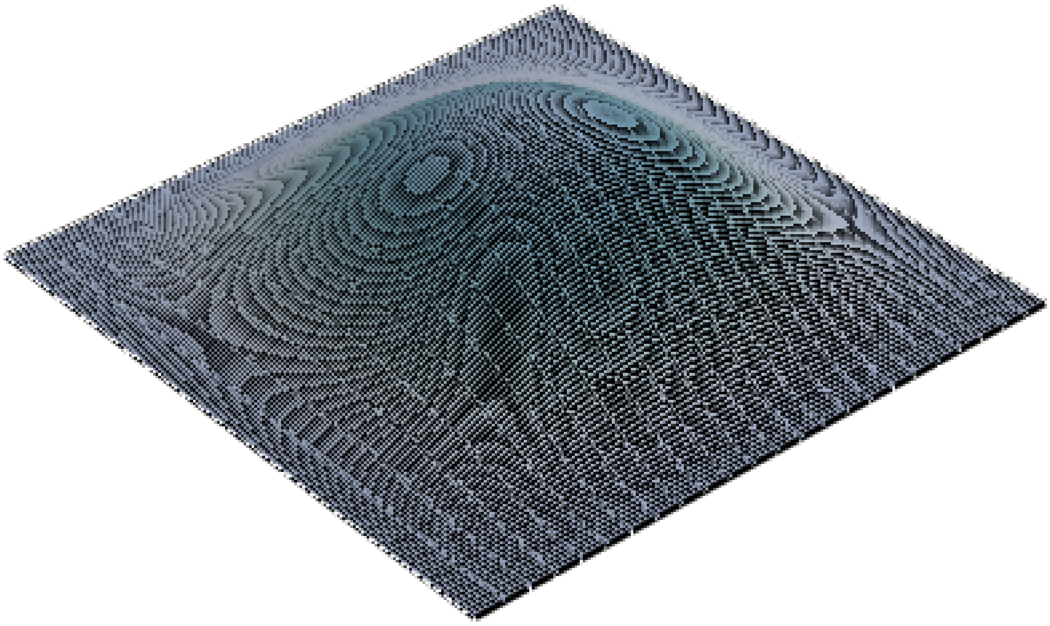
Plot der Verformung mit 100 Elementen

```
plotsol(p,10)
```



Plot der Verformung mit 576 Elementen

```
plotsol(p,24)
```



1.6 Schnittgrößen

```
include("setup.jl")
p.E = 34000e6
p.ν = 0.2
m, wHat = plate(p, 20)
m.data[:post]
f3 = face(m,3)
m.data[:post](f3, :mx)
```

```
0.10358315273364216x₁x₂-0.15599027980834823x₁+0.07343200691307375x₂-0.6946643214133795
```

```
include("setup.jl")

set_theme!(theme_minimal())

update_theme!(
    colormap=:redblue,
    color=3,
    faceplotzscale=1,
    faceplotnpoints=15,
    edgesvisible=true,
    featureedgelinewidth=2.5
```

```
)
plotr(m, :mx, "Biegemoment mx", (-17, 17),a3d=false)
```

```
klappt
klappt
```

Biegemoment mx | min: