Structural calculation for Stair 1

Gravity loads:
Stairs, Inducing landings

2" concrete =	25 psf
Tread/ Riser thickness= 0.081" (12GA) =	4 psf
Misc weight =	6 psf
Total DL =	35 psf

Live load = 100 psf

Design criteria for stair : Design loads are 100 psf uniform load + material DL of stair or a concentrated load of 300 lbs on an area of 4 in^2 , whichever produce greatest stress.

Hand rail loads: LL = 50 plf or 200 lbs concentrate load act in any direction

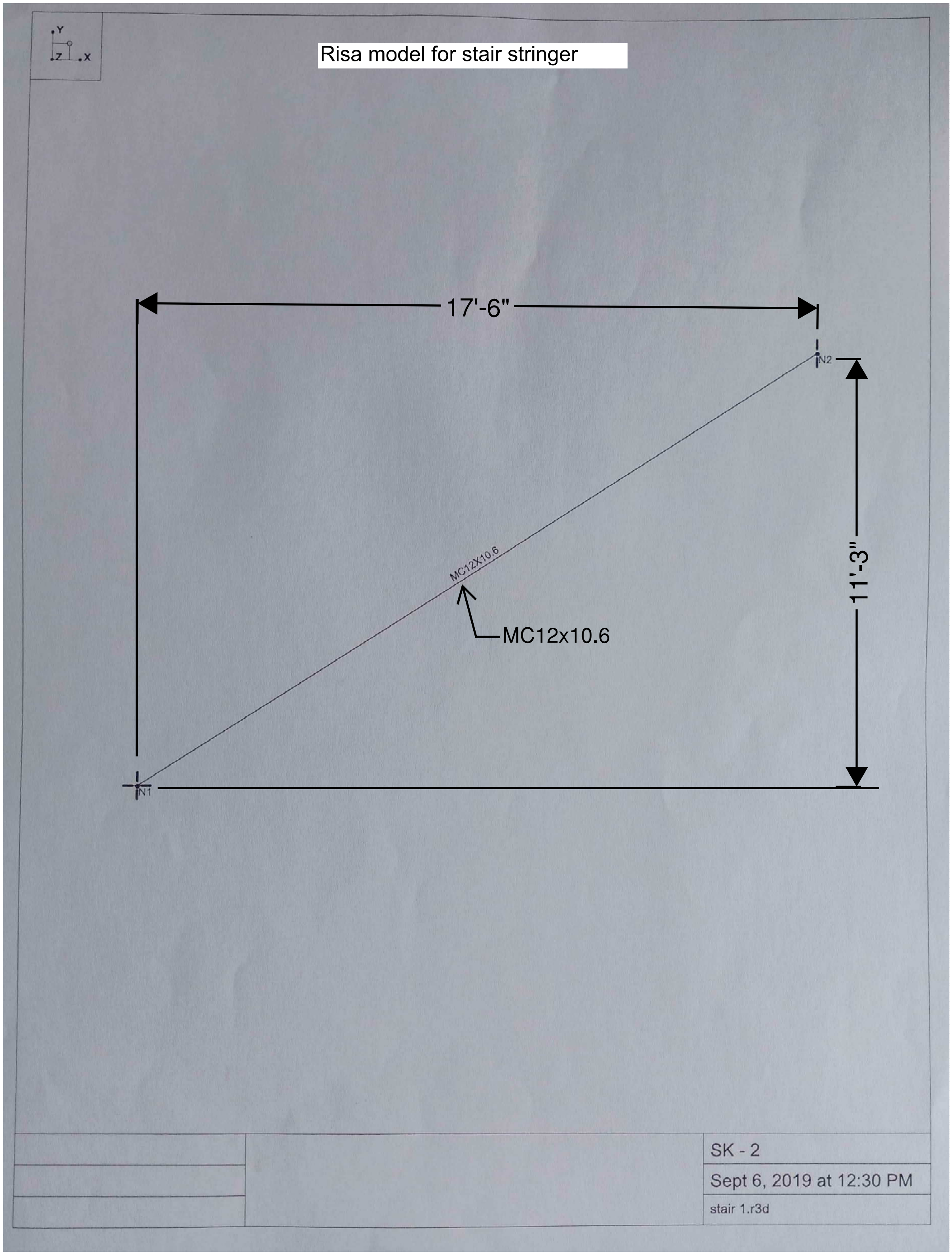
Deflection criteria for DL+LL = L/240 .

Materials

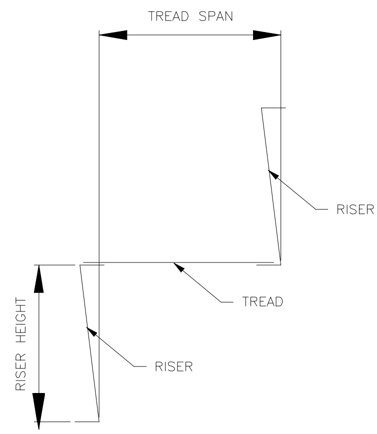
Channels:	ASTM A36, Fy = 36 ksi, Fu = 58 ksi
Pipes:	ASTM A53, Fy = 35 ksi, Fu = 60 ksi
Angles, Plates:	ASTM A36, Fy = 36 ksi, Fu = 58 ksi

Wood: (Assume) Southern pine wood , No.2 grad

Stair Stringer design calc in Risa



Typical Stair Risers



Riser thickness: t_{riser} = 0.081"
Riser depth: b_{riser} = 6"
Riser span: L_{riser} = 45"
Tread run: L_{tre} = 11 "

Riser moment of inertia: $Ix = 6^3 x\ 0.081 /12 = 1.458$ in4

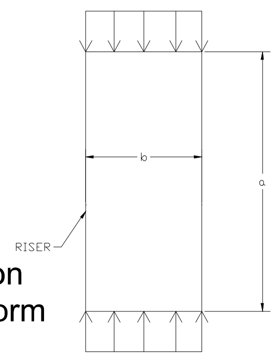
Riser plastic modulus: $Zx = 6^2$ x 0.081 /4 = 0.729 in4

Max moment on riser: $Mx = (DL+LL) \times L_{tre} \times L_{riser}^2 /8 = 2611$ lb in

Max flexural stress: fb_{Riser} = Mx/Z = 3.6 ksi

Allowable flexural stress: Fb = Fy/1.67 = 36/1.67 = 21.55 ksi > fb_{Riser} .... **OK**

Check Riser for 300 lb concentrated load



P_{max} = 300 lbs
$a_{dist} = b_{riser}$ = 6"
b_{dist} = 2" (assume)

$a_{dist}/b_{dist} = 3$

From Roark's formulas for stress and strain sixth edition table 35 case 1.1a(rectangular plate under equal uniform compression on two opposite edges, all edges simply supported)

K_{plate} = 3.29 , Poisons ratio = 0.32 ,
Modulas of elasticity = 29000 ksi

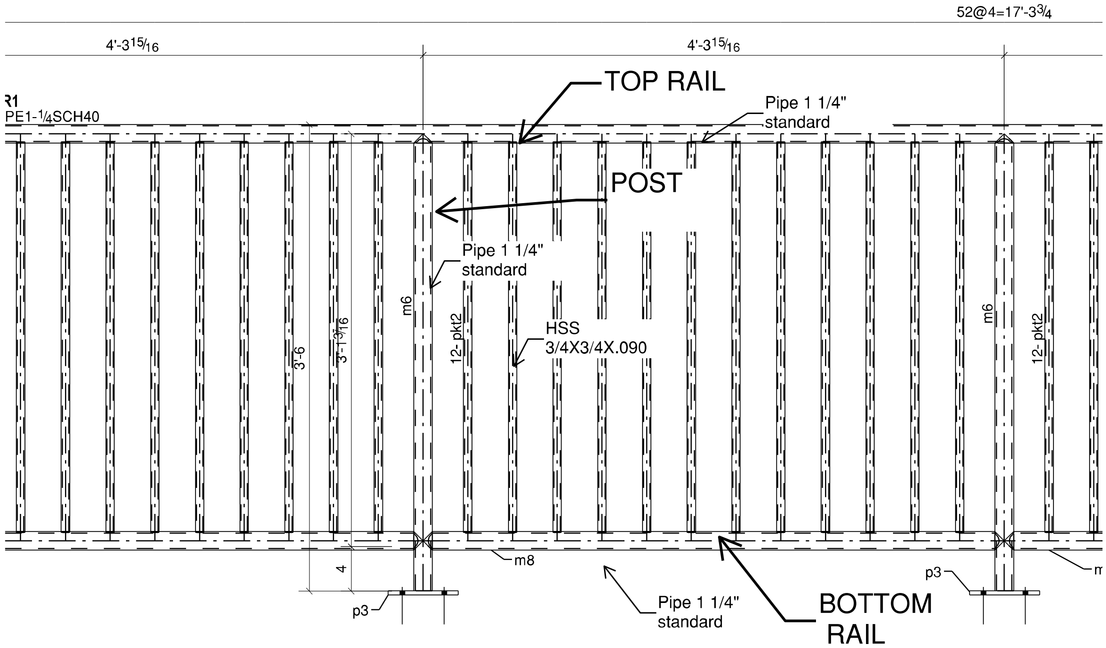
Bucking stress = 3.29x 29000 x $(0.081/2)^2 / (1-0.32^2)$ = 174.34 ksi > Yield stress , use Yield stress

Pallow = 0.6 Fy bdis triser = 3499 lbs > 300 lbs.. **OK**

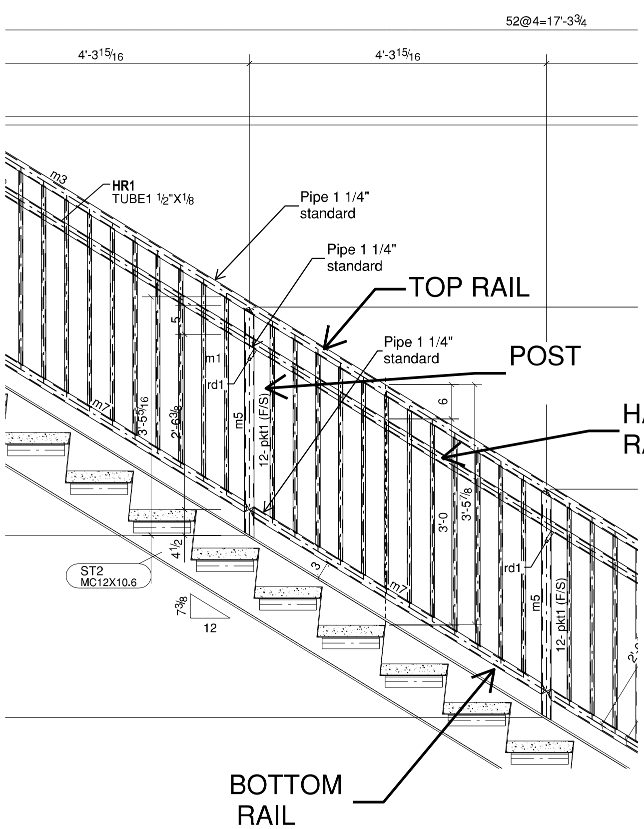
Riser deflection:

Riser deflection = 300x L_{riser}^3 /(48x 29000 x Ix_{riser}) = 0.013 in < L/240 = 0.19 in

Guard rail and Hand rail members design



Guard rail members



Hand rail members

As Hand rail and Guard rail members are same, Hand rail members are govern design and they have longer length

Guard rail and Hand rail members design

Top Rail design:

Top rail length = L_{rail} = sqrt(4.33^2+5.67^2) = 5.06 ft

Design loads are
Self weight of member 1 1/4"Ø standard pipe = 2.27 lb/ft
Distributed load, W = 50 plf or Point load = 200 lbs (act in any direction)

Max Pa = 200 lb
Max Va = 2.27 x 5.06/2 + 200 = 206 lbs
Max Ma = 2.27 x 5.06^2/8 + 200x5.06 /4 = 262 lb ft.

Section Property of 1 1/4"Ø A53 standard pipe

Fy = 35 ksi
Fu = 60 ksi
Area = 0.62 in^2
Z = 0.305 in^3
r = 0.543 in

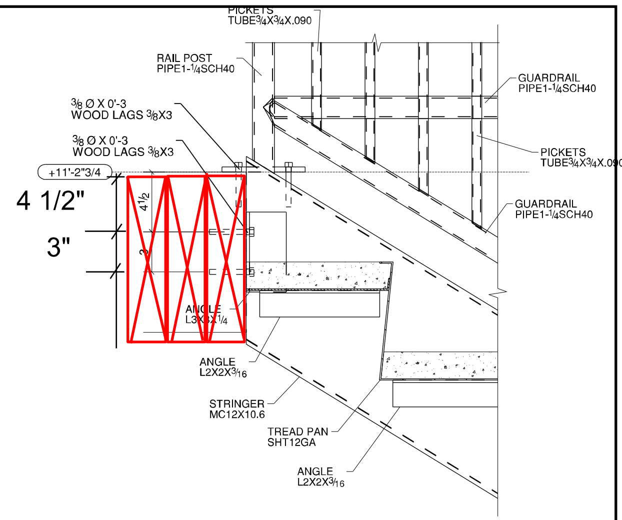
Compression capacity calc
KL_{rail}/r = 112

Critical stress Fcr / factor of safety = 11 ksi (Refer attached page)
Allowable compression capacity = 11 ksi x 0.62 = 6.82 kips > Pa...**OK**

Shear capacity calc
Shear capacity = 0.6x Fyx Ag/(2 x1.67) = 0.6x 35 x 0.62/(2 x1.67) = 3.89 kips > Va...**OK**

Moment capacity calc
Bending stress = Ma /Z = 262 lb/ft x 12 / (0.305 in^3 x 1000)= 10.3 ksi
allowable stress = Fy /1.67 = 20.95 ksi >10.3 ksi.....**OK**

Top Stringer floor connection with wood



DETAIL 2
E2

Load = 3 kips (refer Risa results)

Assume wood Southern pine wood , No.2 grad

Members are (3) 2x12 member,

use 3/4"Ø through bolts for connection.

Use NDS 2015
table 11.3.1,
$Z' = Z \times C_D \times Cm \times Ct \times Cg \times C_\Delta \times Ceg \times Cdi \times Ctn$

Ceg = Cdi = Ctn = 1.0 (as this is not applicable)

z = (760+1000)/2 = 880 lbs (table 12B, NDS) (refer next page)

C_D = 1.0 (occupancy live load , table 2.3.2, NDS)

Cm =1.0 (Table 11.3.3, NDS)

Ct =1.0 (Table 11.3.4, NDS)

Cg = 1.0 (Table 11.3.6C, NDS), Am/As = 4x1.5/0.25 = 24

C_Δ= 1.0 (edge distance and spacing is min 4D = 4x 3/4 = 3"

Z' = 880 lbs

total require capacity = 3 kips/0.88 k = 3.4 nos 3/4"Ø through bolts works, Provide 4 nos total