

Kernel: Python 3 (system-wide)

In [1]:

```
import numpy as np
from matplotlib import pyplot as plt
```

In [2]:

```
# singularities
def sing(x,a,n):
    if not isinstance(x, np.ndarray):
        x = np.array([x])
    ni = np.zeros(x.size)
    for i in range(x.size):
        if x[i] >=a and n>=0:
            ni[i] = (x[i]-a)**n
    return ni/np.math.factorial(n)

def lx(ord_f,pc, tire_l, case):
    p1,p2 = pp(tire_l,case)
    react_f = GVWR*((1-pc)*sing(dx,0,ord_f)+pc/2*
(sing(dx,lw1,ord_f)+sing(dx, lw2, ord_f)))
    other_f = p1*sing(dx,a2,ord_f)+p2*sing(dx,lc,ord_f)+W_tip/base_len*
(sing(dx,0, ord_f+1)-sing(dx,base_len, ord_f+1))
    if case == 1:
        return react_f - other_f - Rc*sing(dx, tire_l, ord_f)
    else:
        return react_f - other_f

def pp(tire_l,load_fac):
    react_f = Rc*((tire_l-a2)*load_fac+wheel_base)+W_tip*(G_tip-a2)
    p2 = react_f/(lc-a2)
    p1 = load_fac * Rc + W_tip - p2
    return p1,p2

def trail(ord_f,pc,tire_len, case=2):
    p1,p2 = pp(tire_len,case)
    react_f = p1*sing(dx,a2,ord_f)+p2*sing(dx,lc,ord_f)-W_tip/tip_len*
(sing(dx,a1, ord_f+1)-sing(dx,a1+tip_len, ord_f+1))#todo singularity(a), mom
= @sig(a,1,2)
    if case == 1:
        rc_f = Rc*sing(dx,tire_len,ord_f)
    else:
        rc_f = Rc*
(sing(dx,tire_len+wheel_base,ord_f)+sing(dx,tire_len,ord_f))
    return react_f - rc_f
```

note case on full front, case on half front,

case on back

In [3]:

```
len_full = 300

# predefined arrays
dx = np.linspace(-1,len_full, 200)
cat_tire_l_arr = np.arange(60,len_full-50,10)
```

In [0]:

In [4]:

```

def run_f(perc=None):
    max_p = [[0,0]]
    react_mat = []

    max_ptip = [[0,0]]
    react_mattip = []
    # loop through locations
    #const
    const_v = Rc*wheel_base+W_tip*(G_tip+G_base)
    const_react = GVWR*(lw1+lw2)/2
    if perc:
        f_arr = [perc]
    else:
        f_arr = cat_tire_l_arr
    for par_v in f_arr:
        if perc:
            p = par_v
            cat_tire_l = (cons_react*p-const_v)/(2*Rc)
        else:
            cat_tire_l = par_v
            p = (2*Rc*cat_tire_l+const_v)/const_react
        if cat_tire_l < a1:
            case = 1
        else:
            case = 2

        # initialize constants for each

        #singularity

        load = lx(0,p,cat_tire_l,case)
        mom = lx(1,p,cat_tire_l,case)

        tip_l = trail(0,p,cat_tire_l,case)
        tip_m = trail(1,p, cat_tire_l,case)
        #, v: {}, m: {'}')
        sig = mom/(2*shear_mod) # stress
        sigtip = tip_m/(2*shear_mod)

        react_mat.append([load, mom, sig])
        max_sig = np.max(np.abs(sig))

        max_p.append([p*1, max_sig*1]) # max stress for this loading
        condition and this location

        react_mattip.append([tip_l, tip_m, sigtip])
        max_sigtip = np.max(np.abs(sigtip))

        max_ptip.append([p*1, max_sigtip*1]) # max stress for this loading
        condition and this location

        # tabulation of this location, and max of location
        max_p = np.array(max_p)
        m_n = np.argmax(max_p,0)
        m_a = max_p[m_n[1],:]

```

```

# adding to list of all locs

# tabulation of this location, and max of location
max_ptip = np.array(max_ptip)
m_ntip = np.argmax(max_ptip,0)
m_atip = max_ptip[m_ntip[1],:]

# max for each percent, len
for i in range(max_p.shape[0]-1):
    fis = max_p[i+1,1]
    fs2 = '|||||' if fis>= yield_s else ''
    print(f'Dis load loc {round(f_arr[i],1)}(in) at rear load:
{int(max_p[i+1,0]*100)}% = Max \u03C3: {round(fis,2)}(psi)::
{round(fis/1000,1)}(ksi){fs2}')

    print(f'\n-----\noverall max at len(in):
{round(f_arr[m_n[1]-1], 2)}, rear load: {int(m_a[0]*100)}%, \u03C3 =
{round(m_a[1], 2)}(psi)')
    # max for each percent, len
    print(f'\n\n-----\ntrailer\n-----\n')

    for i in range(max_ptip.shape[0]-1):
        fis = max_ptip[i+1,1]
        fs2 = '|||||' if fis>= yield_s else ''
        print(f'Dis load loc {round(f_arr[i],1)}(in) at rear load:
{int(max_ptip[i+1,0]*100)}% = Max \u03C3: {round(fis,2)}(psi)::
{round(fis/1000,1)}(ksi){fs2}')

        print(f'\n-----\noverall max at len(in):
{round(f_arr[m_ntip[1]-1], 2)}, rear load: {int(m_atip[0]*100)}%, \u03C3 =
{round(m_atip[1], 2)}(psi)')
        return react_mat,react_mattip,max_p, f_arr

def plot_x(react_mat,react_mattip,max_p, f_arr):
    # SFD BMD, \u03C3 vs distance for each condition of len,percent
    lft = [react_mat,react_mattip]
    plt_n = ['main', 'tip']
    for ii in range(len(react_mat)):
        fig, ax = plt.subplots(1,2)
        for i in range(2):
            ax[i].grid(True)
            m_half = lft[i][ii]

            ax[i].plot(dx,m_half[0])
            ax[i].plot(dx,m_half[1]*1e-2)
            ax[i].plot(dx,m_half[2]*1e-1)

            ax[i].legend(['Shear (lb)', 'Moment(100*lb*in)', 'Sigma
(10*psi)'])
            ax[i].set_title(f'SFD BMD, \u03C3 allong trailer(in) for current
loading on {plt_n[i]}')
            fig.suptitle(f'Plots for len of load: {round(f_arr[ii],2)}(in) rear
Load:{int(max_p[ii,0]*100)}%')

```

In [5]:

```

#test 1
#constants
yield_s = 50000
shear_mod = 5.61
shear_mod_tip=5.49

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```

GVWR = 16000

W_tip = 1500 # tare/2
Rc = GVWR/2 - W_tip

lc = 200
a1 = 104

tip_len = 194
base_len = 200

G_base = base_len / 2
G_tip = tip_len / 2 + a1

a2 = a1 + 16
lw1 = lc - 21
lw2 = lc + 15

wheel_base = 48

react_mat1, react_mattip1, mp, fa = run_f()
plot_x(react_mat1, react_mattip1, mp, fa)

```

Out[5]:

```

Dis load loc 60(in) at rear load: 48% = Max  $\sigma$ : 47750.74(psi)::: 47.8(ksi)
Dis load loc 70(in) at rear load: 53% = Max  $\sigma$ : 46486.3(psi)::: 46.5(ksi)
Dis load loc 80(in) at rear load: 57% = Max  $\sigma$ : 46652.37(psi)::: 46.7(ksi)
Dis load loc 90(in) at rear load: 61% = Max  $\sigma$ : 46795.08(psi)::: 46.8(ksi)
Dis load loc 100(in) at rear load: 65% = Max  $\sigma$ : 45851.01(psi)::: 45.9(ksi)
Dis load loc 110(in) at rear load: 69% = Max  $\sigma$ : 47221.39(psi)::: 47.2(ksi)
Dis load loc 120(in) at rear load: 73% = Max  $\sigma$ : 40164.08(psi)::: 40.2(ksi)
Dis load loc 130(in) at rear load: 77% = Max  $\sigma$ : 33106.78(psi)::: 33.1(ksi)
Dis load loc 140(in) at rear load: 81% = Max  $\sigma$ : 26049.47(psi)::: 26.0(ksi)
Dis load loc 150(in) at rear load: 86% = Max  $\sigma$ : 18992.17(psi)::: 19.0(ksi)
Dis load loc 160(in) at rear load: 90% = Max  $\sigma$ : 11934.86(psi)::: 11.9(ksi)
Dis load loc 170(in) at rear load: 94% = Max  $\sigma$ : 9974.59(psi)::: 10.0(ksi)
Dis load loc 180(in) at rear load: 98% = Max  $\sigma$ : 10410.67(psi)::: 10.4(ksi)
Dis load loc 190(in) at rear load: 102% = Max  $\sigma$ : 10846.76(psi)::: 10.8(ksi)
Dis load loc 200(in) at rear load: 106% = Max  $\sigma$ : 16294.36(psi)::: 16.3(ksi)
Dis load loc 210(in) at rear load: 110% = Max  $\sigma$ : 23351.66(psi)::: 23.4(ksi)
Dis load loc 220(in) at rear load: 114% = Max  $\sigma$ : 30408.97(psi)::: 30.4(ksi)
Dis load loc 230(in) at rear load: 119% = Max  $\sigma$ : 37466.28(psi)::: 37.5(ksi)
Dis load loc 240(in) at rear load: 123% = Max  $\sigma$ : 44523.58(psi)::: 44.5(ksi)

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overall max at len(in): 60, rear load: 48%,  $\sigma$  = 47750.74(psi)

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trailer
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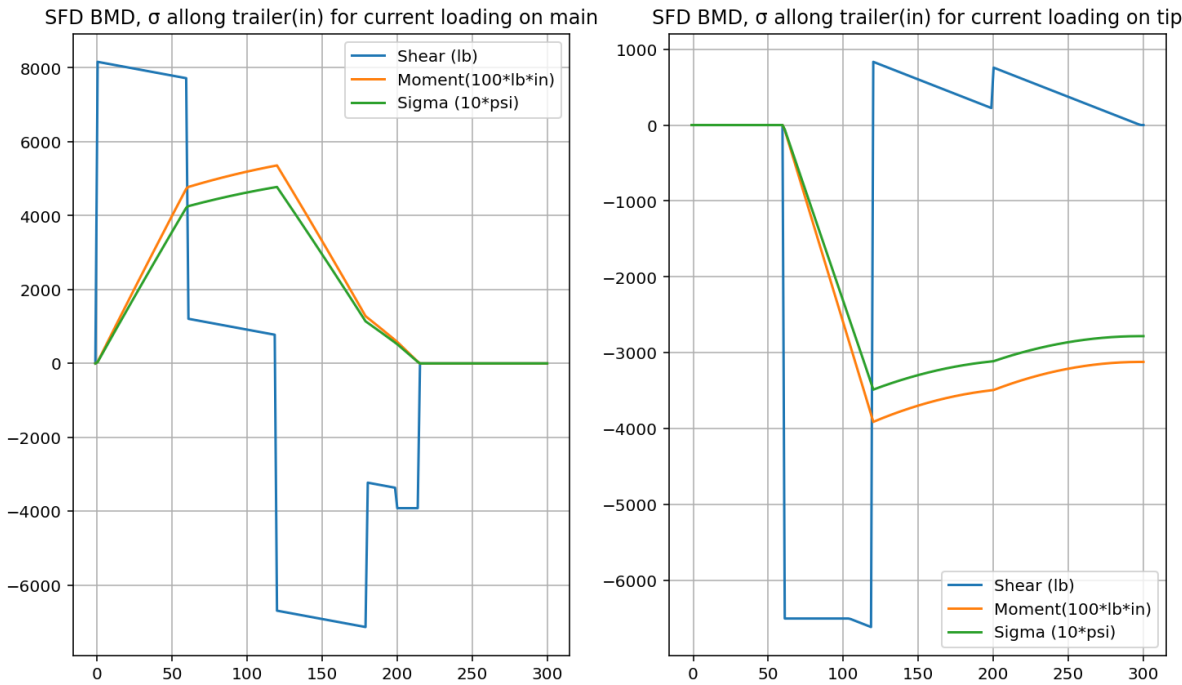
Dis load loc 60(in) at rear load: 48% = Max  $\sigma$ : 34847.19(psi)::: 34.8(ksi)
Dis load loc 70(in) at rear load: 53% = Max  $\sigma$ : 31105.13(psi)::: 31.1(ksi)
Dis load loc 80(in) at rear load: 57% = Max  $\sigma$ : 31105.13(psi)::: 31.1(ksi)
Dis load loc 90(in) at rear load: 61% = Max  $\sigma$ : 31105.13(psi)::: 31.1(ksi)
Dis load loc 100(in) at rear load: 65% = Max  $\sigma$ : 31105.13(psi)::: 31.1(ksi)
Dis load loc 110(in) at rear load: 69% = Max  $\sigma$ : 7386.7(psi)::: 7.4(ksi)
Dis load loc 120(in) at rear load: 73% = Max  $\sigma$ : 9471.29(psi)::: 9.5(ksi)
Dis load loc 130(in) at rear load: 77% = Max  $\sigma$ : 8831.78(psi)::: 8.8(ksi)
Dis load loc 140(in) at rear load: 81% = Max  $\sigma$ : 9847.67(psi)::: 9.8(ksi)
Dis load loc 150(in) at rear load: 86% = Max  $\sigma$ : 10457.03(psi)::: 10.5(ksi)

```

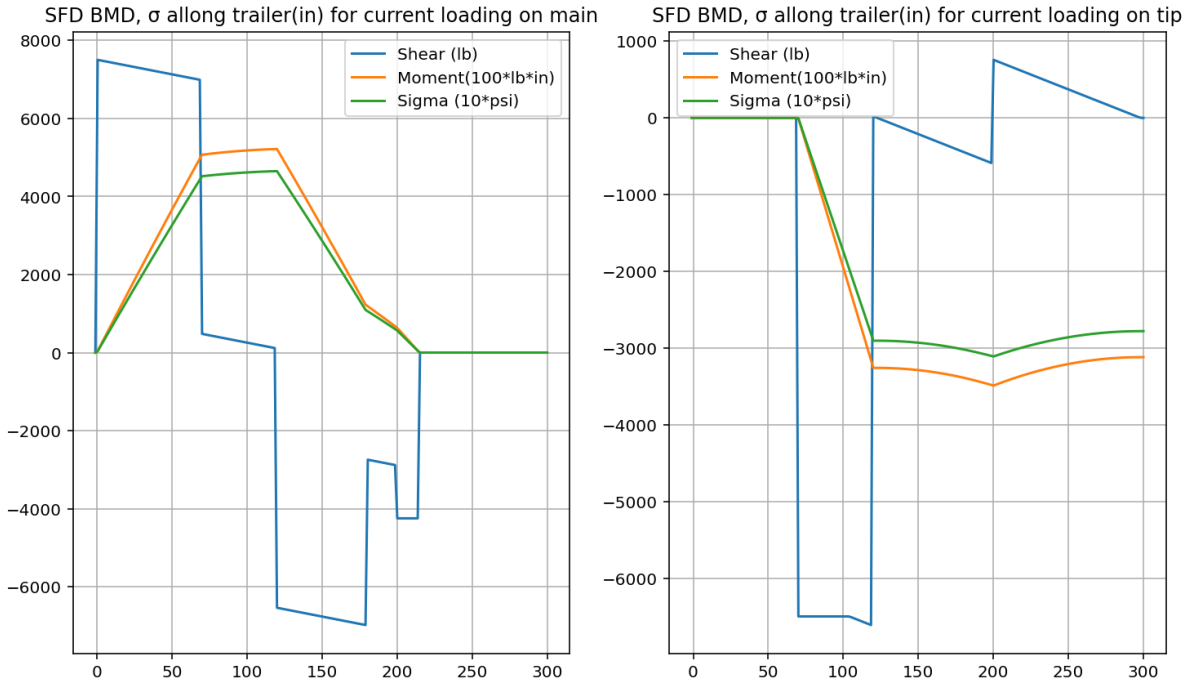
Dis load loc 160(in) at rear load: 90% = Max σ : 7993.65(psi)::: 8.0(ksi)
 Dis load loc 170(in) at rear load: 94% = Max σ : 13626.47(psi)::: 13.6(ksi)
 Dis load loc 180(in) at rear load: 98% = Max σ : 19419.69(psi)::: 19.4(ksi)
 Dis load loc 190(in) at rear load: 102% = Max σ : 25212.92(psi)::: 25.2(ksi)
 Dis load loc 200(in) at rear load: 106% = Max σ : 31006.15(psi)::: 31.0(ksi)
 Dis load loc 210(in) at rear load: 110% = Max σ : 42493.62(psi)::: 42.5(ksi)
 Dis load loc 220(in) at rear load: 114% = Max σ : 54080.07(psi):::
 54.1(ksi)|||||||
 Dis load loc 230(in) at rear load: 119% = Max σ : 65666.53(psi):::
 65.7(ksi)|||||||
 Dis load loc 240(in) at rear load: 123% = Max σ : 77252.98(psi):::
 77.3(ksi)|||||||

 overall max at len(in): 240, rear load: 123%, σ = 77252.98(psi)

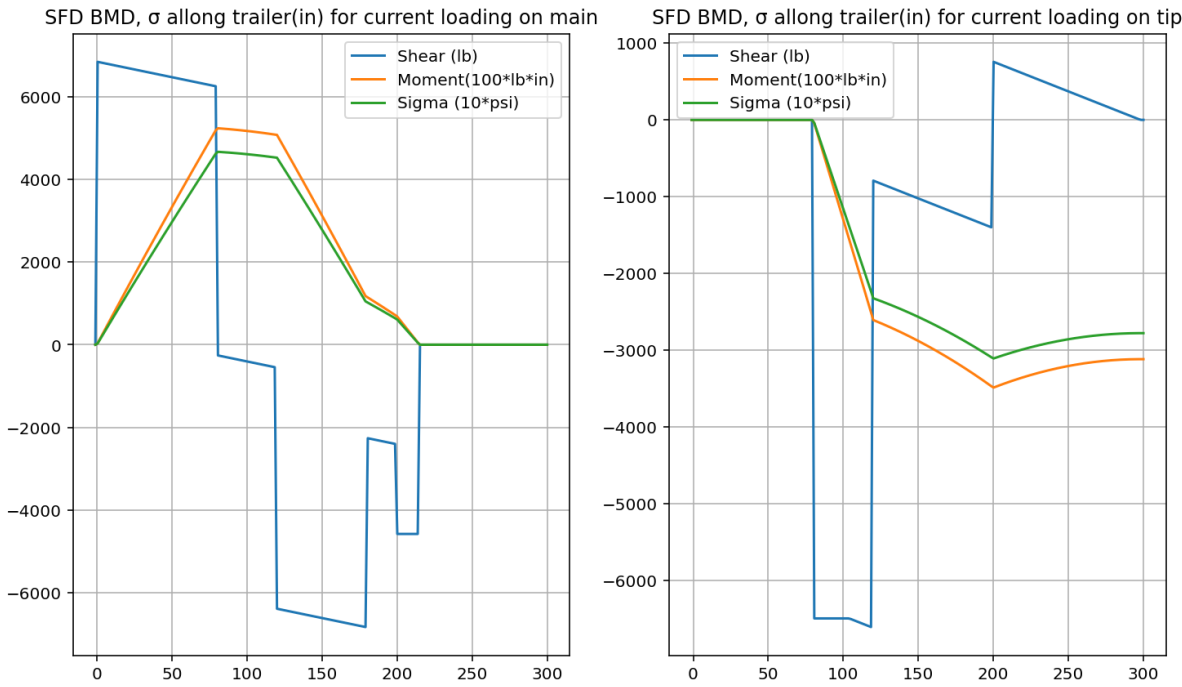
Plots for len of load: 60(in) rear Load:0%



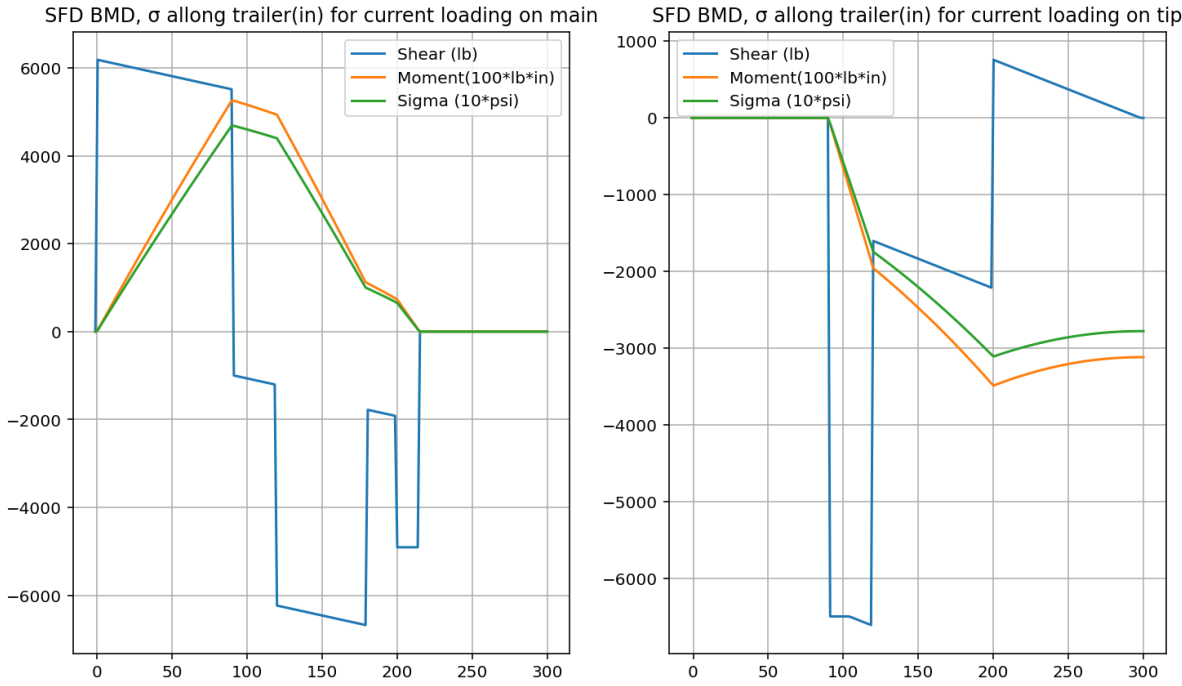
Plots for len of load: 70(in) rear Load:48%



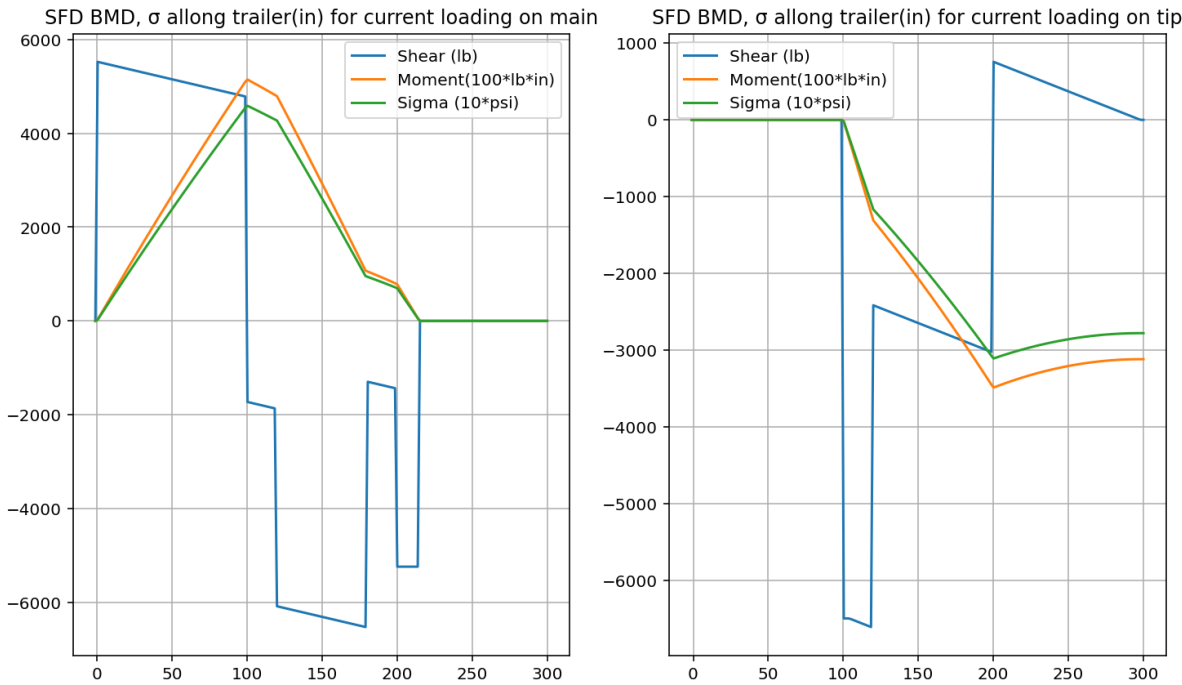
Plots for len of load: 80(in) rear Load:53%



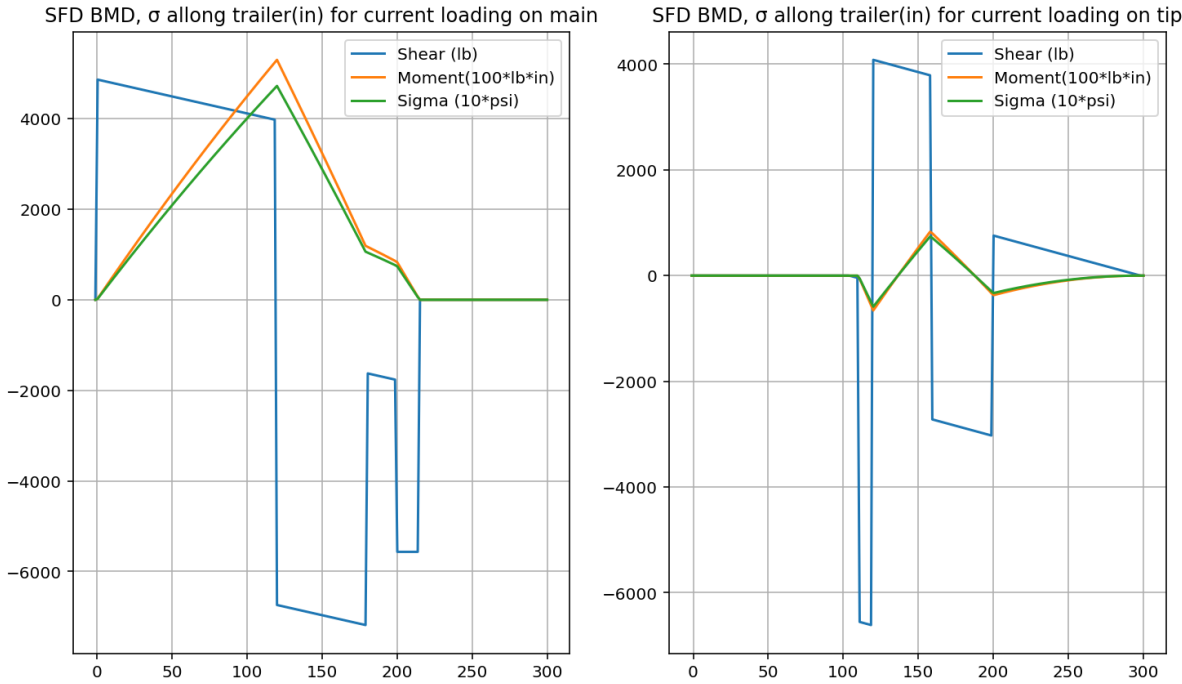
Plots for len of load: 90(in) rear Load:57%



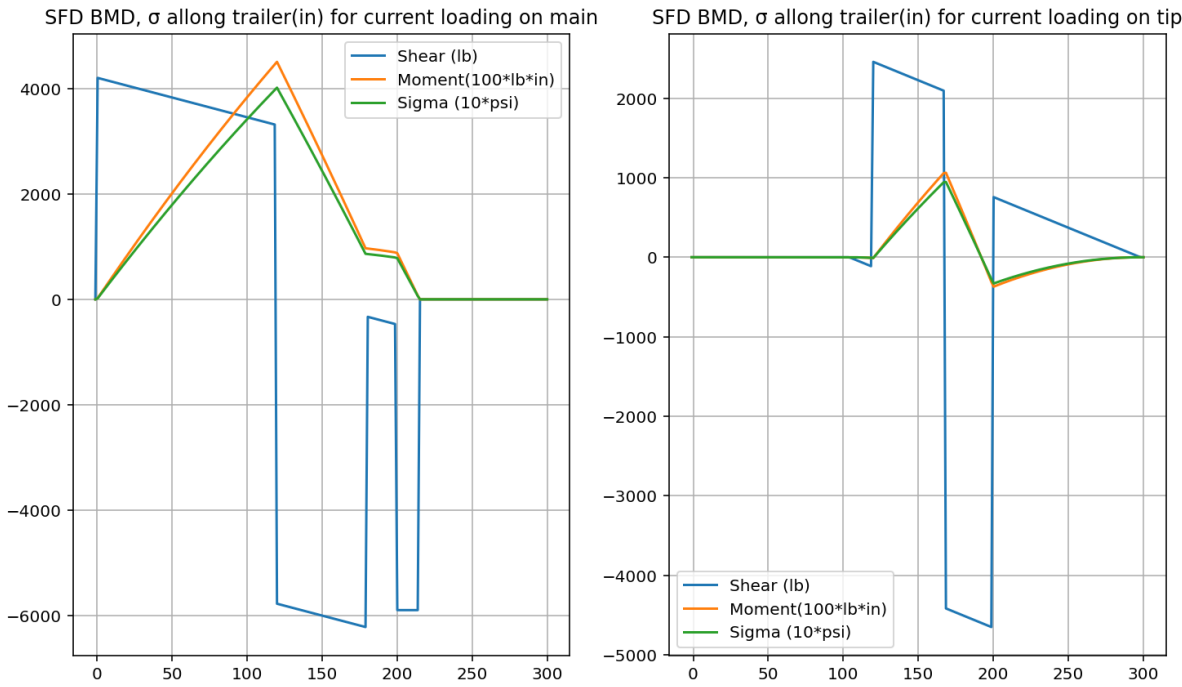
Plots for len of load: 100(in) rear Load:61%



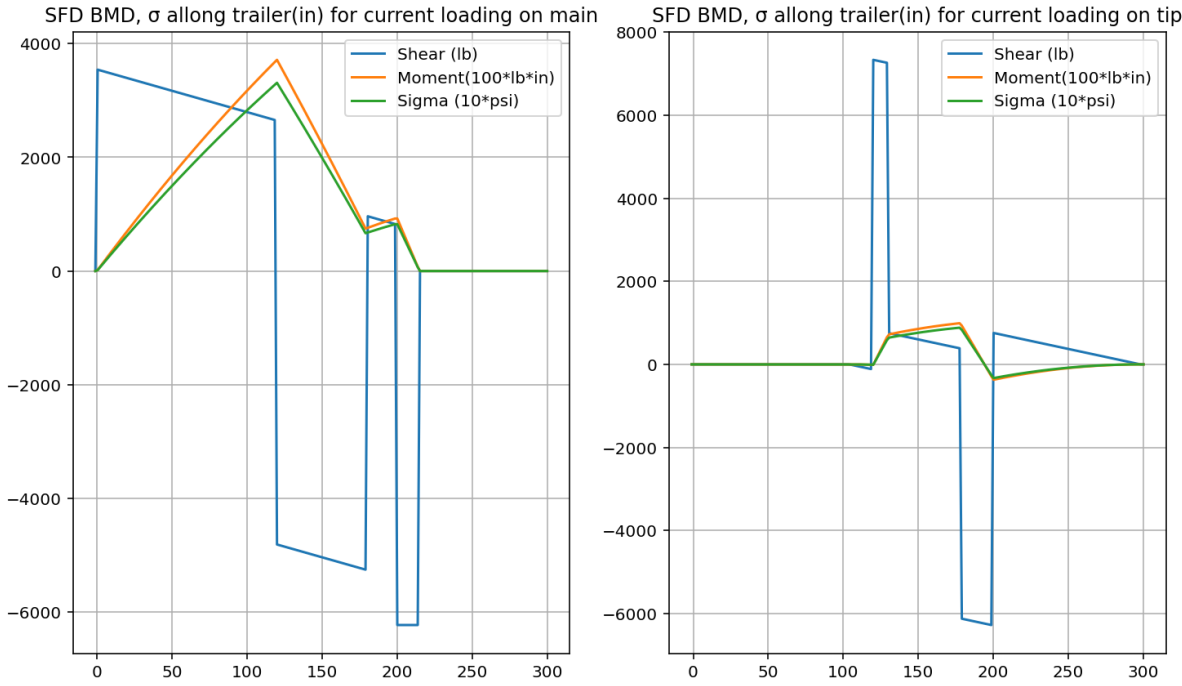
Plots for len of load: 110(in) rear Load:65%



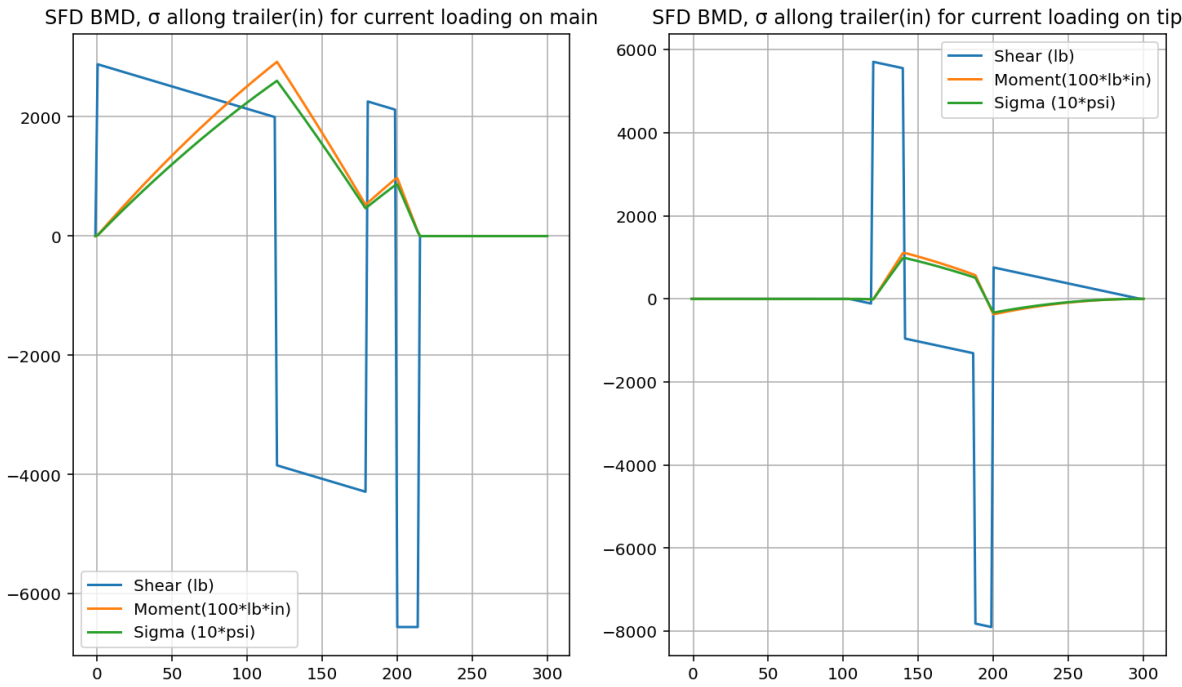
Plots for len of load: 120(in) rear Load:69%



Plots for len of load: 130(in) rear Load:73%



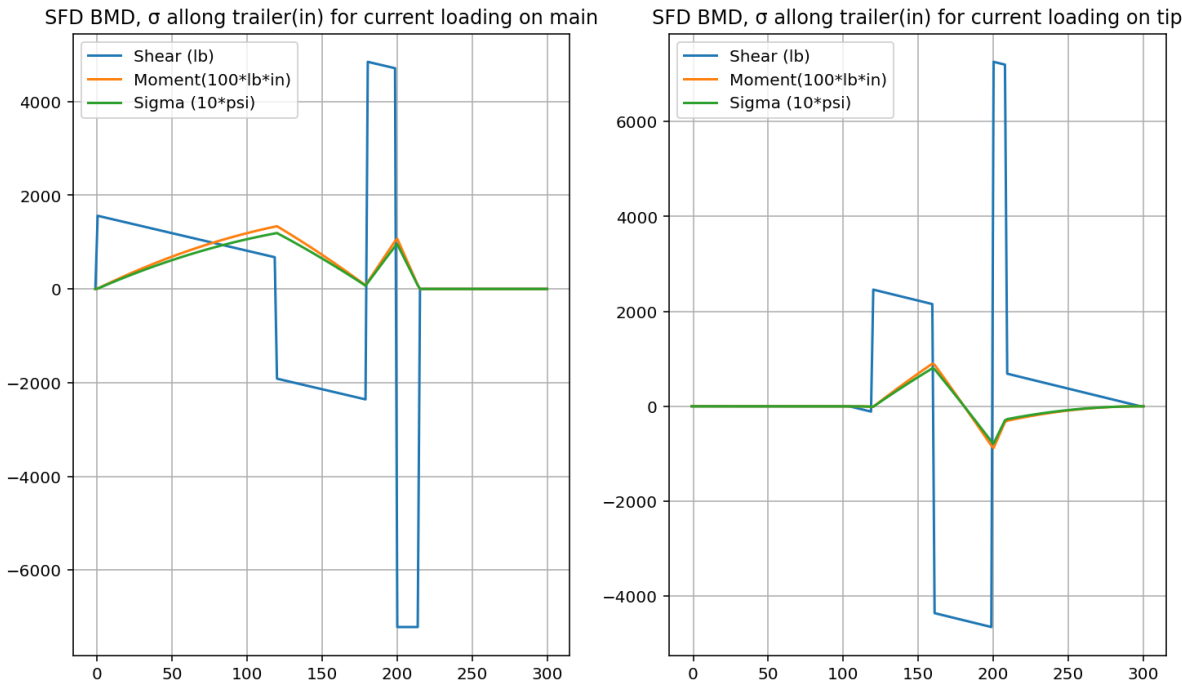
Plots for len of load: 140(in) rear Load:77%



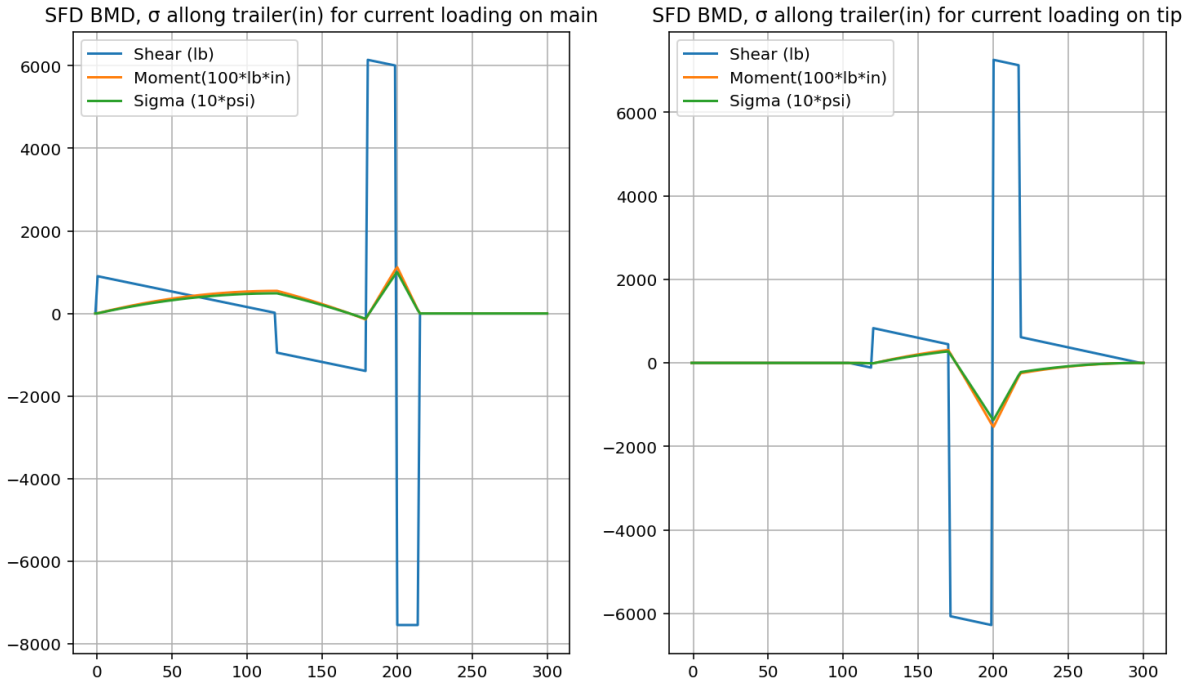
Plots for len of load: 150(in) rear Load:81%



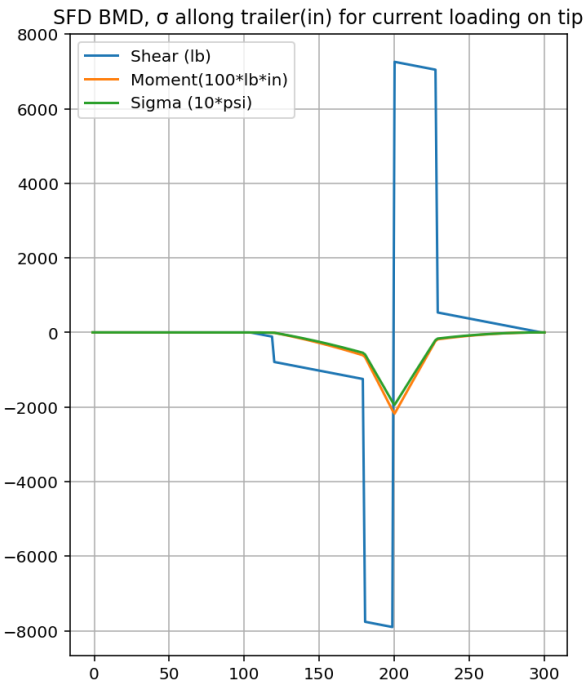
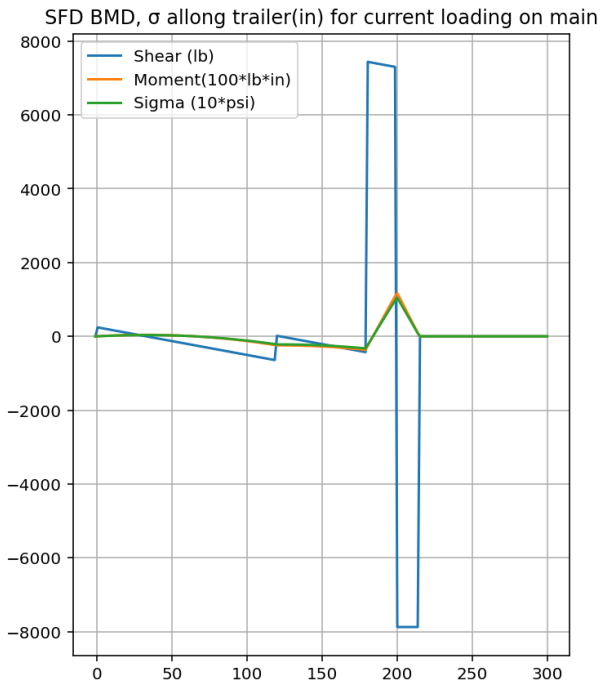
Plots for len of load: 160(in) rear Load:86%



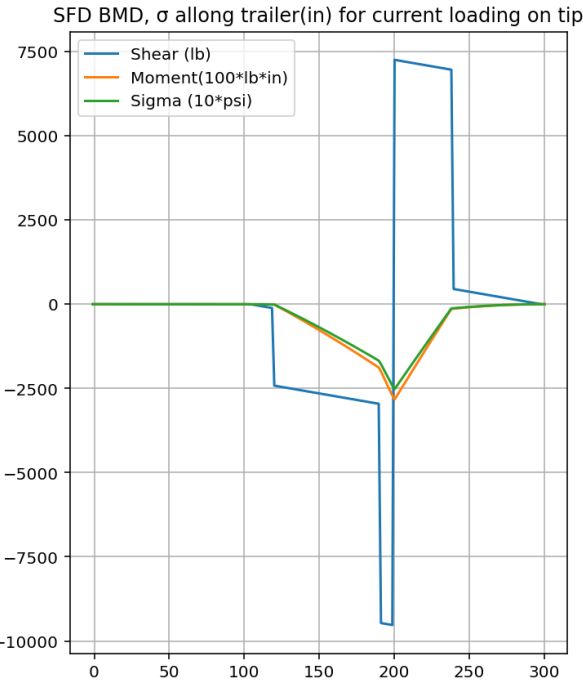
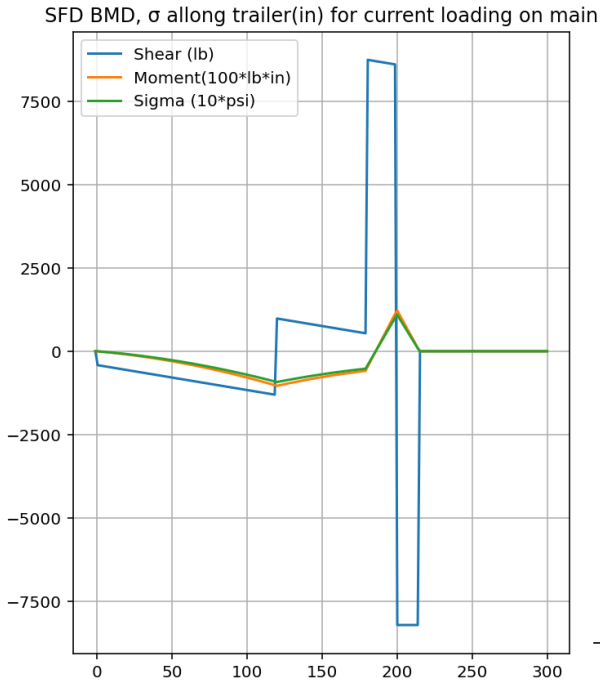
Plots for len of load: 170(in) rear Load:90%



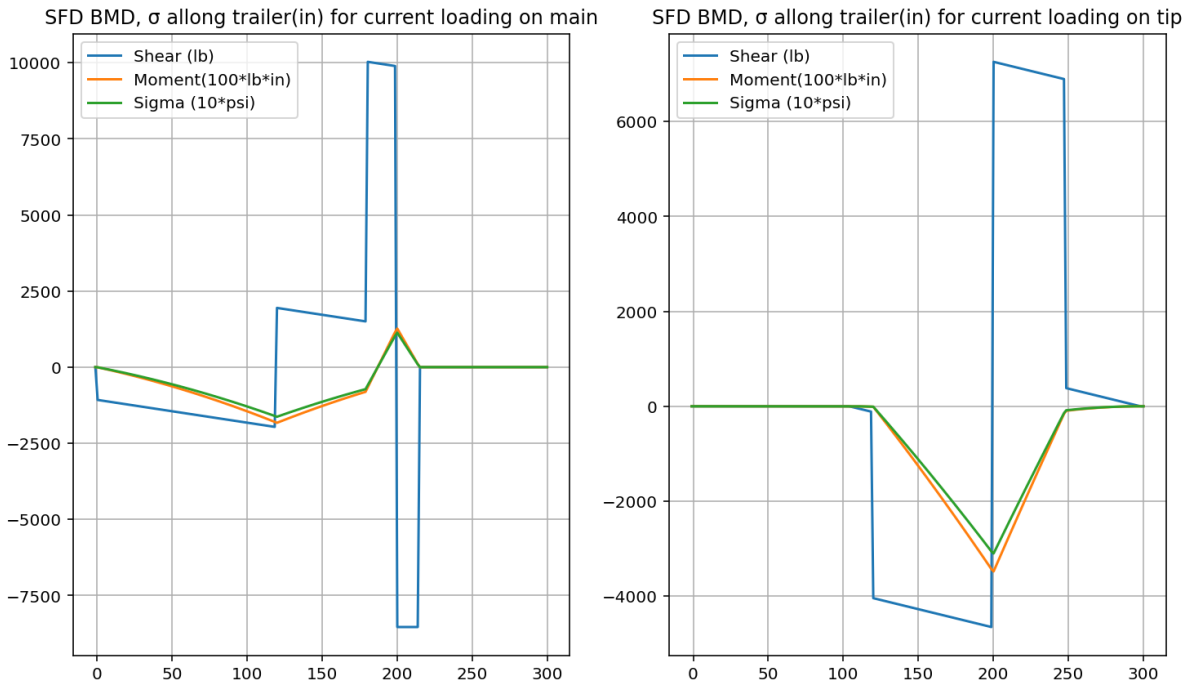
Plots for len of load: 180(in) rear Load:94%



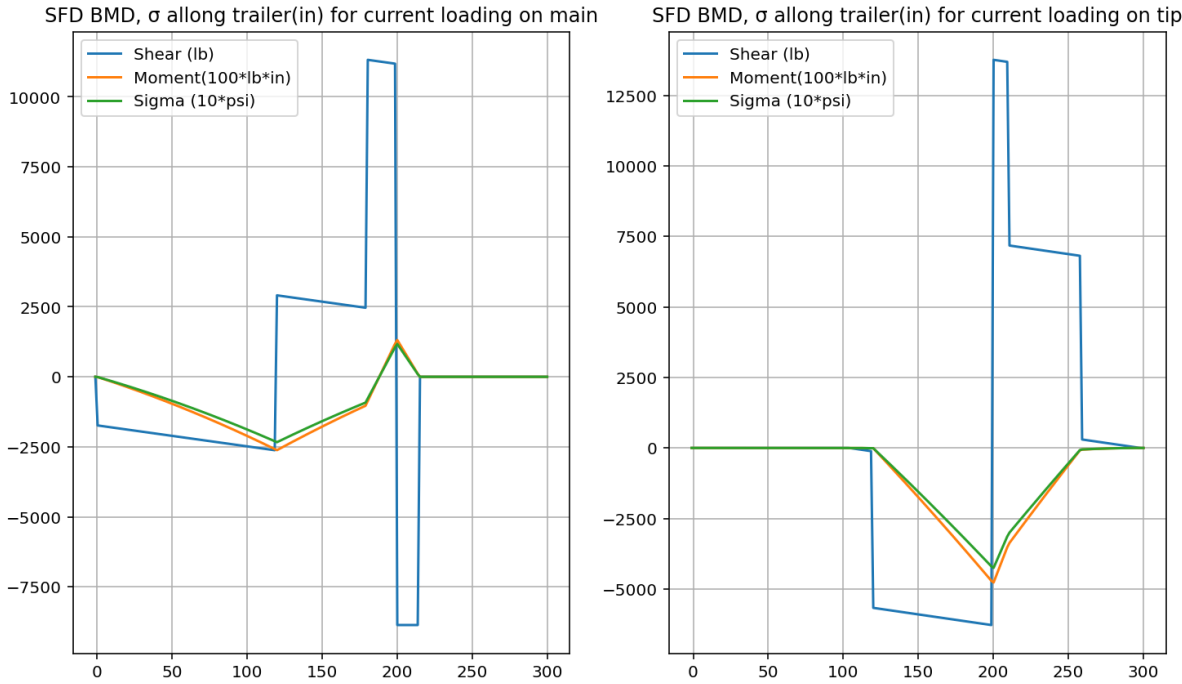
Plots for len of load: 190(in) rear Load:98%



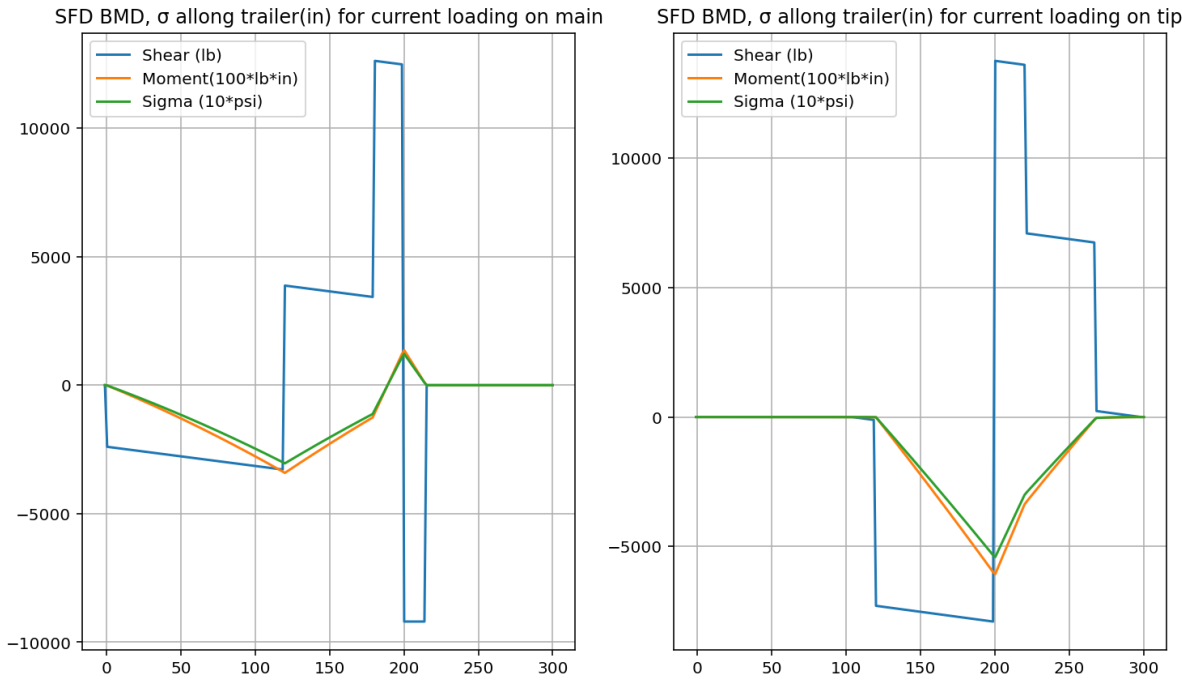
Plots for len of load: 200(in) rear Load:102%



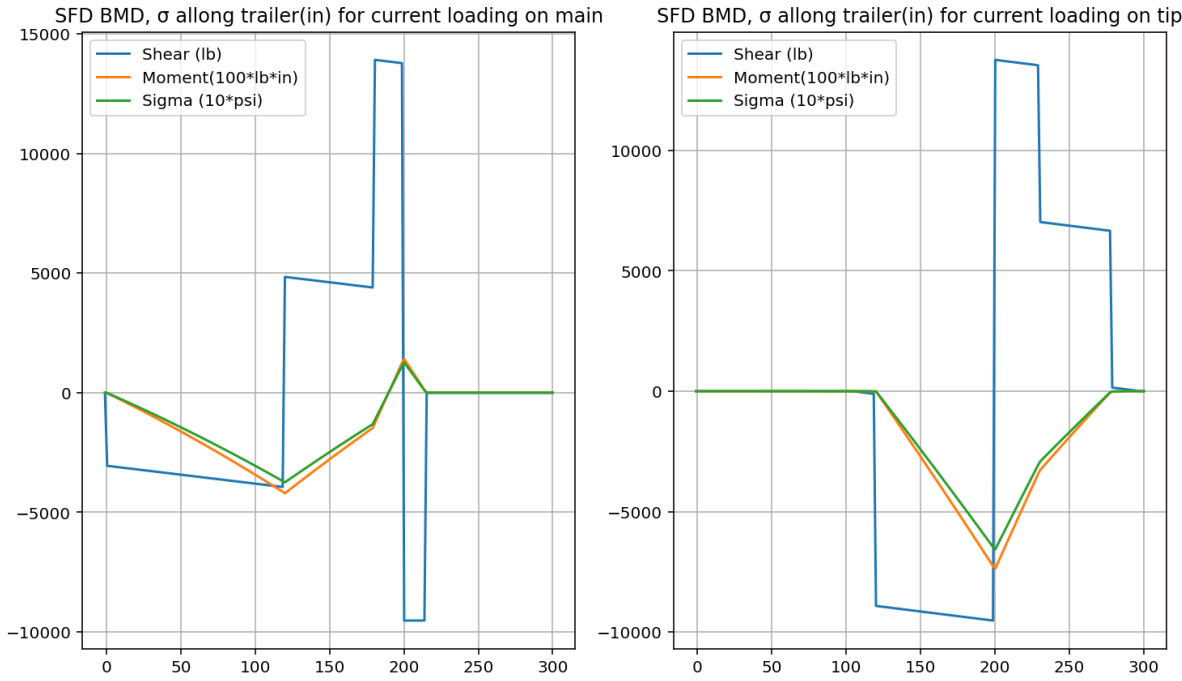
Plots for len of load: 210(in) rear Load:106%



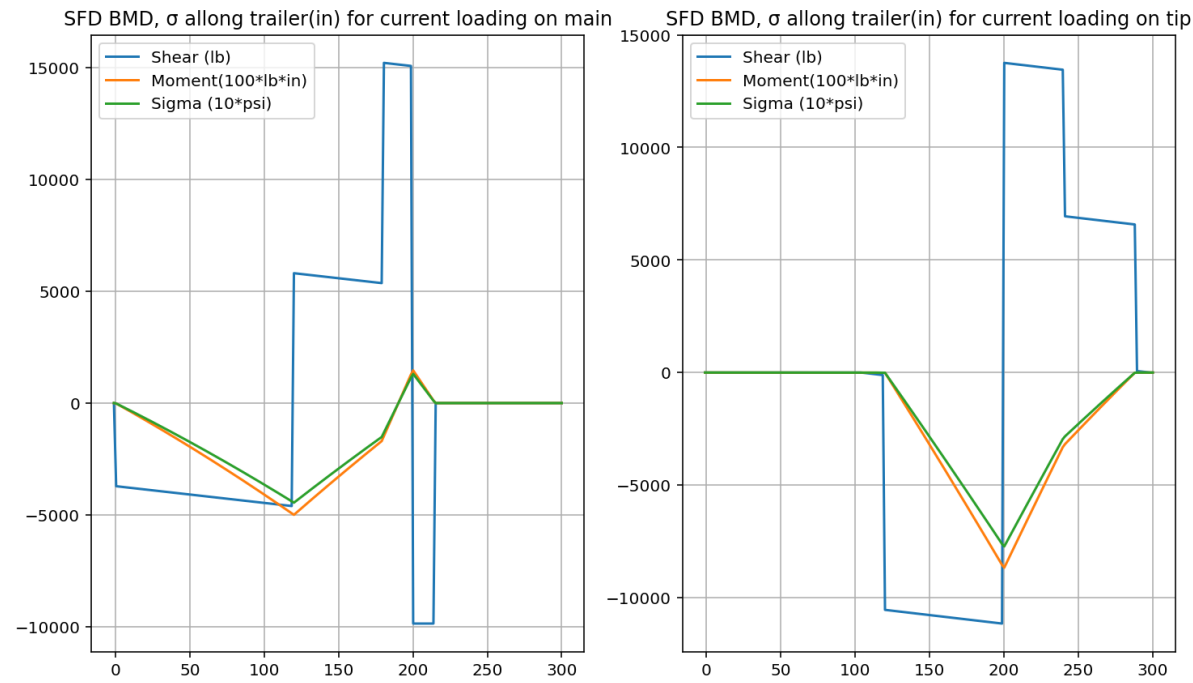
Plots for len of load: 220(in) rear Load:110%



Plots for len of load: 230(in) rear Load:114%



Plots for len of load: 240(in) rear Load:119%



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In [0]:
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