competency_bridge

December 1, 2023

[1]:
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#Pierce Zhang, CMOR 220, Fall 2023, Competency on bridge
#competency_bridge.ipynb
#Plots the specific bridge as documented in the competency
#Last Modified: December 1, 2023
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[2]:
```
import math
import matplotlib.pyplot as plt
import numpy as np
```

[3]:
```
def build_basic_bridge():
    """
    Outputs:
        - adj, (np.ndarray) the adjacency matrix of the bridge
        - xc, (np.ndarray) the x-coords of the bridge fibers
        - yc, (np.ndarray) the y-coords of the bridge fibers
        - len, (np.ndarray) the lengths of each bridge fiber
    """
    num_nodes = 4
    num_fibers = 9
    s = 1/math.sqrt(2)

    adj = np.zeros((num_fibers, 2*num_nodes))
    xc = np.zeros((num_fibers, 2))
    yc = np.zeros((num_fibers, 2))
    length = np.ones(num_fibers)


    # Build the left part of bridge.
    adj[0,0] = 1
    adj[1,2:4] = [s, s]
    xc[0] = [0, 1]
    yc[0] = [0, 0]
    xc[1] = [0, 1]
    yc[1] = [0, 1]
    length[1] = 1/s

    # Build the middle part of bridge.
    adj[2,:] = [0, -1, 0, 1, 0, 0, 0, 0]
    adj[3,:] = [0, 0, -1, 0, 0, 0, 1, 0]
    adj[4,:] = [-1, 0, 0, 0, 1, 0, 0, 0]

    # Add the coordinates
    xc[2] = [1, 1]
    yc[2] = [0, 1]
    xc[3] = [1, 2]
    yc[3] = [1, 1]
    xc[4] = [1, 2]
    yc[4] = [0, 0]

    # Build the right part of bridge.
    adj[-3,-3:] = [-1, 0, 1]
    adj[-2,-2:] = [-s, s]
    adj[-1,-4]  = -1

    # Add coordinates
    xc[-3] = [2, 2]
    yc[-3] = [0, 1]
    xc[-2] = [2, 3]
    yc[-2] = [1, 0]
    length[-2] = 1/s
    xc[-1] = [2, 3]
    yc[-1] = [0, 0]

    # Last fiber
    xc[-4] = [1, 3]
    yc[-4] = [1, 0]
    length[-4] = math.sqrt(5)
    adj[-4,2] = -2/math.sqrt(5)
    adj[-4,3] = 1/math.sqrt(5)
    return adj, xc, yc, length
```

[4]:

```
def plot_bridge(xc,yc,car_weight=0,work=0):
    plt.figure()
    # Plot the fibers of the bridge.
    plt.plot(np.transpose(xc), np.transpose(yc), 'b', linewidth=3);
    # Plots the land area surrounding the bridge.
    plt.fill([0, 0.5, -1, -1], [0, -1, -1, 0], 'k')
    plt.fill([3, 4, 4, 2.5], [0, 0, -1, -1], 'k')
   # plt.title(" 1 Section Bridge when there are no cars")
    plt.title(f'{1} Section Bridge When Cars Weight {car_weight} Units (Work =␣
 ↪{work:.5f})')
```

[5]:

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adj, xc, yc, length = build_basic_bridge()
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[6]:

```
def construct_force_vector(car_weight):
    force = np.zeros(8)
    for i in range(0,4,2):
        force[2*(i+1)-1] = -car_weight
    return force
```

[7]:

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force = construct_force_vector(0.01)
```

[8]:

```
def deform_basic_bridge(adj,xc,yc,length,force):
    dx = xc
    dy = yc
    matrix = np.transpose(adj)@np.diag(np.divide(1,length))@adj
    displacements = np.linalg.solve(np.transpose(matrix)@matrix+0.001*np.
 ↪eye(8),np.transpose(matrix)@force)
    #displacements = np.linalg.solve(matrix,force)
    X = displacements[::2]
    Y = displacements[1::2]
    work = np.transpose(displacements)@force

    # left
    dx[0] += [0,X[0]]
    dy[0] = yc[0]+[0,Y[0]]
    dx[1] = xc[1]+[0,X[1]]
    dy[1] = yc[1]+[0,Y[1]]

    #middle
    dx[2] = xc[2]+[X[0],X[1]]
    dy[2] = yc[2]+[Y[0],Y[1]]
    dx[3] = xc[3]+[X[1],X[3]]
    dy[3] = yc[3]+[Y[1],Y[3]]
    dx[4] = xc[4]+[X[0],X[2]]
    dy[4] = yc[4]+[Y[0],Y[2]]

    #right
    dx[-3] = xc[-3]+[X[2],X[3]]
    dy[-3] = yc[-3]+[Y[2],Y[3]]
    dx[-2] = xc[-2]+[X[3],0]
    dy[-2] = yc[-2]+[Y[3],0]
    dx[-1] = xc[-1]+[X[2],0]
    dy[-1] = yc[-1]+[Y[2],0]

    #last
    dx[-4] = xc[-4] + [X[1],X[3]]
    dy[-4] = yc[-4] + [Y[1],Y[3]]

    return dx,dy,work,X,Y
```

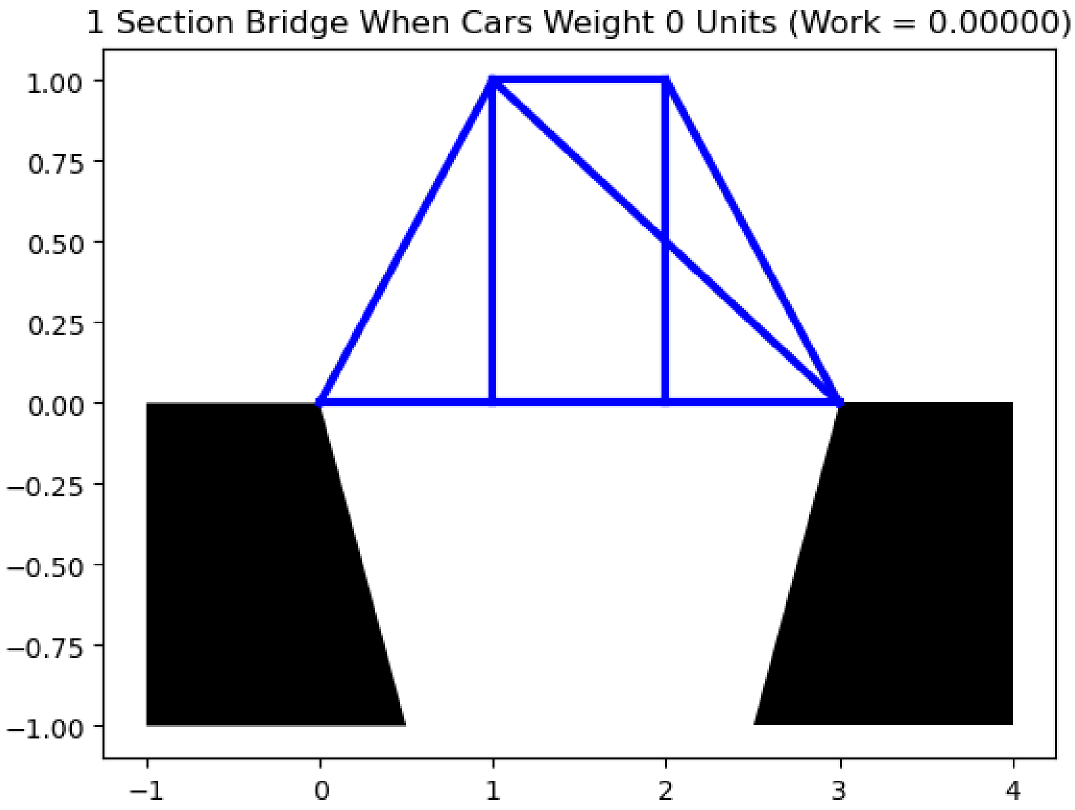
[9]:

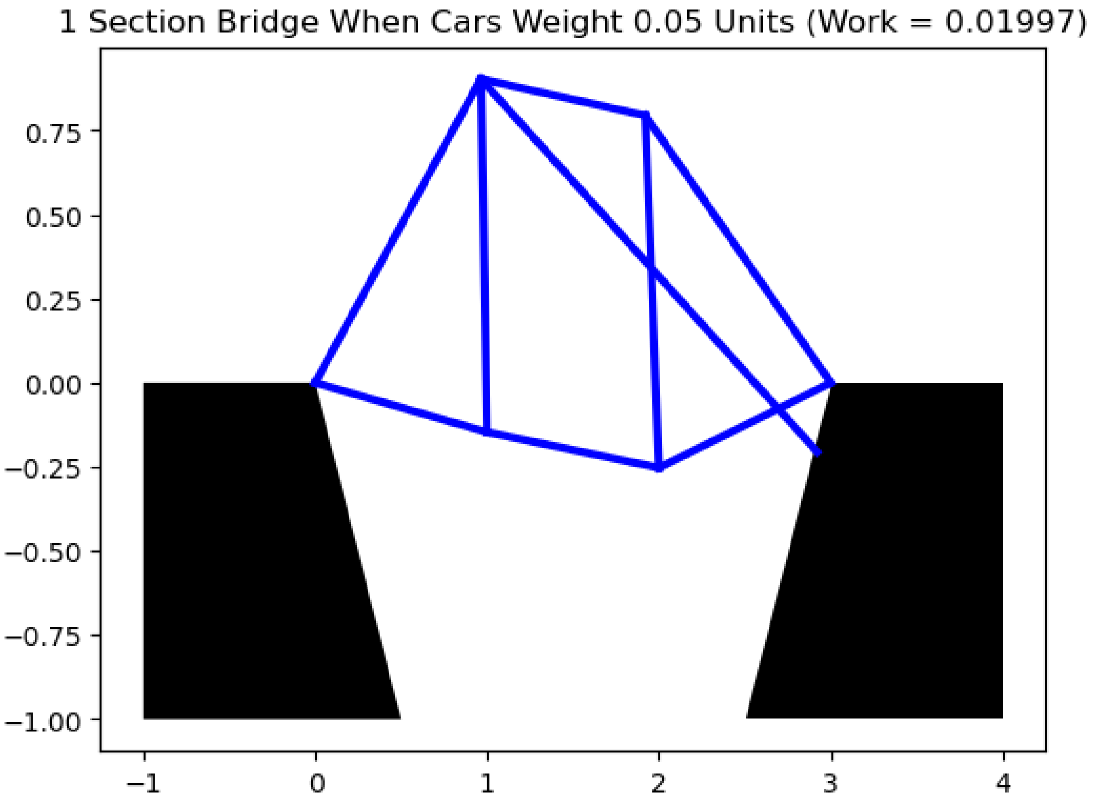
```
def build_load_plot_basic_bridge():

    adj,xc,yc,length=build_basic_bridge()
    for car_weight in [0,0.05]:
        force = construct_force_vector(car_weight)
        dx,dy,work,X,Y = deform_basic_bridge(adj,xc,yc,length,force)
        plot_bridge(dx,dy,car_weight,work)
```

[10]:

```
build_load_plot_basic_bridge()
```




1 Section Bridge When Cars Weight 0.05 Units (Work = 0.01997)
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75
−1.00
−1
0
1
2
3
4

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[ ]:
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