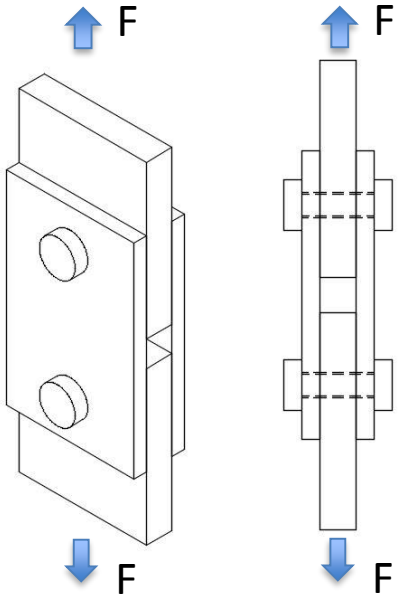
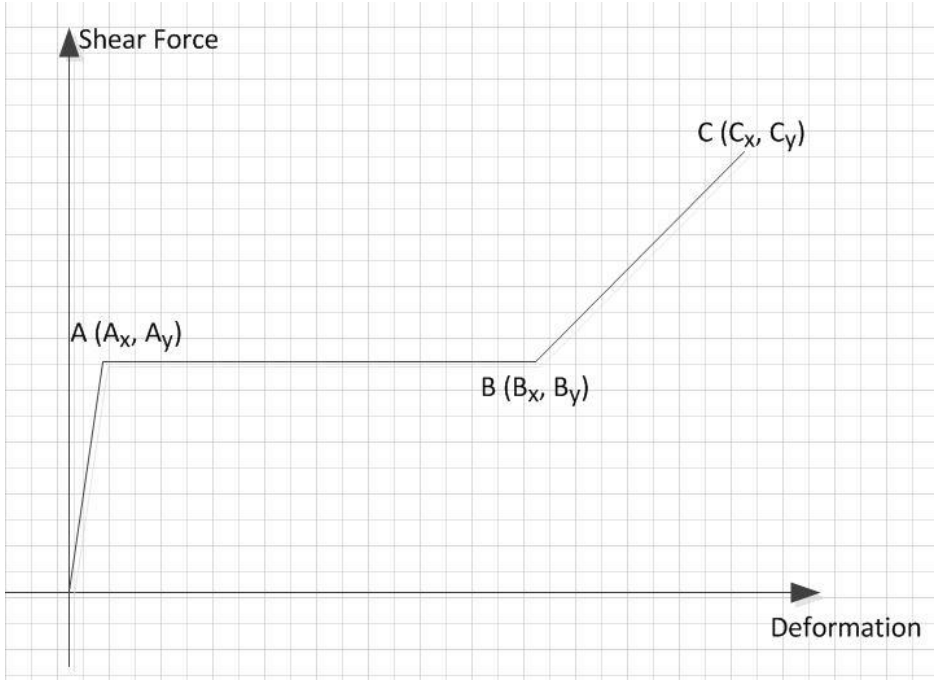
1. Simplified Analytical Model for Bolted Connections

Chenting Ding

Main Supervisor: A/Prof Yu Bai

1. Simplified Analytical Model for Bolted Connection



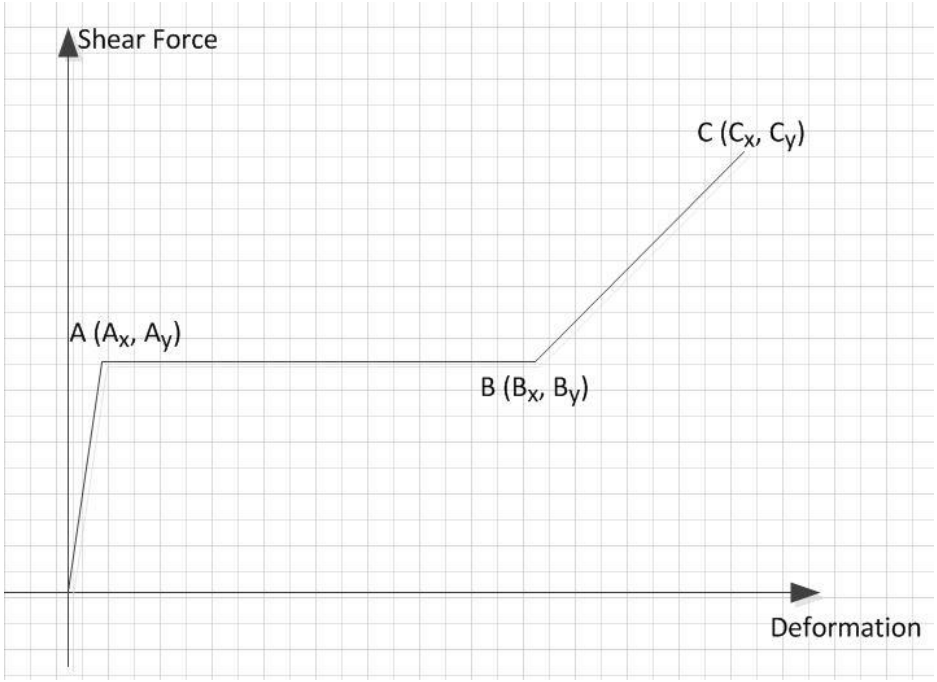


1. Simplified Analytical Model for Bolted Connection

2.1 Method for Determining Point A:

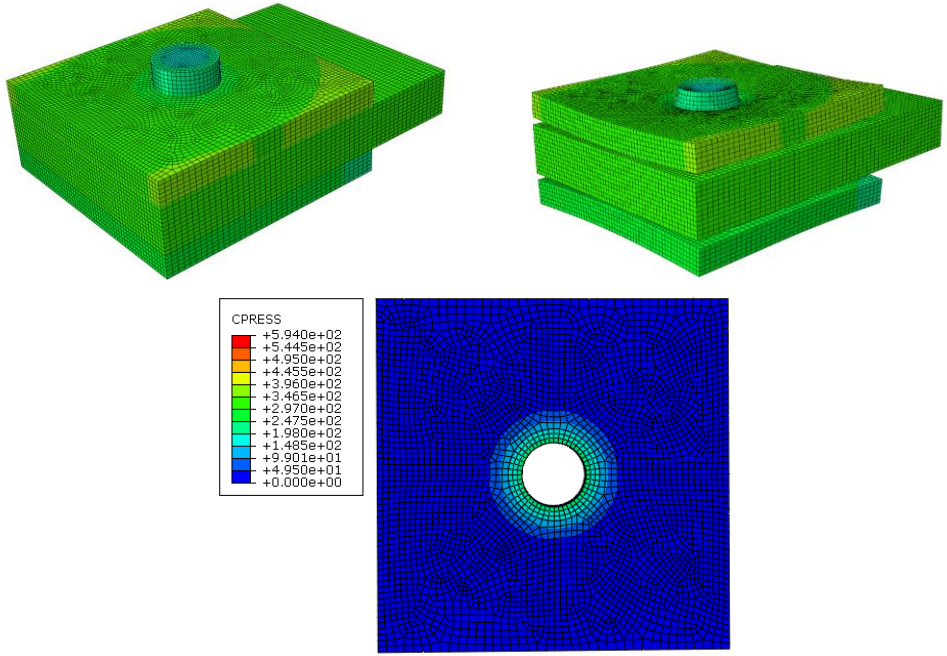
$$A_y = 2\mu N$$

$$A_x = 2A_y\left(\frac{l_p}{EA_1}\right)$$



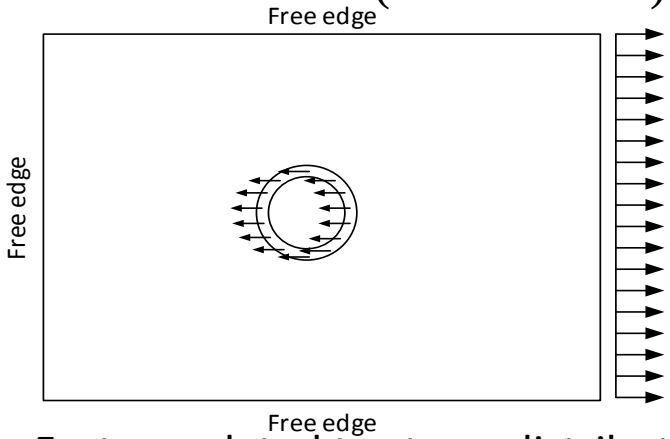
1. Simplified Analytical Model for Bolted Connection

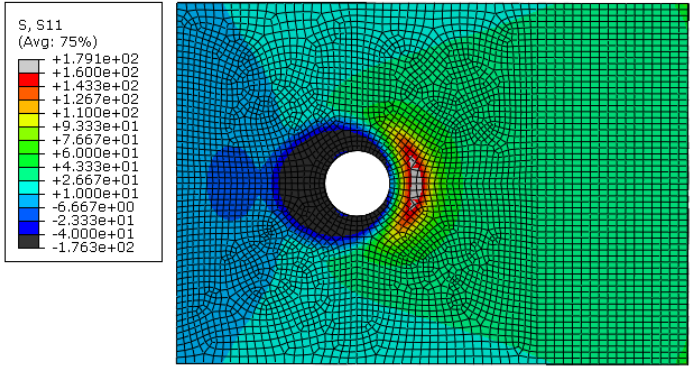
- The contact area



1. Simplified Analytical Model for Bolted Connection

- The stress field (under tension)





Factors related to stress distribution:

1. The external load
2. The ratio of plate width to hole diameter

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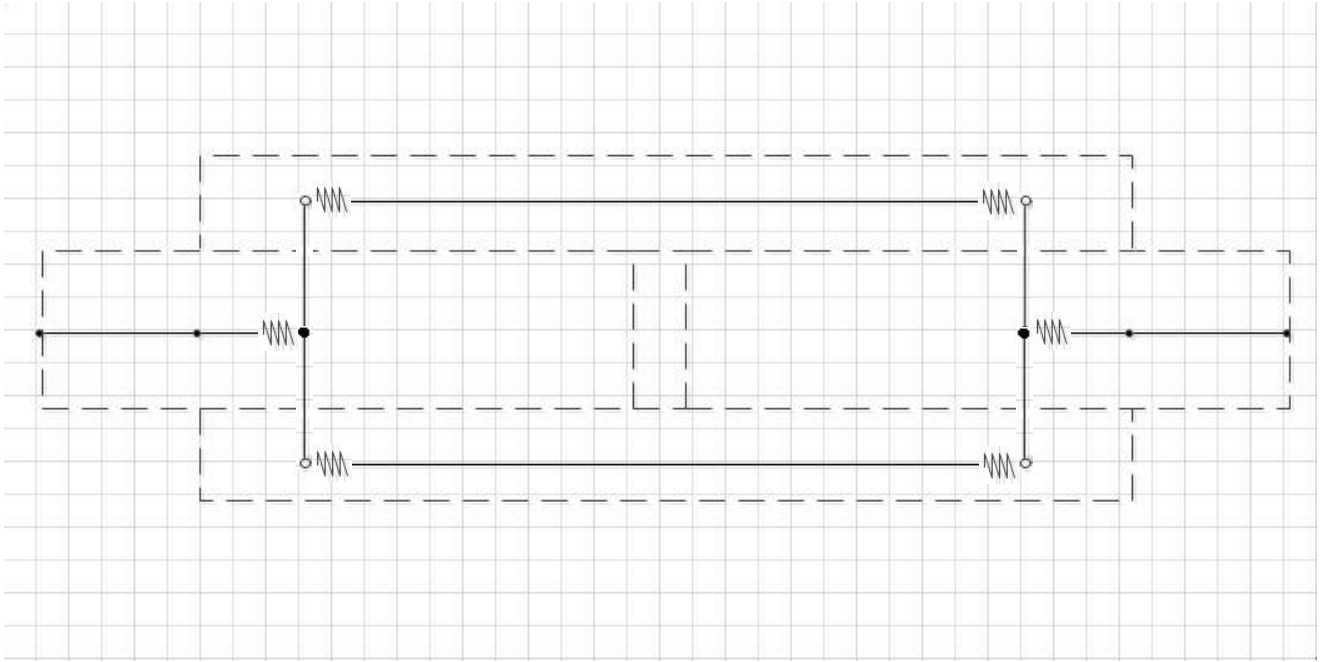
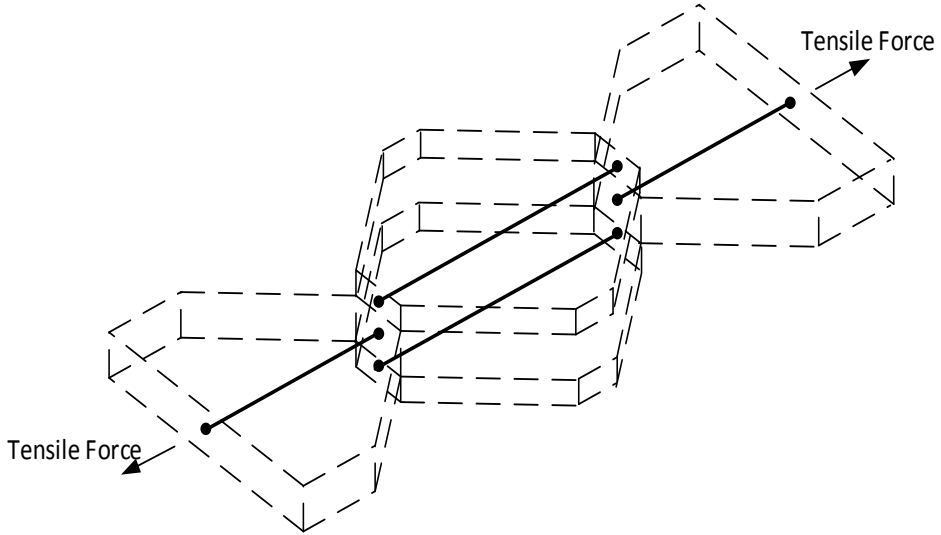


1. Simplified Analytical Model for Bolted Connection

- Model with non-prismatic beams



How to determine the area of cross section A(x)?

1. Simplified Analytical Model for Bolted Connection

- Simulation of a bolted connection with non-prismatic beam elements
- The axial displacement of a beam can be determined by:

$$u_x = \int_0^l \varepsilon(x)\ \mathrm{d}x$$

- The stress in a beam element:

$$\sigma(x) = E\,\varepsilon(x)$$

- Required cross section area in a beam element:

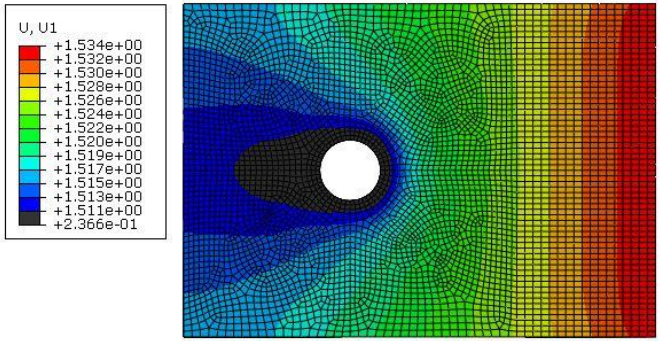
$$A(x) = \frac{F_x}{\sigma(x)}$$

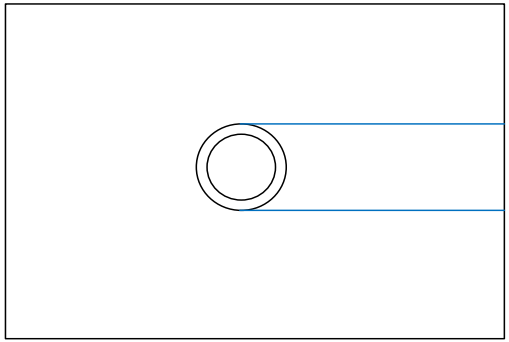
- Required cross section width in a beam element:

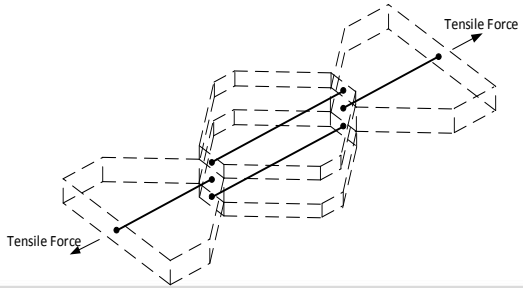
$$L(x) = \frac{A(x)}{t}$$

1. Simplified Analytical Model for Bolted Connection

- Displacement field







1. Simplified Analytical Model for Bolted Connection

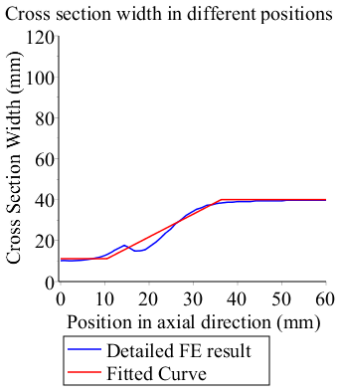
A series of detailed FE analysis are performed.

	Model1	Model2	Model3	Model4	Model5
Plate Width	40 mm	60 mm	80 mm	100 mm	120 mm
Hole Diameter	20 mm	20 mm	20 mm	20 mm	20 mm
Ratio of Plate Width to Hole Diameter	2	3	4	5	6

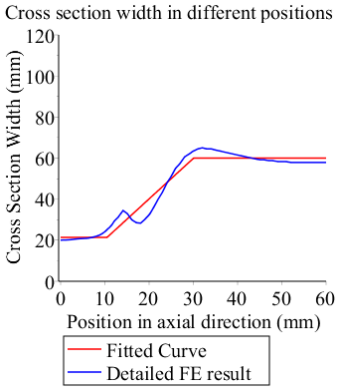
1. Simplified Analytical Model for Bolted Connection

K: Normalized plate width, which is the ratio of plate width to hole diameter

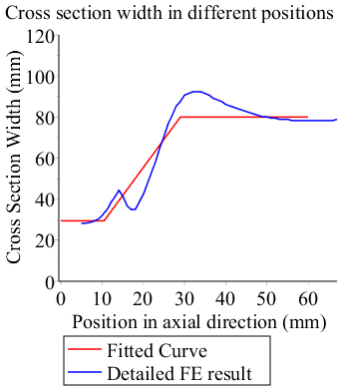
K=2



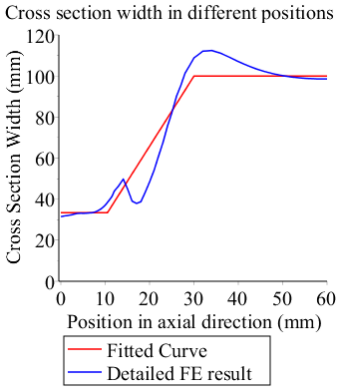
K=3



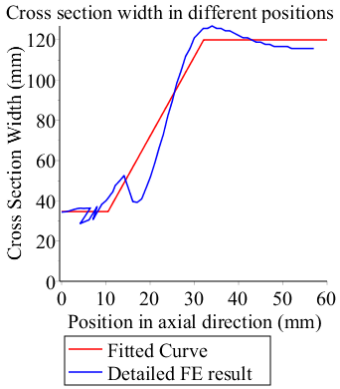
K=4



K=5



K=6



Two parameters to determine:

a_1: The value of normalized initial width, which is normalized by the hole diameter

a_2: The slope of increasing stage

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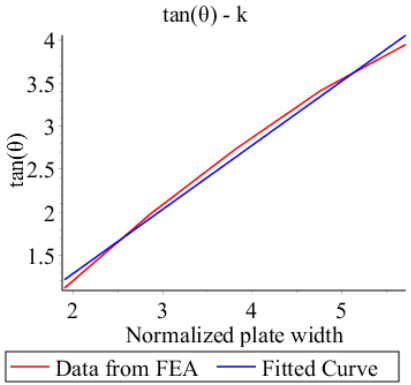

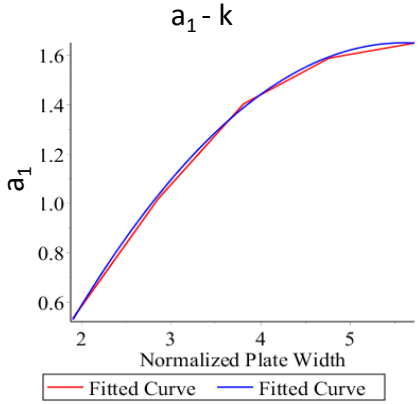

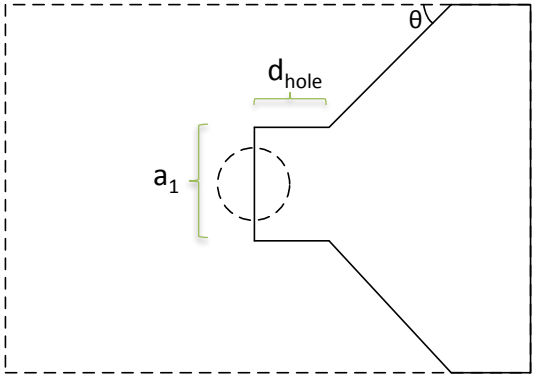

$a_2 = \tan(\theta) = -0.2031+0.7454*k$

$a_1 = -0.9324+0.9241*k-0.0826*k^2$

k: normalized plate width, which is normalized by hole diameter

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- Implementation of beams with variable cross sections in OpenSees

- Steel plates are modelled with Force-based beam column element
- Fiber sections are used.
- Integration method is “Fixed Location Integration”.

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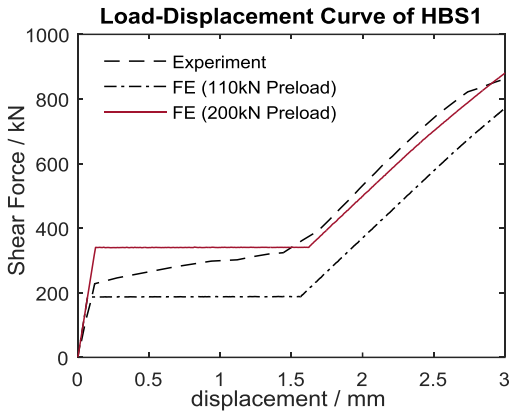

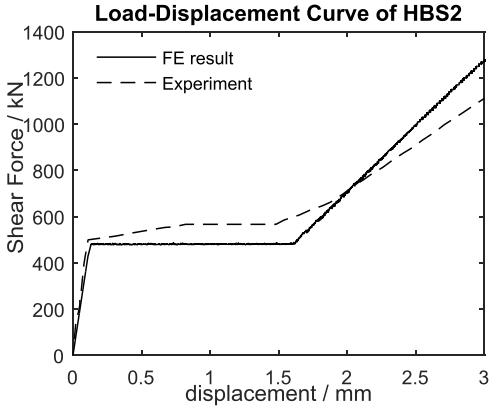

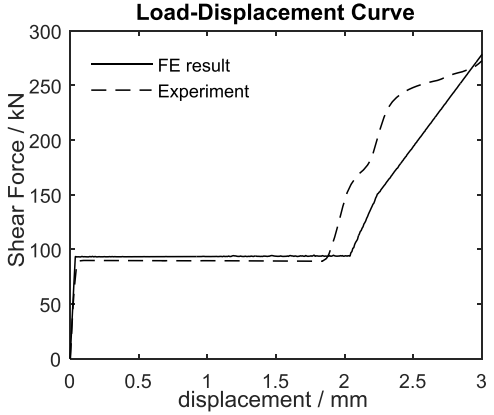

2.Experimental Test of Steel Beam – CFS tube column connection

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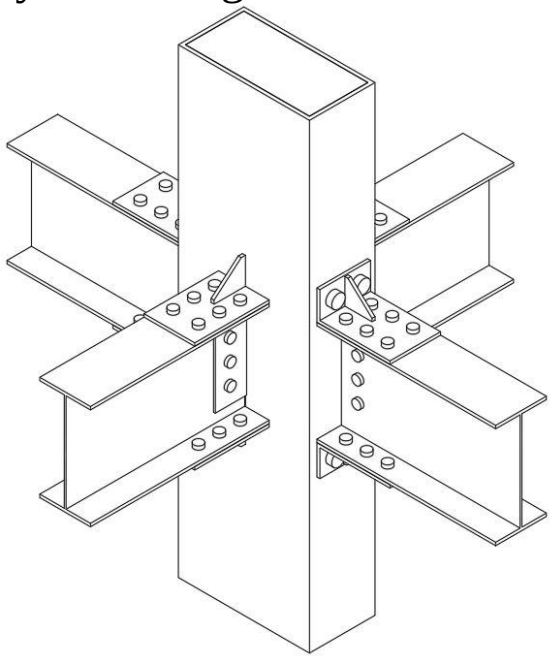
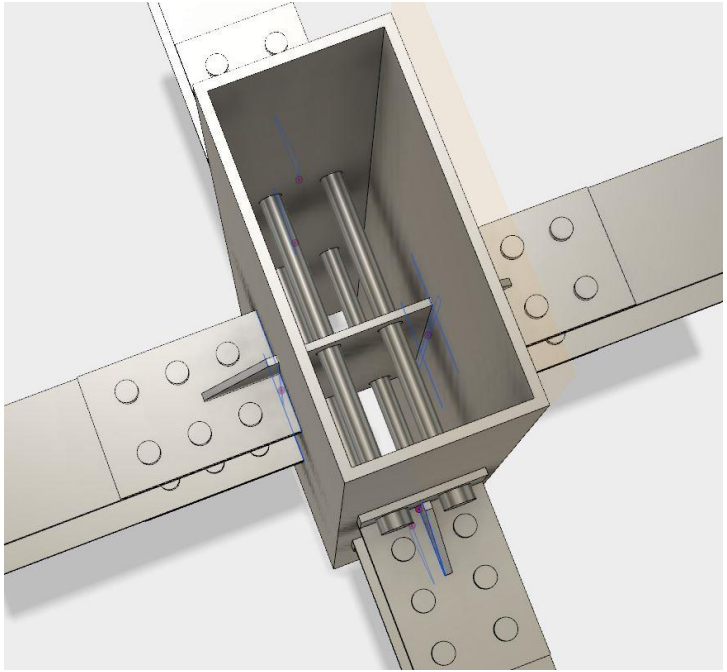
2.Experimental Test of Steel Beam – CFS tube column connection

- Traditional Steel Beam – CFS tube column connection
- Outer ring diaphragm Inner ring diaphragm

2.Experimental Test of Steel Beam – CFS tube column connection

- My new design





2.Experimental Test of Steel Beam – CFS tube column connection

- Experiment plan:
- 3 pairs of comparisons:
- 1. bending in x and y directions
- 2. monotonic and cyclic load
- 3. middle column and corner column