Ultimate anchorage capacity of concrete filled steel box connection as footing

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Objective

• To eliminate the shear key in hybrid composite structures.
• To replace those connection which is heavily reinforced (steel reinforcements are very congested).
• To speed up the construction time and make the structure more environment friendly by reducing the noise and labor work. (Precast structure and no form work and shear connector are required)
Last presentation

Effect of steel box tube thickness

Due to cracking, stiffness changes.

Stiffness remains same prior to cracking.
Axial anchorage capacity of CFSB footing

Specimen details

CFT column
74 x 74 mm
t = 9 mm

Displacement transducer

S = Concrete depth under the column
For S_37, S = 37 mm
For S_106, S = 106 mm

Top view

Lateral view

Axial anchorage capacity of CFSB footing

Material properties

<table>
<thead>
<tr>
<th>Concrete strength (N/mm²)</th>
<th>Column yield strength (N/mm²)</th>
<th>Box yield strength (N/mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>331</td>
<td>267</td>
</tr>
</tbody>
</table>

One quarter specimen was analyzed in order to reduce the analysis time
Axial anchorage capacity of CFSB footing

Comparison of experimental and analytical results

Axial anchorage capacity of CFSB footing

Comparison of experimental and analytical results
Axial anchorage capacity of CFSB footing

Comparison of experimental and analytical results

- Experimental (S_37)
- Experimental (S_106)
- Analytical (S_37)
- Analytical (S_106)

Shows good agreement in terms of ultimate load, but post peak part of the experimental specimen is very ductile.

This is probably because of the extensive local bending deformation of bottom steel plate took place underneath the column, which cannot be simulated by the FEM ignoring geometrical nonlinearity.

Axial anchorage capacity of CFSB footing

Before test

After test
Axial anchorage capacity of CFSB footing

Failure Mechanism

- Crushing of concrete under the column is the dominant factor for the failure of the both specimens
- Stress-strain relationship at the gauss point 7 mm away from the column bottom show compression softening

Stress-strain
relationship at the
gauss point
7 mm away from the
column bottom show
compression softening
Axial anchorage capacity of CFSB footing

Axial capacity of the connection decreases with the decrease of the concrete depth under the column. This is due to reduction of peak stress.

The peak stress decreases with the decrease in the concrete depth is due to the increase in tensile strain in the direction normal to the peak compressive stress.

Connection between concrete filled steel box and column

Column dimensions = 200 x 200
Steel thickness of CFT = 10 mm
Steel box thickness = 10 mm

Boundary condition
Fixed at bottom

Half of the specimen was analyzed in order to reduce the analysis time.
Effect of insertion length

<table>
<thead>
<tr>
<th>Specimen</th>
<th>Insertion length (mm)</th>
<th>Box width (mm)</th>
<th>Box tube thickness (mm)</th>
<th>Concrete strength (MPa)</th>
<th>Column length (mm)</th>
<th>Column size</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>160</td>
<td>800</td>
<td>10</td>
<td>24</td>
<td>800</td>
<td>200 x 200</td>
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<td>2</td>
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<td>10</td>
<td>24</td>
<td>800</td>
<td>200 x 200</td>
</tr>
<tr>
<td>3</td>
<td>210</td>
<td>800</td>
<td>10</td>
<td>24</td>
<td>800</td>
<td>200 x 200</td>
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<tr>
<td>4</td>
<td>260</td>
<td>800</td>
<td>10</td>
<td>24</td>
<td>800</td>
<td>200 x 200</td>
</tr>
</tbody>
</table>

- Peak load increased with increase of insertion length
- This increase of peak load is because of increase of resistive moment

Effect of insertion length

\[ F = R_1 - R_2 \]
Effect of insertion length

\[ F = R_1 - R_2 \]

\( R_1 \) is increasing with increase of insertion length because bearing area is increasing.
Effect of insertion length

\[ F = R_1 - R_2 \]

- Moment arm is increasing with the increase of insertion length
- \( R_1 \) is increasing with increase of insertion length because bearing area is increasing

Effect of concrete strength

<table>
<thead>
<tr>
<th>Specimen</th>
<th>Concrete strength (MPa)</th>
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<tr>
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</tbody>
</table>

- Peak load increased with increase of concrete strength
- This increase of peak load is because of the increase in peak stress with the increase in concrete strength
### Effect of column size

<table>
<thead>
<tr>
<th>Specimen</th>
<th>Column size (mm)</th>
<th>Box width (mm)</th>
<th>Box tube thickness (mm)</th>
<th>Concrete strength (MPa)</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>150 x 150</td>
<td>800</td>
<td>10</td>
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<td>3</td>
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<td>24</td>
<td>800</td>
<td>210</td>
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</tr>
</tbody>
</table>

Peak load increased with increase of column size.

This increase of peak load is because of the increase in bearing area of concrete where crushing in compression takes place.

### Effect of box width

<table>
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<tr>
<td>1</td>
<td>400</td>
<td>210</td>
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Peak load remains almost same with the variation of box width.
### Effect of box tube thickness

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Peak load increased with increase of box tube thickness

Due to better confinement, peak stress is increased and as a result ultimate capacity increased

### Effect of column length

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<td>1600</td>
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For longer pile length, failure (concrete crushing around the column) takes place due to moment and constant moment cause the failure

For shorter pile length, failure (concrete crushing around the column) takes place due to shear.
Conclusions

• The axial anchorage capacity is controlled by the compression softening of the concrete under the column, while the moment anchorage capacity is controlled by the compression softening of concrete around the column.

• The axial capacity decreases with the decrease of concrete depth under the column. This decrease in axial capacity is due to the reduction of concrete peak compressive stress under the column. This reduction of peak stress is due to increase of tensile strain in the direction normal to the compressive stress.

• The moment capacity increases with the increase of column insertion length. This increase of capacity is due to increase of resistive moment provided by the surrounding concrete. Resistive moment increased due to increase of moment arm and resistive force provided by surrounding concrete. Moment arm and resistive force increased due to increase of insertion length.

Conclusions

• The moment capacity increases with the increase of concrete strength. This increase of capacity is due to increase of concrete crushing stress (peak compressive stress) as the resistive moment.

• The moment capacity increases with the increase of column size. This increase of capacity is due to increase of bearing area of the surrounding concrete.

• The moment capacity increases with the increase of box thickness. This increase of capacity is because of the increase of confinement level of concrete surrounding the pile.