Objective:

1. To study the effect of support conditions on the load carrying capacity of a slender column.

2. To compare the experimental buckling loads $P_{cr}$ of test specimens with those predicted by the Euler equation.

Apparatus:

SM105 strut apparatus, mild steel specimen (20 x 3 x 600 mm approx.)

Theory

Buckling load for a slender column with:

(1) **Pinned at both Ends**
Buckling load, $P_{cr} = \frac{\pi^2 EI}{L^2}$

(2) **Fixed at both Ends**
Buckling load, $P_{cr} = \frac{4\pi^2 EI}{L^2}$

(3) **Pinned at one End and Fixed at the other End**
Buckling load, $P_{cr} = \frac{2\pi^2 EI}{L^2}$

where $E$ is the Modulus of Elasticity
I is the minimum moment of inertia of the column section.
L is the height of the column.

* Given that the modulus of elasticity $E$ of specimen is $200 \times 10^3$ N/mm$^2$. 
**Experimental Procedures**

(Determination of buckling loads for various end conditions)

(A) **Pinned Supports at Both Ends**

1. Select the required slender column sample and adjust the rear specimen beam to the correct position and insert the dowel pins.

2. Measure the length by ruler and cross-section of the specimen by venier caliper. Record the measured dimensions in table 1.

3. Insert the specimen with its ends in the Vee shape specimen holders to simulate pinned end conditions. It may be necessary to unscrew the loading knob to reduce the load to zero after the specimen is inserted.

4. Adjust the position of the central cross member so that the dial gauge foot (ball end) rests on the centre-line of the specimen at mid-span.

5. By using the load cell, apply a load “P” to the specimen and ensure that the deflection “δ” is away from the dial gauge. If the deflection “δ” is towards the dial gauge, remove the load, turn the specimen over and reload.

6. Apply load “P” by increments, tapping the dial gauge stem very gently whilst applying the load and record the load and dial gauge reading “δ” for each increment of load in table 2.

(B) **Fixed Supports at Both Ends**

1. Repeat the above procedures for the fixed supports.

2. Record the results in table 1 & 3 as appropriate.

(C) **Pinned Support at One End and Fixed Support at the Other End**

1. Repeat the above procedures for the support conditions as stipulated in (C)

2. Record the results in table 1 & 4 as appropriate.
Results:
1. Test Data

<table>
<thead>
<tr>
<th>Table 1 – Dimensions of Specimens</th>
<th>Length L (mm)</th>
<th>Width W (mm)</th>
<th>Thickness t (mm)</th>
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</thead>
<tbody>
<tr>
<td>Specimen 1</td>
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<td>Specimen 2</td>
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<td>Specimen 3</td>
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<thead>
<tr>
<th>Table 2 – Pinned Ends</th>
<th>20</th>
<th>40</th>
<th>60</th>
<th>80</th>
<th>100</th>
<th>120</th>
<th>140</th>
<th>160</th>
<th>180</th>
<th>200</th>
<th>220</th>
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<tbody>
<tr>
<td>Load “P” (N)</td>
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<tr>
<td>Deflection “δ” (div)</td>
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<thead>
<tr>
<th>Table 3 – Fixed Ends</th>
<th>50</th>
<th>100</th>
<th>150</th>
<th>200</th>
<th>250</th>
<th>300</th>
<th>350</th>
<th>400</th>
<th>450</th>
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<tr>
<td>Load “P” (N)</td>
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<td>950</td>
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<td>Deflection “δ” (div)</td>
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<tr>
<th>Table 4 – One End Pinned and the Other End Fixed</th>
<th>30</th>
<th>60</th>
<th>90</th>
<th>120</th>
<th>150</th>
<th>180</th>
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<td>Deflection “δ” (div)</td>
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<td>Load “P” (N)</td>
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<td>Deflection “δ” (div)</td>
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</table>
2. **Graphical Presentation of Test Data**
   a) Plot a graph of applied load “P” (N) against the lateral deflection $\delta$ (in div.) of each specimen for the complete test.
   Hint: P as y-axis and $\delta$ as x-axis.
   b) Determine the buckling load $P_{cr}$ from the graphs.

**Discussion of Results**
1. Calculate the theoretical buckling load $P_{cr}$ of each specimen by using the Euler equation given.
2. Compare the theoretical and experimental values of the buckling loads obtained.
3. Discuss the effects of end conditions on the buckling load.
4. Discuss the errors involved in this experiment and make suggestions for improvement.

**Laboratory Report**
1. Each student shall submit his / her laboratory report which includes the following items:
   (a) Name of Test
   (b) Objectives of Test
   (c) Test Data
   (d) Test Data presented in Graphical Form.
   (e) Buckling load $P_{cr}$ of each specimen obtained from experiment.
   (f) Theoretical buckling load $P_{cr}$ of each specimen obtained by using Euler formula.
   (g) Comparison of the theoretical and experimental buckling loads.
   (h) Discussion of the effects of end conditions on the buckling load.
   (i) Discussion on the errors involved and suggestions for improvement.
2. Hand in the report on / before ______________.

![Schematic diagram for the set-up](image-url)