Practice

5

Experimental Analysis of critical loads in columns

NAME	
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LAB GROUP	
TEACHER	
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QUIZ	15%	
PARTICIPATION AND PRESENTATION REPORT	5%	
ANNOTATIONS	5%	
CALCULATIONS	10%	
RESULTS	20%	
DISCUSSION OF RESULTS	15%	
QUESTIONS	15%	
CONCLUSION	15%	
TOTAL	100%	

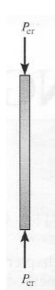
OBJECTIVE

- The student will determine experimentally the critical loads that cause the failure of structural elements known as columns.
- Columns with different cross-sections will be subjected to an axial compression load using the universal machine.
- Will determine the values of the critical loads and compared the experimental results with the analytical results.

FUNDAMENTS

The columns are long and thin structural elements that are characterized by being subjected to axial loads of compression. Like other structural elements, the columns must meet certain security requirements such as strength and stability. However, axial compression loads on long and thin structural elements causes them to have some lateral deflection (figure 1b). This deflection is the way that columns fail and this type of failure is known as buckling.

The buckling is characterized by sudden sideways deflection of a structural member. This may occur even through the stresses that develop in the structure are well below those needed to cause failure of the material of which the structure is composed. The buckling is a very important concept to consider in a building construction due to the instability of a column and as consequence a dramatic failure capable of collapsing it.



(a)

(b)

Figure 1.- Definition of the structural element known as column (R.C. Hibbeler, 2011)
(a) The column does not suffer buckling if $P=P_{cr}$. **(b)** The column suffers buckling when $P>P_{cr}$.

It is very important to know the maximum compression load which can be applied to such an element without the buckling phenomenon occurring since it tells us how is the stability limit in a column.

This limit load is known as the critical load, P_{cr} (Figure 1a). Any additional load to P_{cr} will cause a deflection in the column as seen in Fig. 1b. Therefore, the following can be affirmed:

- If the load applied to the column is lower than critical load ($P<P_{cr}$) so, the column will be considered stable
- If the load applied to the column is higher than critical load ($P>P_{cr}$) so, the column will be considered unstable.
- If the load applied to the column is same than critical load ($P=P_{cr}$) so, the column will be considered in neutral equilibrium.

The value of the critical load (P_{cr}) is obtained through the solution of the differential equation relating the internal moment of the column with its deflection

$$EI\frac{d^2v}{dx^2}=M(x) \quad \textbf{(1)}$$

To solve the Ec. **(1)** it's important to know the internal moment of the column *M(x),* the next step consist in solver the differential equation until to get the function to represent the deflection (v) of the column. This function will require some integration constants, which are obtained through the boundary conditions that correspond to the type of columns end conditions.

After solving Eq. (1) we obtain the following equation, known as the Euler equation (in honor of the Swiss mathematician Leonhard Euler, who solved this problem in 1757), which determines the critical load P_{cr} as

$$P_{cr}=\frac{\pi^2 EI}{L^2} \quad \textbf{(2)}$$

The solution of **(1)** will be different for each type of subjection. However, the expression works to get the critical load and can be write and the constant K depends of type of subjection column:

$$P_{cr}=\frac{\pi^2 EI}{(KL)^2} \quad \textbf{(3)}$$

Types of Columns End Conditions	Theoretical K-Value
Pinned – Pinned	1
Fixed – Pinned	0.7
Fixed - Fixed	0.5
Fixed - Free	2

Table 1. Theoretical K-Value at different types of columns end conditions.

MATERIAL

- Aluminum Columns (E=0.71E6 kg/cm^2) with different section area.
- Vernier and Flex meter.
- Universal Machine UNITED.
- Supports for columns.

ANNOTATIONS

CALCULATIONS

RESULTS

1. For both columns complete:

Columna 1 b= h= L=		
Experimental P_{cr} [kg_f]	Analytical P_{cr} [kg_f]	% Error

Columna 2 b= h= L=		
Experimental P_{cr} [kg_f]	Analytical P_{cr} [kg_f]	% Error

DISCUSSION OF RESULTS

QUESTIONS

1. Mention three ways to increase the value of the critical load in columns.

2. Two columns of equal dimensions but different material, will have the same critical load? Explain your answer.

3. Which of the following conditions does the critical load value produces greater change: when the width of the column increases to double or when the thickness increases to double. Explain why.

CONCLUSIONS AND REFERENCES