Beam incorporated column

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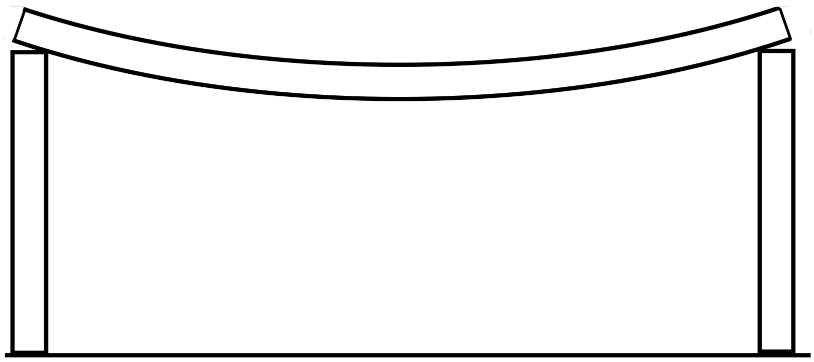
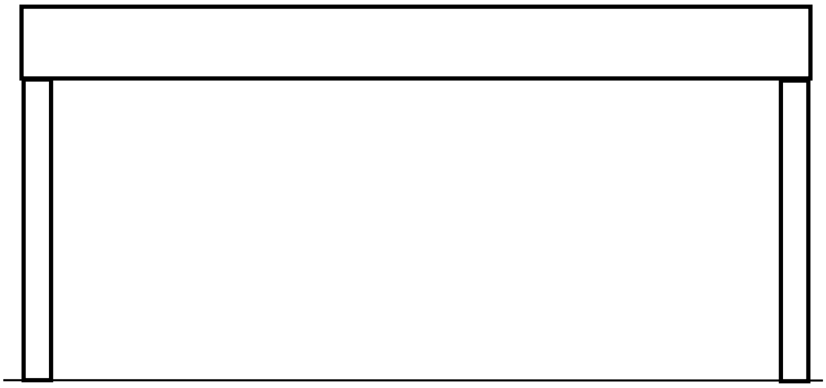
1. Common techniques for large span beams

1.0 Introduction

For large spans between two successive columns, the beam deflects to an unacceptable level.



1.1 First solution: a higher beam



The formula for calculating the maximum deflection of a beam under load is one of the most important formulas in engineering.

Δ = (q*L^4)/384*E*I for fixed beams.
Δ = 5(q*L^4)/384*E*I for simply supported beams.

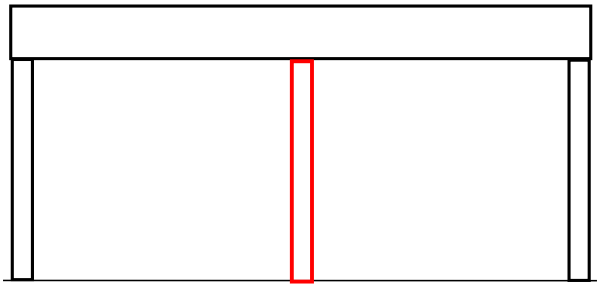
Where **Δ** is the maximum deflection at the midpoint of the span, **q** is the load per unit length, **L** is the span, **E** is the modulus of elasticity, and **I** is the moment of inertia of the beam.

The moment of inertia **I** is itself given by the formula:

I = (bh^3)/12
Where **b** is the width and **h** is the height of the beam. For example:

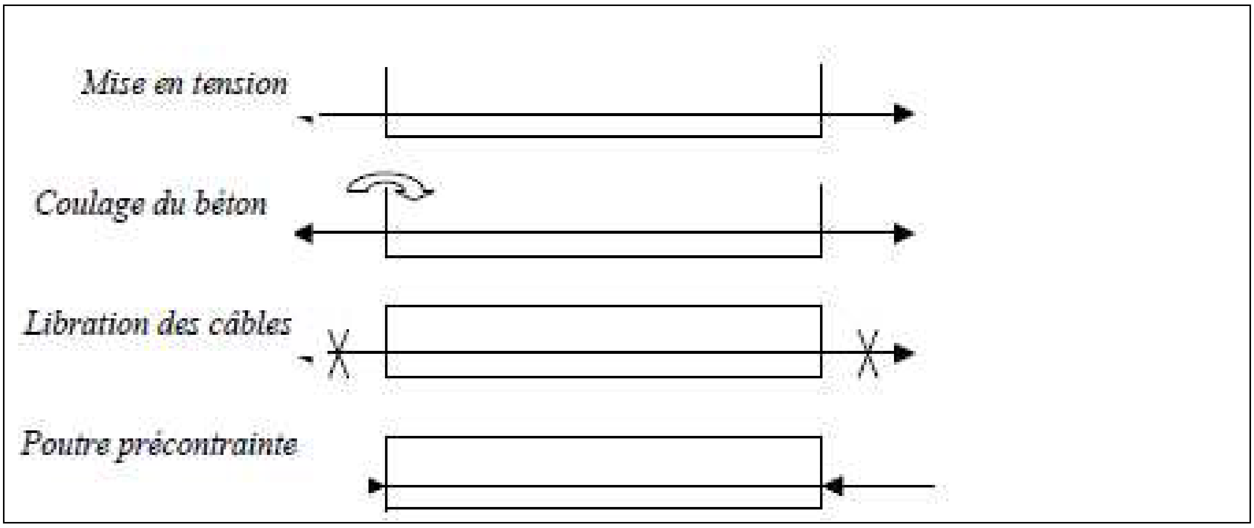
For a beam with a cross-section of 20x20 cm, the moment of inertia is 20x(20x20x20)/12 = 13.333
And for a beam with a cross-section of 20x30 cm, the moment of inertia is 20x(30x30x30)/12 = 45.000
Therefore, increasing the beam height by 1.5 times results in a 3.5-fold decrease in deflection.
This solution works to a certain extent, as it increases the overall dimensions, dead weight, and volume of the materials used.

1.2 <u>Second solution: intermediate column</u>



This is the simplest solution, but it has a major drawback: it significantly disrupts the interior design.

1.3 <u>Third solution: prestressed concrete</u>

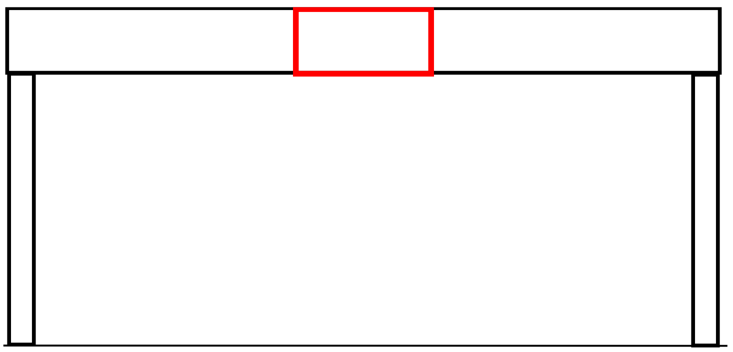


In reinforced concrete, the tension on the underside of the beam resulting from the load is absorbed by the reinforcement. It should be noted that while in reinforced concrete, steel is called "rebars," in prestressed concrete, it is called "tendons." Reinforcement and tendons differ in composition, operating mode, performance, cost, etc.

In prestressed concrete, the concrete absorbs both compressive forces on the upper surface of the beam and tensile forces on the lower surface. The tendons are responsible for enabling it to do so, through the strong compression it exerts.
Thanks to this complex and delicate process, the spans between supports increase considerably.
Prestressed concrete is widely used in bridge construction, among other applications. In the residential sector, it is primarily used in the manufacture of beams for slabs and for pre-concrete slab elements.

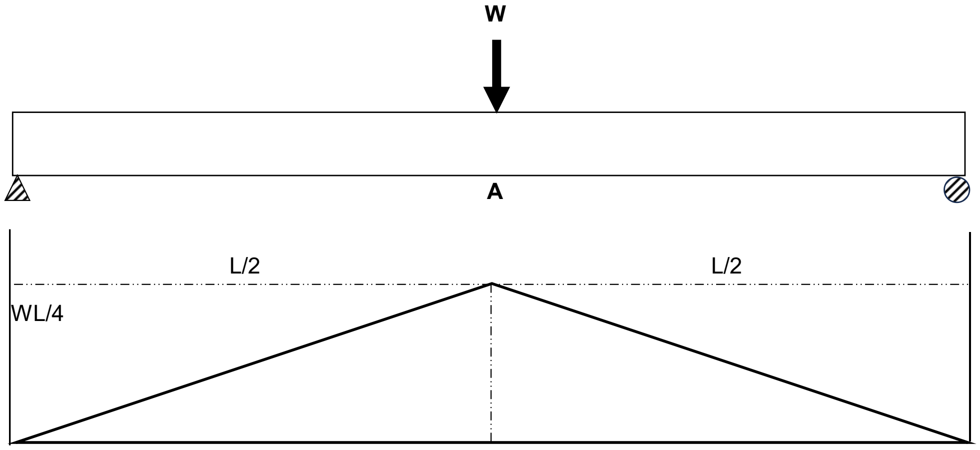
2. The new technique: beam incorporated column

2.1 How it works



The new method developed by Precast-First to achieve a long span consists of reinforcing the beam in its middle so that it cannot break in this area.

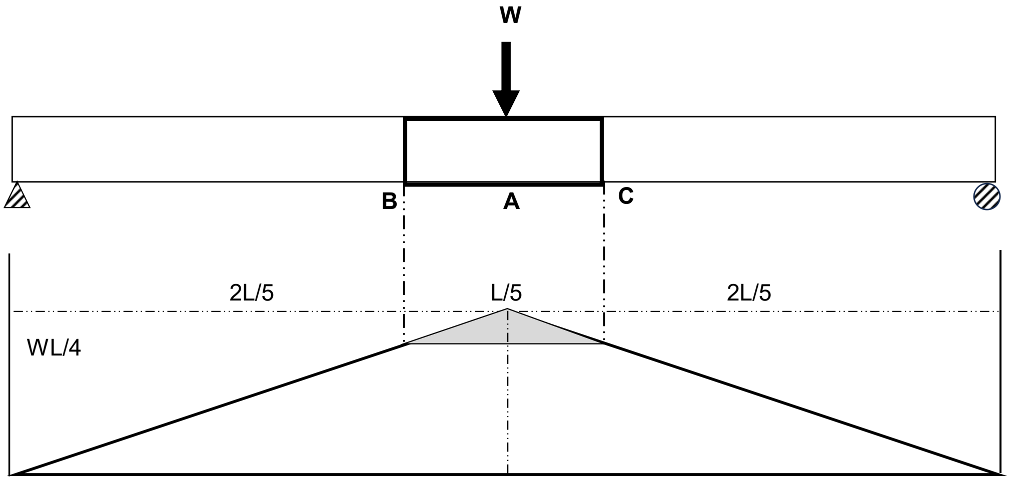
The principle was inspired by the bending moment diagram of a simply supported beam.



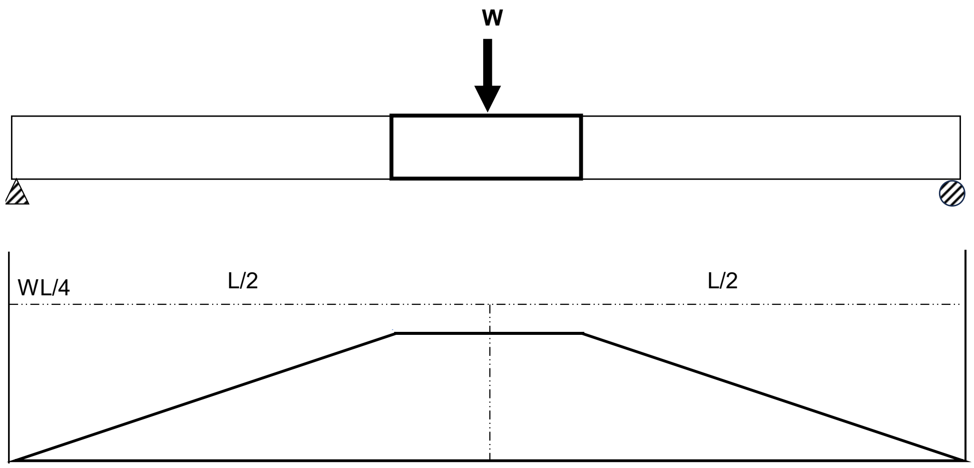
The bending moment diagram is a triangle.

The maximum deflection occurs at mid-span. If the beam is overloaded, the probability of failure occurring in point A is 100%.

One can be tempted to reinforce the mid-span area in tension and in compression, to the point of making it unbreakable. Then probability of failure occurring in point A becomes 0%.



If failure doesn't occur in point A anymore, then it will be in two locations, at both ends of the reinforcement. Breaking a beam in two locations requires a double load comparatively to breaking it in one location. It means that capacity of the beam is therefore doubled.



The bending moment diagram of a beam with an unbreakable mid-span area is a truncated triangle, or trapezoid.

2.2 Conclusion

i) Making beam's mid-span unbreakable doubles its capacity.
ii) The deflection is reduced proportionally to the length of the unbreakable area.

2.3 **Confirmation Tests**

2.3.1 Conventional beam test

A standard beam measuring 20 x 20 x 480 cm was subjected to bending. The supports were spaced 4 m apart. A concentrated load was applied at mid-span.
The load and corresponding deflection were recorded until the specimen failed.

		
Light Load	Heavy Load	Failure occurs in one place: at mid-span.

2.3.2 Fabrication of a beam incorporated column

Un example of horizontal column: 75 cm metal frame, made of a 50 x 50 x 5 mm angle bar.

2.3.3 Testing a beam incorporated column

A beam manufactured as above was subjected to bending until failure.

		
The central zone does not bend.	Failure occurred in two locations: at both ends of the reinforcement.	

2.3.4 Test Results

Poutre normale 20x20x480		Poutre blindée au mileu	
23/11/2024		10/01/2025	
Force kgf	Flèche - cm	Force kgf	Flèche - cm
500	0.50		
750	1.00		
1 000	2.00		
1 250	**3.00**		
1 500		1 520	2.50
1 750		1 750	3.00
2 000		2 010	4.00
2 250		**2 250**	*5.00*
2 500		2 300	

3. Conclusion

3.1 Horizontal column doubles beam's flexural strength, effortlessly comparatively to alternatives.
3.2 Horizontal column reduces the maximum deflection proportionally to its length.

4. Implication for construction codes

4.1 Construction codes adjustment for maximum deflection and buckling height.
Construction codes will need to adjust the maximum deflections for beams, and the buckling height for columns.
For a 4 m beam, for example, some codes recommend a maximum deflection of 1/300, or 400/300 = 1.3 cm. It is a key factor in structural design.
Deflection limitation is dictated by the need to keep a safety factor from the elastic limit of the material on the stress/strain diagram.
With beams incorporated columns, this risk is reduced by 50%. The safety conditions would therefore be the same for a conventional beam designed for a maximum deflection of L/300 on one hand, and for a beam incorporated column designed for a maximum deflection of L/200, on the other hand. In the example of a 4m beam, the maximum deflection would be 2cm instead of 1.3cm.
It results in substantial advantages regarding architectural design and construction cost.

4.2 Adjusting the modulus of elasticity value for beams incorporated columns.
The formula for calculating maximum deflection: **Δ = (q*L^4)/384*E* I**
Factors in the numerator contribute to increasing the deflection, and the elements in the denominator contribute to reducing it.
The moment of inertia **I** depends on the geometric shape of the beam and therefore cannot be influenced by horizontal columns.
However, the modulus of elasticity or Young's modulus **E** can increase if the beam's stiffness increases. In some building codes, **E = 5000 fc^0.5**, while in others, **E = 5375 fc^0.5**, with **fc** being the compressive strength of concrete.
There is a factor that depends on the compressive strength of concrete, and a fixed coefficient that is not identical for all building codes.
As an alternative to increasing maximum deflection value in codes, increasing this coefficient would have the same effect. For example, E = 7000 fc^0.5 instead of E = 5000 fc^0.5, and E = 7375 fc^0.5 instead of E = 5375 fc^0.5.
This alternative is simpler to implement.

5. Patent pending

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Title of Invention

Horizontal columns and vertical beams

Application Information

APPLICATION TYPE	Utility - Nonprovisional Application under 35 USC 111(a)	PATENT #	-
CONFIRMATION #	6573	FILED BY	Libere Nitunga
PATENT CENTER #	74562045	FILING DATE	-
CUSTOMER #	204278	FIRST NAMED INVENTOR	Mr. Libere Nitunga
CORRESPONDENCE ADDRESS	-	AUTHORIZED BY	-

Documents

TOTAL DOCUMENTS: 5

DOCUMENT	PAGES	DESCRIPTION	SIZE (KB)
generatedADS74562045.pdf	5	Application Data Sheet	112 KB
260222_Patent_Application_ Transmital_aia0015.pdf	2	Transmittal Letter	413 KB
260222 Horizontal columns Specification-SPEC.docx	6	Specification	21 KB
Warning: The automatic document description has been replaced.			
260222_Horizontal_columns _Drawings.pdf	2	Drawings-only black and white line drawings	84 KB
260222_Horizontal_columns _Specification.pdf	6	Specification	117 KB