

Thermal analysis of cantilever beam

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Abstract—

Structural and modal analysis of carbon steel members exposed to heat loading is the focus of this research. Both the cantilever and fixed-end components undergo theoretical stress and deflection calculations. The effect of deflection and stress on members with varying cross sections but the same cross section area has been investigated as well. Heat stresses and deformations caused by limited mechanical forces are often overlooked while designing structural components. When it comes to mechanical parts, temperature changes may have an impact. In this study, the effects of temperature change on structure are explored.. As it becomes hotter, the material swells, which might affect its structural performance. If you don't take into consideration the effects of limited settings, you might end up with dangerous designs. The structural performance of constructions that are exposed to high temperatures is significantly impacted by this. The major goal of this inquiry is to analyse beam deflection and stress. ANSYS is used to do feasibility studies, which are then compared to outcomes from real-world tests. As the temperature rises, ANSYS is used to investigate how this impacts the structure's mode shape and frequency.

INTRODUCTION

Deflection, Mode, Mode shape, and Modal analysis are all included in the index. The expansion of a material due to thermal stress is called thermal expansion.

Temperature variations have an impact on almost all mechanical components. Components expand and contract as a result of temperature changes. Thermal stresses are caused by the restriction of the member's expansion. Temperatures over a certain threshold weaken the structure's elasticity and stiffness. Studying how various sorts of restrictions affect a member's response to temperature and mechanical stresses has helped researchers better understand mechanical structure behaviour. Mechanical and thermal stress are applied to a component, and the results are analysed. It was shown that mechanically loaded members with varying restraining support conditions (ASME SA36) were affected by heat loading [9]. Cantilever and supported beams with a point load under thermal loading are studied in this study. When the temperature changes, researchers examine how a loaded beam deflections and slopes in response.

ANSYS [5] is used to do the FEA analysis. Mechanical stresses are common in real-world constructions because of applied loads and constrained thermal expansion. Structural mechanics theories were used in the development of all analytical formulations. Temperatures may influence the behaviour of structures when they are linked to one another. This basic relationship

affects everything in life.
$$\epsilon_{Total} = \epsilon_{Thermal} + \epsilon_{Mechanical} \quad (1)$$

Structural member strain is the sum of the thermal and mechanical strains in the material. Mechanical strain is the single factor that determines the stress in a structure. When thermal stresses are completely restricted, thermal stress will be generated. The member's cross-sectional area will influence its mechanical stress. The bending stress of rectangular and I-section members with the same cross sectional area of 80 mm² are compared to determine the influence of cross section.

NOMENCLATURE

σ = Uniaxial Stress,

MPa P = Load,

N A = Area of Cross section,

mm² T = Temperature,

$1/^\circ\text{C}$ α = Coefficient of thermal expansion ,

$1/^\circ\text{C}$ E = Young's Modulus,

GPa δ = Deflection,

mm μ = Poisson's Ratio ρ = Density,

Kg/m³ ϵ = Temperature Strain γ_m = Lateral deflection due to temperature change,

mm⁴ I = Moment of Inertia,

mm⁴ L = Length ,

mm b = Breadth,

mm h = Height, mm

LITERATURE REVIEW

In this review study, an Artificial Neural Network (ANN) is used as a diagnostic parameter to identify structural problems in a cantilever beam. A lower natural frequency may be found in structures with a lesser mass. Periodic frequency measurements are required to ensure that the structure is operating at its optimal level. Many articles were examined for signs of structural degeneration, despite the challenge of quantifying frequency in dynamic and complicated systems. This book also discusses aspects including the depth of the fracture, the location of the crack, and more. A number of publications have used quick Fourier transforms and artificial neural networks in order to assess natural frequencies and diagnose damage. Structural deterioration was detected using vibrations, finite element analysis, and artificial neural networks (ANN) (ANN).

A Computer Aided Design (CAD) Micro Cantilever Beam for Vapour Detection.

Micro cantilever beams of various sorts and materials are examined in this research. For each micro cantilever beam shape, it is designed, analysed, and simulated. ComSOL In both structural mechanics and chemical module modelling, multiphysics is a valuable tool. Using several beam structures and the corresponding Eigen frequencies, examine the results. Adsorption of reactive species in laminar flow is accomplished by using chemical pillars from surface reactions and deposition processes in the flow cell.

Jib Crane Cantilever Beam Structural Analysis

In this research, a conventional I section cantilever beam is exposed to an equally distributed force (the self-weight) and a concentrated load at the free end. Lateral torsional buckling is the primary failure mode of "slender" beams, and it dictates their design. Online forms and resources are also included in this research. In order to ensure the validity of the findings, finite element analysis and experiments are used to verify the results. An optimization approach is used to find the best possible solution from a number of different designs that are on the table. Samples weighing between 250 and 500 kilogrammes and measuring 3 to 6 metres in length were evaluated for web and flange thicknesses. Structural analysis looks at how varying section sizes effect free-end point loads and uniformly distributed cantilever loads when it comes to structural performance. Additionally, the cross-sectional cross-section of the cantilever beam's web affects its ability to resist buckling in the lateral direction.

Tapered Beam Vibration Analysis

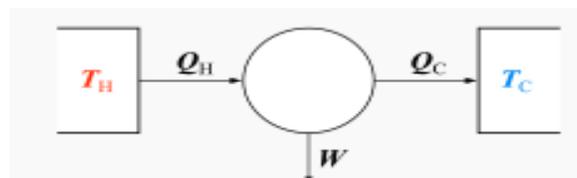
Beams may be classified as either straight or curved, based on the geometric design of their form. Non-uniform beams may be used in architecture, robotics, and other innovative engineering applications because they evenly distribute weight and strength. In order to withstand dynamic forces like wind and earthquakes, these buildings must be built to exacting standards. Understanding a structure's fundamental frequencies and mode shapes is critical. The Euler cantilever beam's natural frequencies may be calculated by solving for the equation of motion. Galerkin's technique and weighted residuals were used to generate a finite element model. For a broad variety of taper ratios, natural frequencies and mode shapes may be found. The natural frequencies and mode shapes of different taper ratios are compared.

Temperature increase

This section is designed to provide a fast overview.

Changes in the volume and surface area of matter occur as a consequence of the expansion of matter as a result of rising temperatures.[1]

For any given material, molecular kinetic energy is inversely related to temperature. When heated, molecules have more kinetic energy. As a result of this, atoms and molecules vibrate more often and maintain a larger average distance between them. As temperatures rise, only a few materials are able to compress. This is a one-of-a-kind event (see examples below). A material's coefficient of thermal expansion may be found by dividing the temperature change by the relative expansion (also known as strain).



Temperature increase

Solids Expanding

The body's capacity to expand and contract must be taken into account when calculating thermal expansion. The expansion or strain caused by a rise in temperature may be calculated using the appropriate coefficient of thermal expansion.

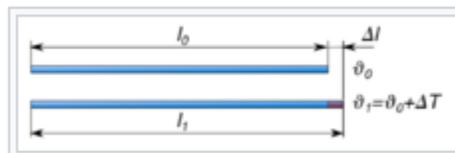
Internal tension may be caused by changes in temperature in a body that is unable to expand. When a body is allowed to expand, the elastic or Young's modulus may be used to determine the strain that would result and the amount of tension needed to bring that strain to a halt. The impact of ambient pressure on an object's size is not necessary in the case of solid materials.

Thermal expansion coefficients of most standard engineering materials are either constant or average over the temperature range in which they are expected to fulfil their function. This is necessary to make accurate calculations.

In a straight line.

Thermal expansion may cause a rod's length to fluctuate.

not volume, but length, is what linear expansion refers to (volumetric expansion). CLTE provides an approximation of the relationship between temperature change and object length change due to thermal expansion (Coefficient of Linear Thermal Expansion). As the temperature rises, the thermal expansion factor increases. If pressure has no impact, we may write:



Thermal expansion may cause a rod's length to fluctuate.

Rubber spacers are required for metal-framed windows.

Rubber tyres must be able to function correctly in all temperatures since they are sensitive to both passive and active heat from the road surface and mechanical flexing and friction.

Long, straight runs of metal hot water heating pipes are not recommended.

To minimise sun kink, large constructions like trains and bridges must have expansion joints.

Cold car engines operate poorly because of the inefficiently high spacings between components until the typical operating temperature is reached.

A gridiron pendulum's pendulum length is increased by using a combination of metals.

When it's hot outside, a power line sags; when it's cold, it's taut. This phenomenon is caused by the tendency of metals to expand when heated.

When a plumbing system experiences thermal expansion, expansion joints bear the brunt of the stress.

Precision engineering is almost always required to account for thermal expansion. It is possible that the sample will move out of the scanning electron microscope's field of view if the temperature changes by only one degree.

When the volume of a liquid changes with temperature, only one direction of flow is possible via a thermometer that uses a liquid, such as mercury or alcohol.

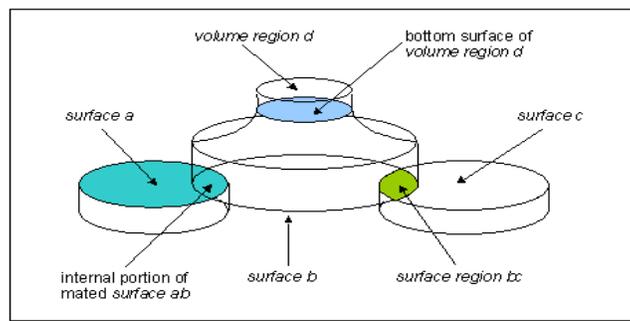
Because the coefficients of thermal expansion of the two metals differ, a bimetallic strip is required.

Internal Surface Heat Loads

Both interior and exterior surfaces may be heated with Creo Simulate. Heat loads may be applied to two types of interior surfaces:

The inner region of a mated surface ab, or the point at where two surfaces meet.

The bottom internal surface of a volume.



The mated segment of surface a's heat load would be calculated using surface an as a reference.

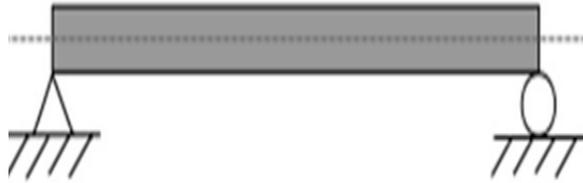
To determine the quantity of heat being transferred from the mated surface, an initial surface area would be created.

Beam

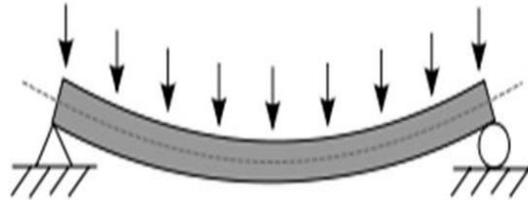
Introduction

In order to support weight, a beam is a structural component that may bend. The bending moment is the result of the interaction between the beam's weight, span, and the forces acting on it from the outside. Cross-sectional form, length, and material are used to categorise beams.

This includes truck and vehicle frameworks, machine frames, as well as other mechanical or structural systems that use beam constructions.



Beam cross section



Metal, stone, or wood-metal combinations may also be used to construct beams, which are often constructed from squared timber. Thus, beams may sustain horizontal loads, such as earthquake or wind loads, as well as compression, like a collar beam, which can be employed to support the rafter thrust. When loads are carried from beams to walls, girders, and columns, a domino effect is set into motion. Joists may be supported by beams in light-frame constructions.

A beam in carpentry may be referred to as either a plate or a beam depending on the context.

In certain cases, the kind of support a beam possesses might assist categorise it.

The forms and widths of beams used in engineering may vary greatly:

"Simply supported" beams may be freely rotated and have no moment resistance, which is why they're called that.

The term "fixed beam" refers to a beam that cannot be turned since it is supported at both ends.

On one end, overhangs extend beyond the support of a fundamental beam.

On each side of the beam, there are two protruding ends.

The beam must have more than two points in order to be considered "continuous."

Cantilever beams have just one end supported by a structure.

In order to define a truss, you need to connect a cable or rod to the beam.

Moment of Inertia:

The "I" in the beam formula stands for the two-moment-of-area. An inertia or "moment of inertia" may be calculated by multiplying two tiny patches of neutral axis area by $(dA \cdot r^2)$ and

($dA \cdot r^2$). Consequently, the distance squared of each section's area from the axis is included in the overall area. The more stiff the beam is when bent, the greater I grows when utilising a certain material.

SHAPE IN GENERAL:

The I or H cross section is preferable for beams in reinforced concrete construction over the rectangular cross section. To increase the beam's overall stiffness, additional material is placed away from its neutral axis, increasing its second moment of inertia.

Using this approach, you can only bend it in the I-direction. beam's As a result, bending the beam into an H-shape reduces its efficiency compared to leaving it straight. The most efficient form for 2D geometry is a cylindrical shell or tube since it can bend in any direction, no matter how far it bends. In contrast, bending I or broad flange beams in a single direction is preferable.

When the same stress conditions and cross-sectional area are applied to the beam, it deflects less (volume of beam per length). This is what is meant by the term "effective."

It is possible to employ various ways of construction, such as angles, channels, or tubes, if required.

An example of a thin-walled beam may be seen here:

The use of thin-walled beams in the construction of structures is an excellent substitute (structure). Panels are piled on top of one another in thin-walled beams to generate closed or open cross sections (structure). Tubes are available in a variety of shapes and sizes for use in closed components. Structures like I-beams, T-beams, and L-beams may have free spaces. Since the bending stiffness per unit cross sectional area of thin-walled beams is greater than that of thick-walled rods or bars, they are often used in structural applications. This technique allows for the construction of strong buildings with a little amount of material. Composite laminates may be attached to thin-walled beams. Librescu pioneered the use of thin-walled beams and composite laminates.

CANTILEVERS' POWER OUTLETS

Two separate types of cantilevers are the vertical and the horizontal cantilevers (typically horizontal). Trusses or slabs may also be used to construct cantilever constructions. When the cantilever is subjected to moment and shear stresses, it is pushed against the support.

Cantilever construction, as opposed to systems supported at both ends with loads imposed between the supports, permits overhanging buildings without external bracing, such as a post and lintel system's simply supported beam.

APPLICATIONS:

A few notable examples of cantilever architecture are cantilever bridges and balconies (see corbel). It is common practise to create cantilevers in pairs since each cantilever supports one end of a central section. A bridge like this may be seen in motion on the Forth Bridge in

Scotland. In classic timber-framed homes, the jetty or forebay is a cantilever. The cantilever barn, a kind of log construction popular in the southern United States, has a long history there.

Cantilevers are often used in the building industry. Even if the half built structure creates a cantilever, the whole construction does not have the same effect. When temporary supports (falsework) cannot be employed to maintain the structure in place while it is being erected, this has a significant benefit (e.g., over a busy roadway or river, or in a deep valley). This technique is used in several of the Navajo Bridge's cantilever bridges, where the spans are jacked apart in order to emphasise the compression of the cantilevers before they are finally joined again. When it comes to creating cable-stayed bridges, cantilevers play an important role. Box girder bridges are often constructed as a single structure, rather than in sections. From a single support, a cantilever bridge may be constructed in both directions.

Their stability is maintained via the utilisation of torque and rotational equilibrium in these structures.

Cantilevers were employed by Frank Lloyd Wright to build vast balconies in Fallingwater. When the East Stand at Elland Road Stadium was finished in 2013, it was the world's biggest cantilever structure. Old Trafford Football Ground's cantilever top has no structural supports to obstruct spectators' views. The roof of Miami Stadium was a lot like this one. St James' Park in Newcastle-upon-Tyne is home to a cantilever that is the biggest in Europe and is used by Newcastle United Football Club.

Two examples of cantilever design are in use today: radio towers and wind-resistant chimneys.

The following are the positives and disadvantages:

Advantages

Because there is no counterweight on the other side, it is not necessary (probably the main reason you would ever have a cantilever beam).

A negative bend might be produced as an alternative to a positive curve. The backspan of a cantilever will bend in the same direction as the cantilever when a uniform weight is applied.

Disadvantages

Deceleration was a big factor.

The outcome is virtually always bigger moments.

Another method is to utilise a fixed support or backspan and look for an uplift in the support at a greater distance away.

An overview of computer-aided design (CAD).

Many innovative innovations and technologies have been patented in our industrial civilization throughout the years. The digital computer has had a much greater influence on the economy than any previous technological advancement.

In the drawing office, computers are rapidly being utilised to design and define technical components. There are several subcategories of CAD, but "computer-aided design" (CAD) is the most often used. In computer-aided design (CAD), interactive computer graphics systems are the most often used tool (CAD). In the field of mechanical design and geometric modelling, the use of computer-aided design approaches has had a considerable influence.

There are several good reasons for using a CAD system to support the engineering design function:

- To increase the productivity
- To improve the quality of the design
- To uniform design standards
- To create a manufacturing data base
- To eliminate inaccuracies caused by hand-copying of drawings and inconsistency between
Drawings

INTRODUCTION TO PRO/ENGINEER:

Pro/ENGINEER is the industry's standard 3D mechanical design suit. It is the world's leading CAD/CAM /CAE software, gives a broad range of integrated solutions to cover all aspects of product design and manufacturing. Much of its success can be attributed to its technology which spurs its customer's to more quickly and consistently innovate a new robust, parametric, feature based model, because the Pro/E technology is unmatched in this field, in all processes, in all countries, in all kind of companies along the supply chains. Pro/Engineer is also the perfect solution for the manufacturing enterprise, with associative applications, robust responsiveness and web connectivity that make it the ideal flexible engineering solution to accelerate innovations. Pro/Engineer provides easy to use solution tailored to the needs of small, medium sized enterprises as well as large industrial corporations in all industries, consumer goods, fabrications and assembly, electrical and electronics goods, automotive, aerospace etc

Advantages of Pro/Engineer:

It is much faster and more accurate. Once a design is completed. 2D and 3D views are readily obtainable.

The ability to incorporate changes in the design process is possible.

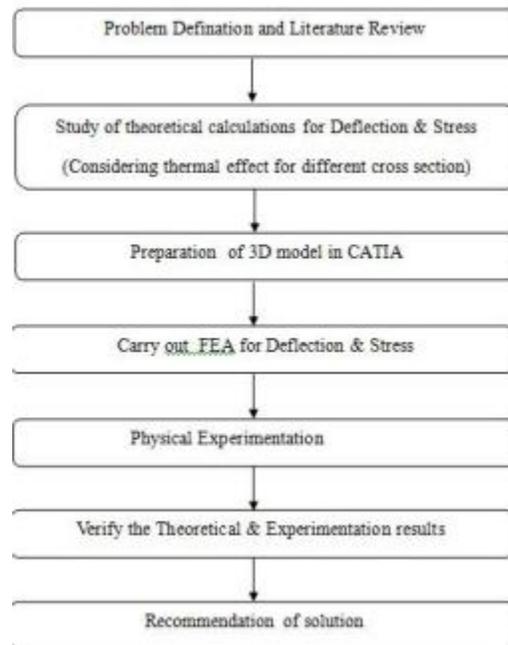
It provides a very accurate representation of model specifying all other dimensions hidden geometry etc.

It provides a greater flexibility for change. For example if we like to change the dimensions of our model, all the related dimensions in design assembly, manufacturing etc. will automatically change.

It provides clear 3D models, which are easy to visualize and understand.

ProE provides easy assembly of the individual parts or models created it also decreases the time required for the assembly to a large extent.

Methodology



Material Specification

Material : Structural Carbon Steel. ASME SA36. [9]

Young's Modulus (E) = 200 GPa

Poisson's Ratio (μ) = 0.26

Density (ρ) = 7850 Kg/m³

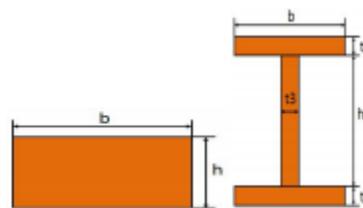
Tensile Strength = 400-500 MPa

Yield point Strength = 250 MPa

Coefficient of Thermal Expansion (α) = $12 \times 10^{-6} / ^\circ\text{C}$

Temperature ($^\circ\text{C}$)	20	100	200	300	400	500
Young's Modulus (GPa)	200	200	189	168	147	126

Moment of Inertia calculation for rectangular and I-Section



Rectangular and I-Section

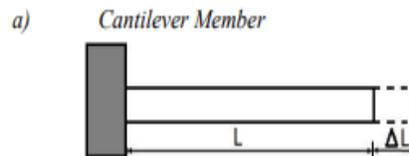
a) *Rectangular Section*

$$I = \frac{bh^3}{12} \quad (2)$$

b) *I-Section*

$$I = \frac{bd^3}{12} - \frac{(b-t_3)(d-2t_1)^3}{12} \quad (3)$$

Stress and deflection due to temperature change



Thermal expansion of Cantilever member

Change in the dimensions of cantilever member due to increase in temperature is given below

$$\text{Change in length } (\Delta L) = \alpha L \Delta T \text{ mm} \quad (4)$$

$$\text{New length } (L_e) = L + \Delta L = L(1 + \alpha \Delta T) \text{ mm} \quad (5)$$

$$\text{New breadth } (b_e) = b + \Delta b = b(1 + \alpha \Delta T) \text{ mm} \quad (6)$$

$$\text{New Height } (h_e) = h + \Delta h = h(1 + \alpha \Delta T) \text{ mm} \quad (7)$$

Stress does not induce in member because of free expansion.

Fixed member

For fixed member, axial expansion is zero. Which induces thermal stress inside body because of restraining force. Thermal stress causes lateral deflection similar to buckling. Lateral deflection is calculated using relation

$$\text{Lateral deflection } (y_m) = \frac{2L}{\pi} \sqrt{\epsilon + \frac{\epsilon^2}{2}} \text{ mm} \quad (8)$$

$$\text{Temperature Strain } (\epsilon) = \alpha \Delta T \quad (9)$$

$$\text{Restraining Force} = EA\alpha\Delta T \quad (10)$$

$$\text{Axial Stress} = E\alpha\Delta T \quad (11)$$

Stress and Deflection of member with point load

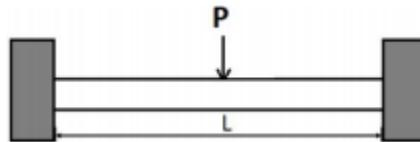
Cantilever member



Cantilever member

$$\text{Deflection } (\delta) = \frac{PL^3}{3EI} \text{ mm} \quad (12)$$

$$\text{Bending Stress } (\sigma_b) = \frac{My}{I} \text{ MPa} \quad (13)$$



Fixed Member

$$\text{Deflection } (\delta) = \frac{PL^2}{192EI} \text{ mm} \quad (14)$$

$$\text{Bending Stress} = \frac{My}{I} \text{ MPa} \quad (15)$$

Combined Mechanical and thermal loading

$$\epsilon_{\text{total}} = \epsilon_{\text{thermal}} + \epsilon_{\text{mechanical}} \quad (16)$$

Illustration 1 shows a structural carbon steel (ASME SA36) component with a point load of 1000 N. It has a cross-sectional area of 80 mm² and is 400 mm in length. Determine the tension and deflection of a cantilever member with a rectangular cross section at each of the following temperatures: Temperatures up to 200°C

The cantilever component of the I-section

Structural member with reticular sections

An I-sectioned, non-moving component 40 mm b and 20 mm h are the sectional measures. B=46mm, h=70 mm, t1=t2=5.2 mm, and t3=4.6 mm in the I-section of the I-section Section IV contains all the expressions needed to run the computations and compile the results.

A cantilever component with a rectangular section

Temperature	°C	20	200	300	400	500
Young's Modulus (E)	MPa	200000	189000	168000	147000	126000
Length (Le)	mm	400	400.864	401.344	401.824	402.304
Width (be)	mm	40	40.0864	40.1344	40.1824	40.2304
Height (he)	mm	20	20.0432	20.0672	20.0912	20.1152
y	mm	10	10.0216	10.0336	10.0456	10.0576
Bending Moment (M)	N-mm	400000	400864	401344	401824	402304
Moment of Inertia (I)	mm ⁴	26666.67	26897.81	27026.88	27156.4	27286.4
Deflection (δ)	mm	4	4.223681	4.745958	5.417473	6.312844
Bending Stress (ob)	MPa	150	149.3541	148.9971	148.6413	148.2868

Table 2. Cantilever Member with I- Section

Temperature	°C	20	200	300	400	500
Young's Modulus (E)	MPa	200000	189000	168000	147000	126000
Length (Le)	mm	400	400.864	401.344	401.824	402.304
Flange Width (be)	mm	46	46.09936	46.15456	46.20976	46.26496
Web Height (he)	mm	70	70.1512	70.2352	70.3192	70.4032
Flange thickness (t1e = t2e)	mm	5.2	5.211232	5.217472	5.223712	5.229952
Web thickness (t3e)	mm	4.6	4.609936	4.615456	4.620976	4.626496
Total Depth (de)	mm	80.4	80.57366	80.67014	80.76662	80.8631
y	mm	40.2	40.28683	40.33507	40.38331	40.43155
Bending Moment (M)	N-mm	400000	400864	401344	401824	402304
Moment of Inertia (I)	mm ⁴	808904.1	815915.7	819830.7	823759.8	827702.9
Deflection (δ)	mm	0.131866	0.13924	0.156457	0.178595	0.208112
Bending Stress (ob)	MPa	19.87875	19.79315	19.74583	19.69869	19.65171

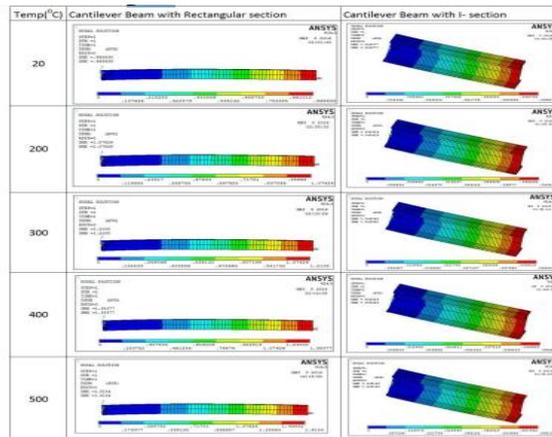
Table 3. Fixed Member with Rectangular Section

Temperature	°C	20	200	300	400	500
Young's Modulus (E)	MPa	200000	189000	168000	147000	126000
Length (Le)	mm	400	400	400	400	400
Width (be)	mm	40	40.0864	40.1344	40.1824	40.2304
Height (he)	mm	20	20.0432	20.0672	20.0912	20.1152
y	mm	10	10.0216	10.0336	10.0456	10.0576
Bending Moment (M)	N-mm	50000	50000	50000	50000	50000
Moment of Inertia (I)	mm ⁴	26666.67	26897.81	27026.88	27156.40	27286.40
Deflection due to point load (δ)	mm	0.063	0.066	0.073	0.084	0.097
Bending Stress (ob)	MPa	18.75	18.63	18.56	18.50	18.43
Temperature strain (ε _t)		0	0.00216	0.00336	0.00456	0.00576
Restraining force	N	0.00	328004.40	454623.74	541157.81	587315.87
Uniform Axial Stress	MPa	0	408.24	564.48	670.32	725.76
Mid span deflection due to ΔT	mm	0.00	11.85	14.78	17.22	19.36
Total Deflection (δ _t)	mm	0.06	11.91	14.85	17.31	19.46

Table 4. Fixed member with I-Section

Temperature	°C	20	200	300	400	500
Young's Modulus (E)	MPa	200000	189000	168000	147000	126000
Length (Le)	mm	400	400	400	400	400
Flange Width (be)	mm	46.000	46.099	46.155	46.210	46.265
Web Height (he)	mm	70.000	70.151	70.235	70.319	70.403
Flange thickness (t1e = t2e)	mm	5.200	5.211	5.217	5.224	5.230
Web thickness (t3e)	mm	4.600	4.610	4.615	4.621	4.626
Total Depth (de)	mm	80.400	80.574	80.670	80.767	80.863
Area (A)	mm	800.400	803.861	805.788	807.716	809.647
y	mm	40.200	40.287	40.335	40.383	40.432
Bending Moment (M)	N-mm	50000	50000	50000	50000	50000
Moment of Inertia (I)	mm ⁴	808904.112	815915.720	819830.699	823759.750	827702.907
Deflection (δ)	mm	0.002	0.002	0.002	0.003	0.003
Bending Stress (ob)	MPa	2.485	2.469	2.460	2.451	2.442
Temperature strain (ε _t)		0	0.00216	0.00336	0.00456	0.00576
Restraining force	N	0.000	328168.403	454851.055	541428.384	587609.525
Uniform Axial Stress	MPa	0.000	408.240	564.480	670.320	725.760
Mid span deflection due to ΔT	mm	0.000	11.847	14.781	17.224	19.364
Total Deflection (δ _t)	mm	0.002	11.850	14.783	17.227	19.367

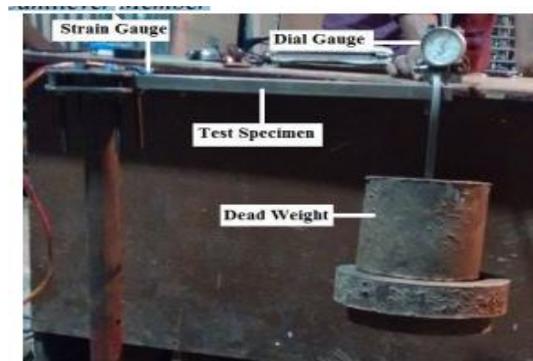
Analysis Results for Cantilever member with rectangular and I-Section are given below



both rectangular and I-section test configurations, the deflection of the cantilever component

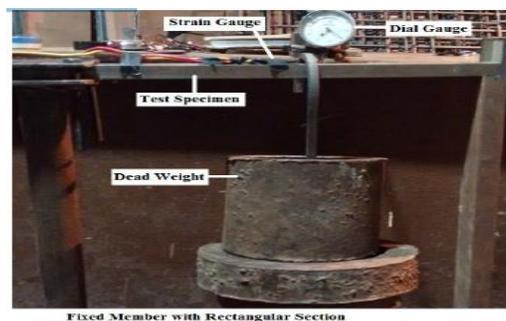
A load attachment and a deflection pointer are part of the test setup. A rectangular component is shown in the setup.. The I-section component will be used as a template for this configuration. A 1000N point stress is applied to both the cantilever and a fixed portion at temperatures ranging from 200°C to 5000°C. Below is an example of how to set up a rectangle for testing.

Cantilever Member



Cantilever Member Test setup

2)Fixed member



Fixed Member with Rectangular Section

Fixed Member Test setup

Sample Calculation for stress at 200C

Reading from strain gauge

$$\text{Strain} = 3.93$$

2) Stress Calculation

By Hooke's law,

$$\text{Young's Modulus (E)} = \text{Stress/Strain}$$

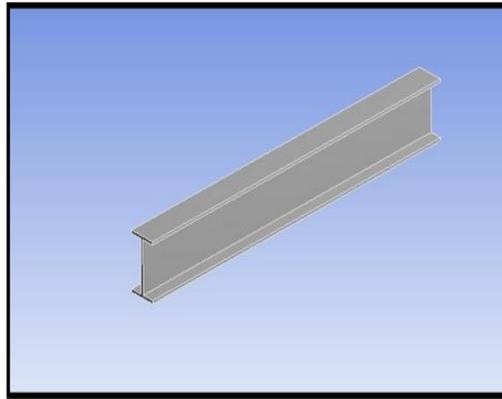
$$\text{Stress} = E \times \text{Average Strain}$$

$$= 200000 \times 0.000740$$

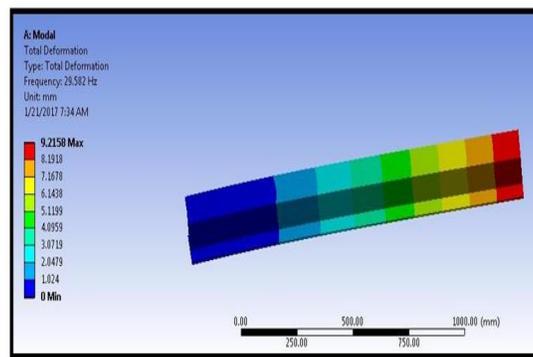
$$= 148.05 \text{ MPa}$$

Model analysis

MODAL ANALYSIS OF CANTILEVER BEAM



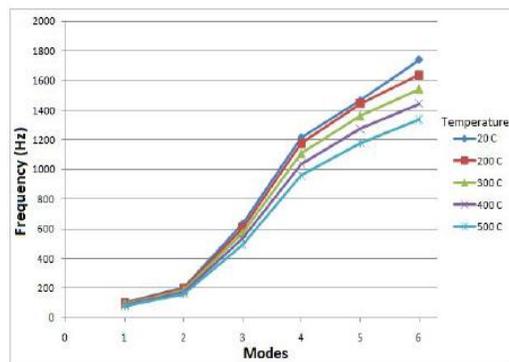
MATERIAL-STEEL



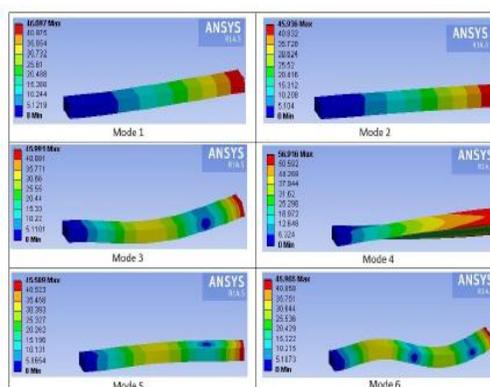
Temperature affects the mode shape and modal frequency of rectangular and I sections of cantilever members, according to ANSYS R14.5. Only Cantilever Members have access to the mode from their photographs. It's important to keep in mind that there are four sets of findings.

Section of a rectangle Results of modal analysis on a rectangular section cantilever member (Table 6).

Mode	Frequency (Hz)					
	20°C	100°C	200°C	300°C	400°C	500°C
1	102.19	102.19	98.68	93.04	87.03	80.57
2	202.89	202.89	196.52	185.28	173.31	160.46
3	633.1	633.1	604.68	570.1	533.28	493.72
4	1216.9	1216.9	1176.2	1109	1037.4	960.4
5	1465	1465	1445.2	1362.6	1274.6	1180
6	1741.9	1741.9	1637.8	1544.2	1444.4	1337.3



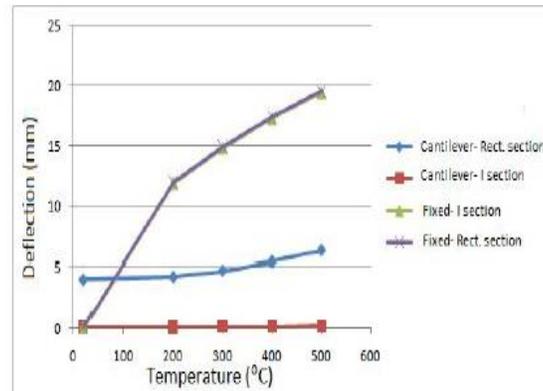
Graph between Modes and Frequency



Modal Analysis for Cantilever member with rectangular section.

RESULTS AND DISCUSSIONS

The results for stress and deflection are tabulated in Section IV. Graph for temperature Vs Deflection is plotted.



This figure is especially useful since it demonstrates how cantilever members allow the beam to expand freely across its whole length. None of this adds to the stress of the situation.

Temperature changes cause a spike in deflection.

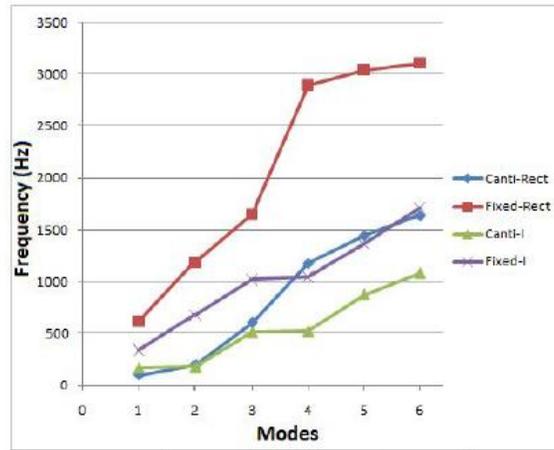
For the same cross sectional area, the deflection of a Rectangular section member is about 30 times greater than that of an I section member.

Rectangular sections have eight times the bending stress of I-sections.

The Member's Stability

A force P is applied in the opposite direction of the thermal expansion of a stationary component, resulting in an equal and opposite axial tension. If this tension continues to grow, it will finally come to an end. If elastic-plastic materials are employed, they will continue to perform as they have in the past.

- ❖ A rise in yield stress occurs. The beam will fail before it reaches its yield stress if it has weak spots in its thickness.
- ❖ Increased deflection occurs as a consequence of temperature variations, which weaken the structure's structural integrity.
- ❖ For the same cross sectional area, rectangular section members are subjected to more than ten times as much bending stress than I-section members.
- ❖ The cantilever has less deflection than a fixed component. Forces generated by friction and heat
- ❖ Modal frequency may be reduced by raising the member's temperature. See how various members do in the 2000C charts below.



Modes Vs Frequency Graph at 2000C

Conclusion

Numerical calculations, analysis and testing are used to verify the design of structural carbon steel members. The structure's performance is degrading, as shown by statistics on thermal stress and deflection. – This includes both mechanical and thermal pressures on structural components. This technology may be used to create aeroplane wings and temperature-changing heating systems. They're in line with the forecasts, according to the findings of the trials. Flame heating has no influence on the quality of the final product. T-Sections and other structural components with varying cross sections may be studied in the future. An excellent tool for locating the best place to do a certain activity. A spinning shaft, for example, may benefit from more effort.

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