

Beam Analysis Application

Software Report

Version 1.0.0

5 February 2020

Akash Anand

Application Purpose

To analyse loading conditions of a single beam in two dimensions. Both statically determinate and indeterminate computations are supported.

Input Capabilities

1. **Supports:** Capable of handling any arbitrary number of fixed supports, pin supports, and roller supports placed at any location along the beam.
2. **Point Loads:** Capable of handling any arbitrary number of point loads pointing in either upwards or downwards direction at any location along the length of the beam.
3. **Moments:** Capable of handling any arbitrary number of concentrated moments in either clockwise or counter-clockwise direction at any location along the length of the beam.
4. **Distributed Loads:** Supports the implementation of the following types of loads:
 - i. Constant Load: A distributed load of constant magnitude pointing in either upwards or downwards directions between two points along the length of the beam.
 - ii. Linear Ramp: A triangular load between two points along the length of the beam with initial magnitude 0 and arbitrary final magnitude joined by a straight line.
 - iii. Trapezoidal Load: A distributed load between two points along the length of the beam with arbitrary initial and final magnitudes joined by a straight line.
 - iv. General Polynomial Ramp Load: A distributed load between two points along the length of the beam with arbitrary initial and final magnitudes joined by a curve of any arbitrary decimal exponent.
5. **Geometry:** The user can input any arbitrary beam length. The cross section of the beam is used to calculate moment of inertia. The following cross sections are supported:
 - i. Custom: Any custom moment of inertia can be input
 - ii. Rectangular: Custom height and breadth
 - iii. Circular: Custom diameter
 - iv. Pipe: A hollow circular beam with a fixed thickness
 - v. I Beam: A general asymmetrical I beam
6. **Material:** The user is free to input any custom young's modulus.

Features of the Output Reports

On completion of computations, the software reports the following values

1. **General Results:**

- i. Beam Properties: Calculates and reports beam length, elastic modulus, second moment of area.
- ii. Loading Function: Reports the loading conditions of the beam in terms of singularity functions.
- iii. Reaction Loads: Calculates the reaction forces and moments at the various supports.
- iv. Pictorial Beam Representation: Displays an approximate pictorial representation of the beam. This is meant only to act as a visual aid to understand the loading function, and is not to be taken stand-alone.

2. **Shear Force**: Displays a shear force graph and the shear force function in terms of singularity functions.

In case of simple computations, the report also features the maximum shear force and its location on the beam.

3. **Bending Moment**: Displays a bending moment graph and the bending moment function in terms of singularity functions. In case of simple computations, the report also features the maximum bending moment and its location on the beam.

4. **Deflection**: Outputs a graph depicting the deflection of the beam as a function of its position and also the deflection function in terms of singularity functions

5. **Slope**: Outputs a graph depicting the slope of the beam as a function of its position and also the slope function in terms of singularity functions

Performance

Complex loading conditions can take up to 20 seconds to compute. Computation of the values of maximum shear force/bending moment/deflection were found to be highly computationally intensive, and hence these features were removed for complex computations.

Deficiencies in the Current Version

The deficiencies in the current version are primarily due to bugs present in the inbuilt python Sympy libraries for continuum mechanics. Once these bugs are fixed in future Sympy versions, it can be expected that these deficiencies will be solved in this web-app.

1. **Maximum Deflection**: The maximum deflection and its location cannot be computed due to bugs present in the corresponding functions in the Sympy 1.5.1 python libraries. When these bugs are fixed by python developers, this feature can be re-implemented in the software.
2. **Maximum Shear Force and Bending Moment**: The Sympy 1.5.1 python functions used to calculate maximum shear force and bending moment are highly computationally inefficient. It was observed that calling these functions results in the computation taking far too much time, and hence they were removed from the application. In case of simple loading conditions (computations involving any combination of one fixed support, one point load, and one concentrated moment only), however, these features are available in this version.

-
- 3. **Deflection Plot:** Perhaps due to bugs in the python Sympy 1.5.1 library, deflection plots cannot be calculated for certain statically indeterminate problems.
 - 4. **Pictorial Beam Representation:** The pictorial representation of the beam shown in the report has following errors due to bugs present in the corresponding Sympy 1.5.1 function:
 - i. Loads are displayed in a direction opposite to the actual direction.
 - ii. Fixed Supports located in the middle of the beam cannot be drawn and are hence drawn at the end of the beam.

Due to these errors, the pictorial representation should not be viewed alone. The loading function displayed above the picture is accurate.