SIMULATION SYSTEMS OF BEAM DEFLECTION FOR DESIGN MECHANISM BEAM

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ABSTRACT

Beam Deflection System is a part of theory's mechanics which is necessarily to study in design for mechanics beam in mechanical engineering. It can be applied for many designs such as cable bridges, frames, and machines. The problems for calculation could be complicated and many methods are involved (only superposition method was selected). The functional using in the software will be receiving the several conditions from toolbox those are 1) Ability is designing by choosing cross-sectional area types Shaft - Beam, I – Beam, and Square-Beam 2) Ability is designing of the beam for the difference type of load action are point load, distributed load and moment Load 3) The alternative options will be provide by choosing simple support or cantilever beams. Finally, the conclusion of the software has two parts 1) Show result by Shear Force Diagram (S.F.D), Bending Moment Diagram (B.M.D) and deflection 2) Show answer of S.F.D, B.M.D and deflection. The results of a software which compared to the calculation is very similar.

KEYWORDS: Beam Deflection, Shear Force Diagram, Bending Moment Diagram

1. Introduction

Beam Deflection Systems is usefully developed for study in the area of calculated mechanism beam. Which is used for design the structure & link of robotics, frames & machines and analysis effective of deflection for analyzed the maximum deflection length of the structure in machine and robotics. Which are able to take the load without any cause of serious damage. Which is can use for analysis the Shear Force Diagram (S.F.D) of structure and beam, as well as helps to analyzed the Bending Moment Diagram (B.M.D) in the area of mechanical engineering, which are designed able to against the action of the impact. The calculated method has four different ways there are: 1) Double Integration Method 2) Area Moment Method 3) The Conjugate Beam Method and 4) Method of Superposition, which can developed as a computer program for reducing the difficulty of calculating manually action force such as point load, distributed and moment and moment of inertia choose a cross section area of three different types of beams. There are, Shaft - Beam, I – Beam and Square-Beam and the program will be transferring the data to the modulus of elasticity database. The modulus of elasticity database will perfectly store the complete type of all materials. Moreover, it's can report all the information, which has been analysis and report in the form of graph and charts which easy to understand such as Bending Moment Diagram and Shear Force Diagram. Its can reported as a chart and diagram accurately, which good for the research who is starting to work on the information mechanical engineering or mechanics of solid and the engineer, who lack of experience.

2. Approach and methods

The major parts of the beam design process consist of: Types of beam, Types of load and moment of inertia.

2.1 Types of beam

Type of beam that use for designing the mechanics & mechatronics Engineering includes consists of four types there are:

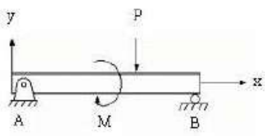
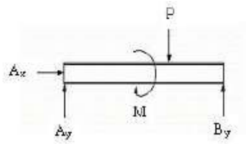
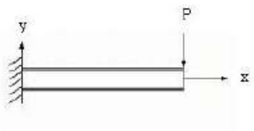
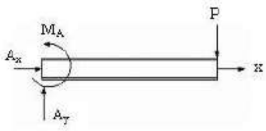
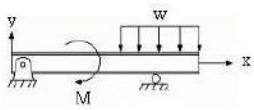
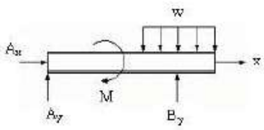
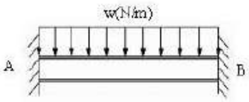
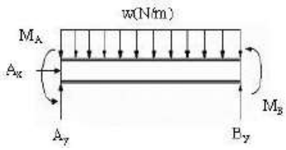
1) Simple supported beam is an ending part that use to supported as hinge which has reaction at $x-y$ direction and roller that has reaction at y direction as shown in 1.1 Table 1.

2) Cantilevered beam is an ending part of a beam that one side is fixed and the other side is set free which has an several types of reaction as shown in 1.2 Table 1.

3) Simple beam with overhang as similar as the simple supported beam on the other hand, roller supported does not place at the end of the beam, as shown in 1.3 Table 1.

4) Fixed beam is a part of the beam that is fixed at both side which cause the one – force and one moment y direction. Types of the four beams are shown in 1.4 Table 1.

Table 1 Types of beams and free body diagrams

Types of beam	Beam and forces vector	Free body diagram (F.B.D)
1.1 Simple Supported Beam [1]		
1.2 Cantilevered Beam [1]		
1.3 Simple Beam with Overhang [1]		
1.4 Fixed Beam [1]		

2.2 Types of load

Types of load or weight which has an action on the beam can be translated into four types there are:

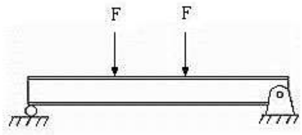
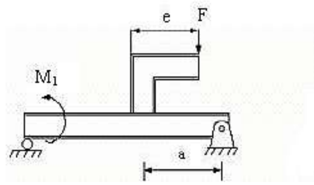
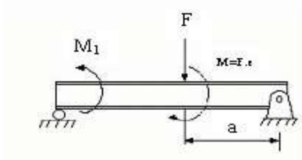
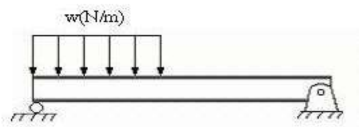
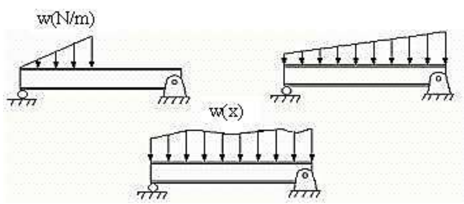
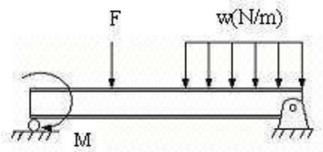
1) Point load is a force that has an action to a particular point or a specific area as shown in 2.1 Table 2.

2) Couple or moment is the moment or couple which attempt to rotate the beam as shown in 2.2 Table 2.

3) Distributed load is an action force that has an impact on the upper beam-distributed load which has an impact through the whole length or one particular part of the beam, there are two types : 1) Uniformly distribute load, which is an action force that has a very stable of the impact. 2) Non - uniformly distributed load is an action force that has the number of impact that is not really stable, depends on the equation of those action force as shown in 2.3 Table 2.

4) Combine Load is a beam that can handle many kinds of the action force types of four load as shown in 2.4 Table 2.

Table 2 Types of load

Types of load	Beam and Forces Vector
2.1 Point Load [2]	
2.2 Couple or Moment [2]	Action Forces 
	Free Body Diagram 
2.3 Distributed Load [2]	Uniformly Distributed Load 
	 Non-Uniformly Distributed Load
2.4 Combine Load [2]	

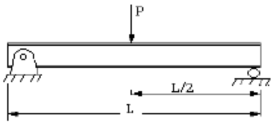
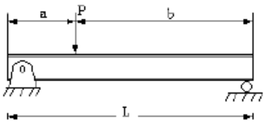
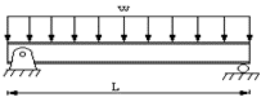
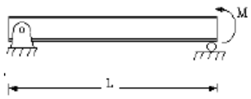
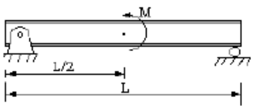
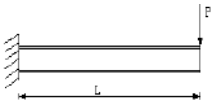
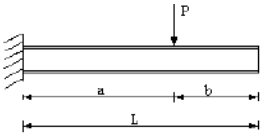
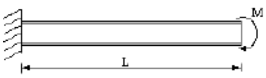
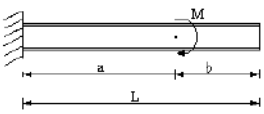
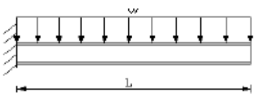
2.3 Calculating deflection of beam by Method of Superposition

The methods of calculating the value of the beam deflection has four different ways there are 1) Double Integration Method 2) Area Moment Method 3) The Conjugate Beam Method 4) Method of Superposition. The Method of Superposition takes the result of the equation from the Double Integration Method or Area Moment Method and use them for the beam which received the weight of each methods and then use the computer program to calculate the complicated equations as shown in the table of Method of Superposition by boundary condition of each types of the beam as shown in Table 4.

Table 3 List of symbols

No.	symbols	Quantity	SI Unit
1	P	Action force	N
2	W	Distribute load	N/m
3	M	Moment or Couple	N.m
4	M_{max}	Maximum moment	N.m
5	V	Shear force	N
6	M_A, M_B	Moment or Couple at point A, B	N.m
7	E	Modulus of elasticity	GPa
8	I	Moment of inertia	m^4
9	A_x, A_y	Reaction force at point A direction x - direction, y - direction	N
10	B_x, B_y	Reaction Force at point B direction x - direction, y - direction	N
11	y	Deflection	m
12	y_{max}	Maximum deflection	m
13	x	Distance of load	m

Table 4 Formula Method of Superposition [3]

Case	BEAM	V	M	Y
1		$\frac{P}{2} \quad 0\le x\le \frac{L}{2}$ $-\left(\frac{P}{2}\right) \quad \frac{L}{2}\le x\le L$	$\frac{Px}{2} \quad 0\le x\le \frac{L}{2}$ $\frac{P(L-x)}{2} \quad \frac{L}{2}\le x\le L$	$-\frac{(Px(3L^2-4x^2))}{48EI}$ $-\frac{(Px_1(3L^2-4x_1^2))}{48EI};x_1=L-x$
2		$\frac{Pb}{L} \quad 0\le x\le a$ $-\left(\frac{Pa}{L}\right) \quad a\le x\le L$	$\frac{Pba}{L};x=a$ $\frac{Pa(L-b)}{L};x=b$	$-\left(\frac{Pax(L^2-x_1^2-b^2)}{6LEI}\right)$ $-\left(\frac{Pb}{6LEI}\left(\frac{L}{b}(x-a)^3+(L^2-b^2)x-x^3\right)\right)$
3		$p\left(\frac{L}{2}-x\right)$ $0\le x\le L$	$\frac{wLx}{4} \quad 0\le x\le \frac{L}{2}$ $\frac{wL}{4}(L-x) \quad \frac{L}{2}\le x\le L$	$-\left(\frac{wx}{24EI}(L^3-2Lx^2+x^3)\right)$ $\left(\frac{wx_1}{24EI}(L^3-2Lx_1^2+x_1^3)\right);x_1=L-x$
4		$\frac{M}{L} \quad 0\le x\le L$	$\frac{M}{L}(L-x) \quad 0\le x\le L$	$-\left(\frac{Mx}{6LEI}(2L^2-3Lx+x^2)\right)$
5		$\frac{M}{L}$	$\frac{Mx}{L} \quad 0\le x\le \frac{L}{2}$ $\frac{M}{L}(L-x) \quad \frac{L}{2}\le x\le L$	$-\left(\frac{Mx}{24LEI}(L^2-4x^2)\right) \quad 0\le x\le \frac{L}{2}$ $\left(\frac{Mx_1}{24LEI}(L^2-4x_1^2)\right) \quad \frac{L}{2}\le x\le L$
6		$\frac{M}{L} \quad 0\le x\le L$	$\frac{Ma}{L} \quad (x=a)$ $\frac{M}{L}(b-L) \quad (x=b)$	$-\left(\frac{Mx}{6LEI}(6aL-3a^2-2L^2-x^2)\right)$ $\left(\frac{Mx_1}{6LEI}(6bL-3b^2-2L^2-x_1^2)\right) \quad x_1=L-x$
7		$+P$	$-(P(L-x))$	$\left(\frac{Px^2}{6EI}(3L-x)\right)$
8		$+P$ 0	$-(P(a-x))$	$-\left(\frac{Px^2}{6EI}(3a-x)\right)$ $-\left(\frac{Pa^2}{6EI}(3x-a)\right)$
9		0	$-M$	$-\left(\frac{Mx^2}{2EI}\right)$
10		0 0	$-M$	$-\left(\frac{Mx^2}{2EI}\right) \quad 0\le x\le a$ $-\left(\frac{Ma^2}{2EI}(2x-a)\right) \quad a\le x\le L$
11		$+(W(L-x))$	$-\left(w\left(\frac{L^2}{2}-Lx+\frac{x^2}{2}\right)\right)$	$-\left(\frac{wx^2}{24EI}(6L^2-4Lx+x^2)\right)$

3. Results and discussion

As the results of this research, which compare the data between the value that is calculated by the computer program and the values that is calculated by human for the most accurate results as show in the table.

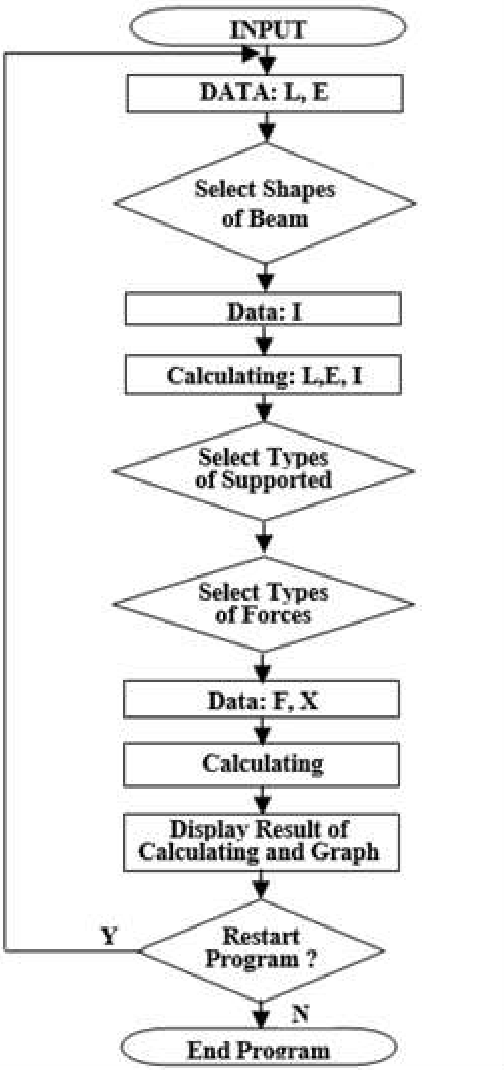


Figure 1 Flowchart of a Beam Deflection program

The Figure 1 Flowchart of a Beam Deflection program shows the sequence of developing the Beam Deflection program begin with, input the value of the initial condition to the program and the let it calculate until the result is generated.

Simple problem of beam is shown in Figure 2. Force is action at a position half beam. Cross section is a square –beam 150 x 300 mm. length 100 m. Material of beam is carbon steel. Calculating moment (*M*), maximum moment (M_{max}), shear force(*V*), deflection (*y*) and Maximum Deflection (y_{max}).

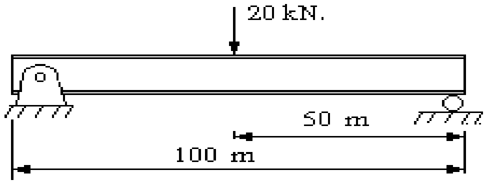


Figure 2 System of Beam in problem

Table 5 Summary of resultant by calculating

x(m)	*V*(kN)	*M*(kN.m)	*y*(m)
0	+ 10	0	0
20	+ 10	200	-3.388
40	+ 10	400	-5.630
60	- 10	400	-5.630
80	- 10	200	-3.388
100	- 10	0	0

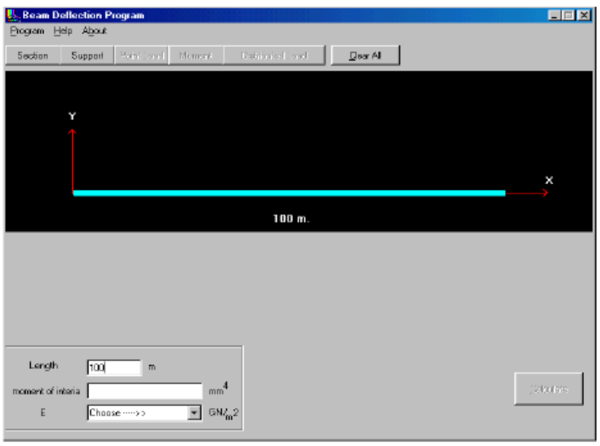


Figure 3 The first page of the calculating Deflection of Beam Program

The Figure 3 shows the page of the program that stated to calculate that length of the beam that has an action force, the variable are length of beam (L), moment of inertia (I) and modulus of elasticity (E).

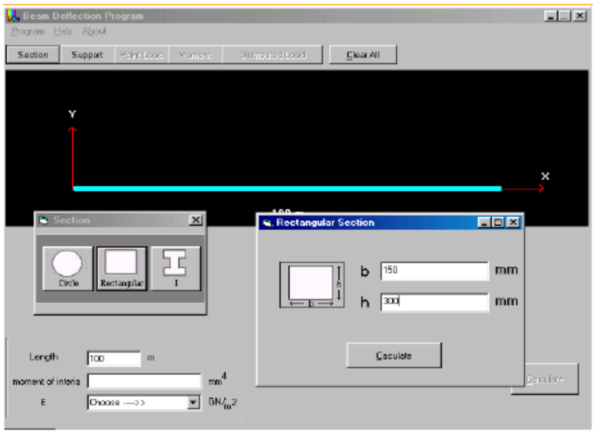


Figure 4 **Explains how the values can be placed into the program as a parameter, the variable consists of moment of inertia (I) of rectangular beam**

The Figure 4 shows how the value can be placed to the program, the variable are moment of inertia (I) as the section of the object is shaped up as a rectangle and consists of b = 0.15 m and h = 0.3 m. The program is designed to have several options of the surfaces there are shaft, beam, I – beam and rectangular beam then click at the section.

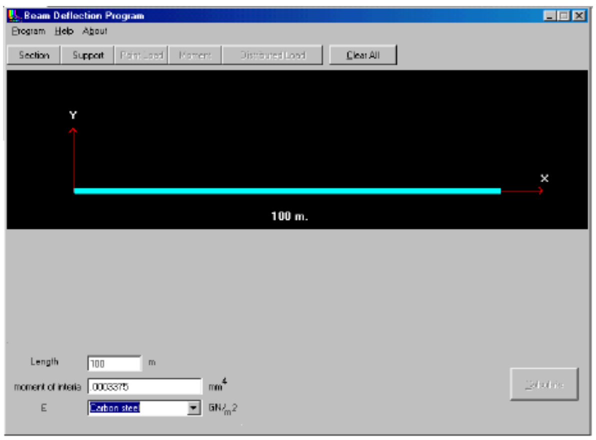


Figure 5 **The value of moment of inertia (I) and the value of modulus of elasticity (E) which depends on type of material**

The Figure 5 shows the value of moment of inertia (I) and the value of modulus of elasticity (E) which depends on type of material.

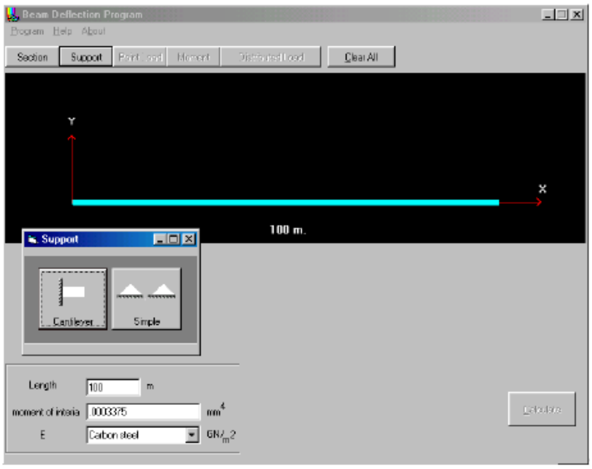


Figure 6 The alternated ways of the supported

The Figure 6 shows the optional points of the supported which can be choose by click at the supported then the program will display the picture of supported which has 2 options there are simple supported beam and cantilevered beam. The question display beam as a simple supported.

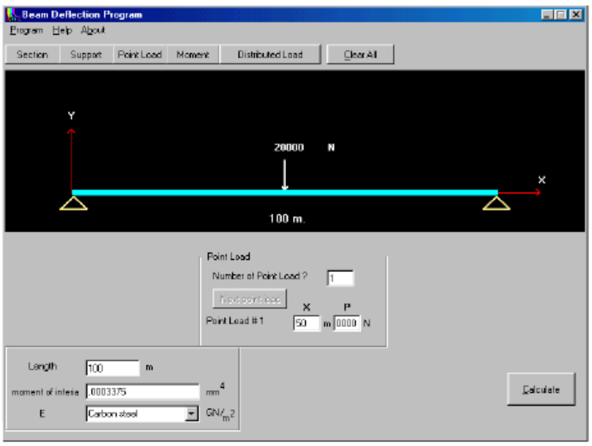


Figure 7 The position of the action force which will be a major impact to the beam

The Figure 7 shows that process of choosing the type of force acting on the beam. The action force can be selected by click at point load, moment or distributed load the location of load can be input to X and the amount of the action at variable P. Since all of the values are placed into the specific variables and the type of force acting fo on the beam is selected then program will ready start to calculate. Click at calculate then program will report the value of the results, as shows in Figure 8.

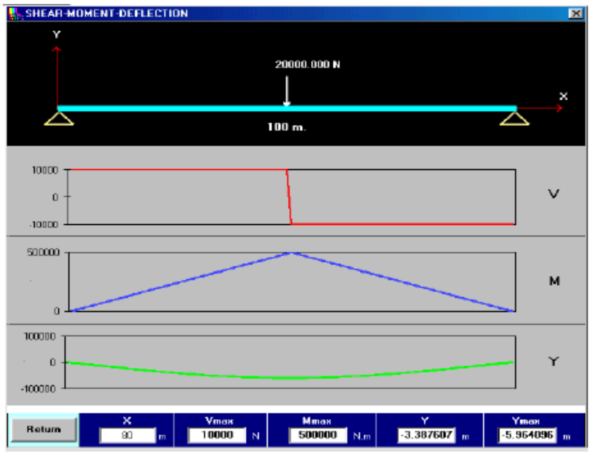


Figure 8 The all of result and graphs of program.

The all results of computation are shown the Figure 8 that consist of Shear Force Diagram (S.F.D), maximum shear force (V_{max}), Bending Moment Diagram (B.M.D), maximum moment of beam (M_{max}), deflection of beam (y) at distance x-direction (x), and maximum deflection of beam (y_{max}).

4. Conclusion

The results of Beam Deflection Program compare to the results which are solved by persons. As shown the outputs of the researches that are a simple supported beams and also tests with many types of beams which followed the values of initial conditions and boundary conditions all together has 11 methods, Method of Superposition shows that the results of all methods have exactly the same value and very accurate, which collected for the students of mechanical engineering and mechatronics engineering in the university by designing the structure & simulation frame & machine and mechanism link to complete the study and the whole process perfectly.

References

[1] Beer FP, Jhonston ER. Mechanics of materials. 2nd ed. New York: McGraw-Hill; 1992.

[2] American Institute of Steel Construction (AISC). Manual of Stress Construction. 8th ed. Chicago: American Institute of Steel Construction;1980.

[3] Timoshengo SP, Gere JM. Theory of elastic stability. 2nd ed. New York: McGraw-Hill; 1961.

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