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EFFECT OF APPLIED STATIC STRESSES ON THE BEHAVIOR OF MECHANICAL ELEMENT

A.S. Abdalaziz A.N. Rashid A.A. Hamid

Mechanical Engineering Department, University of Mosul, Mosul, Iraq
ahmed.saadoon@uomosul.edu.iq, ahmed.n.rashid@uomosul.edu.iq, abdulhaqqhamid@uomosul.edu.iq

Abstract- This research include study the effect of the applied static load on the deflection value produced for a mechanical element which is used in construction of a bending load cell. Different conditions were taken in this research include the value of the applied load, section type, section dimensions, type of raw materials and length of the element so three types of metallic materials were chosen for the construction of the mechanical element, these are steel, aluminum and brass. A load of one ton is selected as a maximum load which applied on a section element. Square element was chosen with two different dimensions of section and two lengths. It was noticed from the results that the maximum deflection occurs in aluminum element whereas the minimum deflection produced in the steel element. Also, the maximum deflection is noticed in the elements of taller lengths which have the little section for all types of metals. Finally, three empirical formulas were established for the all conditions that can be used to calculate deflection of each element at a specific condition.

Keywords: Bending, Load Cell, Element, Static, Deflection.

1. INTRODUCTION

Torque and force have been sensed and measured using load cells. They are used frequently for weighing measures in a variety of fields [1], thus load cell may be defined a transducer used for measuring force and outputs this force as an electrical signal. Different types of load cells exist: compression load cell, torsion load cell and bending load cell which is interested in this research. The industrial society creates new complex service kinds that respond to current industrial needs [2], thus this advancement in technology necessitates an expansion of scientific knowledge in several industrial domains, one of which is the technology of load cell building. One of the common types of load cells used in commercial weighing applications is the bending load cell.

Although they are rarely acknowledged, beams are essential to our daily lives. From bridges to cranes, decks to any roofed construction, beams are everywhere, and most likely we utilize them without even realizing it. An object's (or medium's) deformation, which is a change in its size and shape, is brought on by external forces. Stress, which in SI units is measured in Pascal, expresses the magnitude of the forces that induce deformation, while strain, which has no dimensions, expresses the extent of the deformation under stress [3] but in bending there are many different kinds of beams available nowadays and in this study, we only looked at the cantilever beam which is by definition a beam with one end fixed while the other end is hanging and unsupported. Several factors influence on the response of cantilever, these elements comprise the item's measurements (length, width, and thickness), as well as the material's characteristics.

The rigidity of a cantilever is determined by its geometric shape and the material used to make it (how it responds when a force is applied). The geometric shape of a basic rectangular cantilever depends on the thickness, length, and width of the beam. Each of these variables influences the movement and bending of a cantilever. Additionally, all types of load cells must be protected from corrosion caused by humidity or chemical agents in an industrial setting such as pipelines, extractive industries, and mining fields. To prevent corrosion caused by these agents, load cells must be effectively sealed against moisture. Otherwise, general corrosion, stress corrosion, and pitting corrosion could damage strain gauges and cause the mechanical element to corrode [4].

2. RESEARCH METHOD

In this research specimens were taken as a cantilever of different square section as (10 mm, 20 mm and 30 mm) for two lengths of cantilever (25 mm and 40 mm). The applied load is selected as (10000) N. This study's objective is to investigate these mentioned effects on the elastic deflection of the metallic cantilever used as a mechanical element in a bending load cell. Different types of metallic materials were selected, these are steel, aluminum and brass as a raw material which is used in construction of the element of bending load cell i.e., this research include study the effects of cross-sectional area (I), length and type of material under static load on the maximum deflection occurred in the mechanical element of a bending load cell. The dimensions selected for the element of bending load cell are listed in Table 1, T represents thickness, W represents width and L represents length of element and (A=T because of square section). Figure 1 represents the selected element in the research.

Table 1. Dimensions of element

L (mm)	A (mm)	T (mm)
25	10	10
40	10	10
25	20	20
40	20	20
25	30	30
40	30	30

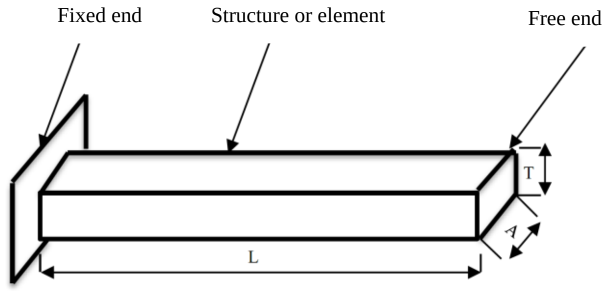

Figure 1. Dimensions of selected element

3. ANALYSIS AND RESULTS

A spring beam's deflection is influenced by its length, cross-sectional design, and the type of a material, also the place of the applied force and the support method used. The equation used in this research is for homogenous, linear elastic material element which designed in this research for a given deflection and then to determine which length and section is suitable to use. The maximum deflection can be determined for elements using relation ($FL^3/3EI$), where:

F: applied load
L: length
E: elastic modulus
I: moment of inertia = $a^4/12$
A: rib of square [5]

Tables 2, 3 and 4 have been formed for three types of element materials. These are steel type, aluminum type and brass type. Figures 2-4 represent the results obtained from above Tables.

Table 2. Results for steel element

F(N)	L(mm)	a(mm)	I(mm^4)	Max. deflection (mm)
10000	25	10	833.33	0.301
10000	25	20	13333.33	0.018
10000	25	30	67500	0.0037
10000	40	10	833.33	1.236
10000	40	20	13333.33	0.077
10000	40	30	67500	0.015

Table 3. Results for aluminum element

F(N)	L(mm)	a(mm)	I(mm^4)	Max. deflection (mm)
10000	25	10	833.33	0.801
10000	25	20	13333.33	0.05
10000	25	30	67500	0.0099
10000	40	10	833.33	3.28
10000	40	20	13333.33	0.205
10000	40	30	67500	0.0405

Table 4. Results for brass element

F(N)	L(mm)	a(mm)	I(mm^4)	Max. deflection (mm)
10000	25	10	833.33	0.612
10000	25	20	13333.33	0.0383
10000	25	30	67500	0.00756
10000	40	10	833.33	2.5
10000	40	20	13333.33	0.156
10000	40	30	67500	0.0309

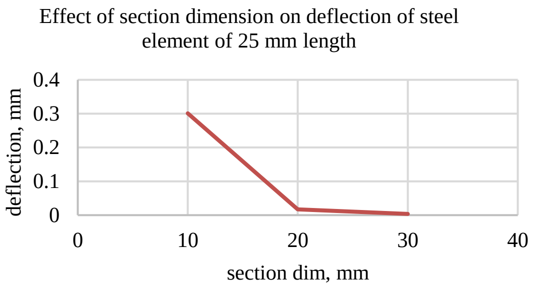

Figure 2. Effect of section dimension on deflection of steel element of 25 mm in length

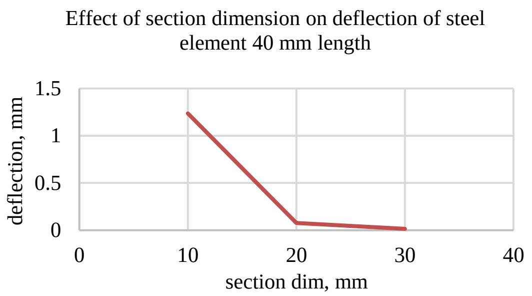

Figure 3. Effect of section dimension on deflection of steel element of 40 mm in length

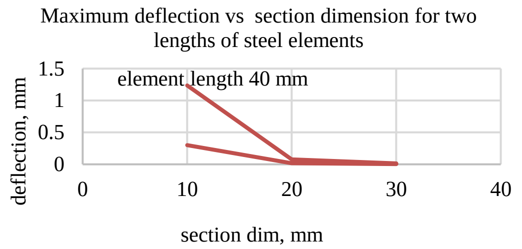

Figure 4. Maximum deflection versus section dimension for two lengths of steel elements (25 and 40 mm)

External forces on an object (or medium) cause its deformation, which is a change in its size and shape. The strength of the forces that cause deformation is expressed by stress, which in SI units is measured in the unit of pressure (Pascal). The extent of deformation under stress is expressed by strain, which is dimensionless [4] so from Figures 2-4, it was noticed that the deflection of the steel element decreased with increasing section dimension for the two lengths of the elements, and decrease of element length effect on minimize the values of deflection occurred in the element due to static loads.

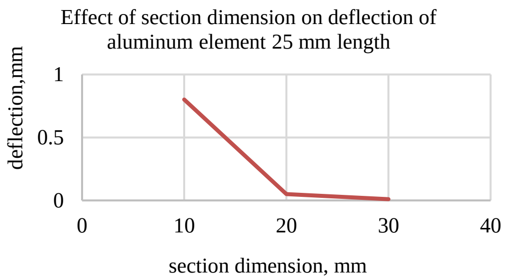

Figure 5. Effect of section dimension on deflection of aluminum element of 25 mm in length

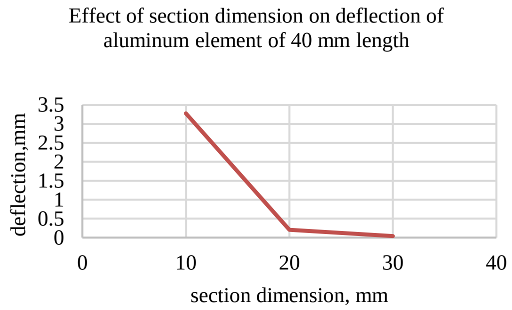

Figure 6. Effect of section dimension on deflection of aluminum element of 40 mm in length

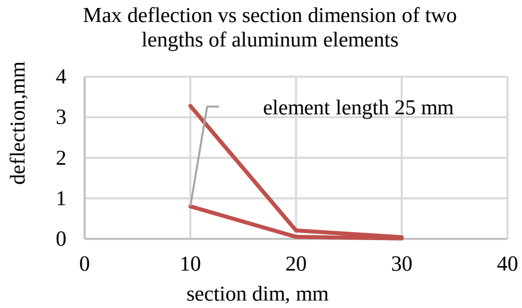

Figure 7. Maximum deflection versus section dimension of two lengths of aluminum elements

It was noticed from Figures 5-7 that the deflection of the aluminum element decreased with increasing section dimension for the two lengths of the elements, and decrease of element length effect on minimize the values of deflection occurred in the element due to static loads.

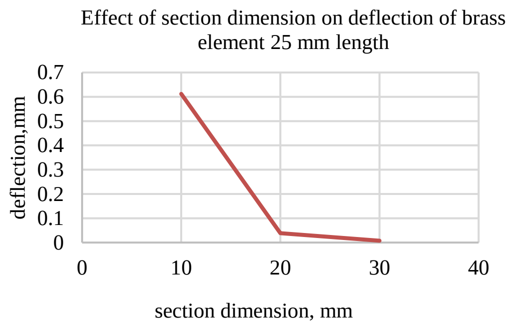

Figure 8. Effect of section dimension on deflection of brass element of 25 mm in length

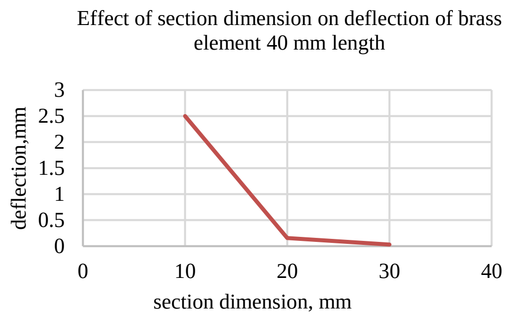

Figure 9. Effect of section dimension on deflection of brass element of 40 mm in length

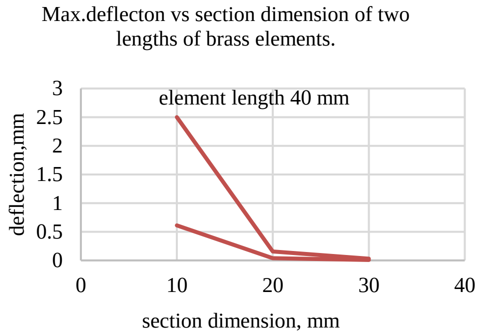

Figure 10. Maximum deflection versus section dimension of two lengths of brass elements

It was noticed from Figures 8-10 that the deflection of the brass element decreased with increasing section dimension for the two lengths of the elements, and decrease of element length effect on minimize the values of deflection occurred in the element due to static loads.

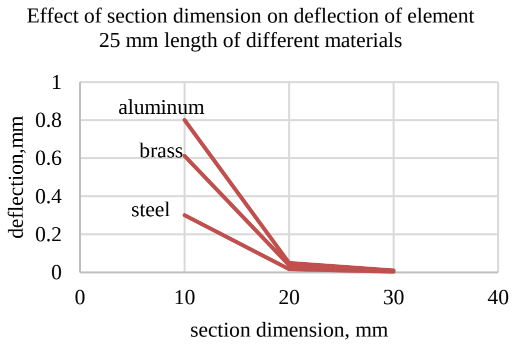

Figure 11. Effect of section dimension on deflection of element of 25 mm in length of different materials

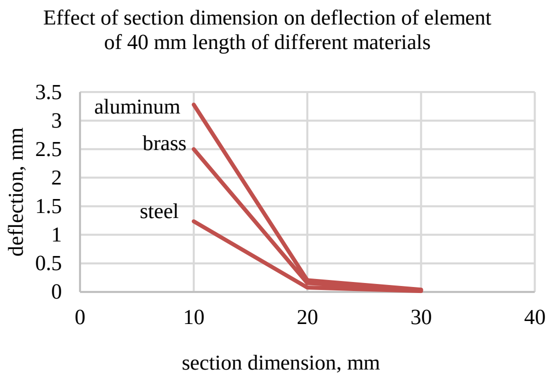

Figure 12. Effect of section dimension on deflection of elements have 40 mm length for different materials

It was noticed from Figure 11 that the deflection of the steel elements for 25 millimeters element length have the minimum values of the elements and the aluminum element has the maximum deflection and the brass element is between and this is due to the variation in the mechanical properties between the steel, aluminum and brass exactly elastic modulus which is about 207000 GPa for steel but for aluminum is about 78000 GPa, also Figure 12 have an agreement with Figure 7 but the deflection here is larger than as a reason of increasing the length of the element. Then to focus the type of relation between applied static load and deflections occurred due to loading, length and cross-sectional area of element were selected from the results above, these are 25 mm length and (100 mm²) cross sectional area for the three materials i.e., steel, brass and aluminum, then the relation between deflection and load have been plotted. Tables 5-7 and also Figures 13-15 represent these relations.

Table 5. Load-deflection results of steel element

Deflection (mm)	*F* (N)
0.1	3311.98
0.2	6623.97
0.3	9935.95
0.4	13247.94
0.5	16559.93
0.6	19871.91
0.7	23183.9
0.8	26495.88

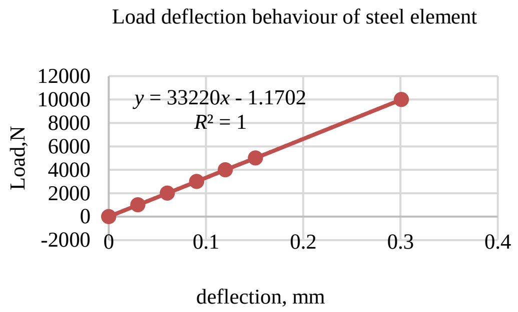

Figure 13. Load-deflection behavior of steel element

Table 6. Load-deflection results of aluminum element

Deflection (mm)	*F* (N)
0.1	1247.99
0.2	2495.99
0.3	3743.98
0.4	4991.99
0.5	6239.99
0.6	7487.99
0.7	8735.99
0.8	9983.99

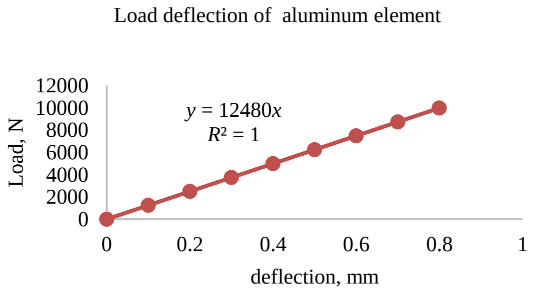

Figure 14. Load-deflection behavior of aluminum element

Table 7. Load-deflection results of brass element

Deflection (mm)	*F* (N)
0.1	1631.99
0.2	3263.99
0.3	4895.99
0.4	6527.97
0.5	8159.96
0.6	9791.95
0.7	11423.95
0.8	13055.94

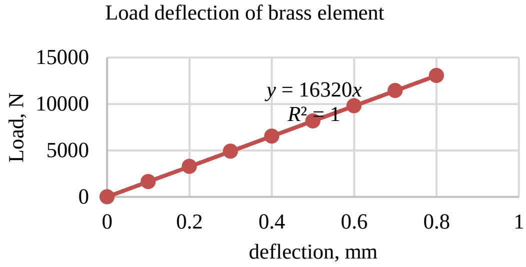

Figure 15. Load-deflection behavior of brass element

Empirical formulas: Also, it was found an empirical formula for each element in the research at a specified condition as 25 mm length and 100 mm² square section, steel element have the equation $Y=33220X-1.1702$. The aluminum element has behavior obey to the empirical formula $Y=12480X$ where the brass element has the empirical equation $Y=16320X$, Y is representing the elastic deflection in mm and X represent the load in newton and to minimize deflection occurred in the element one should increase the cross-sectional area, select the material that have higher elastic modulus to manufacture the element [7].

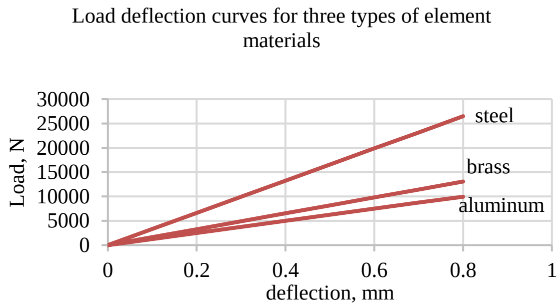

Figure 16. Load-deflection behavior of different types of elements

4. CONCLUSIONS

1) In steel element (mechanical part), deflection is decreased with increasing section dimension for the two lengths of the elements.
2) Decrease of element length effect on minimize the values of deflection occurred in the steel element due to static loads.
3) The deflection of the aluminum element decreased with increasing section dimension for the two lengths of the elements, but the decrease of element length effect on minimizes the values of deflection occurred in the aluminum element due to loads.

4) For brass element, it was noticed that the deflection of the element decreased with increasing section dimension for the two lengths of the elements. Also, the decrease of element length effect on minimizes the values of deflection occurred in the brass element.
5) From the results, empirical formulas are created for each element at a specific condition of 25 mm length and 100 mm^2 square section.
6) The empirical formula for steel element is Y=33220X-1.1702 at a constant condition, which Y is deflection and X is the load.
7) The aluminum element has behavior obey to the empirical formula Y=12480X, which Y is deflection and X is the load.
8) The formula of brass element is Y=16320X, which Y is deflection and X is the load.

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BIOGRAPHIES

Ahmed Saadoon Abdalaziz was born in Mosul, Iraq in January 1966. He received his bachelor degree in production and metallurgy from Technology University, Baghdad, Iraq in 1987. He received the M.Sc. degree from Mosul University, Mosul, Iraq in 1999. Since 1987 till 2003 he worked as an engineer in Ministry of Industry, and from 2003 till now he worked as a lecturer at Mechanical Engineering Department, College of Engineering, University of Mosul. His research interest is in heat treatment of steels and nonferrous alloys, material selection, adhesives, and physical metallurgy.

Ahmed Nafie Rashid was born in Mosul, Iraq in October 1973. He received the bachelor degree in production and metallurgy from Mosul University, Mosul, Iraq in 1996. He received the M.Sc. degree from the same university in 1999. Since 2001 till now he worked as a lecturer at Mechanical Engineering Department, College of Engineering, University of Mosul. His research interest is in metal forming, composite materials, adhesives, and metallurgy.

Abdulhaqq A. Hamid was born in Mosul, Iraq in December 1966. He received the B.Sc. degree in Mechanical Engineering from University of Mosul, Mosul, Iraq in 1988. He obtained the M.Sc. degree in Mechanical Engineering with specialization in applied mechanics from the same university in 1997. He received the Ph.D. in Mechanical Engineering, Tribology and Composites Materials from Indian Institute of Technology Roorkee, Roorkee, India in 2006. He joined as Assistance Lecturer in Mechanical Engineering Department at University of Mosul in 1992. His research areas of interest are tribology, fatigue and composites materials. Have published many research papers in these areas of interest in International, national journals and conferences. Have supervised many numbers of B.Sc. final projects and M.Sc. thesis. He has the credits many consultancies national projects.