Validation of Fixed-End Beam Analysis with Uniform Loads Using Android-Based Applications

Samsul A. Rahman Sidik Hasibuan [a*], Irwan [a], Dwi Kurniati [b] and Talitha Zhafira [c]

[a] *Department of Civil Engineering, Medan Area University, Jl Kolam, No 1, Medan, 20223, Indonesia.*
[b] *Department of Civil Engineering, Technology Yogyakarta University, Jl. Glagahsari No. 63, D.I. Yogyakarta, 55164, Indonesia.*
[c] *Department of Civil Engineering, Semarang University, Jl. Soekarno Hatta, Kota Semarang, Jawa Tengah, 50196, Indonesia.*

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Original Research Article

ABSTRACT

The beam structure is an essential structural element to construction professionals, and most engineers must be familiar with beams. The type of beam structure discussed in this article is a fixed-end beam structure with uniform loads. Calculating the forces and structural deformations manually takes longer and requires good accuracy. Various software and applications can be installed easily in this increasingly sophisticated era. The Easy Beam Analysis Application is one application that can be used to obtain internal forces and structural deformations quickly and accurately. Easy Beam Analysis is an Android-based application that can be installed via the Play Store. In this article, fixed-end beam structures with uniform loads are modelled and analyzed using the Easy Beam Analysis Application. This article aims to validate the results of manual calculations

_____

*Corresponding author: Email: samsulrahman@staff.uma.ac.id;

according to the static equilibrium requirements, especially fixed-end beams with uniform loads. This article will also validate it by manual accounting according to static equilibrium requirements. Furthermore, the analysis results with the Easy Beam Analysis Application and manual calculations have been obtained and validated. It can be seen that the results of the analysis do not have a significant difference. So, it can be concluded that structural analysis with the Easy Beam Analysis Application can be a fast and accurate solution.

Keywords: Fixed-end beam; easy beam analysis; uniform loads.

1. INTRODUCTION

The beam structure is an important structural element to construction professionals, and most engineers must be familiar with beams. These structures play an important role in how weight is transferred and ensure that the foundation of the building is firmly anchored in the ground. The most common types of beam structures include simple beams, cantilever beams, fixed-ended beams, continuous beams, and so on. Beam structure is very important to understand in construction and structural engineering because beams are the first to carry the weight of a building. The type of beam structure discussed in this article is a fixed-end beam structure with uniform loads. The structural analysis of fixed-end beams includes a scientific discipline that studies the forces and shifts in a system due to loads acting on the structure [1]. The fulcrum is where the construction rests and the reaction works. The type of support influences the type of construction because each style has its characteristics. In the structural analysis, it is known that there are three types of supports, namely pin supports, roll supports, and fixed supports. Beams with fixed ends (tightly anchored) are constructed to resist translation and rotation. The ends of the beam are locked so tightly that they do not move or rotate due to the moment. In terms of static equilibrium [2] 3 equations are available, namely $\Sigma Fx = 0$, $\Sigma Fy = 0$, and $\Sigma Mz = 0$. Static equilibrium equations can calculate support reactions if the structure belongs to a specific static system. In general, the calculation of support reactions on a structure is necessary and must be carried out before calculating the forces and deformation of the structure.

Calculating the forces and structural deformations numerically takes longer and requires good accuracy. Various software and applications can be installed easily in this increasingly sophisticated era. One application [3] that can quickly and accurately obtain internal forces and structural deformations is the Easy Beam Analysis Application. Easy Beam Analysis is an Android-based application that can be installed for free via the play store. The Easy Beam Analysis application can be used to obtain internal forces and structural deformations quickly and accurately. The Easy Beam Analysis application can easily and quickly calculate reaction forces, shear forces and bending moments, slope, deflection and stress diagrams for beam analysis. The Easy Beam Analysis application follows the principles of statics and dynamics, materials mechanics, and solids mechanics and is thus highly applicable to structural engineering and mechanical engineering. Easy Beam Analysis is the perfect App for engineering students to accompany homework problems and check solutions to statics, materials mechanics or solids mechanics. It is also very useful for professionals in structural and mechanical engineering to make quick calculations regarding beam calculations. Easy Beam Analysis supports two modes: Statically Determined Beam and Continuous Beam [4-7]. This article aims to validate the results of manual calculations according to the static equilibrium requirements, especially beams with uniform loads. This article will also validate it by manual analysis according to static equilibrium requirements.

2. METHODOLOGY

The fixed-end beam structure is modelled and analyzed in this article using the Easy Beam Analysis Application [8-11]. Then the case studies to be completed are shown in Fig. 1. The steps for modelling and analysis with the Easy Beam Analysis Application are shown as a flowchart in Fig. 2. The data used in the modelling and analysis are as follows:

a. Distributed loads (q)   = 7 t/m;
b. Lengths (L)   = 5 m;
c. Frame element   = default software.
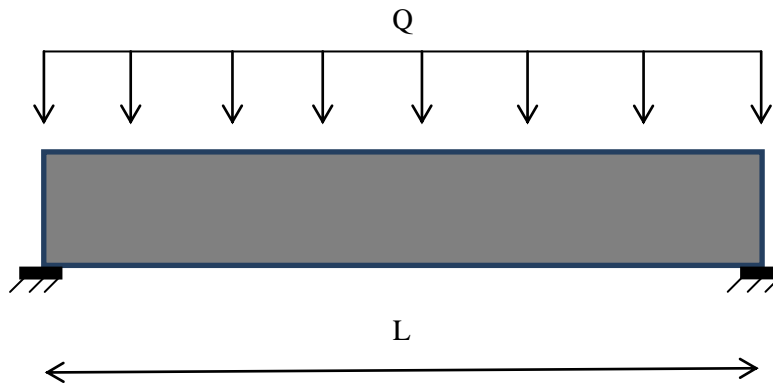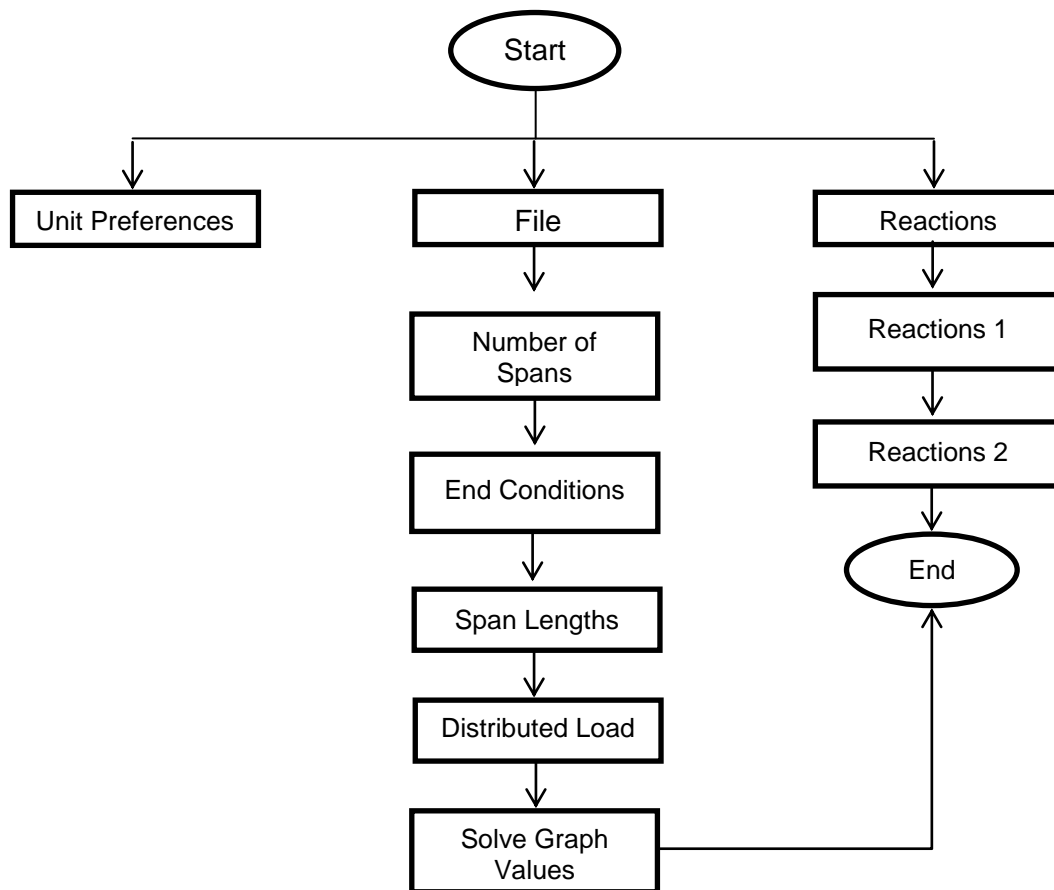
Fig. 1. Case study

Fig. 2. Flow chart

Next, the steps for running the Easy Beam Analysis Application are shown to analyse fixed-end beam structures with uniform loads.

a. Select settings (top right three dots) > unit preferences > input units to be used (Fig. 3).
b. Select file (top left) > number of spans > fill in the number of spans (Fig. 4).

c. Select file (top left) > end condition > select pinpoint base (Fig. 5).
d. Select file (top left) > span length > input beam span (Fig. 6).
e. Select file (top left) > distributed loads > input distributed loads (Fig. 7).
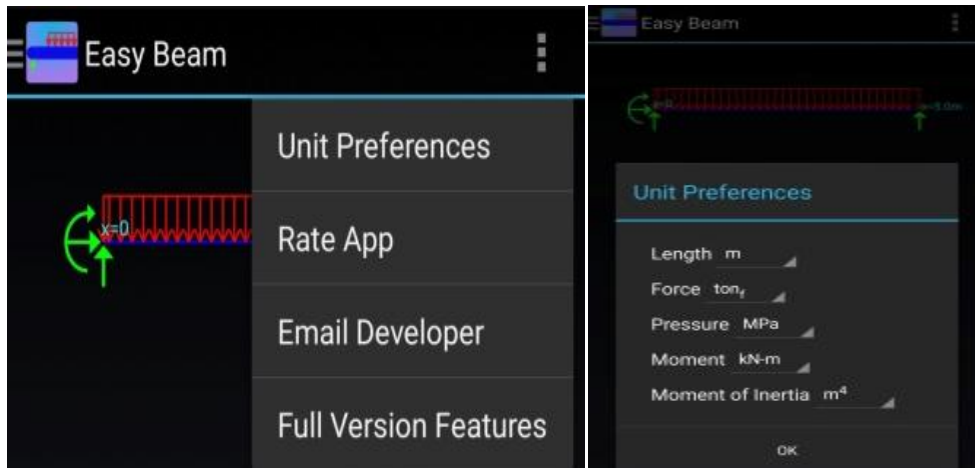f. Select the file (top left) > solve for the graph value > see the output of the internal force (Fig. 8).
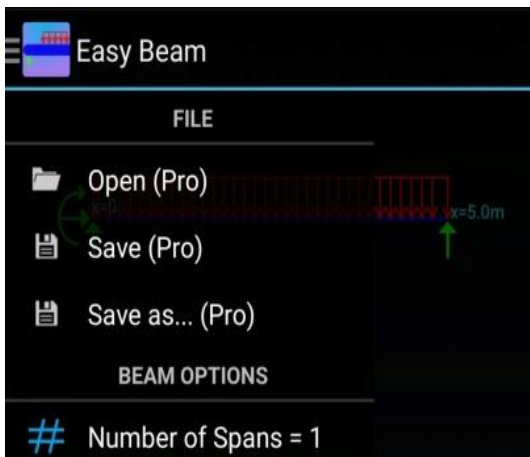
Fig. 3. Unit preferences
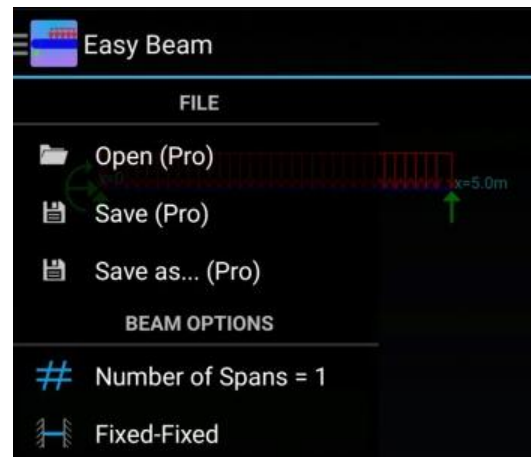

Fig. 4. Number of spans

Fig. 5. End condition

Fig. 6. Span lengths
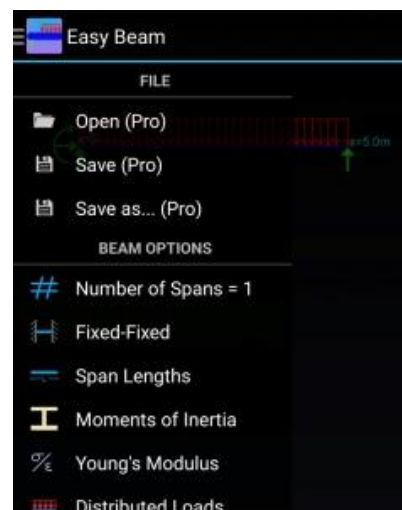
Fig. 7. Distributed loads
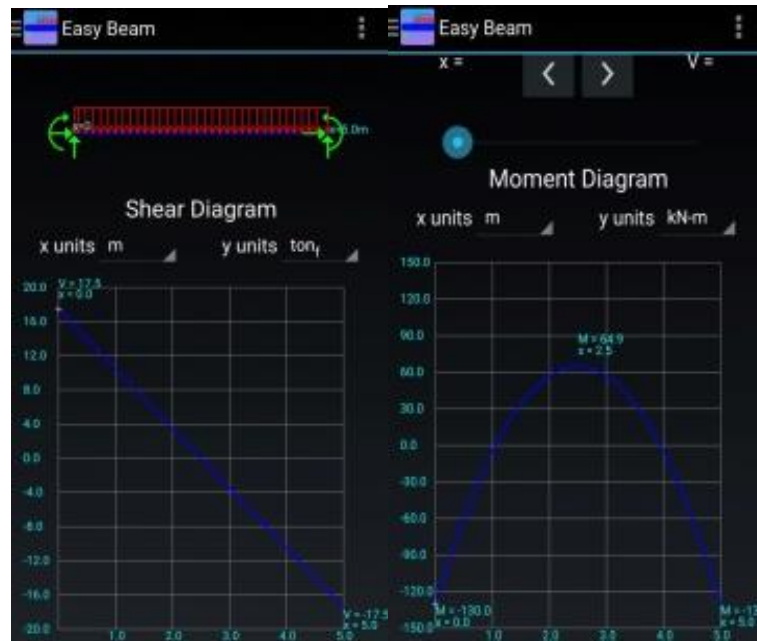
Fig. 8. Output internal force

Table 1. Validation of result

	SFD		BMD	
	Max (ton-m)	Min (ton-m)	Max (ton-m)	Min (ton-m)
Easy Beam Analysis	17,5	17,5	6,6	13,3
Manual	17,5	17,5	7,3	14,5

3. RESULTS AND DISCUSSION

3.1 Results

Analysis of fixed-end beam structures with the Easy Beam Analysis Application has been obtained. The analysis results are shown as shear force diagrams and bending moment diagrams. Furthermore, the results obtained from the Easy Beam Analysis Application are recapitulated and validated with the results of manual calculations that have been adjusted to the static equilibrium requirements (Table 1).

3.2 Discussion

The validation of the analysis results using the Easy Beam Analysis Application and the manual shows a difference in the value, but it is insignificant. In Fig. 8, the moment is shown in kN-m units, so it needs to be converted to ton-m units.

4. CONCLUSION

In this article, manual calculations have discussed and validated the results of the analysis of fixed-end beam structures with the Easy Beam Analysis Application. It can be seen that the analysis results obtained did not have a significant difference. So, it can be concluded that structural analysis with the Easy Beam Analysis Application can be a fast and accurate solution.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Afriani, R. Simple beam structural analysis using Microsoft Visual Basic 6.0, Civil Engineering Study Program, Faculty of Engineering, Muhammadiyah University, Surakarta. Surakarta: Muhammadiyah University of Surakarta; 2014.
2. Szumigała M. 'Iterative methods of beam-structure analysis', in modern building materials, structures and techniques, Mbmst 2016. The Author(S). 2017:1093–1101.
   DOI: 10.1016/J.Proeng.2017.02.169

3. Tanjung D. 'Structure analysis simulation of Sap2000 7.4 student version using finite element method'. Al Ulum Seri Saintek. 2013;1(2):222–237.

4. Bentley System Official Website. 'Bentley System Inc; 2014.
Available:Https://Www.Bentley.Com

5. Computer and Structures Inc. 'Etabs'. Barkeley, California: USA; 2003.

6. Computer and Structures Inc. 'Sap2000'. Barkeley, California: USA; 2007.

7. Wildebeastmedia. Easy beam analysis; 2014.

8. Tampubolon SP, Mulyani AS. 'Analysis and calculation of wooden framework structure by using structural analysis program (Sap)-2000 and method of joint. In IOP Conference Series: Earth And Environmental Science. IOP Publishing; 2021.
DOI: 10.1088/1755-1315/878/1/012042

9. Hasibuan SARS, Azmi F, Anisa Y. Comparative study of beam structure analysis using android and Sap2000 based applications. Journal of Gradation of Civil Engineering. 2022;6(1):23-33.

10. Hasibuan S. Plane truss structural analysis solutions with opensees. In Kahuripan National Seminar. 2020:290-294.

11. Sholeh MN. Sap2000 V22 structural analysis; 2021.