International Journal of Innovative Research in Computer Science & Technology (IJIRCST)
ISSN: 2347-5552, Volume-11, Issue-1, January 2023
https://doi.org/10.55524/ijircst.2023.11.1.13
Article ID IRP1358, Pages 62-67
www.ijircst.org

Solution of Beam Structure Analysis Using SAP2000

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ABSTRACT- The beam structure is an essential structural element for construction professionals, and most engineers should be familiar with beams. The type of beam structure discussed in this paper is a simple beam structure. Calculating the forces and structural deformations numerically takes longer and require good accuracy. In this increasingly sophisticated era, various kinds of software are available, one of which is SAP2000, which can be used to obtain internal forces and structural deformations quickly and accurately. In this paper, a simple beam structure is modeled and analyzed using SAP2000 software. This paper aims to provide solutions for analyzing structures, especially simple beams. Manual calculations will also validate this paper according to the requirements of static balance. Furthermore, the analysis results using SAP2000 software and manual calculations have been obtained and validated. The analysis results showed that the values obtained did not significantly differ. So it can be concluded that structural analysis with SAP2000 software can be a fast and accurate solution.

KEYWORDS- beam structural, simple beam, SAP2000.

I. INTRODUCTION

The beam structure is an important structural element for construction professionals, and most engineers should be familiar with beams. This structure plays an important role in transferring weight and ensures that the building's foundation is firmly planted in the ground. The most common types of beam structures include simple beams, cantilever beams, beams with fixed ends, continuous beams, and others. The beam structure is essential to understand in construction and structural engineering because the beam is the first to carry the load of a building. The type of beam structure discussed in this paper is a simple beam structure.

Simple beam structure analysis is a scientific discipline that studies the forces and shifts that occur in a structure due to the loads acting on the structure [1]. A simple beam structure is an element supported by hinge supports and roller supports at both ends. The pedestal is where the construction rests, and the reaction takes place. The type of base affects the type of construction because each type of base has its characteristics. In the structural analysis, it is known that there are three types of supports; namely, connection supports, roller supports, and clamp supports. Because the load acting on the beam is simple, there will be two support reactions in the joint and one support reaction on the rollers. In terms of static equilibrium [2] there are three equations, namely Fx = 0, Fy = 0, and Mz = 0 [3],[4].

Static equilibrium equations can calculate support reactions as long as the structure belongs to a specific static system. In general, the calculation of support reactions in a design is necessary and must be carried out before calculating the forces and deformations of the structure. Calculating the strengths and structural deformations numerically takes longer and require good accuracy. In this increasingly sophisticated era, various kinds of software are available, one of which is SAP2000 [5] which can be used to obtain internal forces and structural deformations quickly and accurately. Structural analysis software is divided into two categories: general-purpose software [6] and design-oriented software [6–9].

General-purpose software is used for various scientific and engineering purposes. SAP2000 is software used to analyze building structures and has been widely used worldwide. This program results from a research and development team led by Professor Edward L. Wilson from the University of California for more than 25 years [10]. In this paper, a simple beam structure is modeled and analyzed using SAP2000 software. This paper aims to provide solutions for analyzing structures, especially simple beams. Manual calculations will also validate this paper according to the requirements of static balance.

II. METHODS

In this paper, a simple beam structure is modeled and analyzed using the SAP2000 software [10–15]. Then the case study to be completed is shown in Figure 2. The steps of modeling and analysis with SAP2000 software are offered in a flow chart in Figure 3. The data used in the modeling and analysis are as follows:

1) Uniform loads (q) = 3 t/m;
2) Concentrated loads (P) = 5 ton;
3) Frame element = default software.

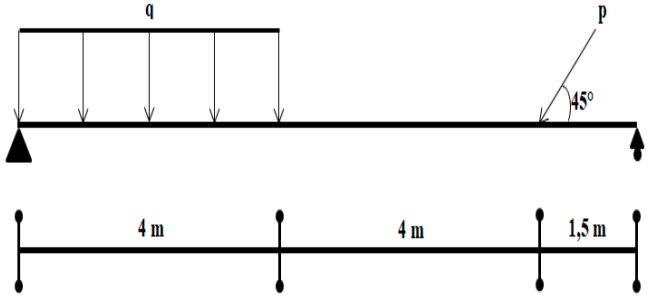

Figure 1: Case study

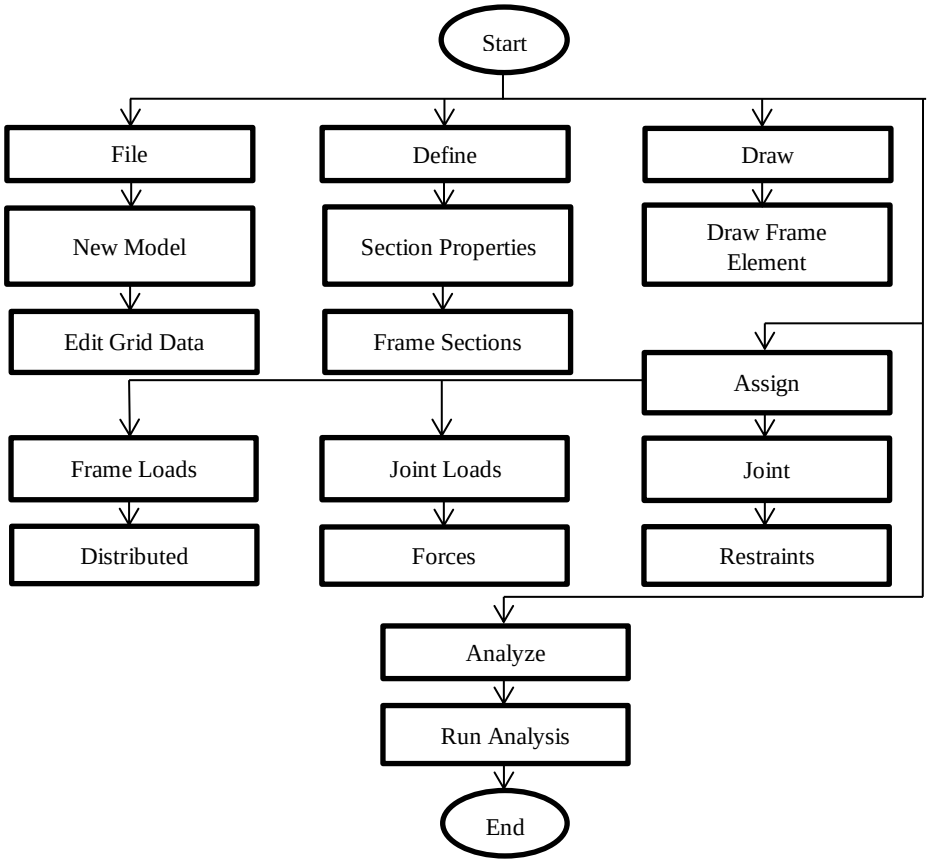

Figure 2: Flow chart

Next, the steps for running the SAP2000 software are shown to analyze simple beam structures with uniform loads and concentrated loads.

1) Select file > new model (Figure 4)

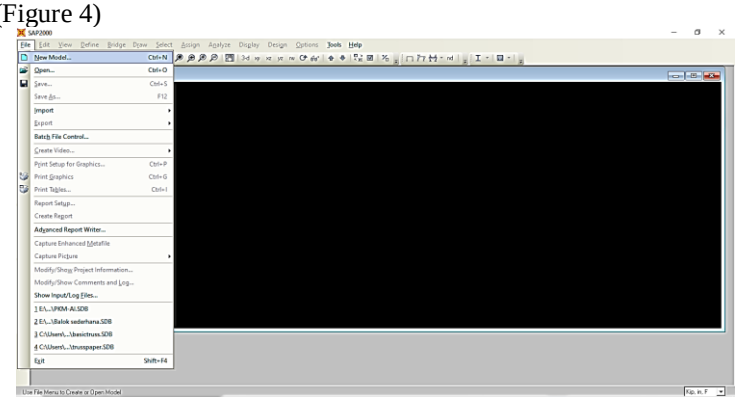

Figure 4: File > new model

2) Select unit > grid only > edit grid data (Figure 5)

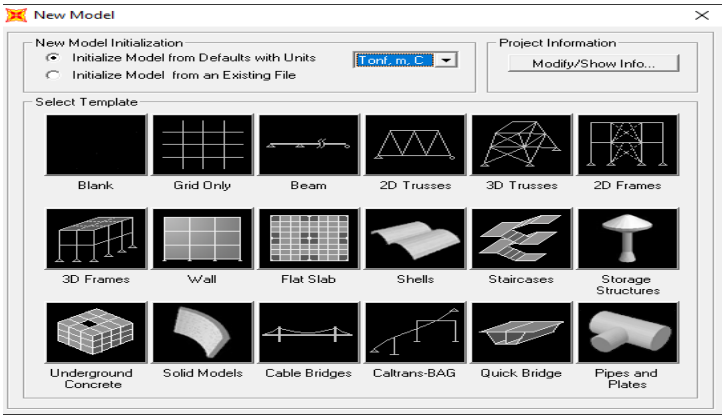

Figure 5: Grid only > edit grid data

3) Set view > select axis XZ (Figure 6)

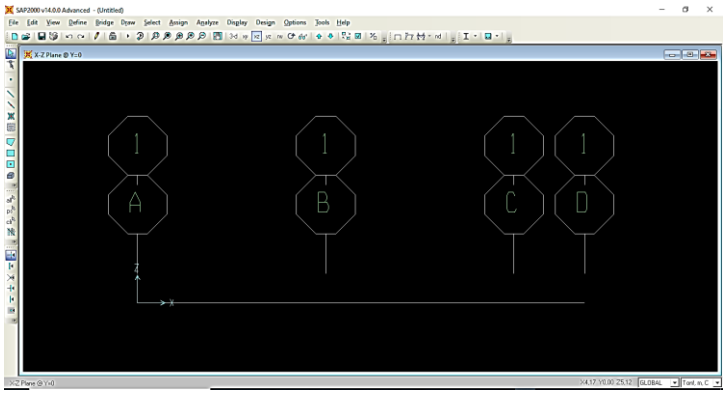

Figure 6: Set view > select axis XZ

4) Select draw > draw frame/cable/tendon > draw frame (Figure 7)

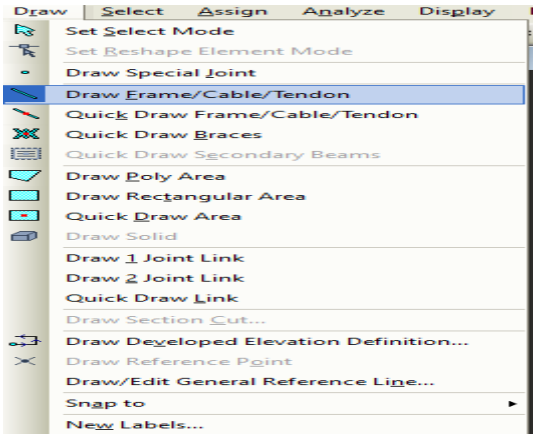

Figure 7: Draw > draw frame/cable/tendon

5) Click the left end of the support grid point > assign > joint > restraints > select hinge support. Repeat the same steps to make the roller support at the right end (Figure 8)

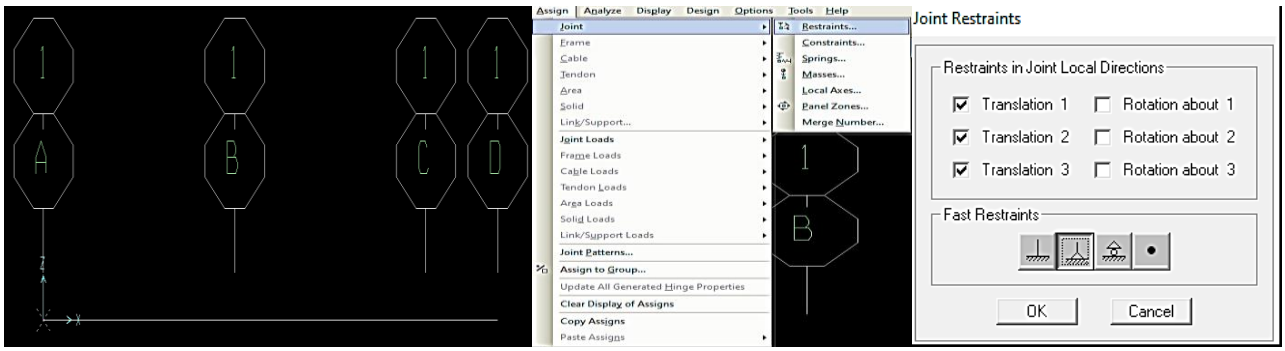

Figure 8: Grid point support > assign > joint > restraints

6) Click frame > assign > frame loads > distributed > input value of uniform loads (Figure 9)

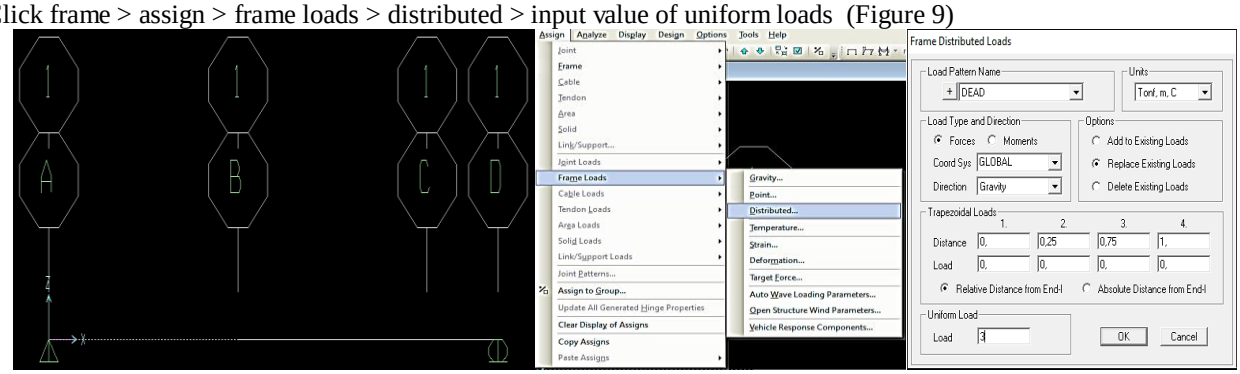

Figure 9: Frame > assign > frame loads > uniform loads

7) Click frame > assign > joint loads > joint forces > input value of concentrated loads (Figure 10)

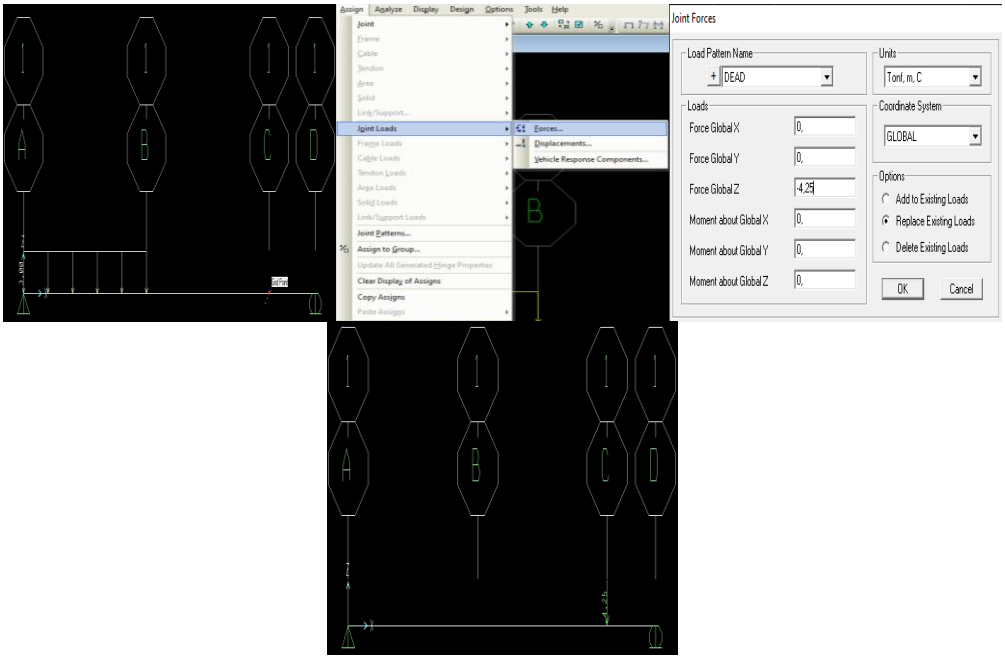

Figure 10: Frame > assign > joint loads > joint forces

8) Click analyze > run analysis > run now > save (Figure 11)

9)

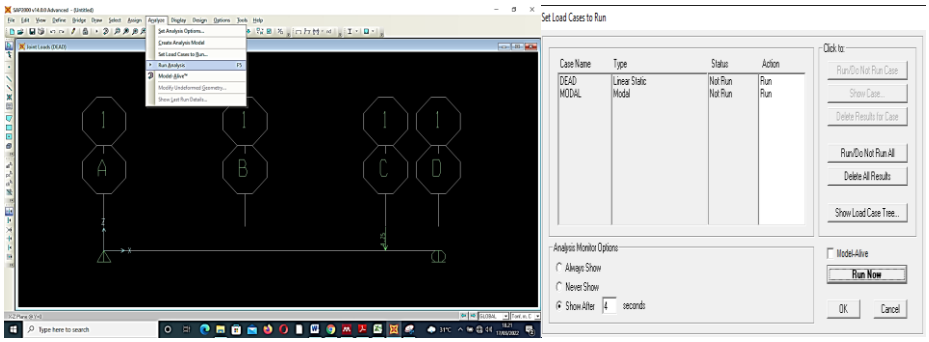

Figure 11: analyze > run analysis

10) Click display > show forces/stresses > frame/cable > select moment 3-3 for BMD and shear 2-2 for SFD and reactions to hinges and roller supports (Figure 12)

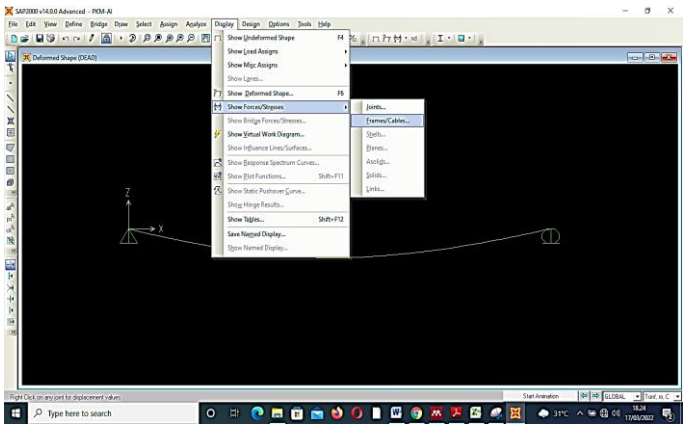

Figure 12: Internal forces output

III. RESULTS AND DISCUSSION

A. Results

A simple beam structure analysis has been obtained using the SAP2000 software. The results of the study are shown in the form of equivalent loads (Figure 13), shear force diagrams (Figure 14), and bending moment diagrams (Figure 15).

Figure 13: Equivalent Load

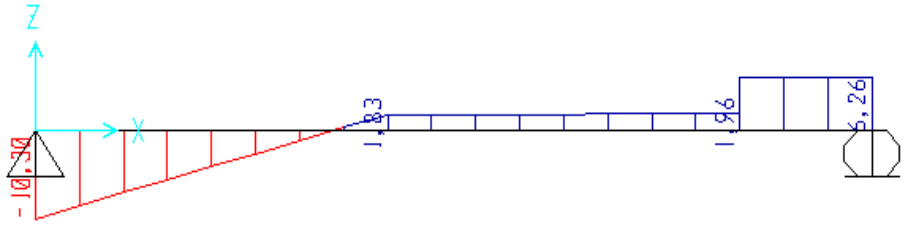

Figure 14: Shear force diagram

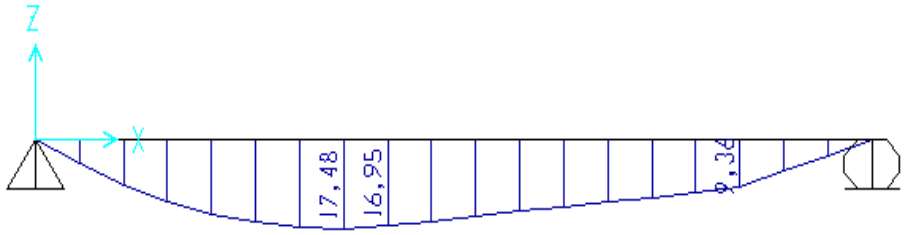

Figure 15: Bending moment diagram

Furthermore, the results obtained from SAP2000 are recapitulated and validated with the results of manual calculations that have been adjusted to the requirements of static equilibrium (Table 1).

Table 1: Validation of results

	Rs	Rr	SFD				BMD					
			j1	j2	j3	j4	x	x2	max	x4	x8	x9,5
SAP2000	10,3	6,3	10,3	-1,8	-6,3	0	0	14,5	17,5	17	9,4	0
Manual	10,7	8	10,7	-1,3	-5,4	0	0	15,6	19,1	18	8,2	0

Note:

1) SFD is a shear force diagram;
2) BMD is bending moment diagram;
3) Rs is the reaction at the hinge support;
4) Rr is the reaction at the roller support;
5) j1, j2, etc. are joints at point 1, point 2, etc;
6) x0, x2, etc

B. Discussion

Validation of analysis results with SAP2000 and manual seems to have different values because the initial assumption of beam elements is set as software default. Please note that the shear force diagram in SAP2000 and the manual will differ for positive and negative signs, but the value remains the same. So this is not a problem.

IV. CONCLUSION

In this paper, the simple beam structure analysis results using SAP2000 have been discussed and validated by manual calculations. The analysis results showed that the values obtained did not significantly differ. So it can be concluded that structural analysis with SAP2000 can be a fast and accurate solution.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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