# MODELLING IN SIMPLE BEAM STRUCTURE WITH SAP 2000 AND AUTODESK RSA PROFESSIONAL

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| Article Info | ABSTRACT |
|---|---|
| | Simple beam is one application of determinate static structure components. The static structure is a structure that can be solved by a determinate static basic equation. This study aims to create a simple beam model which is then analyzed using two softwares contain SAP 2000 Version 11 Nonlinear and Autodesk RSA Professional 2012. The results of both modeling can be compared with some different steps in both softwares. Simple beam modeling with the two software results in the same reaction value for point and distributed loads. By comparing three stages of completion of a simple beam structure with two different cases are point and distributed loads produce the same support reactions. Analysis with SAP 2000 and Autodesk RSA Pro software can to complete the structure more easily and quickly.<br><br> |

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## INTRODUCTION

Simple beam is one application of determinate static structure components. The determinate static structure is a structure that can be solved by a determinate static basic equation includes $\Sigma H = 0$, $\Sigma V = 0$, and $\Sigma M = 0$ [1]. A simple beam is a beam structure consisting of a single beam and two joints, in which the first joint is hinge that is able to withstand horizontal and vertical forces and the second joint is roll that only can support vertically forces only. The determinate static structures can be applied to some conditions to simplify a structural problem [2]. Structural components are used in a building system to support loads safely and reliably [3]. Both joints are unable to hold the moment. Simple beam structure modeling in many cases can be simplified by using softwares such as Structural Analysis Program (SAP) 2000 and Autodesk Robot Structural Analysis Professional (Autodesk RSA Pro). This study aims to create a simple beam model which is analyzed using two softwares contain SAP 2000 Version 11 Nonlinear and Autodesk RSA Professional 2012. The results of both modeling can be compared with some different steps in both softwares. As a reference analysis, the model is solved by mathematical calculations using equations of a determinate static structure.

## METHOD

The method of this research is completion of calculation analysis and modeling on simple beam structure. The software used is Structural Analysis Program (SAP) 2000 version 11 Non-linear and Autodesk Robot Structural Analysis Professional (Autodesk RSA Pro) 2012. The calculation result will be achieved is the reaction on simple beam structure for two loading types that is point and distributed loads. This study does not discuss diagrams for shear forces (Dx), normal forces (Nx), and moments (Mx). These softwares are based on finite element and Graphic User Interface (GUI) to facilitate the user in making structure model. The difference between the two softwares where the results of SAP 2000 is quantitative description, while the output of Autodesk RSA Pro that detailed engineering drawings in internationally standardized.

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## RESULTS AND ANALYSIS
### Mathematic Calculations
1.  **Simple Beam with Point Load**
    The problem in the simple beam structure that discussed is beam AB with point load $P = 1$ ton (down), and span long $l = 10$ m so that the model can be drawn (see Figure 1). Please, calculate the reaction on the two joints of the beam structure!
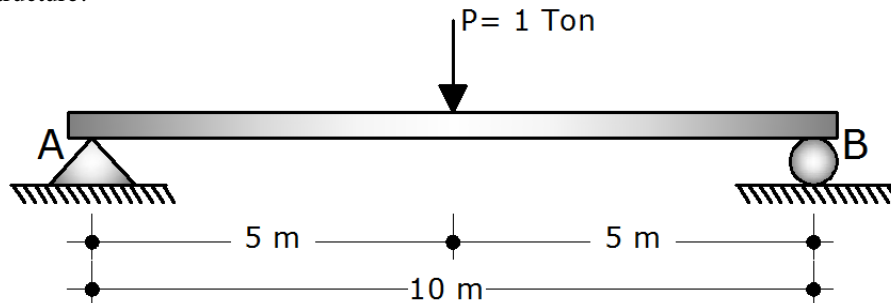


Figure 1. The model of a simple beam structure with point load

**Solution :**
- $\Sigma V = 0$
  $P = V_A + V_B$, because P in the middle of the span, then:
  $V_A = V_B = \frac{1}{2}P = \frac{1}{2}.1 = 0,5$ Ton $= 500$ Kg ($\uparrow$)
- $\Sigma H = 0$ (The equilibrium has been met because there is no horizontal load)
- $\Sigma M_A = \Sigma M_B = 0$

  $\Sigma M_A = P. \frac{1}{2}l - V_B.l$                     $\Sigma M_B = V_A.l - P. \frac{1}{2}l$
  $\quad = \frac{1}{2}Pl - \frac{1}{2}Pl = 0$                 $\quad = \frac{1}{2}Pl - \frac{1}{2}Pl = 0$
  $\quad = \frac{1}{2}.1.10 - \frac{1}{2}.1.10$              $\quad = \frac{1}{2}.1.10 - \frac{1}{2}.1.10$
  $\quad = 5$ Ton $- 5$ Ton $= 0$                            $\quad = 50$ Ton $- 50$ Ton $= 0$

2.  **Simple Beam with Distributed Load**
    The problem in the simple beam structure with distributed load with the details of the beam AB with $q = 10$ tons / m '(down), and $l = 10$ m so that the model can be drawn (see Figure 2). Calculate the reaction on the joints of the beam structure!
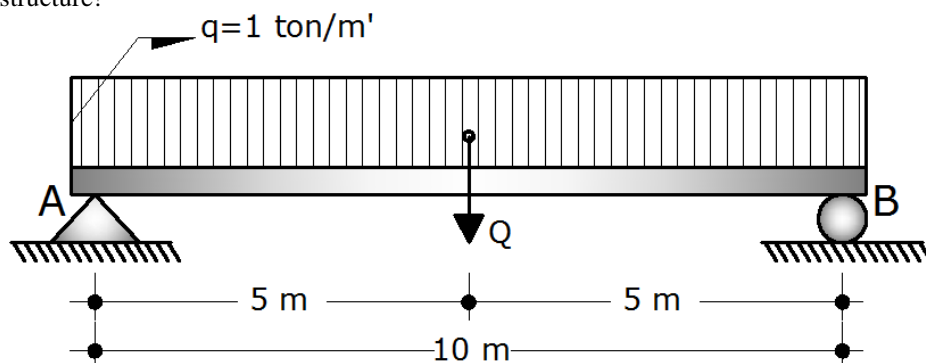


Figure 2. The model of a simple beam structure with distributed load

**Solution :**
- $\Sigma V = 0$
  $Q = V_A + V_B$,
  $V_A = V_B = \frac{1}{2}ql = \frac{1}{2}.10 = 5$ ton ($\uparrow$)
- $\Sigma H = 0$ (The equilibrium has been met because there is no horizontal load)
- $\Sigma M_A = \Sigma M_B = 0$

  $\Sigma M_A = Q. \frac{1}{2}l - V_B.l$                     $\Sigma M_B = V_A.l - Q. \frac{1}{2}l$
  $\quad = \frac{1}{2}ql^2 - \frac{1}{2}ql^2$                $\quad = \frac{1}{2}ql^2 - \frac{1}{2}ql^2$
  $\quad = \frac{1}{2}.1.10^2 - \frac{1}{2}.1.10^2$         $\quad = \frac{1}{2}.1.10^2 - \frac{1}{2}.1.10^2$
  $\quad = 50 - 50$ ton $= 0$                                $\quad = 50 - 50$ ton $= 0$

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**Modeling with SAP 2000**
**1.    Simple Beam with Point Load**
        Modeling in simple beam structure with SAP 2000 Version 11 Nonlinearity is very easy, because this program is very well known at international level and widely used by contractors including in Indonesia [4]. A simple beam problem with a point load on problems 3.1 and 3.2 referring to Figure 1 can be modeled by making simple beams as shown in Figure 3 with the application of free bar material.
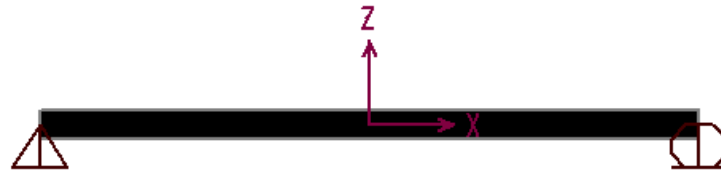


**Figure 3. Simple beam structure model with SAP 2000**

Subsequently a simple beam is subjected to dead load by set the self weight multiplier with a value of 0 (zero). The value of dead load for point load is 1 ton (down) in the middle of the span. The result is shown in Figure 4.



**Figure 4. The application of point load on the simple beam in SAP 2000**

The final step is to perform a simple beam analysis that has been made with a point load of 1 ton in the middle of the span. The results of the analysis check are shown in Figure 5, where the vertical reaction results at A ($V_A$) = 0,5 ton (up) and vertical reactions at B ($V_B$) = 0,5 ton (up). These results show similarities with mathematical calculations on problem 3.1.
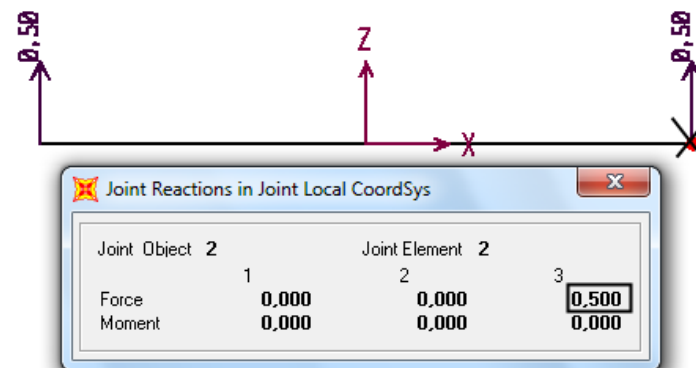


**Figure 5. The analysis results of simple beam with a point load in SAP 2000**

**2.    Simple Beam with Distributed Load**
        Simple beam problem with the distributed load on the problem 3.2 refers to Figure 2 is almost the same as the step on the completion of a simple beam with a point load, only difference in the application of the distributed load as shown in Figure 6. The value of the distributed load that applied is 1 ton/m '(down). The Self load multiplier changed to 0 (zero).
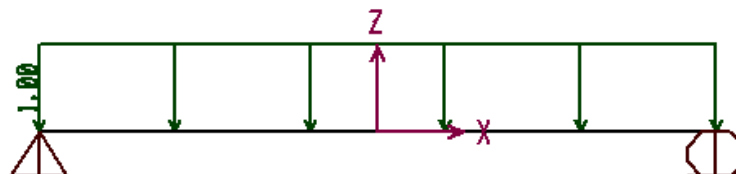


**Figure 6. The application of distributed load of 1 ton/m' on a simple beam in SAP 2000**

Analyze the simple beam model that has been made with a distributed load of 1 ton/m'. The results of the analysis check are shown in Figure 7, where the vertical reaction results in A ($V_A$) = 5 tons (up) and vertical reactions at B ($V_B$) = 5 tons (up). These results show similarities with mathematical calculations on problem 3.2.
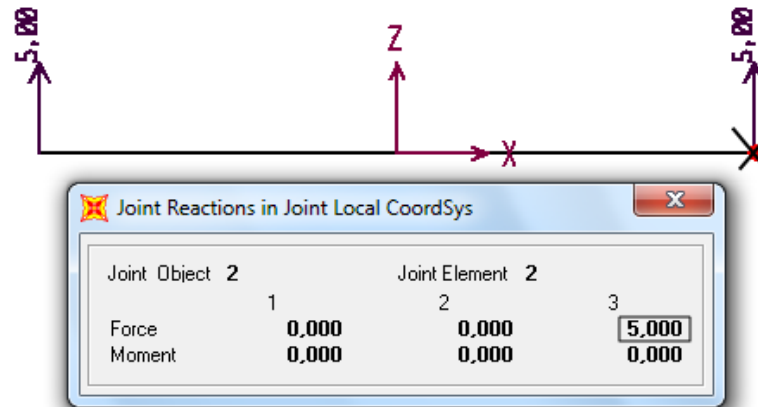
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**Figure 7. The analysis results of simple beam with distributed load in SAP 2000**

**Modeling with Autodesk RSA Professional**
**1.    Simple Beam with Point Load**
    Autodesk Robot Structural Analysis Professional has advantages other than finite-based element is also supported by the Graphic User Interface (GUI) that is very dynamic [5] and flexible so makes easier for users to draw structural model with high level of complexity even [6]. Problems 3.1 and 3.2 can be solved by creating a simple beam model as in Figure 8 with the free material type.
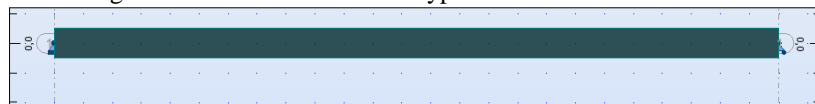


**Figure 7. The model of simple beam structure with Autodesk RSA Pro**

The simple beams are subjected to dead loads by change the self weight multiplier with a value of 0 (zero). The value of dead load for a point load is 1 ton in the middle of the span. The result is shown in Figure 8.



**Figure 8. The application of point load on the simple beam in Autodesk RSA Pro**

Analysis is done to know the reaction. The analysis results are shown in Figure 9 and 10, where the vertical reactions in A ($V_A$) = 0,5 ton = 5 kN (up) and vertical reactions at B ($V_B$) = 0,5 ton = 5 kN (up). These results show similarities with mathematical calculations on problem 3.1.
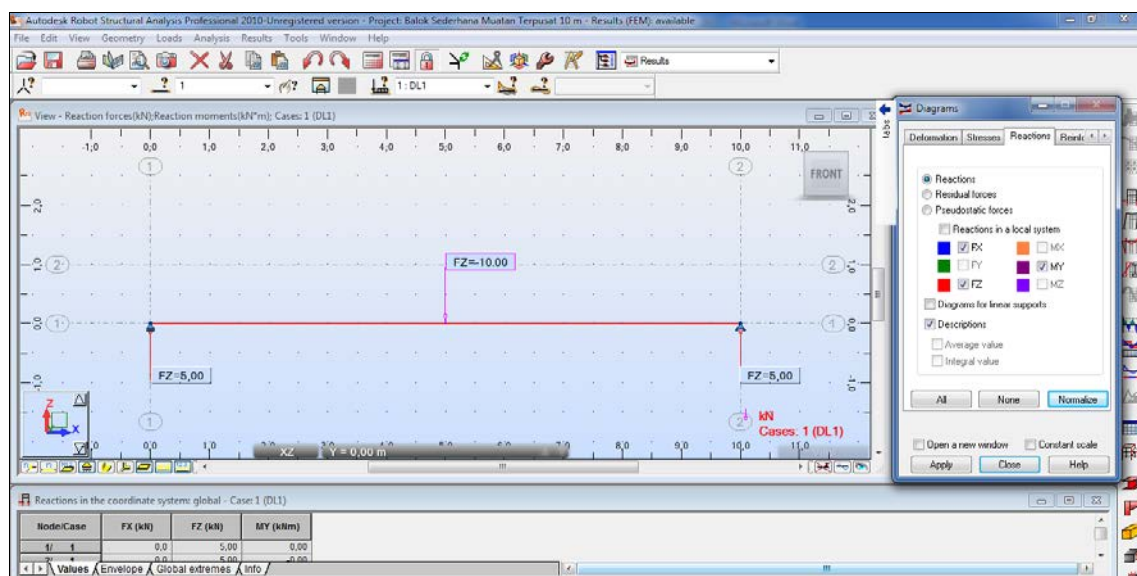


**Figure 9. The analysis results of simple beam with a point load in Autodesk RSA Pro**

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**Reactions in the coordinate system: global - Case: 1 (DL1)**

| Node/Case | | FX (kN) | FZ (kN) | MY (kNm) |
|---|---|---|---|---|
| 1/ | 1 | 0,0 | 5,00 | 0,00 |
| 2/ | 1 | 0,0 | 5,00 | -0,00 |
| | | | | |
| Case 1 | DL1 | | | |
| Sum of val. | | 0,0 | 10,00 | -0,00 |
| Sum of reac. | | 0,0 | 10,00 | -50,00 |
| Sum of forc. | | 0,0 | -10,00 | 50,00 |
| Check val. | | 0,0 | 0,0 | 0,0 |
| Precision | | 0,0 | 0,0 | |

**Figure 10. The reaction at two joints of simple beam with point load**

## 2. Simple Beam with Distributed Load

Simple beam problem with distributed load in Problem 3.2 as shown in Figure 11. The value od distributed load that applied is 1 ton/m' (down). The self weight multiplier is changed to 0 (zero).
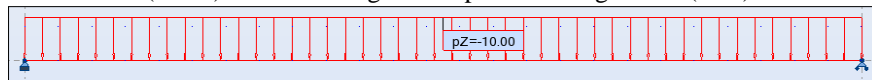


**Figure 11. The application of distributed load on the simple beam in Autodesk RSA Pro**

Analyze the simple beam model that has been made with a distributed load of 1 ton/m'. The results of the analytical checks are shown in Figure 12 and 13, where the vertical reaction results in A ($V_A$) = 5 ton = 50 kN (up) and vertical reactions at B ($V_B$) = 5 ton = 50 kN (up). These results show similarities with mathematical calculations on problem 3.2.
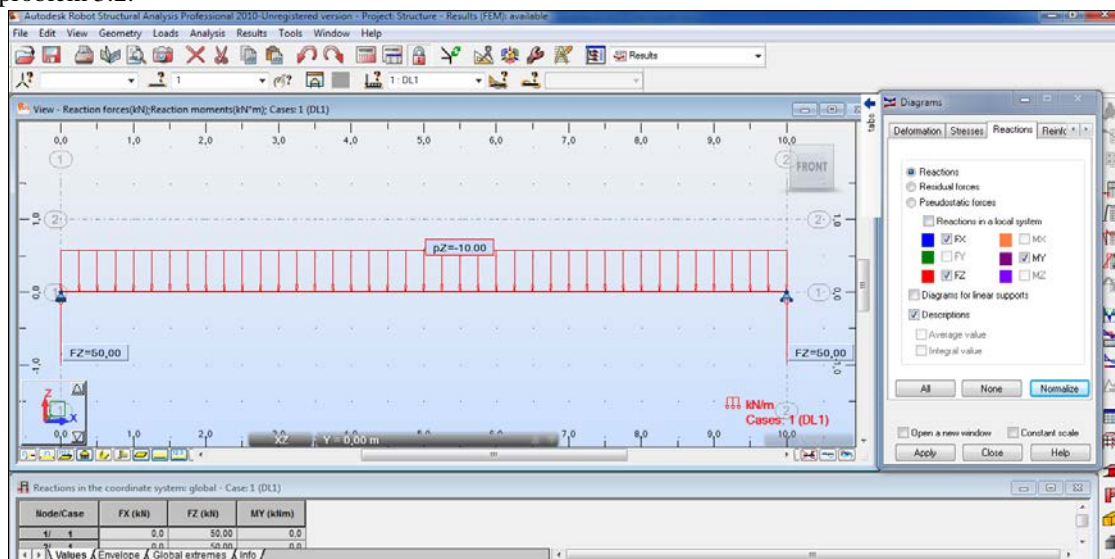


**Figure 12. The analysis results of simple beam with a distributed load in Autodesk RSA Pro**

| Node/Case | | FX (kN) | FZ (kN) | MY (kNm) |
|---|---|---|---|---|
| 1/ | 1 | 0,0 | 50,00 | 0,0 |
| 2/ | 1 | 0,0 | 50,00 | 0,0 |
| | | | | |
| Case 1 | DL1 | | | |
| Sum of val. | | 0,0 | 100,00 | 0,0 |
| Sum of reac. | | 0,0 | 100,00 | -500,00 |
| Sum of forc. | | 0,0 | -100,00 | 500,00 |
| Check val. | | 0,0 | 0,0 | 0,0 |
| Precision | | 0,0 | 0,0 | |

**Figure 10. The reaction at two joints of simple beam with distributed load**

## 4. CONCLUSION

Simple beams as one of the structures that apply determinate static structures can be modeled with computer software ie Structural Analysis Program (SAP) 2000 version 11 Nonlinearity and Autodesk Robot Structural Analysis Professional (Autodesk RSA Pro) 2012. The simple beam modeling with two softwares resulting in the same reaction value for point and distributed load. The mathematical calculation for a simple beam with a span of 10 m is subjected to a point load of 1 ton (down) in the middle of the span to produce a two reactions of 5 tons (up). This result when compared with the analysis using SAP 2000 obtained two reactions of 5 tons (up) and the analysis result of Autodesk RSA Pro obtained of 50 kN (up). The result of mathematical calculation for simple beam with span of 10 m is subjected to distributed load of 10 ton/m' (down) produce two reactions of 50 tons (up). The results of the analysis with SAP 2000 obtained two reactions of 50 tons (up) and the Autodesk RSA Pro analysis resulted 50 kN (up) reactions. By comparing three stages of a simple beam completion with two different cases ie point and distributed loads produce the same joints reactions. Analysis with SAP 2000 and Autodesk RSA Pro software can to complete the structure easily and quickly.

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