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THE COMPARISON OF SLAB DEFLECTION BASED ON FIELD MEASUREMENT, MANUAL CALCULATION (LEVY METHOD) AND FINITE ELEMENT METHOD (PROGRAM SAP 2000)

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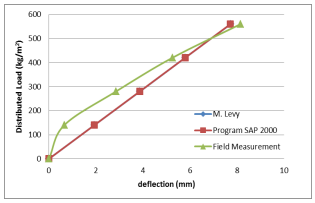
Graphical abstract



Abstract

Concrete slab is a structural system that uses beams as a support element slab. The placement of beams at the whole edges of slab, so that the load received by the slab can be transfer into beams. The slab will be deformed/deflection when the loads are given. The value of slab deflection is dependent on the placement of beam support at the edges. This research was conducted on the two boundary condition that is simple support at the two edges and rigid support at whole edges. Calculating the value of deflection based on the results of field measurements and then compared with Marcus Levy method and Finite element method (FEM). Based on the study, the numbers of mesh affected to the value of deflection. The results of deflection with Program SAP 2000 will be approached deflection by Method M. Levy for the mesh division with large numbers. The deflection of slab on the field measurement approached manual calculations and Program SAP2000 with a simple support at the surrounding the edges. The comparison of deflection was obtained for the simple support based on manual calculations and field measurement has a difference of 0.3% - 1%. Where the value of deflection on the field measurement is smaller than the manual calculation.

Keywords: Deflection, field measurement, manual calculation, FEM

1.0 INTRODUCTION

A slab is a flat two dimensional planar structural element having thickness small compared to its other two dimensions. It primarily transfers the load by bending in one or two directions. Reinforced concrete slabs are used in floors, roofs and walls of buildings and as the decks of bridges. [chandradara]. A slab is supported by beam structure. The placement of the beams support at the edges of slab, so that the loads are received a surface of slab can be supplied to the beam. The slab will be deformed/deflection when the loads are given. The value of slab deflection is dependent on the placement of beam support at the edges. Based on a theory of slab, If a slab has simple support the deflection will be large than a slab has a rigid support at the edges. According to ACI Code (1995) calculation of deflection is not required provided the slab thickness is not less than a certain quantity. The quantity depends on: presence or absence of drop panels, ratio of flexural stiffness of beam section to flexural stiffness of a width of slab bounded laterally by centrelines of adjacent panels (if any) on each side of the beam, ratio of clear spans [1].

To determine the deflection of slab, it can be calculated with various methods of calculation such as classical methods (M. Levy), yield line analysis (used for ultimate/limit analysis), and numerical analysis (finite element method). In this study, in calculating the value of deflection based on the results of field measurements and then compared

with Marcus Levy method and Finite element method. So that the results of this study can be analyzed the influence of the loads that are given to the value of deflection on a slab.

2.0 LITERATURE REVIEW

Here is the reference used in calculating and analyzing the value of deflection and internal moments that occur in the structure of the slab. Translation of the calculation formula of each method will be described below.

2.1 Marcus Method

The most widely used methods is Marcus method (1929) that is known as Method 3 in the ACI-318-63 [2]. In this study, a deflection formula of Marcus Method is used in the design of slab as in the following formula. The equation of deflection a slab in the midspan is:

$$w = \frac{5ql^4}{384EI} \quad (1)$$

And the moment equation can use table on "Regulation of Reinforced Concrete 1971". Where in the table there are different length and width ratio of plates and various types of placement, this study will use a simple support at edges of slab. The equation are used to calculate moment on the midspan of slab are :

The equation of moments on the midspan of slab with simple support

$$Mlx = 0{,}056\, ql_x^2 \quad (2)$$

$$Mly = 0{,}037 ql_x^2 \quad (3)$$

The equation of moment on the midspan of slab with rigid support

$$Mlx = 0{,}036\, ql_x^2 \quad (4)$$

$$Mly = 0{,}017 ql_x^2 \quad (5)$$

2.2 M. Levy Method

M. Levy method is used to determine the deflection of the slab. The deflection at the slab generally occur as a result of two forces acting, the first is internal moments that happen as a result of the support, this moment worked on the edges of each slab and evenly distributed along the sides of the slab. The second is the force that occur from the external loads, for example, is a distributed load, causing a deflection on the slab. The Levy's Method is applicable to the bending of rectangular plates with particular boundary condition on the two opposite and arbitary conditions of support on the remaining [3].

Based on a theory of slab, on a rectangular slab with a simple support at the edges of slab and act distributed load in the surface of the slab, used Fourier series to determine the function of the load. The simplify the formula are used in this method to determine deflection of slab as a equation below:

$$w = 0{,}00774 \frac{qa^4}{D} \quad (6)$$

where :

$$D = \frac{Eh^3}{12(1-v^2)} \quad (7)$$

2.3 Finite Method (Program SAP 2000)

In the analysis of slab using Program SAP 2000 takes some data that should be incorporated into this program, such as the compressive strength of concrete, the dimensions of the slab [5]. Having done some modeling plate on SAP Program, the deflection value obtained by dividing up the slab section into the grid. In this study the distribution grid is done by dividing the total slab 6x6, 12x12, 24x24, and 48x48, This is done by assigned of a mesh area.

3.0 METHODOLOGY

The geometry and material properties that are used in analyzing the structure of the slab, namely:

- The length of the slab (b): 9000 mm
- The width of the slab (a): 6000 mm
- Thick of slab (h): 0.15 m
- Poisson ratio (v): 0.3
- Density of reinforced concrete: 2400 kg/m^3

In determining the amount of the value of deflection from field testing, it can use load water with a certain height which behave like a static load on a slab. The height of the water given in this study was 14 cm, 28 cm, 42 cm and 56 cm. Once the load water given to the slab, measuring instruments used to determine the deflection is dial gauge. It is placed on the bottom side of the plate to the position in the middle of the plate x and y directions.

Results from field measurements will be compared with the method of analysis (Marcus and Levi's Method). Beside of analysis above, the values of slab deflection using finite element method, Program SAP 2000.

4.0 RESULTS AND DISCUSSION

4.1 The Deflection used Loading Test

The result from the loading test as shown in Table 1. It is used in accordance with the SNI T-15-1991-03 "Tata Cara Penghitungan Struktur Beton Untuk Bangunan Gedung" [4].

Table 1 The Deflection based on water level as a Load in the slab

No.	Water Level [cm]	Deflection Dial Gauge [mm]
1	0	0
2	14	0,65
3	28	2,85
4	42	5,25
5	56	8,15

4.2 The Deflection based on M. Levy Method

Manual methods are used to analyze the slab is a Levy Method. It used fourier series to define mathematical function of displacement and load on the slab. This method also analyzes internal moment by using differential equations, and the boundary conditions. This research was conducted on the two boundary condition with simple support at the two edges and rigid support at whole edges. The values of deflection and internal moment for the slab with simple support as shown in Table 2.

Table 2 The Value of Deflection And Internal Moment with Simple Support

No.	Water Lavel (cm)	Deflection (mm)	Moment (x) (N)	Moment (y) (N)
1	0	0	0	0
2	14	1,946	3.815	2.51
3	28	3,892	8.185	5.02
4	42	5,838	12.277	7.53
5	56	7,784	16.37	10.04

4.3 The Values of Deflection with Program SAP 2000

Analysis method by using Program SAP 2000 is a way of analyzing the structure of the most commonly used now. The program used finite element method in analyzing the slab. By dividing the slab into sections called a mesh. In this research the slab is divided into several sections, specifically 6x6, 12x12, 24x24, 48x48. The values of deflection based on analyzing Program SAP 2000 as shown in Table 3 below.

Table 3 The Values of Deflection Using Program SAP 2000 With Simple Support

No.	Water Lavel (cm)	Load (kg/ m²)	6x6	12x12	24x24	48x48
1	0	0	0	0	0	0
2	14	140	192,99	193,00	192,99	192,99
3	28	280	385,98	386,00	385,99	385,99
4	42	420	578,97	579,01	578,99	578,98
5	56	560	771,97	772,01	771,99	771,98

4.4 The Comparison of Results

Based on results from loading test, Levy Method and analyzing SAP 2000, it can be compared to perceive the behaviour of the deflection of slab. The comparison of deflection slab with simple support shown in Table 4 and Figure 1.

Table 4 The Comparison of Deflection with Simple Support

No.	Water Lavel (cm)	Load (kg/m²)	Metode M. Levy (mm)	SAP 2000 (mm)	Dial Gauge (mm)
1	0	0	0	0	0
2	14	140	1,93	1,93	0,65
3	28	280	3,87	3,86	2,85
4	42	420	5,79	5,79	5,25
5	56	560	7,73	7,72	8,15

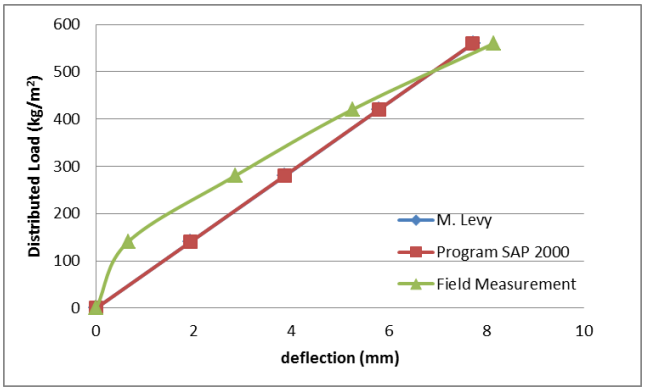


Figure 1 The Comparison of Deflection with Simple Support

In this study, the values of deflection with rigid support at the whole edged are analyzed. The results of deflection for this support can shown in Table 5 and Figure 2.

Table 5 Comparison of deflection with Fixed Support

No.	Water Lavel (cm)	Load (kg/m²)	Metode M. Levy (mm)	SAP 2000 (mm)	Dial Gauge (mm)
1	0	0	0	0	0
2	14	140	0,55	0,55	0,65
3	28	280	1,10	1,10	2,85
4	42	420	1,65	1,65	5,25
5	56	560	2,20	2,20	8,15

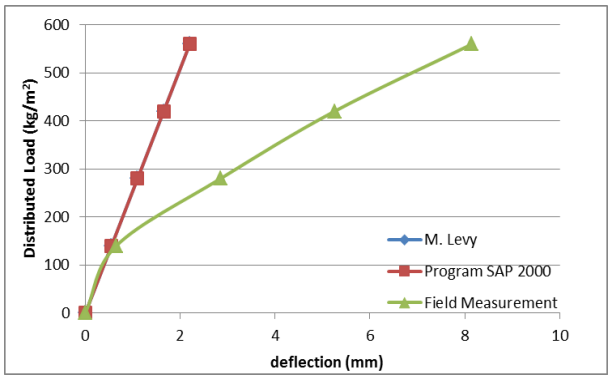


Figure 2 The Comparison of Deflection with Rigid Support

4.0 CONCLUSION

Based on the study about the value of slab deflection, it can be concluded:

- Concrete slab that receives a load of 560 kg/m² is still behave elastic. It can be seen from the maximum deflection occurs not over the limit set by SNI T-15-1991-03.
- The modeling of Program SAP 2000, distribution slab divided into sections, it called "mesh". Based on research with various types of support can be concluded that the numbers of mesh affected to the value of deflection. The results of deflection with Program SAP 2000 will be approached deflection by M. Levy Method for the mesh division with large numbers.
- The deflection of slab on the field measurement approached manual calculations and Program SAP2000 with a simple support at the surrounding the edges.
- The comparison of deflection was obtained for the simple support based on manual calculations and field measurement has a difference of 0.3% - 1%. Where the value of deflection on the field measurement is smaller than the manual calculation. This indicates that the structures of slab is more rigid in the field, because of the structure are reviewed gain another stiffness from surrounding structures like beam or slab structure.

In the case of the support of slab with simple support at two edges and the other has rigid support were obtained results that the value of deflection slab grather than if the slab has a rigid support at the whole edges.

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