Atir Software Development LTD

STRAP - Plate bending

Verification

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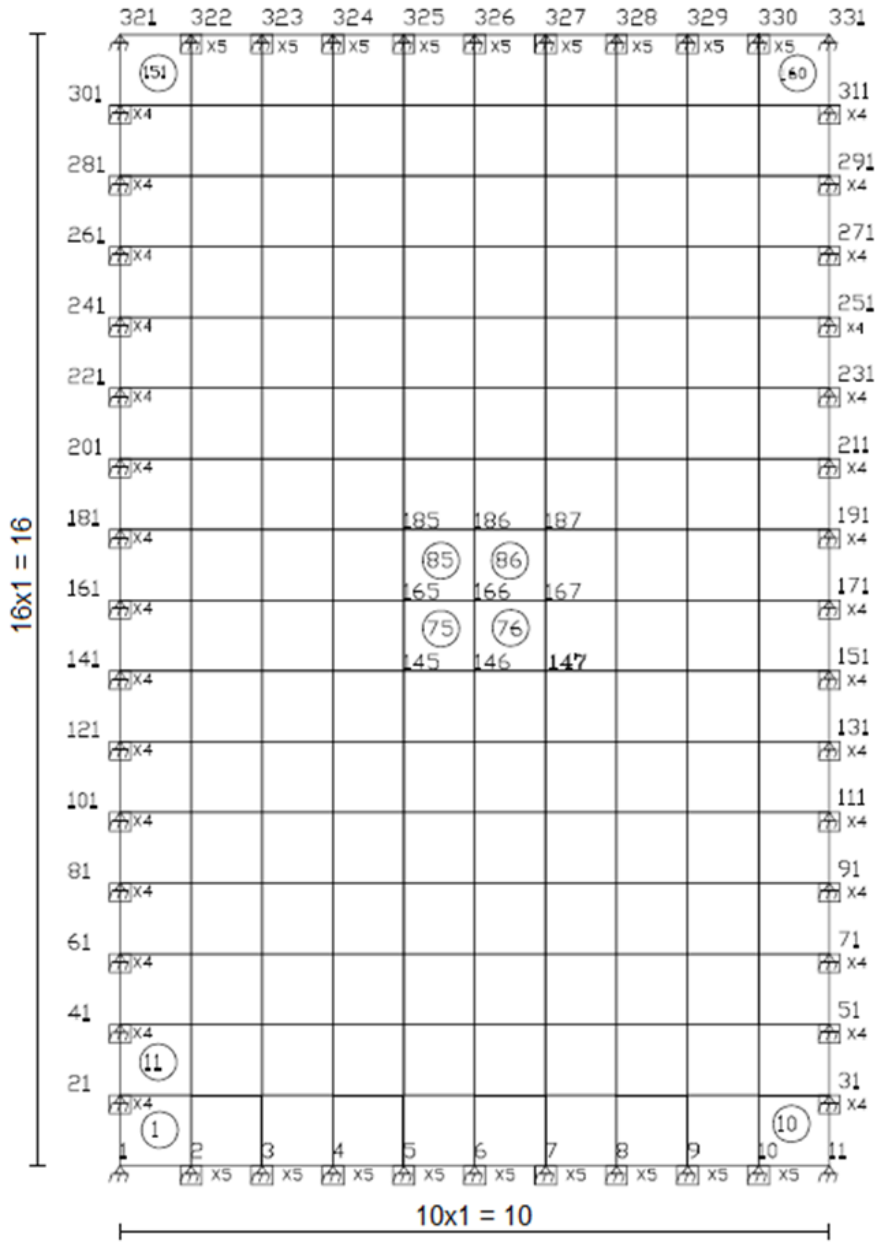
Table of contents

1. Plate bending

1.1 Description

A thin rectangular plate, simply supported along all four edges, subject to a uniformly distributed area load.



1.2 Geometry

Dimensions: 10 x 16 [m]; Thickness: 0.2 [m]

Modulus of Elasticity: 1,000,000; Poisson ratio: 0.3

Elements: 10 x 16 grid rectangular elements.

Supports: Pinned (restrained against rotation parallel to edge).

1.3 Loads

Uniform pressure: -1.0 [T/m^2] in the X3 direction on all elements.

1.4 Reference

Timoshenko and Woinowsky-Kreiger, *Theory of Plates and Shells, 2nd Edition. (Chapter 5, table 6)*, McGraw-Hill Book Company

1.5 Comparison of Results

Element	Node	Result type	Result		Deviation
			Theoretical	STRAP	
-	166	Deflection	0.11341	0.11317	0.21%
86	166	M_x	8.62	8.652	0.37%
86	166	M_y	4.92	4.936	0.32%

2. Concrete design moments

2.1 Description

The plate bending model of example 3.10 is used to verify the calculation of the concrete design moments (Wood & Armer).

The Wood & Armer equations are listed in the STRAP User's Manual. Note that these equations are based on the standard engineering sign convention (sagging moment = positive), while the STRAP sign convention gives opposite results (sagging moment = negative). For clarity, the calculations in this example use the standard engineering sign convention.

2.2 Geometry / Loads

Refer to the previous plate bending example.

2.3 Reference

R.H. Wood, "*The Reinforcement of Slabs in Accordance with a Pre-determined Field of Moments*".

"Concrete" magazine - February 1968

2.4 STRAP Results

Element	Element results			Wood & Armer moments			
				Bottom		Top	
	Mx	My	Mxy	Mx*	My*	Mx*	My*
1	0.2802	0.2392	4.166	4.446	4.405	-3.885	-3.926
32	3.357	2.163	2.354	5.711	4.517	0.0	0.0
51	1.601	0.8648	1.422	3.023	2.286	0.0	-0.3975
75	8.459	4.840	0.0438	8.503	4.884	0.0	0.0

2.5 Calculation of Results

The Wood & Armer moments were verified by hand calculation and are summarized in the following table. The results are identical.

	Bottom	Top
Equations	$M_x^* = M_x + \lvert M_{xy}\rvert$ $M_y^* = M_y + \lvert M_{xy}\rvert$ $If\ M_x^* < 0 \therefore M_x^* = 0$ $M_y^* = M_y + \left\lvert \frac{M_{xy}^2}{M_x} \right\rvert$ $If\ M_y^* < 0 \therefore M_y^* = 0$ $M_x^* = M_x + \left\lvert \frac{M_{xy}^2}{M_y} \right\rvert$	$M_x^* = M_x - \lvert M_{xy}\rvert$ $M_y^* = M_y - \lvert M_{xy}\rvert$ $If\ M_x^* > 0 \therefore M_x^* = 0$ $M_y^* = M_y - \left\lvert \frac{M_{xy}^2}{M_x} \right\rvert$ $If\ M_y^* > 0 \therefore M_y^* = 0$ $M_x^* = M_x - \left\lvert \frac{M_{xy}^2}{M_y} \right\rvert$

Element	Mx*	My*	Mx*	My*
1	0.2802 + 4.166 = 4.4462	0.2392 + 4.166 = 4.4052	0.2802 - 4.1666 = -3.8858	0.2392 - 4.166 = -3.9268
32	3.357 + 2.534 = 5.711	2.163 + 2.354 = 4.517	3.357 - 2.354 = 1.003 but $M_x^* > 0$: use $M_x^* = 0$ and $M_y^* = 2.163 - \left\| \frac{2.354^2}{3.357} \right\|$ = 0.5123 but $M_y^* > 0$: use $M_y^* = 0$	2.163 - 2.354 = 0.191
51	1.601 + 1.422 = 3.023	0.8648 + 1.422 = 2.2868	1.601 - 1.422 = 0.179 but $M_x^* > 0$: use $M_x^* = 0$ and $M_y^* = 0.8648 - \left\| \frac{1.422^2}{1.601} \right\|$ = -0.3980	0.8648 - 1.422 = -0.5572
75	8.459 + 0.0438 = 8.5028	4.840 + 0.0438 = 4.8838	8.459 - 0.0438 = 8.4152 but $M_x^*, M_y^* > 0$: use $M_x^*, M_y^* = 0$	4.840 - 0.04438 =4.762