Design of slabs using Wood-Armer method:

P152/Advances structural Mechanics-David Johnson

Design moments:

Introduction

Whichever method is used to determine the moment distribution in a slab or plate, the next problem confronted is normally that of how to ensure that the strength of the plate is adequate to resist the calculated moments. This problem may be viewed as one of knowing how to design, in particular, for the **twisting moments, M_{xy}**.

In the case of a reinforced concrete slab, which is reinforced by an orthogonal system of bars placed in the *x*- and *y*-directions, the problem is to determine the *design moments* M_{x^*} , M_{y^*} the reinforcement should be designed for if adequate strength is to be available in *all* directions. Once M_{x^*} , M_{y^*} have been found, the reinforcement may be designed to resist these moments by the normal analysis of a section in bending. The design moments are commonly referred to as *Wood–Armer* (Wood, 1968) moments, and the following recommendations follow Wood's suggestions.

3.8.2 Recommendations

Bottom reinforcement

Generally

$$M_x^* = M_x + |M_{xy}|, \quad M_y^* = M_y + |M_{xy}| \qquad (3.71)$$

If either M_{x^*} or M_{y^*} in equations (3.71) is found to be negative, it is changed to zero, as follows: either

or

$$M_x^* = M_x + \left|\frac{M_{xy}^2}{M_y}\right| \quad \text{with} \quad M_y^* = 0 \qquad (3.72)$$

Or

$$M_y^* = M_y + \left|\frac{M_{xy}^2}{M_x}\right| \quad \text{with} \quad M_x^* = 0 \qquad (3.73)$$

If, in these changed formulae, the wrong algebraic sign results for M_{x^*} or M_{y^*}, then no such reinforcement is required.

If *both*M_{x^*} and M_{y^*} are negative, then no bottom reinforcement is required.

Top reinforcement

Generally

$$M_x^* = M_x - |M_{xy}|, \quad M_y^* = M_y - |M_{xy}| \qquad (3.74)$$

If either M_{x^*} or M_{y^*} in equations (3.74) is found to be positive, then change to either

$$M_x^* = M_x - \left|\frac{M_{xy}^2}{M_y}\right| \quad \text{with} \quad M_y^* = 0 \qquad (3.75)$$

or

$$M_y^* = M_y - \left|\frac{M_{xy}^2}{M_x}\right| \quad \text{with} \quad M_x^* = 0 \qquad (3.76)$$

If, in these changed formulae, the wrong algebraic sign results for M_{x^*} or M_{y^*}, then no such reinforcement is required.

If *both* M_{x^*} and M_{y^*} are negative then no top reinforcement is required.

Example – simply supported slab design moments

Referring to Fig. 3.16, the design moments at various points of the simply supported slab considered previously may be evaluated as follows:
At centre (C): $M_x = M_y = +0.023qL^2$, $M_{xy} = 0$

Bottom reinforcement: $M_{x^*} = M_{y^*} = +0.023qL^2$
Top reinforcement: $M_{x^*} = M_{y^*} = 0$

At quarter point (1): $M_x = M_y = +0.009qL^2$, $M_{xy} = –0.011qL$

Bottom reinforcement: $M_{x^*} = M_{y^*} = +0.020qL^2$
Top reinforcement: $M_{x^*} = M_{y^*} = –0.002qL^2$

At corner (A): $M_x = M_y = 0$, $M_{xy} = –0.019qL^2$

Bottom reinforcement: $M_{x^*} = M_{y^*} = +0.019qL^2$
Top reinforcement: $M_{x^*} = M_{y^*} = –0.019qL^2$

From the above, it may be seen that top (torsional) reinforcement is only required close to the corners, as would be expected, and that the bottom reinforcement requirements at the centre and corners are rather similar. Naturally, much less bottom steel is needed close to the centre point of an edge.

Example 3.8 – fixed-edge slab design moments

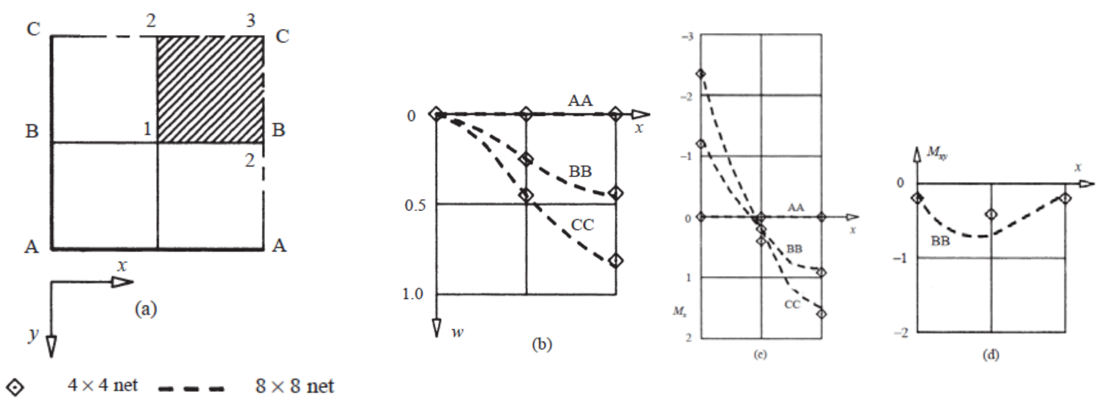

Fig. Fixed-edge slab: (a) reference plan of quarter slab; (b) w (x $10^{-3}qL^4/D$);
(c) M_x (x $10^{-2}qL^2$); (d) M_{xy} (x $10^{-2}qL^2$); (e) Q_x (x $10^{-1}qL$); (f) V_y (x $10^{-1}qL$)

With reference to Fig., the design moments will be calculated at point D, not because this is a particularly critical slab location, but simply to illustrate the application of the design moment computations:
At point D: $M_x = –0.008qL^2$; $M_y = +0.002qL^2$; $M_{xy} = –0.005qL^2$

Bottom reinforcement: $M_{x^*} = –0.003qL^2$; $M_{y^*} = +0.007qL^2$
So take equation (3): $M_{x^*} = 0$; $M_{y^*} = (+0.002 + 0.005^2/0.008)qL^2 = +0.005qL^2$
Note that the subsidiary calculation results in some moment reduction but that this will be small if the design moment with the offending sign was also small.
Top reinforcement: $M_{x^*} = –0.013qL^2$; $M_{y^*} = –0.003qL^2$.