Reinforced Concrete Design 2 – CM302

Dr. Hany N. Maximos

Lecture;
- Mondays: 8:30am – 10:30am @ E314

Tutorial;
- Tuesdays: 10:30am – 12:30pm @ E337

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RC2-CM302; Course Aims

- By the end of this course, you will be able to;
  - Design flooring systems such as:
    - One way solid slabs
    - Two way solid slabs
    - Ribbed slabs (H.B.)
  - Design of floor’s beams according to ECP
  - Design of RC columns
    - Design of short columns subject to bi-axial bending
    - Design of slender columns
  - Design of RC Stairs
    - Cantilever Type
    - Slab Type
  - Calculating Deflection of different RC members

RC2-CM302; Course Schedule

<table>
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<th>Week</th>
<th>Date</th>
<th>Topic</th>
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<tr>
<td>1</td>
<td>24/9/2012</td>
<td>Review and Introduction (using Design Aids)</td>
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<tr>
<td>2</td>
<td>1/10/2012</td>
<td>One way solid slabs</td>
</tr>
<tr>
<td>3</td>
<td>8/10/2012</td>
<td>Two way solid slabs</td>
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<tr>
<td>4</td>
<td>15/10/2012</td>
<td>Ribbed Slabs (hollow blocks)</td>
</tr>
<tr>
<td>5</td>
<td>22/10/2012</td>
<td>Beams</td>
</tr>
<tr>
<td>6</td>
<td>29/10/2012</td>
<td>わかりません</td>
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<tr>
<td>7</td>
<td>5/11/2012</td>
<td>Interaction Diagram</td>
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<td>8</td>
<td>12/11/2012</td>
<td>Design of Sections Subjected to M&amp;P</td>
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<td>9</td>
<td>17/11/2012 – 22/11/2012</td>
<td>MID-TERM EXAMS PERIOD</td>
</tr>
<tr>
<td>10</td>
<td>26/11/2012</td>
<td>Slender Columns</td>
</tr>
<tr>
<td>11</td>
<td>3/12/2012</td>
<td>Torsion</td>
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<tr>
<td>12</td>
<td>10/12/2012</td>
<td>Cantilever Type Stairs</td>
</tr>
<tr>
<td>13</td>
<td>17/12/2012</td>
<td>Slab Type Stairs</td>
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<tr>
<td>14</td>
<td>24/12/2012</td>
<td>Deflection</td>
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<tr>
<td>15</td>
<td>31/12/2012</td>
<td>Projects Presentation</td>
</tr>
</tbody>
</table>
RC2-CM302; Teaching Methods

- Course information will be delivered through:
  - Lectures
  - Tutorials
  - Projects

RC2-CM302; Assessment

- Course assessment will be performed according to the following breakdown:
  - Assignments: 10 points (10%)
  - Project: 10 points (10%)
  - Quizzes: 10 points (10%)
  - Mid-Term Exam: 20 points (20%)
  - Final Exam: 50 points (50%)

- Total: 100 points (100%)
RC2-CM302; Course Materials

- Course Materials;
  - Lectures’ notes
  - Text Books;

Introduction & Review
Design Equations

\[ C = T \]

\[ 0.67 \left( f_{cu} / \gamma_c \right) a.b = A_s f_y / \gamma_s \]

\[ a = \left( \frac{A_s f_y}{\gamma_s} \right) \left( \frac{0.67 f_{cu}}{\gamma_c} \right)^b \]

Design Equations (cont’d)

Taking moment about comp. face

\[ M_u = \left( \frac{A_s f_y}{\gamma_s} \right) \left( d - \frac{a}{2} \right) \]
Using Design Aids

- Egyptian Code of Practice (ECP203) included design aids for designing of different RC sections; rectangular and T section.

- Design Aids are in the form of Charts used to estimate the section depth (d) and the reinforcement area ($A_s$).

Using Design Aids (cont’d)

- New quantities are presented ($R1$) and ($\omega$)

$$R1 = \frac{M_u}{f_{cu}bd^2}$$

$$\omega = \frac{A_s f_y}{bd f_{cu}} = \mu \frac{f_y}{f_{cu}}$$
Using Design Aids (cont’d)

Design Equations (cont’d)

\[
M_{\text{umax}} = \frac{R_{\text{max}} f_{\text{cu}} b d^2}{\gamma_c}
\]

\[
\mu_{\text{max}} = \frac{A_{\text{smax}}}{b d} = \frac{0.67f_{\text{cu}} a_{\text{umax}}}{\gamma_c d} + \frac{f_y}{\gamma_s}
\]

Source: ECP 2006 (4-2-1-2-c)
Design Equations (cont’d)

<table>
<thead>
<tr>
<th>Wrenches of m.</th>
<th>$c_{max}/d$</th>
<th>$f_{max}$</th>
<th>$R_{max}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>240/350</td>
<td>0.50</td>
<td>8.56x10^-4$f_{cu}$</td>
<td>0.214</td>
</tr>
<tr>
<td>230/450</td>
<td>0.48</td>
<td>7.00x10^-4$f_{cu}$</td>
<td>0.208</td>
</tr>
<tr>
<td>360/520</td>
<td>0.44</td>
<td>5.00x10^-4$f_{cu}$</td>
<td>0.194</td>
</tr>
<tr>
<td>400/600</td>
<td>0.42</td>
<td>4.31x10^-4$f_{cu}$</td>
<td>0.187</td>
</tr>
<tr>
<td>450/520**</td>
<td>0.40</td>
<td>3.65x10^-4$f_{cu}$</td>
<td>0.180</td>
</tr>
</tbody>
</table>

$f_{cu}$ N/mm²

Using Design Aids (cont’d)

DESIGN CHART FOR SECTIONS SUBJECTED TO SIMPLE BENDING
(Table 4-1)
Code Requirements

\[
A_s_{\text{min}} = \text{smaller of} \begin{cases} 
\frac{0.225 \sqrt{f_{cu}}}{f_y} b d \geq \frac{1.1}{f_y} b d \\
1.3 A_s 
\end{cases}
\]

\[
\text{but not less than} \begin{cases} 
\frac{0.25}{100} b \ d \ (\text{mild steel}) \\
\frac{0.15}{100} b \ d \ (\text{high grade}) 
\end{cases}
\]

Source: ECP 2006

Design Example

**Given**

\[ M_u = 400 \ \text{kN.m} \]
\[ b = 200 \ \text{mm} \]
\[ f_{cu} = 30 \ \text{N/mm}^2 \]
\[ f_y = 280 \ \text{N/mm}^2 \]
\[ d = 1000 \ \text{mm} \]

**Solution**

\[
R_1 = \frac{M_u}{f_{cu} b d^2} = \frac{400 \times 10^6}{30 \times 200 \times 1000^2} = 0.0667
\]
Design Example

**Given**

\[ M_u = 400 \text{ kN.m} \quad b = 200 \text{ mm} \]
\[ f_{cu} = 30 \text{ N/mm}^2 \quad f_y = 280 \text{ N/mm}^2 \]
\[ d = 1000 \text{ mm} \]

**From Chart**

\[ \omega = 0.0833 \]

\[ A_s = \omega \left( \frac{f_{cu}}{f_y} \right)bd \]
\[ = 0.0833 \times \left( \frac{30}{280} \right) \times 200 \times 1000 = 1786 \text{mm}^2 \]
Check for $A_{s,\text{min}}$

$$A_{s,\text{min}} = \text{smaller of } \left\{ \begin{array}{c} \frac{0.225 \sqrt{f_{cu}}}{f_y} b d \geq \frac{1.1}{f_y} b d \quad = 880 \text{ mm}^2 \\ 1.3 A_s \quad = 2322 \text{ mm}^2 \end{array} \right\}$$

$$A_{s,\text{min}} = 2322 \text{ mm}^2 > A_s \text{ ............. OK}$$