PRESENTATION BY
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AWARENESS PROGRAMME ON GENERAL ISSUES

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Concept of RCC
Mechanisms for Bond Resistance in Reinforced Concrete

- Chemical Adhesion
- Friction Resistance
- Gripping Action
- Mechanical Interlock
Methods to Improve Bond Between Steel and Concrete

- Using Deformed or Twisted Bar
- Using Rich Mix of Concrete
- Adequate Compaction and Curing of Concrete for Proper Setting
- Providing Hooks at the end of reinforcing bar
FORM WORK

Proper formwork for beam
Importance of Grade of Concrete

Young’s modulus of Concrete = 5000√f_{ck}

\[ R = V_{\text{MAX}} = \frac{wL}{2} \]

\[ V_x = w\left(\frac{L}{2} - x\right) \]

\[ M_{\text{max}} \text{ (at centre)} = \frac{wL^2}{8} \]

\[ M_x = \frac{wx}{2} (L - x) \]

\[ \Delta_{\text{max}} \text{ (at centre)} = \frac{5wL^4}{384EI} \]

\[ \Delta_x = \frac{wx}{24EI} (L^3 - 2Lx^2 + x^3) \]

Young’s modulus of Concrete = 5000√f_{ck}
Nominal Cover

Reasons for Nominal Cover
➢ To Protect the Reinforcement against Corrosion
➢ To Provide Cover against Fire
➢ To Develop the Sufficient Bond Strength along the surface area of steel bar

Table 3 Environmental Exposure Conditions
(Clause 8.2.2.1 and 35.3.2)

<table>
<thead>
<tr>
<th>SI No.</th>
<th>Environment</th>
<th>Exposure Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>i)</td>
<td>Mild</td>
<td>Concrete surfaces protected against weather or aggressive conditions, except those situated in coastal area.</td>
</tr>
<tr>
<td>ii)</td>
<td>Moderate</td>
<td>Concrete surfaces sheltered from severe rain or freezing whilst wet</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Concrete exposed to condensation and rain</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Concrete continuously under water</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Concrete in contact or buried under non-aggressive soil/ground water</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Concrete surfaces sheltered from saturated salt air in coastal area</td>
</tr>
<tr>
<td>iii)</td>
<td>Severe</td>
<td>Concrete surfaces exposed to severe rain, alternate wetting and drying or occasional freezing whilst wet or severe condensation.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Concrete completely immersed in sea water</td>
</tr>
<tr>
<td>iv)</td>
<td>Very severe</td>
<td>Concrete surfaces exposed to sea water spray, corrosive fumes or severe freezing conditions whilst wet</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Concrete in contact with or buried under aggressive sub-soil/ground water</td>
</tr>
<tr>
<td>v)</td>
<td>Extreme</td>
<td>Surface of members in tidal zone</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Members in direct contact with liquid/solid aggressive chemicals</td>
</tr>
</tbody>
</table>

Table 16 Nominal Cover to Meet Durability Requirements
(Clause 26.4.2)

<table>
<thead>
<tr>
<th>Exposure</th>
<th>Nominal Concrete Cover in mm not Less Than</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild</td>
<td>20</td>
</tr>
<tr>
<td>Moderate</td>
<td>30</td>
</tr>
<tr>
<td>Severe</td>
<td>45</td>
</tr>
<tr>
<td>Very severe</td>
<td>50</td>
</tr>
<tr>
<td>Extreme</td>
<td>75</td>
</tr>
</tbody>
</table>

NOTES
1. For main reinforcement up to 12 mm diameter bar for mild exposure the nominal cover may be reduced by 5 mm.
2. Unless specified otherwise, actual concrete cover should not deviate from the required nominal cover by +10 mm.
3. For exposure condition ‘severe’ and ‘very severe’, reduction of 5 mm may be made, where concrete grade is M35 and above.
Development Length

Development Length in Working Stress

\[ L_d = \frac{\phi \sigma_s}{4 \tau_{bd}} \]

where

- \( \phi \) = nominal diameter of the bar,
- \( \sigma_s \) = stress in bar at the section considered at design load, and
- \( \tau_{bd} \) = design bond stress given in 26.2.1.1.

Development Length in Limit State

\[ L_d = \frac{0.87 X f_y X \phi}{4 \tau_{bd}} \]

Bond Area for a length of 500mm
For 20mm Dia Single Bar = 31,416 mm²
For 12 mm Dia Three Bars = 56,549 mm²
The transverse (external) shear force is denoted as $V$ (and has a maximum value near the support, equal to the support reaction). It is resisted by various mechanisms, the major ones

1. shear resistance $V_{cz}$ of the uncracked portion of concrete;
2. vertical component $V_{oy}$ of the 'interface shear' (aggregate interlock) force $V_{ai}$;
3. dowel force $V_{d}$ in the tension reinforcement (due to dowel action); and
4. shear resistance $V_{s}$ carried by the shear (transverse) reinforcement, if any.

\[ V = V_{cz} + V_{oy} + V_{d} + V_{s} \]
Shear modes failure

(a) beam under concentrated loads

TIED-ARCH ACTION

anchorage failure

 FAILURE MODES

tie failure by yielding/fracture

tension crack (eccentric compression)

crushing failure in compression chord

(b) Case 1: Deep Beams: $a/d < 1$
(c) Case 2: $1 < a/d < 2.5$
(d) Case 3: $2.5 < a/d < 6$

(e) web-crushing failure
CRITICAL SECTIONS FOR SHEAR

(a) and (d) show typical critical sections for shear in structural engineering. The diagrams illustrate the distribution of shear forces ($V_u$) and the critical distance ($d$) from the point of application of the load. Diagram (b) highlights the application of a heavy load ($2d$) and its effect on the critical section. Diagram (c) demonstrates a simplified section with a single shear force application, emphasizing the importance of understanding shear forces in reinforced concrete design.
Shear stress distribution in Homogeneous Beams of Rectangular sections

- Figure (a) shows the loading on the beam.

- Figure (b) illustrates the flexural and shear stresses. The stress components are labeled as $f_x$, $f_y$, and $\tau$.

- Figure (c) depicts the principal stresses, with $f_x = \frac{M}{I}$ and $\tau = \frac{VQ}{lb}$. 

The equations for the stresses are:

- $f_x = \frac{M}{I}$
- $\tau = \frac{VQ}{lb}$
Principal Stress Trajectories
Potential crack pattern
Modes of cracking

(a) flexural cracks

(b) web–shear crack

(c) flexure–shear cracks

(d) secondary cracks

(e) dowel forces in bars
Basic principle in Earthquake Resistant Design
MINIMUM CLEARANCE BETWEEN INDIVIDUAL BARS AS PER SP 34

8.1A

MIN. COVER
25 mm OR * 

MIN. HORIZONTAL SPACING
= Ø OR (h_a + 5 mm) *

8.1B

MIN. VERTICAL SPACING
= 15 mm OR 2/3 h_a OR Ø *

8.1C

MIN. HORIZONTAL SPACING
= LARGER BAR DIA. OR
(h_a + 5 mm) *

8.1D

MIN. VERTICAL SPACING
= 2/3 h_a OR Ø OR 15 mm *

8.1E

MIN. HORIZONTAL SPACING
= LARGER BAR DIA. OR (h_a + 5 mm) *

*= WHICHEVER IS GREATER
Ø = DIAMETER OF THE BAR
h_a = NOMINAL/ MAX. SIZE OF AGGREGATE
HANGER REINFORCEMENT AT JUNCTION OF MAIN BEAM
SIMPLIFIED CURTALIMENT RULES FOR SIMPLY SUPPORTED BEAMS AS PER SP 34
SIMPLIFIED CURTALIMENT RULES FOR CONTINUOUS BEAMS AS PER SP 34

CLEAR SPAN

END SUPPORT (RESTAINED)

* 0.15 L₁ SHOULD NOT BE LESS THAN L₄

INTERMEDIATE SUPPORT
Elevated level Service Reservoir
ANNULAR RAFT TOP REINFORCEMENT
Foundation Construction Techniques
Arrangement of Motors for Pumping Out of Water from Bore
After Excavation With Leveling Course
RAFT FOUNDATION FOR 1500kL CAPACITY ELSR
CRACKS IN SIDE WALLS AT LIFT JOINTS DURING CONSTRUCTION
AGE OF TANK: 32 Yrs
HORIZONTAL CRACKING AT LIFT JOINT AND VERTICAL CRACKING DUE TO POOR CONSTRUCTION JOINT
DEMADE TO THE BRACE BEAM DUE TO LEAKING OF WATER FROM TANK PORTION
CRACKS (AT STARTING STAGE) IN SIDE WALL LIFT JOINTS

AGE OF TANK: 6 Yrs
DETERIORATION IN BEAM COLUMN JUNCTION (INTZE TANK)
CAPACITY: 1136 K L
AGE OF TANK: 30Yrs
TESTING OF A BEAM (3m X 0.15m X 0.3m)
<table>
<thead>
<tr>
<th>ANALYTICAL RESULTS:</th>
<th>EXPERIMENTAL RESULTS:</th>
</tr>
</thead>
<tbody>
<tr>
<td>DESIGN MOMENT - 27.82kN-m</td>
<td>MOMENT AT FAILURE - 65.15kN-m</td>
</tr>
<tr>
<td>DESIGN SHEAR -33.15kN</td>
<td>SHEAR AT FAILURE - 59.50kN</td>
</tr>
<tr>
<td>MOMENT AT FAILURE/DESIGN MOMENT = 2.34</td>
<td>SHEAR AT FAILURE/DESIGN SHEAR = 1.79</td>
</tr>
</tbody>
</table>
Reinforcement Arrangement

FIG. 9-10 REINFORCEMENT DETAILS OF SKEW DECK SLAB
(Main reinforcement parallel to carriageway)
Kadalundi River rail bridge