SLAB ON GRADE

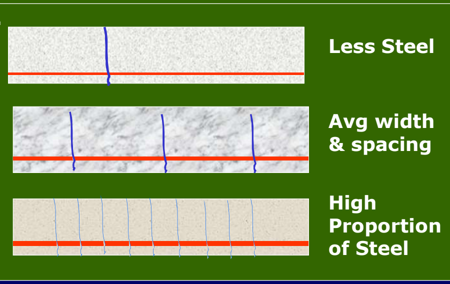
CRACKING IN R. C.

- Cracks are induced in RC members by the action of loads and by environmental conditions.
- If a small cube of concrete is cast, it will not exhibit cracking apparent to naked eye.
- If a long specimen with relatively small x-section is made containing reinforcement, and the ends of reinforcement are held to prevent any movement,after a few days it will be found cracked.

CRACKING IN R. C.

- Depending on the relation between the quantity of reinforcement, the bar size, and the cross sectional area of concrete, either a few wide cracks, or a large number of fine cracks will form.
- The cracks are induced by the resistance of the reinforcement to the strains in the concrete caused by chemical hydration of the cement in the concrete mixture.

CRACKING IN R. C.



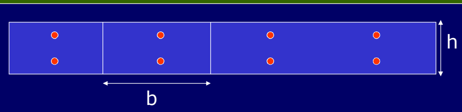
CRACK DISTRIBUTION

- Cracking due to early thermal movement may be controlled by reinforcement. The objective is to distribute the overall strain in the member by reinforcement and by movement joints, so that the crack widths are acceptable or, if considered desirable, that the concrete remains uncracked.

CRACK DISTRIBUTION

- The designer may choose to have closely spaced movement joints with a low steel ratio, or widely spaced joints with a high steel ratio.
- The decision is dependant on the size of the structure, method of construction, and economics.

CRITICAL STEEL RATIO



$$\rho = \frac{A_s}{bh}$$

$$A_s f_y = bhf_{ct}$$

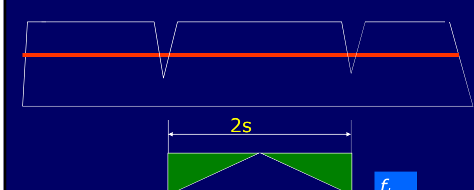
$$\left(\frac{A_s}{bh}\right)_{crit} = \frac{f_{ct}}{f_y}$$

f_{ct}=direct tensile strength of concrete

CRITICAL STEEL RATIO

f'_c	f_{ct}
30	1.4
20	1.15

CRACK SPACING



$$f_b s \sum u_s = f_{ct} bh$$

CRACK SPACING

$$f_b s \sum u_s = f_{ct} bh$$

$$f_b s \frac{4A_s}{\phi} = f_{ct} bh$$

$$\frac{\sum u_s}{A_s} = \frac{N\pi\phi}{N\frac{\pi\phi^2}{4}} = \frac{4}{\phi}$$

$$\sum u_s = \frac{4A_s}{\phi}$$

CRACK SPACING

$$s = \frac{f_{ct}}{f_b}\frac{\phi}{4\rho_c}$$

$$s_{\max} = \frac{f_{ct}}{f_b}\frac{\phi}{2\rho_c}$$

f_{ct}=Direct Tensile Stress

f_b=Bond Stress

Bar Type	f_{ct}/f_b
Plain	1
Deformed	2/3

CRACK WIDTHS

- The number and width of cracks which form depends on the total contraction strain which is unrelieved by the joints in the length of section.
- The contraction strain is sum of shrinkage strain and the thermal strain (due to changes in the ambient temperatures after the str is complete)

CRACK WIDTHS

- Assuming that the steel ratio is greater than critical steel and with full restraints, the tensile strain in the concrete may be assumed to vary from zero adjacent to a crack to a value ε_{ult} midway between cracks at a distance s_{max} apart.
- The average strain in the uncracked concrete is therefore $0.5\varepsilon_{ult}$.

CRACK WIDTHS

- The strain due to the maximum crack width, which is difference between the total contraction strain and the strain remaining in the concrete is therefore given by

$$\frac{w}{s_{\max}} = \varepsilon_{te} + \varepsilon_{cs} - 0.5\varepsilon_{ult}$$

CRACK WIDTHS

$$\frac{w}{s_{\max}} = \varepsilon_{te} + \varepsilon_{cs} - 0.5\varepsilon_{ult}$$

Where

w=maximum crack width

s_{max}= maximum crack spacing

ε_{cs}=total shrinkage strain

ε_{te}=thermal contraction strain

ε_{ult}=ultimate tensile strain in concrete

CRACK WIDTHS

ε_{ult}=200 μ strains

ε_{cs}=100 μ strains

ε_{te}=w/s_{max}

ε_{te} is therefore due to cooling from peak of hydration temperature T_1 to ambient temperature. There is also a further variation in temperature T_2 due to seasonal changes after concrete is set.

CRACK WIDTHS

- When considering strain due to T_1 an effective coefficient of expansion of one half for mature concrete should be used (due to high creep strain in immature concrete).
- For mature concrete and seasonal variations due to T_2, the tensile strength of the concrete is lower than its bond strength--------------

CRACK WIDTHS

- Hence s is much less for mature concrete when T_2 is appropriate;thus the actual contraction can be effectively halved.

CRACK WIDTHS

$$\frac{w}{s_{max}} = \varepsilon_{te} + \varepsilon_{cs} - 0.5\varepsilon_{ult}$$

$$= \frac{1}{2}\alpha(T_1 + T_2) + 100 - \frac{200}{2} = \alpha\frac{T_1 + T_2}{2}$$

$$w = s_{max}\ \alpha\ \frac{T_1 + T_2}{2}$$

CRACK WIDTHS

- α=12x10^{-6} /^{o}C
- T_1=30^{o}C for concreting in summer and 20^{o}C for concreting in winter.
- T_2=20 , 10 ^{o}C respectively for summer and winter construction. May be taken=0 if full contraction joints are provided at not more than 15 m c/c.

CRACK WIDTHS

$$w = s_{max}\ \alpha\ \frac{T_1 + T_2}{2}$$

$$s_{max} = \frac{f_{ct}}{f_b}\frac{\phi}{2\rho_c}$$

$$\rho_c = \frac{f_{ct}}{f_b}\frac{T_1 + T_2}{4w}\alpha\,\phi$$

THE END