Methods for Defining a Strength Criterion

Technical assessment

In the technical assessment of a structure, one identifies all possible ways that its performance might be unsatisfactory and seeks to ensure that such situations are avoided. The use of *codes of practice* is the standard approach for this but there may be situations that are beyond the scope of the codes (see Millennium Bridge). A set of structural *Eurocodes* are used in the UK and throughout Europe.

The codes of practice give rules for a range of technical criteria. Checking against the rules is traditionally called 'structural design' but 'technical assessment' as used here as a more precise term.

Assessment for strength

A very important issue is strength – the ability of a structure to support loads. The basic approach to strength is to ensure that the strength criterion will be satisfied:

$$F \leq R \qquad \text{(a)}$$

That is, the load - F - on the structure or any part of the structure, must be less than or equal to the resistance - R.

Factor of safety method

Calculated factor of safety: FoS =

Ultimate stress/working stress = $F_y/\sigma_{working}$

Use the yield stress as the ultimate stress.

Use a required factor of safety (RFS) of at least 2.0, i.e. the calculated FoS should greater than 2.0

Strength criterion: FoS > 2.0

For example:

The safe working load (SWL) for a crane is 50 kN . This means that a lift greater than 50kN is not allowed. If the area of the lifting cable is 800mm, the stress in the cable is:

$\sigma_{working}$ = F/A = 500000/800 = 62.5 N/mm^2

If the yield stress in the cable is: f_y = 345 N/mm^2, the FoS is 345/62.5 = 5.5

This is greater that 2.0 therefore the cable size is adequate at the SWL. The area of the cable could be reduced by half.

Allowable stress method

$\sigma_{allowable}$ is the maximum stress allowed in the material. This is the yield stress divided by the required factor of safety i.e.

$\sigma_{allowable}$ = F_y/RFS

Strength criterion: $\sigma_{working}/\sigma_{allowable} \leq 1.0$

For the crane example:

$\sigma_{allowable}$ = F_y/RFS = 345/2 = 172 N/mm^2

Strength criterion:

$\sigma_{working}/\sigma_{allowable}$ = 62.5/172 = 0.36 ≤ 1.0

This method is the same as the factor of safety method. The allowable stress method was used by structural engineers but has been mainly superseded by the partial factor method.

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