TN471_cracking_example

SAFETY OF CONCRETE MEMBERS AT INITIATION OF CRACKING

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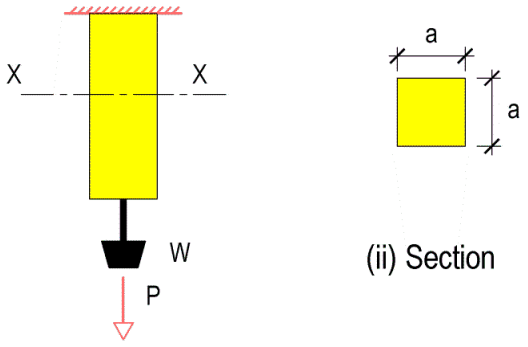
The objective of this simple example is to illustrate that the *initiation of cracking at a section* of a concrete member is governed by the characteristics of the *entire structure*, including its spans, supports, and loads. However, the *safety* of the *section* subsequent to cracking depends on the properties of the cracked section *only*, namely the geometry of the section, its material properties and its reinforcement. The differentiation between the two is significant, when it is applied to the safe design of concrete members.

Figure 1 shows a 10x10 inch (30x30 cm) hanging concrete bar. The axial tensile strength of the bar material is 200 psi (1.4 MPa). This means that the bar breaks apart if its axial tensile stress exceeds this limit. The bar carries a 12 k (53.4 kN) weight at its tip.

Two questions are raised.

1 – What is the value of the force P that can be added to the weight W to cause cracking of the bar at section X-X. Neglect the weight of the bar.

2 – If due to the addition of the force P the bar cracks at section X-X, how much reinforcement must be available across the crack, in order to avoid breakup of the bar in two pieces. Assume each rebar can take 5 kips (22.25 kN).



(i) Elevation

FIGURE 1 Hanging bar with a weight W at its end. The force P that leads to cracking at X-X, and safety of the bar after cracking are investigated (a=10-in. ; 30 cm; W=12k 53.4 kN) (P800)

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Question 1 – Initiation of Cracking
Section X-X cracks, when the tensile stress reaches its capacity of 200 psi (1.4 MPa)

Capacity = area x stress = 10x10x200/1000 = 20 k (89.0 kN)
Force P = capacity – existing force = 20 -12 = **8 kips** (35.6 kN)

Question 2 – How to make the section safe, after crack is initiated?
Section X-X cracks, when the tensile stress on it reaches its capacity of 200 psi (1.4 MPa)
Cracking will occur, when the force across the section is 10x10x200/1000 = 20 kips (89.0 kN)

Once section cracks, can no longer sustain tension across the cracked faces. The entire demand force at the section X-X must be resisted by reinforcement. Since each bar can take 5 kips (22.25 k), the number of bars is:

20/5 = 4 bars

CONCLUSION;
The force that initiates cracking (P=8 k; 35.6 kN) is different from the force that causes rupture of the section (P=20 k; 89 kN). For "safety" of the member, the latter applies. Note that the value of the rupture force for safety is independent from the applied force P. But, the initiation of cracking depends on P – namely the geometry of the entire member and the external force acting on it.