Cracks in concrete

The cracking phenomenon

When placed concrete typically contains more water than is required for hydration of the cement. As the concrete hardens and starts to lose the excess water, shrinkage begins. If the concrete is unrestrained, no cracks will develop. But it is virtually impossible to support a structure of any appreciable size without some restraint.

The cracking phenomenon is complex and depends upon a number of things; rate and amount of drying, drying shrinkage, tensile strength, tensile strain, creep, elasticity, degree of restraint, and other factors.

While most types of cracking do not affect structural stability or durability, all cracks are unsightly and in extreme cases cracking can reduce the use and serviceability of the structure. For this reason, cracking should be kept to a minimum.

In the laboratory, drying shrinkage tests are the most easily and most frequently performed tests in relation to shrinkage/cracking problems. However, there is sometimes too much emphasis on the drying shrinkage of hardened concrete as the criterion of susceptibility to cracking.

Drying shrinkage alone is influenced by many factors - water/cement ratio; amount, fineness and composition of cement; mineral composition, stiffness, shape, surface texture, and grading of the aggregate; characteristics and amount of any admixture; size and shape of the concrete mass; and conditions of humidity and temperature.

Preventative measures at the time of placing and curing remain the best means of minimizing cracking.

Some Types and Causes

In most cases where cracks appear in concrete the crack can be identified and the cause of cracking established. An extensive survey carried out revealed that concrete cracking can be attributed to the following:

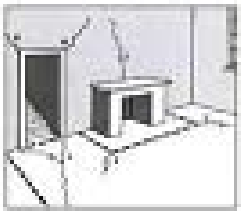
- construction and supervision problems - approx. 36%
- design defects approx. 27%
- ambient conditions (temperature, humidity, etc.) - approx. 21%
- quality of materials - approx 17%

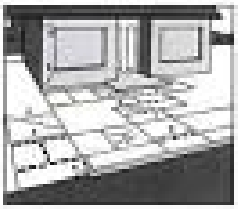
In addition all cracks can be grouped into two broad categories:

- cracks occurring before and during hardening
- cracks occurring after hardening of concrete

Recognising Cracks

1. Shrinkage cracks avoid by cutting contraction joints along dotted lines
2. Shrinkage cracks caused by stress concentration at corners - prevent by placing expansion joint along dotted line, or by using reinforcing steel
3. Settlement cracks caused by movement of sub-grade or footings
4. Cracks due to heaving under the slab through poor drainage of sub-grade
5. Expansion cracks prevent by placing expansion joints at dotted lines
6. Shrinkage cracks in feathered sections. Narrow feathered sections should be avoided
7. Plastic shrinkage cracks, due to quick loss of water to dry sub-grade or to the atmosphere
8. Shrinkage cracks at door or window corners avoid by use of reinforcing steel or (in solid concrete walls) by careful placement of low-slump concrete





Inside **Outside**

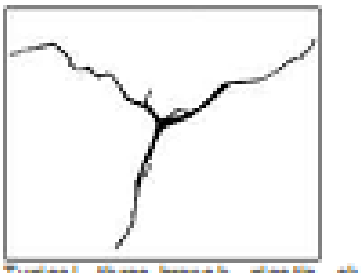
Cracks before and during hardening

Plastic shrinkage cracks occur when wind velocity, low relative humidity, high ambient temperature, or a combination of all three, cause water to evaporate from a concrete surface faster than it can be replaced by bleeding to the surface. The rapid evaporation which causes this cracking can be checked by windbreaks, shading and surface treatments.

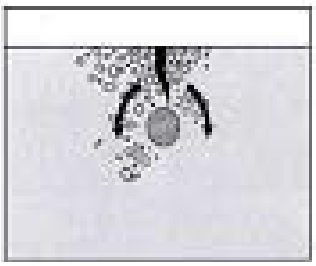
Vertical cracks may be caused by the settlement of concrete around reinforcing bars. Such cracks occur when the concrete near the surface takes a partial set while the rest of the concrete is still able to settle. Cracking of this type can be identified by a pattern which follows reinforcement. Thus cracks can often be prevented by revibration of concrete. Slopping cracks sometimes appear when coarse aggregate particles near the surface form a skeleton in which cement paste can settle and separate. Once again, vibration and revibration will reduce or prevent cracking.

Relatively small movements of formwork in the early stages of hardening will cause cracks. Swelling or bulging of timber, springing of nails, clumsy or excessive use of vibrators are the common causes of form movement resulting in irregular cracks.

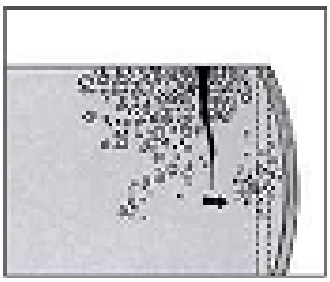
Wide cracks, sometimes extending through the slab, occur when sub-grade subsides before concrete has developed strength. This may occur because the sub-grade is not level and well compacted, or is muddy, or is unstable for any other reason.



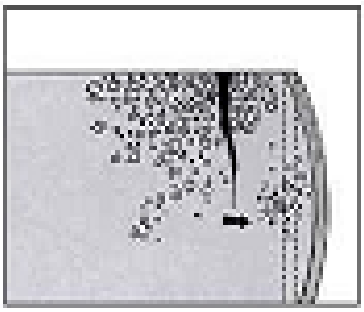
Typical three-branch plastic shrinkage crack, caused by too rapid loss of water soon after concrete has been finished



When concrete settles over obstructions Such as reinforcing bars, cracks may appear along the surface above the obstruction. Avoid this by using low-slump concrete and vibrating well throughout the depth of formwork



Slight bulging or shifting of forms may Cause cracking. Usually the concrete Surface will be slightly distorted if form has moved



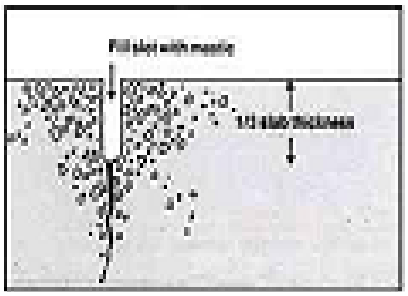
Uneven sub-grade, or rupture of any covering over Subgrade may allow concrete to shift while setting. Deep cracks usually result.

Cracks after hardening

This category covers the performance of concrete whose shape can no longer be altered without damage It includes cracks caused by drying shrinkage, as well as those which result from the temperature movements which take place in all materials exposed to the elements. Unless the structure concerned permits movements of its members without development of excessive stresses, extensive cracking often may occur. Crazing cracks after hardening can result from excessive floating which tends to draw water and cement to the surface, which then comprises weak concrete subject to high shrinkage stresses. More often, they result from poor curing. Other cracks which occur after hardening can be caused by lack of adequate reinforcement at corners, insufficient depth of concrete over bends in reinforcement, nesting of reinforcing steel in concrete, lack of expansion and contraction joints.

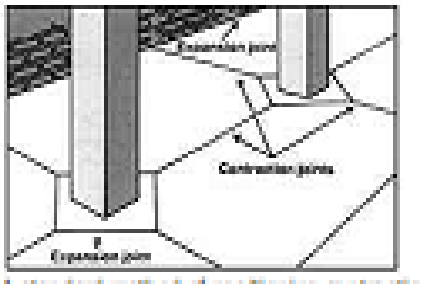
Slots and joints

Shrinkage cracks cannot always be prevented, but they can be controlled by making planes of weaknesses to establish the direction of cracking when contraction occurs. This is done by cutting slots one third the thickness of the slabs, and is done as soon as the concrete is hard enough to resist damage by the saw. Cracking, if it occurs, will then occur neatly beneath the line of the slot. (If the cutting is left much later than the point of time mentioned, surface cracks may suddenly appear, veering off in the line of sawing.)



Construction joints cut one-third the dept of The slab permit free contraction and help establish direction of any cracking

The contraction should be cut at logical points of stress in paths, at ½ to 2 metre intervals (lightweight paths can be scored with a double edger); in driveways or large floors, at 5 to 7 metre intervals. Where the floor is divided into bays by columns, the joints may be placed from column to column for better appearance (see illustration). However, they should not be more than 7 metres apart unless slabs contain substantial steel reinforcement. Expansion joints, or isolation joints, usually consist of pre-moulded tar material 10mm thick, as deep as the slab, and as long as the slab. They should be placed where paths of driveways meet, and where slabs meet a column base, wall, or any other mass which will resist expansion in that direction (see illustration).



A standard method of positioning contraction and expansion joints in a floor divided into bays by columns

Summary

The majority of cracks occur within 2-3 days after concrete has been placed. These are preventive measures which will minimise cracking in that period:

- see that sub-grade is well-compacted
- check that form work is firm
- ensure that sub-grade and form work are moist before pouring
- do not add water to ready-mixed concrete in placing
- compact low-slump mixes well
- cut sufficient contraction joints to allow for shrinkage
- provide expansion joints where necessary
- start curing as soon as possible
- maintain proper curing for an adequate period.

By the use of the procedures in this publication and by exercising proper care you will obtain the best performance from your READYMIX concrete. READYMIX concrete, READYMIX laboratories have trained technical staff who are available to answer any technical enquiries you may have and assist in designing concrete mixes and conduct trial mixes specifically for your needs.