TARMAC

Non-structural cracking of concrete

Concrete can withstand very large compressive stresses but only small tensile stresses, particularly at an early age. Cracking in concrete occurs when the tensile stress within the concrete becomes greater than it can withstand.

The causes of cracking in concrete may be divided into two distinct groups:

- Those which produce structural cracking
- Those which produce non-structural cracking

The causes of structural cracking

Structural cracking in concrete may be caused by a number of factors including:-

- Overloading of the concrete element.
- Failure of the support under the concrete element.
- Creep of the concrete, which is caused by long term loading of the hardening concrete.

This Topic Brief describes the causes, effects and remedy of non-structural cracking. It does not consider structural cracking.

The causes of non-structural cracking

Non-structural cracking in concrete may be caused by any one or a combination of:-

- Plastic settlement of the fresh concrete.
- Shrinkage of the concrete due to:
  - Plastic shrinkage of the fresh concrete.
  - Early age thermal contraction.
  - Long term drying shrinkage aggravated by moisture movement.
  - Seasonal thermal movement.
- Surface crazing of the concrete.
- Cracking due to expansive forces within the concrete caused by:-
  - Reinforcement corrosion due to chloride moisture attack.
  - Alkali-silica reaction.
  - Early frost damage.
  - Freeze/thaw damage.
  - Sulphate attack on the cement in the mix.

Plastic settlement and shrinkage cracks are usually associated with some form of constraint which prevents the concrete from moving freely. Restraint is generally a function of design and/or construction details, never the concrete mix itself.

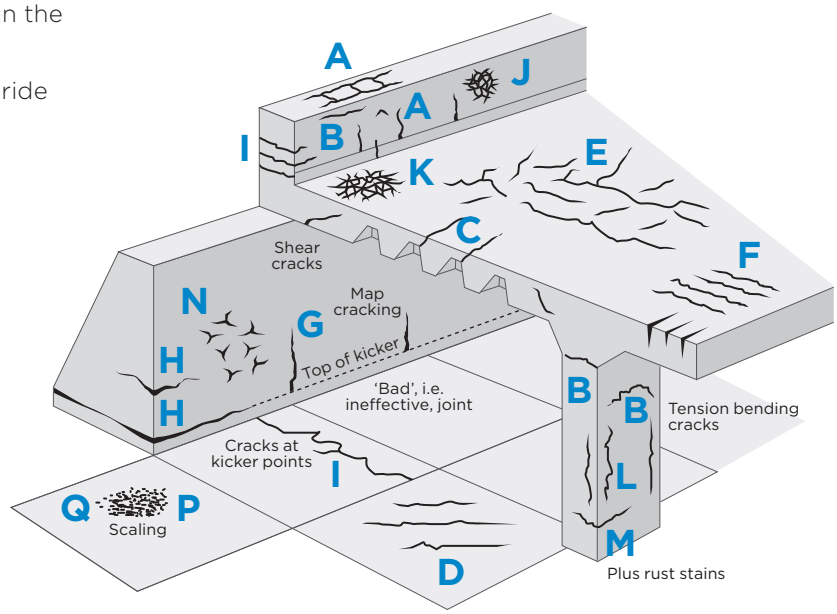
The different types of non-structural cracking

The cause of cracking may not be easily identified, because a particular type may be caused by a combination of several different factors. Cracks initially produced by one factor may be enlarged due to the influence of additional factors.

The causes of non-structural cracking may be identified by:-

- The time when the crack occurred.
- The crack shape and pattern.
- The position of the crack in the concrete element. See diagram below and table opposite.

The time that a crack occurs after the concrete has been poured is a good indicator of its cause, as this knowledge eliminates many other reasons why cracking has taken place.



Non-structural cracking of concrete

Type of cracking		Diagram Letter	Most Common Location	Primary Cause	Secondary Causes/ Factors	Time of Appearance After Pour	How Common	Prevention or Remedy	Comments
Settlement									
Plastic	Over reinforcement	A	Deep sections	Water bleeding to the surface and evaporating Settlement of heavier particles in the mix	Rapid early drying conditions e.g. sunny, windy, exposed location Slow setting due to retarding admixtures or cement characteristics	10 minutes to 3 hours	Fairly common	Revibrate (if concrete still plastic) Protect from drying weather conditions Reduce bleeding Use air-entrained concrete	Cracks generally follow lines of restraint to equal settlement e.g. reinforcement bars, changes in section depth
	Arching	B	Top of columns						
	Change of depth	C	Trough and waffle slabs						
Shrinkage									
Plastic	Diagonal	D	Roads and floor slabs	Rapid early drying conditions e.g. sun, wind, causing water to evaporate from the surface of the concrete faster than it is replaced by bleed water causing a volume reduction of the concrete at the surface		30 minutes to 6 hours	Very common	As above, plus improve early curing (maintain high humidity) Include polypropylene fibres in the concrete	Cracks rarely run to edge of element or are longer than 1 metre Cracks do not go through aggregate particles
	Random	E	Reinforced concrete slabs						
	Over reinforcement	F		As above, plus steel near the surface orientating the cracks					
Early age thermal	External constraint	G	Thick walls	Excessive temperature generated by the cement hydrating	Concrete allowed to cool too rapidly Excessive joint spacing Insufficient reinforcement	1 day to 2-3 weeks	Fairly common	Insulate Reduce the heat generated by using a low heat or blended cement Include steel fibre reinforcement	The thermal properties of the concrete should be taken into account by the designer to control cracking, particularly joint spacing on paving, slabs and walls
	Internal restraint	H	Thick slabs	Excessive temperature gradient within the concrete					
Long-term drying		I	Thin slabs and walls	Insufficient joints Incorrect design	Excessive shrinkage (shrinkable aggregates) Insufficient curing	Several weeks or months	Rare	Reduce water content of the concrete Improve curing Use of low shrinkage aggregates	Usually caused by a fundamental design or construction fault
Crazing									
Surface	Against framework	J	Fair faced concrete	Impermeable formwork	Cement rich surface Poor curing Over-vibration near formwork	1-7 days, sometimes much later	Fairly	Change formwork finish	Appears as fine map cracking Generally looks better with time Rarely more than a cosmetic problem
	Floated concrete	K	Slabs	Over-troweling			Very	Improve finishing and curing	
Expansion									
Reinforcement corrosion	Natural	L	Columns and beams	Lack of cover	Permeable concrete Poor workmanship and/or completion	2 years or more	Common in older concrete	Do not use accelerator containing calcium chloride Can be effectively repaired by specialist contractor	Reinforcement corrodes, expands bursting concrete Cracks usually show rust staining
	Chloride	M	Concrete exposed to de-icing or sea salts	Excess chlorides Chloride migration					
Alkali-silica reaction		N	Damp locations	Alkalis in the cement react in the presence of water with a component of some aggregates to produce a gel which absorbs water and expands		5 years or more	Very rare	Impossible to repair but not as serious as it appears Refer to concrete supplier for advice on prevention	Appears as map cracking, sometimes with a white gel extruding from the cracks
Early frost damage		P	Thin sections and slabs	Water in fresh concrete freezes and expands		1-24 hours	Fairly common	Keep concrete above 5°C until curing is completed, use insulation	Frost damaged concrete may have no structural strength and will require replacement
Freeze/thaw damage		Q	Paving	Water soaks into the surface of hardened concrete, freezes and expands causing the surface to crumble		Anytime after the concrete has hardened	Fairly common	Use good quality, air-entrained concrete Cure well	Aggrevated by de-icing salts

Prevention of non-structural cracking

Good practice in structural design, selection of the constituent materials, concrete mix design and on-site workmanship aims to reduce the occurrence of non-structural cracking in concrete to a minimum. It is particularly important that the concrete is correctly cured after placing and protected from extremes of temperature.

However, it should be remembered that concrete is not a dimensionally stable material and is, therefore, inherently liable to crack. This fact is recognised by designers who include steel or fibre reinforcement to eliminate or control certain types of non-structural cracking.

Guidance on the prevention of non-structural cracking is given in the table on page 3.

Repair of non-structural cracks

Not all non-structural cracks need to be repaired, as many are simply a cosmetic problem. If they do need repairing it must be determined if they are dormant or live. Some cracks, such as those caused by plastic shrinkage, are generally dormant almost as soon as they occur. Where there is thermal contraction any subsequent cracking may follow the lines of weakness induced by the plastic shrinkage cracks. This will render the cracks live once again.

Dormant cracks are normally simply sealed by the injection of an epoxy resin or cementitious sealer into the cracks.

Live cracks should be treated as movement joints and should be capable of accommodating any anticipated movement. They will need to be sealed with a material which permits sufficient movement without cracking the seal and they may require to be grooved to provide a sufficient slot width for the sealer to perform correctly.

If non-structural cracks require repairing, specialist advice should be sought.

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