# IS CRACKING OF CONCRETE INEVITABLE?

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## Introduction

The causes and consequences of cracking vary considerably depending on the application. In some structures cracking is to be avoided completely. However, in reinforced flexural members, not allowing cracking may not result economical at all.
Cracks in concrete may promote corrosion of reinforcement, deterioration and leaching of concrete, damage of structural members and appearance concerns; in short, loss of durability, and decrement of functionality as well as esthetics value.
Concrete cracks for many different reasons. Generally, cracking is cause by plastic shrinkage due to external drying, subgrade support deficiencies, thermal loading, aggregate reaction, corrosion of embedded steel, vehicular impact, overloading, and so on.

## Shrinkage effect

Shrinkage cracks are caused by restraint of volume changes in the concrete member. As moisture leave the member, the concrete shrinks. To minimize the stresses cause by drying shrinkage, the water content in concrete should be as low as possible, this since the more water in the mix, the more water that must come out of the mix.
Restraining factors, such as uneven subgrade and reinforcement tie-bars into foundations walls, will restrain shrinkage movement and cause cracks when those restraining forces become larger than concrete tensile strength. Therefore, in order to minimize tensile stresses, the concrete should be able to contract wherever tensile stresses may occur.

## Temperature effect

Temperature ideal condition would be to eliminate any temperature change. Measures for the prevention of temperature cracking are generally those which minimize the temperature change. This is accomplished by reducing the placing temperature of concrete, by minimizing the temperature rise after placement, or by combining these methods.
*Lowering the placing temperature* may be achieve by restricting concrete placement during the hotter part of the day, use evaporative cooling of aggregates stockpiles, replacement of a portion of the mix water with ice, etc.
Measures to *minimize the temperature in the concrete* immediately *after the placement* include: the use of embedded pipes for internal cooling, reducing the cement content, using low-heat cement, use of pozzolans, use of retarding agents, air entraining admixtures, and water curing.
*Pozzolans* are use in concrete for several reason, one of them is to obtain a lower total heat from the cementing material of the mix, since the heat produced by same amount of cement would be around 50 % higher.
*Air entraining admixtures* lower the cracking tendency of concrete. Increasing the air content to a value between 4 and 6 vol%, the cracking temperature is lowered approximately 5° C.
*The retarding agents* reduce the early rate of heat generation of the cement so that the total heat generated during the first two or three days will be lower than of a mix without retarder. In this way, artificial cooling can effectively remove the heat generated after this time.
*Water curing* effect is to reduce the absorbing heat from outside of concrete during the early age when exposure temperatures are higher than the interior temperatures. On the other hand, when concrete temperatures are higher than exposures temperatures, the effect is to increase the loss of heat from the interior to the surfaces.
On cross-sections of large thickness, curing can only influence the surface of the concrete member, this curing is favorable if the expansion of the concrete is restrained during the surface cooling. Furthermore, the concrete surface should not be cooled too long to avoid additional tensile stress at the surface, while the center of the cross-section is still heating

up and expanding.

**Load effect**
Flexural cracking is always present in efficiently designed reinforced concrete flexural members as soon as steel reaches a stress of 41 MPa or higher. For flexural crack control, the consideration is the maximum permissible crack width before reinforcement corrosion becomes a problem.
In concrete pavement, cracking control methods include the use of transversal joint at such interval to eliminate or reduce the possibility of cracking. This method natural replaced cracks by joints, or man-made cracks, resulting in joints having the same deficiencies of natural cracks. Another method is based on providing relatively heavy continuous reinforcement to control cracks once they form. The reinforcement holds cracks tightly closed and preserves the structural integrity of the pavement. The fine cracks have enough load transfer and stress reducing properties and do no require sealing.

**Internal expansion**
*Alkali-silica* reaction is another cause for cracking. Concrete may crack due to internal expansion arouse by reaction of alkalies in solution in the concrete with soluble silica in the aggregates. Therefore, the three essential ingredients for alkali-silica expansion are: reactive form of silica, sufficient alkali, and sufficient moisture within the concrete. Sealers or elastomembranes, are useful to preventing moisture ingress into the concrete; however, they may not stop the reaction once started. Preventive measures should begin testing the proposed aggregates and cement, and investigating the environment. Additions of pozzolans to reduce cement content or reduce reactivity may be indicated. Besides, since avoidance of potentially reactive aggregates is not always possible, one remedial technique may be the use of limestone sweetening. This consist in replacing a part of the total aggregate value by limestone in order to reduce the expansion potential.
Another cause of concrete internal expansion, and subsequently cracking, is *corrosion* of embedded metal. This can be avoided if agents that cause corrosion are prevented to reach the metal. Measures developed for structures exposed to a corrosive environment include increasing concrete cover over reinforcement, use of impermeable concrete, sealers application, use of exposy coated reinforcement, incorporating inhibitors, and cathodic protection.

**Design factors**
Mayor design factors that affect cracking include span length, concrete properties, girder type, dead load deflection, base restraint, concrete cover, and reinforcement.
Many transportation agencies have observed that cracking is more common on continuous span structures, and on structures supported by steel girders than those supported by concrete girders.
Recommendations to reduce deck cracking include the design of stiffer decks and the use of additional reinforcement. Also, decreased spacing of temperature and shrinkage steel was recommended.

**Construction factors**
Weather conditions during construction influence cracking. Adverse conditions include high wind, low and high temperatures, low humidity, and direct sunshine.
Evaporation rates should be measure at job sites. Sun shades, winds breaks, and fogging should be used in period of high evaporation.
Construction personnel should be sufficient to provide a timely finish. Concreting should be finish in about 60 to 70 hours, in order to avoid that the concrete placed last will crack due to tensile stresses resulting from contractions which will occur in the older concrete.

**Conclusion**
Research and survey of concrete structures have provided significant improvement on the understanding of the cracking phenomenon. From these investigations, useful measures to avoid or reduce cracking have been derived. Nevertheless, still there are some uncertainties in everyday construction work, weather a particular concrete will crack or not. Therefore, it seems necessary that research should continue to increase both basic understanding and practical field measures.