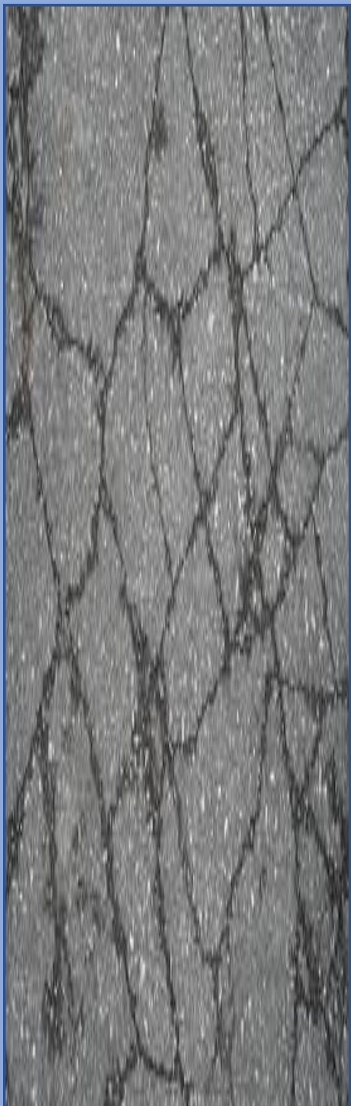
ALMISNED READYMIX

المسند للخرسانة

In-house Training Purposes Only

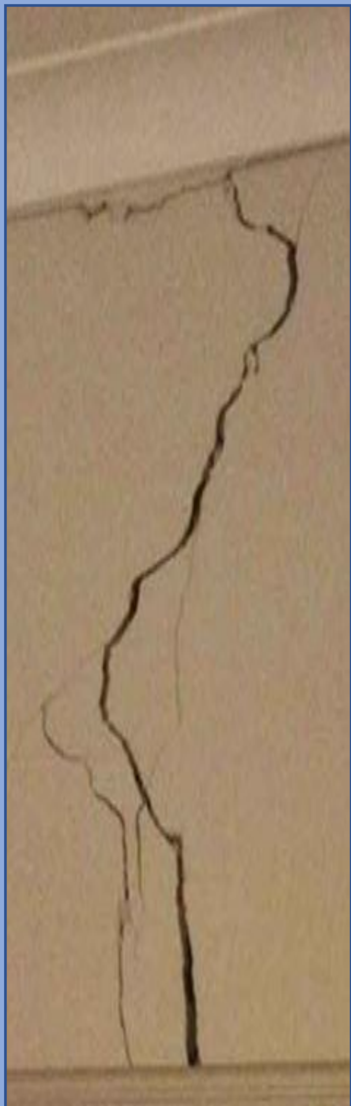
UNDERSTANDING THE CAUSE OF CONCRETE CRACKS ON FRESH POURED CONCRETE

HAIRLINE CRACK



SHRINKAGE CRACK

SETTLEMENT CRACK



STRUCTURAL CRACK

Introduction:

Concrete is one of the most widely used construction materials globally, renowned for its strength, durability, and versatility. However, despite its robust nature, concrete structures are susceptible to cracking, which can compromise their integrity and longevity. Understanding the causes of concrete cracks is paramount for engineers, contractors, and anyone involved in construction to ensure the durability and safety of concrete projects.

In this introduction, we will delve into the primary factors contributing to concrete cracking, providing a foundational understanding of why cracks occur in freshly poured concrete. By comprehending these causes, stakeholders can implement preventive measures and appropriate mitigation strategies to minimize the occurrence of cracks and enhance the overall quality of concrete structures.

Objective:

The objective of understanding the causes of concrete cracks is to proactively identify and address potential issues, minimize risks, optimize construction practices, enhance durability, and ensure compliance with regulatory requirements. By achieving these objectives, stakeholders can deliver safer, more durable, and cost-effective concrete structures that meet the needs of users and communities for years to come.

Purpose:

understanding the causes of concrete cracks is essential for ensuring structural integrity, enhancing durability, minimizing costs, maintaining aesthetics, mitigating liability, and improving construction practices. It enables stakeholders to proactively address potential issues during the design and construction phases, ultimately leading to safer, more durable, and aesthetically pleasing concrete structures.

Key Points to Address:

Inherent Properties of Concrete:

Concrete is a composite material composed of cement, aggregates, water, and admixtures. Despite its strength, concrete exhibits certain inherent properties that make it susceptible to cracking under specific conditions.

Hydration and Curing:

The process of concrete hydration, wherein cement particles react with water to form a crystalline structure, is crucial for its strength development. Proper curing is essential to maintain adequate moisture levels and temperature, preventing premature drying and ensuring uniform hydration throughout the concrete mass.

Temperature Variations:

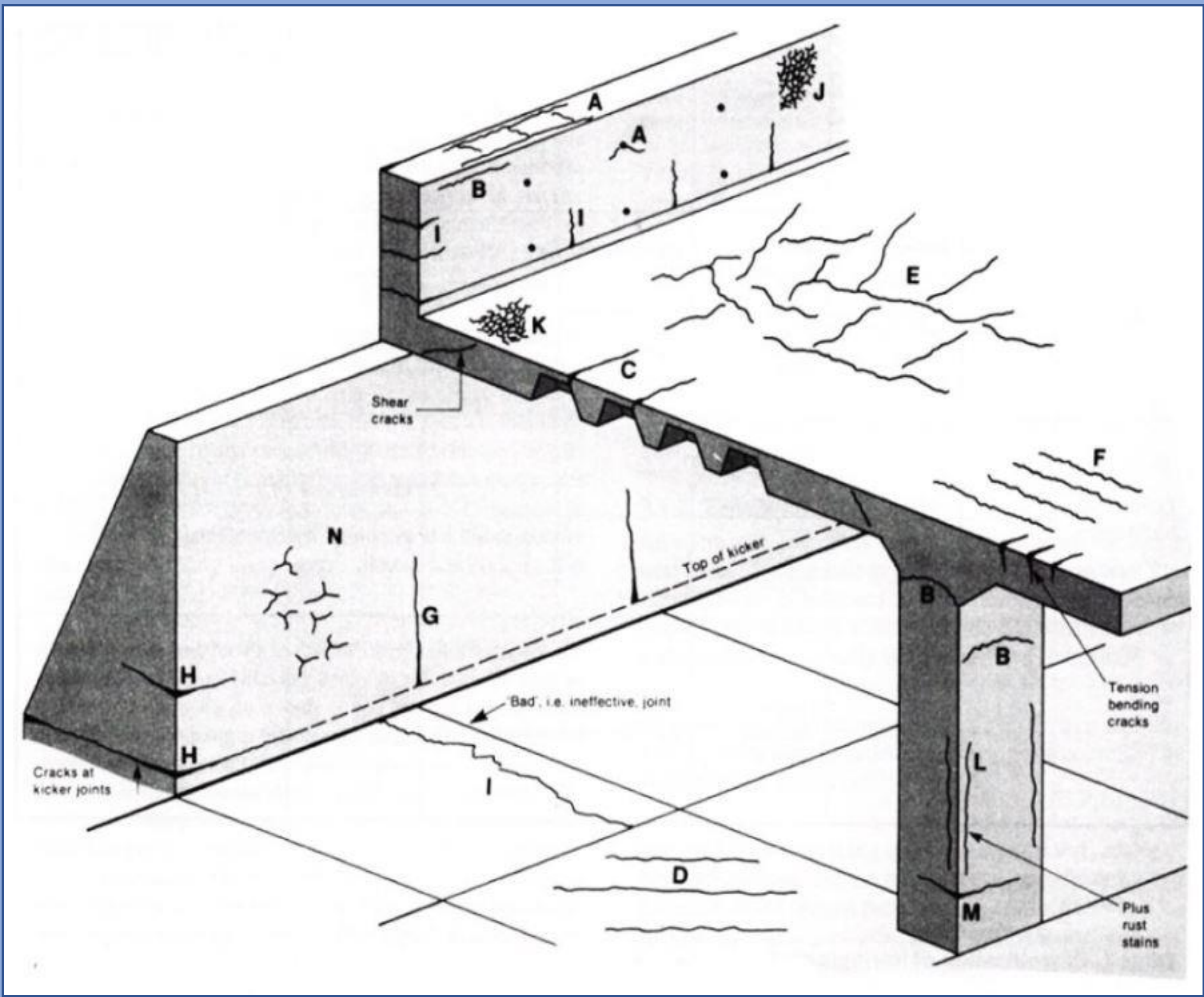
Temperature differentials can induce thermal stresses within concrete, leading to cracking. Rapid changes in temperature, such as exposure to direct sunlight or freezing conditions, can exacerbate these stresses, particularly in large concrete structures.

Shrinkage:

As concrete cures and moisture evaporates, it undergoes shrinkage, which can result in internal tensile stresses and subsequent cracking. Factors such as the water-to-cement ratio, aggregate type, and admixture usage influence the extent of shrinkage and its impact on cracking.

Structural Overloading:

Excessive loads or structural movements beyond the design capacity can cause overstressing of concrete members, leading to cracking. Proper structural analysis and design considerations are essential to prevent overloading-induced cracks.



Types of Cracks in Concrete Table (A)

Types of Cracks in Concrete connection with Table (A)

Letter	Type of Crack	Subdivision	Most Common Location	Primary Cause (excluding restraint)	Secondary Cause/Factor	Time of Appearance
A	Plastic Settlement	Over reinforcement	Deep section	Excess bleeding	Rapid early drying condition	Ten minutes to three hours
B		Arching	Top of columns			
C		Change of depth	Trough and waffle slab			
D	Plastic Shrinkage	Diagonal	Roads and Slabs	Rapid early drying	Low rate of bleeding	Thirty minutes to six hours
E		Random	Reinforced concrete slabs			
F		Over reinforcement		Ditto plus steel near surface		
G	Early Thermal Contraction	External restrain	Thick wall	Excess heat generation	Rapid cooling	One day to three weeks
H		Internal restrain	Thick Slab	Excess temperature gradient		
I	Long-Term Drying Shrinkage		Thin wall and slab	Inefficient joints	Excessive shrinkage inefficient curing	Several weeks or months
J	Crazing	Against formwork	Fare face concrete	Impermeable formwork	Rich mixes	One to seven days sometime much later
K		Floated concrete	Slab	Over trowelling	Poor curing	
L	Corrosion of Reinforcement	Natural	Columns and Beam	Lack of cover	Poor quality concrete	More than two years
M		Calcium chloride	Precast Concrete	Excess calcium chloride		More than five years

Four common concrete cracks:

Hairline Cracks:

Hairline cracks defines as cracks in an exposed concrete surface having widths so small as to be barely perceptible. Although this definition doesn't give a numerical value for width (or require the viewer to wear bifocals to see the crack), it probably applies to cracks less than about 0.003 inch (0.08 mm) in width.

Hairline cracks can be very shallow or quite deep, depending on the cause. However, there is no way to determine crack depth based on crack width. (***Reference ACI 116R-90***)

What causes hairline cracks?

Hairline cracks are thin cosmetic cracks that are caused by "***temperature or humidity fluctuation"***. These fluctuations can result in plaster shrinkage or swelling, creating small fissures and call hairline cracks.

Are hairline cracks in concrete normal?

Yes, cracks in concrete are normal due to the shrinkage that happens when the concrete hardens and cures. Concrete can also crack if it experiences extremely cold or hot temperatures. Some cracks in concrete are inevitable due to the structure of the surface.

Shrinkage Crack:

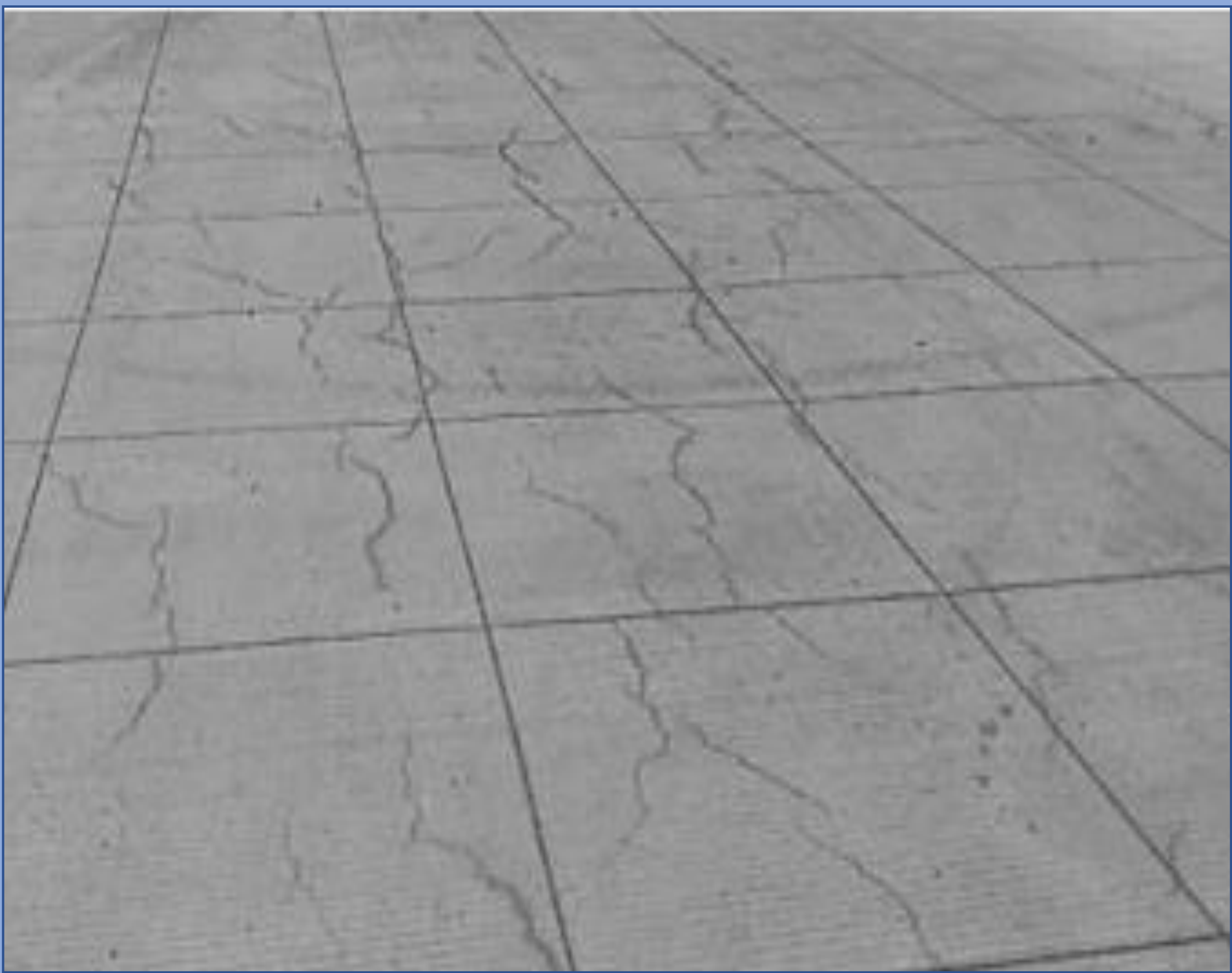
Concrete shrinkage cracks are a common issue that occurs when concrete experiences a volume reduction due to water loss during the curing process. This can cause the concrete to shrink and crack. Most shrinkage cracks are hairline and not structurally significant.

VARIOUS FORMS OF SHRINKAGE

Plastic Shrinkage

After the fresh concrete has been placed in forms, concrete undergoes a volumetric contraction while it is in plastic state (before the concrete has set). This is known as Plastic Shrinkage, Pre hardening or Pre-setting shrinkage. This Plastic shrinkage sometimes results in the formation of Cracks. This happens if concrete surface loses bleed water faster than the rate of bleeding. Quick drying of concrete at the surface results in shrinkage and as concrete in plastic state cannot resist any tension, short cracks develop. These cracks occur within a few hours (i.e. between one – two hours) of placing concrete, although often they may not be noticed until at least the next day.

These cracks usually are parallel to one another and are spaced 0.3m to 1m apart. These cracks may be as much as 5cm to 10cm in depth and up to 3mm in width. At the surface, the cracks are wider and taper down rapidly. They do not extend to free edges of the concrete, as there is no restraint to contractions there and hence no tensile stresses are developed in concrete.

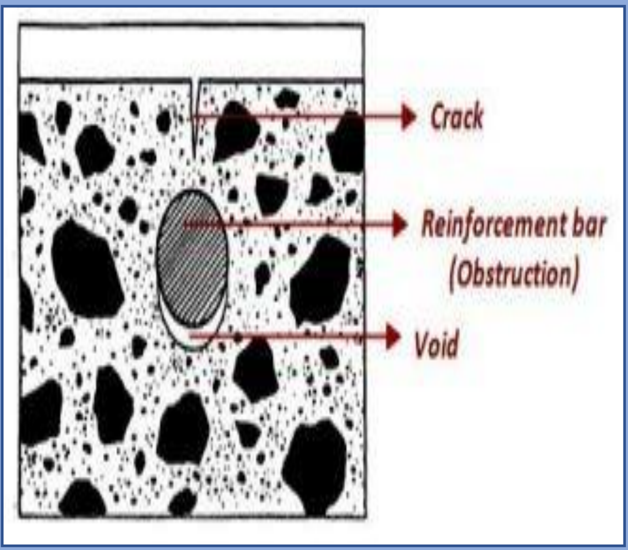


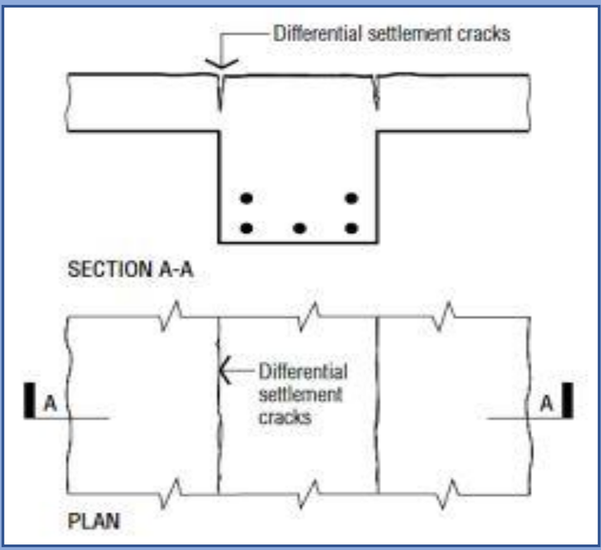
Prevention of Plastic Shrinkage Cracks:

1. The fresh concrete should be protected from direct sunrays and strong winds for at least 24 hours.
2. Where feasible, carry out the concreting works during early hours of the day.
3. Concrete should not be placed on dry subgrade. It should be made wet by sprinkling water before the concrete is placed.
4. Avoid use of warm water and warm aggregates in order to keep the temperature of fresh concrete low.
5. Dampen the formwork, ensuring that any excess water is removed prior to placing concrete.
6. Keep the aggregates under shade. In hot weather, lower the temperature of the fresh concrete by using chilled mixing water or replacing some of this water with crushed ice.
7. The concrete should be placed and finished fast.
8. Cover the freshly placed concrete with tarpaulins or plastic sheet to prevent evaporation of bleed water.
9. Start curing as soon as possible after placing of concrete but before the surface water-sheen fully disappears.
10. The use of sufficient proportions of synthetic or steel fibers in concrete can provide improved control of plastic cracking.

Plastic Settlement

The cracks due to Plastic Settlement are commonly mis-understood to be due to shrinkage. Plastic Settlement cracks occur when there is a relatively high amount of bleeding and some form of obstruction (e.g. reinforcement bars, tie bolts of formwork, large aggregate particles etc.,) to the downward settlement of the solids. These obstructions 'break the back of concrete' and generate voids under them 'belly' as shown. As a result, cracks are formed directly over formwork tie bolts or over the reinforcement near top of a section due to the arching of concrete over the obstacle causing tension in concrete. These cracks are typically found along the line of reinforcement or over obstacles. The amount of settlement tends to be proportional to the depth of concrete, i.e., the deeper the section, the greater the settlement. At lines of changes of section, e.g., at a beam/slab junction, the differential amount of settlement can lead to cracks forming at the surface.





Prevention of Plastic Settlement:

1. Use mixes with lower bleeding characteristics e.g., lower slump and more cohesive mixes.
2. Wet the subgrade before placing concrete to avoid excessive water loss from the base of the concrete.
3. Increase the ratio of cover to reinforcing bar diameter, i.e., by increasing the cover or decreasing the size of the bars.
4. Reduce obstruction to settlement.
5. Avoiding the use of retarding admixtures is sometimes suggested as a way of minimizing plastic settlement cracking, but in hot weather the benefits of their use outweigh the disadvantages.
6. Set all formwork accurately and rigidly so that it will not move during concrete placement.
7. Place concrete in deep sections first (including columns) and let it settle prior to placing and compacting the top layers (ensuring that the two layers blend together).
8. Fully compact the concrete.
9. Start curing as soon as possible after placing of concrete but before the surface water-sheen fully disappears.

Drying Shrinkage

After hardening, concrete starts drying. The excess water (not consumed for hydration) leaves the system causing contraction or shrinkage. This excess water, called water of convenience would have been added to get adequate workability and finish-ability. The loss of free water contained in hardened concrete, does not result in any appreciable dimension change. It is the loss of water held in gel pores that causes the change in the volume. Under drying conditions, the gel water is lost progressively over a long time, as long as the concrete is kept in drying conditions. Cement paste shrinks more than mortar and mortar shrinks more than concrete. Concrete made with smaller size aggregate shrinks more than concrete made with bigger size aggregate. The magnitude of drying shrinkage is also a function of the fineness of gel. The finer the gel the more is the shrinkage.

The shrinkage that takes place after the concrete has set and hardened is called Drying Shrinkage and most of it takes place in the first few months. Any restraint to this contraction causes tensile stresses to develop in concrete causing cracks. A very small part of this shrinkage can be recovered on immersion of concrete in water. The rate of this shrinkage is time dependent. 15 – 30% of total shrinkage (after say 20 years) occurs in two weeks, 40 – 70% in three months and 66 – 80% in one year.

Prevention of Drying Shrinkage:

1. Use minimum water content (consistent with placing and finishing requirements). To compensate for the reduction in workability, plasticizers can be used.
2. Use the highest possible aggregate content and largest possible maximum aggregate size.
3. Use concrete with workability as low as is compatible with ease of placing and achieving full compaction.
4. Do not use admixtures known to increase drying shrinkage, e.g., those containing calcium chloride.
5. Provide adequate and early curing to exposed surfaces, particularly on large flat areas.
6. Eliminate external restraints as much as possible, particularly by providing movement joints wherever applicable.
7. Provide reinforcement steel at closer spacing (generally 15cm in slabs) in order to control crack width.

Conclusions:

Prevention or minimizes concrete cracks

Concrete cracks can be nerve-wracking to deal with, impacting not only the aesthetics, but also the structural integrity of a building. There's no way to completely eradicate cracks, but here are 10 ways to minimize these bothersome defects.

Keep an eye on the temperature.

Cracking can occur due to large temperate differences between the concrete and the air and/or the surface it's being placed on. Never place concrete on surfaces that are less than 35° F (or 1.7°C), and be sure that the temperature difference between the concrete and the air should not be greater than 20° F, except when temperatures above 50° F occur for more than half of a 24-hour period. With slab on grade construction, ensure that the subgrade is properly compacted and the slab and subgrade are sloped for proper drainage. In cold weather, be sure any snow or ice is removed before placing the concrete.

Prevent excess water.

Control measures are needed to prevent differential volume changes in the concrete. High water content in a concrete mix design is one of the primary causes of differential volume changes that cause high shrinkage and excessive cracking. The use of chemical admixtures, such as water reducers, creates easy-to-place, high slump concrete, without adding excess water.

Look into using synthetic micro fibers.

Settlement cracking can occur due to restraint by reinforcing steel. Using micro fibers can help reinforce concrete to prevent these cracks. By equally distributing micro fibers throughout the concrete, you can improve impact resistance and crack control.

Brace formwork.

Ensure that the brace formwork can withstand the pressure of the concrete without movement. In addition, general formwork design (following ACI 347) can reduce cracking (i.e., thin form board between properly spaced braces can still allow for cracking).

Use formed joints.

Ensure proper control joint spacing for flatwork in addition to walls of any thickness. For contraction joints, for example, use the height of the wall (for walls greater than 12' tall) and three times the height of the wall (for walls less than 8' tall). However, control joints should be used for walls of any thickness.

Explore pre-curing options.

Fogging or the use of surface plastic between finishing operations can mitigate cracking. In severe weather conditions, you may want to reschedule placement.

Provide sufficient concrete cover.

Put protective concrete covering specially on hot weather where concrete is exposed directly to sunlight, windy weather and high humidity to avoid rapid lost of concrete moisture.

Start curing the concrete as quickly as possible.

A longer curing period than is generally required for compressive strength may be needed in cold weather to reduce cracking. Apply a curing compound or protect it with damp burlap or other covering for at least three days. You may then want to add a second coat of curing compound.

Cool gradually.

The concrete surfaces exposed to cold weather should be gradually cooled at the end of the protection period to protect against surface cracking.

Pay special attention to timing of the concrete finishing process.

During finishing, initial screeding should be followed immediately by bull floating. Don't do finishing work when water is on the surface or before concrete has finished bleeding.

Reference

ACI 224.1 R 07 - Causes, Evaluation, and Repair of Cracks in Concrete Structures

Section 5 Part 8 Transportation and Placing of Concrete

Section 5 Part 9 Formwork

Section 5 Part 10 Curing

Section 5 Part 14 Protective Treatments for Concrete

Section 5 Part 15 Hot Weather Concreting