Concrete Cracks

PREVANTING CONCRETE CRACKES

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Introduction:

Concrete is a composite construction material composed of cement (commonly Portland cement) and other cementitious materials such as fly ash and slag cement, aggregate (generally a coarse aggregate made of gravels or crushed rocks such as limestone, or granite, plus a fine aggregate such as sand), water, and chemical admixtures.

The word concrete comes from the Latin word "concretus" (meaning compact or condensed), the perfect passive participle of "concresco", from "com-" (together) and "cresco" (to grow).

Concrete solidifies and hardens after mixing with water and placement due to a chemical process known as hydration. The water reacts with the cement, which bonds the other components together, eventually creating a robust stone-like material. Concrete is used to make pavements, pipe, architectural structures, foundations, motorways/roads, bridges/overpasses, parking structures, brick/block walls and footings for gates, fences and poles.

Even after good selection of the above ingredients and producing a good concrete mix will be of no use if in construction site the following important procedure is not followed

A.Controlling water quantity.

b. Good compaction.

c. Careful and continuous curing.

It is well established that adding more water is as bad as consuming more food to a human body. More water is the culprit who makes many problems with the properties of concrete .The layman- masons and masteries like to add more water for their easy workability .It should be controlled by the engineer in the site.

Hope that everyone knows the importance of compaction .May be sometimes good articles on this will be posted in the forum.

It is known fact the concrete should be nourished by continuous curing .the importance of curing can be read in many good books on concrete and journal, article. Few articles will be posted in the forum in due course of time.

To help the young engineer I furnish the information below as taken from the web sites and with the web site addresses about some important aspects like preventing cracks in concrete. More detailed information can be read by browsing the web site.

Why Concrete Cracks

Cracks in concrete are extremely common but often misunderstood. When an owner sees A crack in his slab or wall, especially if the concrete is relatively new, he automatically Assumes there's something wrong. This is not always the case. Some types of cracks are Inevitable. The best that a contractor can do is to try to control the cracking. This is done By properly preparing the subgrade, assuring that the concrete is not too wet, utilizing Reinforcement where needed, and by properly placing and spacing crack control joints And expansion joints. However, sometimes cracks happen in spite of any precautions Taken

The **American Concrete Institute** addresses this issue in ACI ٣٠٢.١-٠٤. ***"Even with the Best floor designs and proper construction, it is unrealistic to expect crack-free and Curl-free floors. Consequently, every owner should be advised by both the designer and Contractor that it is normal to expect some amount of cracking and curling on every Project, and that such occurrence does not necessarily reflect adversely on either the Adequacy of the floor's design or the quality of its construction (Ytterberg ١٩٨٧; Campbell et al. ١٩٧٦)".***

Diagnosing ٦ Types of Concrete Cracks

Plastic Shrinkage Cracks

Probably the single most common reason for early cracks in concrete is plastic shrinkage. When the concrete is still in its plastic state (before hardening), it is full of water. This Water takes up space and makes the slab a certain size. As the slab loses moisture while Curing it gets a bit smaller. Because concrete is a very rigid material, this shrinking Creates stress on the concrete slab. As the concrete shrinks, it drags across its granular Subgrade. This impediment to its free movement creates stress that can literally pull the Slab apart. When the stress becomes too great for the now hardened concrete, the slab

Will crack in order to relieve tension. ***Especially in hot weather, shrinkage cracks can Occur as early as a few hours after the slab has been poured and finished.***
Often, plastic shrinkage cracks are only a hairline in width and are barely visible. However, even though a crack is hairline, it extends through the entire thickness of the Slab. It's not just on the surface as one might think.
One factor that contributes significantly to shrinkage is mixing the concrete too wet. If Excessive water is introduced into the mix; the slab will shrink more than if the correct Amount of mix water were used. This is because the additional water takes up more Space, pushing the solid ingredients in the mix farther apart from each other. It's similar To over-diluting a pitcher of Kool-Aid. By doing so, a weaker solution is created. When The excess water leaves the slab; the solid particles have larger voids between them. These empty spaces make the concrete weaker and more prone to cracking.

Unfortunately, wetter concrete is easier to place and finish, especially in hot weather. This is one reason that many concrete finishers add water to concrete mixer trucks: it Makes their work easier. A few gallons per cubic yard will not significantly affect the mix
. However, if an excessive amount of water is added, one can unwittingly reduce the concrete's strength.Plastic shrinkage cracks can happen anywhere in a slab or Wall, but one place where they almost always happen is atre-entrant corners. Re-entrant corners are corners that point into a slab. For example, if one were to pour concrete around a square column, he would create four reentrant corners. Because the concrete cannot shrink around a corner, the stress will cause the concrete to crack from the Point of that corner (See Figure ١).

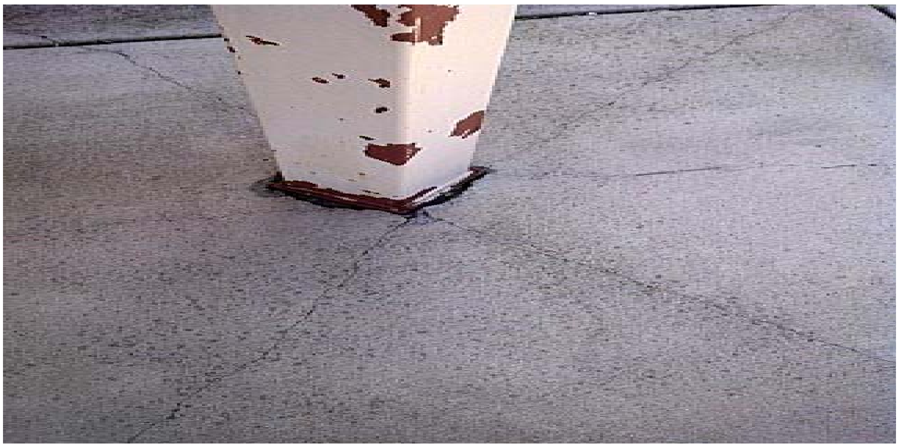


Figure ١ Shrinkage cracks originating at re-entrant corner

A rounded object in the middle of a slab creates the same problem as a re-entrant corner. This is commonly evidenced around slab penetrations such as pipes, plumbing fixtures, drains, and manhole castings. The concrete cannot shrink smaller than the object it is poured around, and this causes enough stress to crack the concrete.
(See Figure ۲).

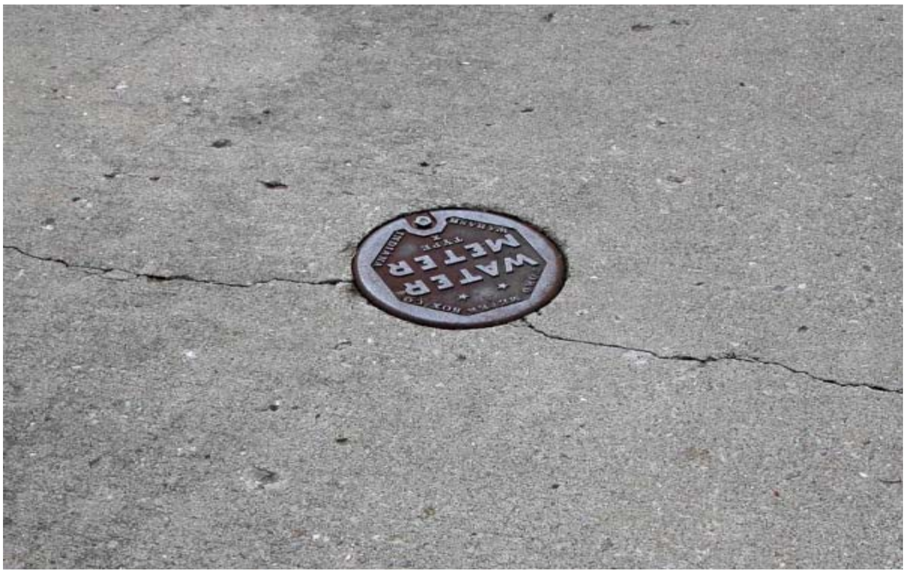
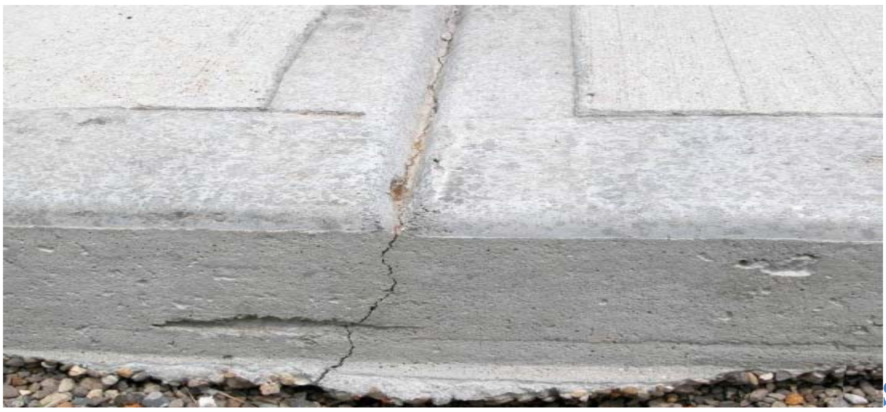


Figure ۲ Shrinkage crack at slab penetration

To combat random shrinkage cracks, control joints (often mistakenly referred to as Expansion joints) are incorporated into the slab.Control joints are actually contraction joints becausethey open up as the concrete contracts or gets smaller.They are simply grooves that are tooled into freshconcrete, or sawed into the slab soon after the concrete reaches its initial set. Control joints create a weak place in the slab so that when the concrete shrinks, it will crack in the joint instead of randomly across the slab. (See Figure ۳).



Shrinkage crack at slab penetration Figure ۲

Figure ۳ A successful crack control joint or a crack control joint to be effective, it should be ¼as deep as the slab is thick. That is, on a typical four inch thick slab, the joints should be no less than one inch deep; a six inch thick slab would require ١.٥ inch deep joints, etc. To minimize the chances of early Random cracking, these joints should be placed as soon as possible after the concrete is poured. If the control joint is not deep enough, the concrete can crack near instead of in it Crack (See Figure ٤)

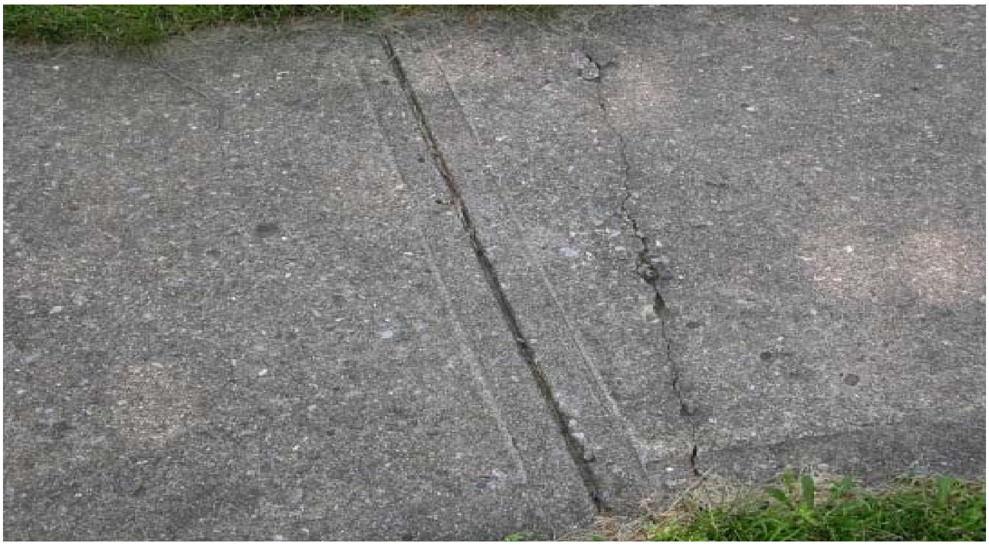


Figure ٤ A crack next to a too-shallow joint

Crack control joints should be placed at all re-entrant corners and slab penetrations, and evenly spaced throughout the rest of the slab. A good rule of thumb for four inch thick residential concrete is to place joints so that they separate the slab into roughly equal square sections, with no joint being further than about ١٠ feet from the nearest parallel joint. Followintervals. A ١٦' x ٦٤' driveway would have one jointwing these guidelines , a four foot wide sidewalk would be cross- jointed at four footrunning up the center lengthways, and joints cut across itevery ٨ feet. This pattern would create sixteen ٨' x ٨' Sections. If a driveway is ١٢ feet wide or less, the center joint up its length can usually be safely omitted, and the cross joints spaced the same distance as the driveway is wide (for example, an eleven foot wide driveway would have no center joint and cross joints every eleven feet). If joints are not placed where they need to be,the concrete will createits ownjoints by cracking.It's interesting to note that it often cracks in the same pattern as it should have been jointed (See Figure ٥).

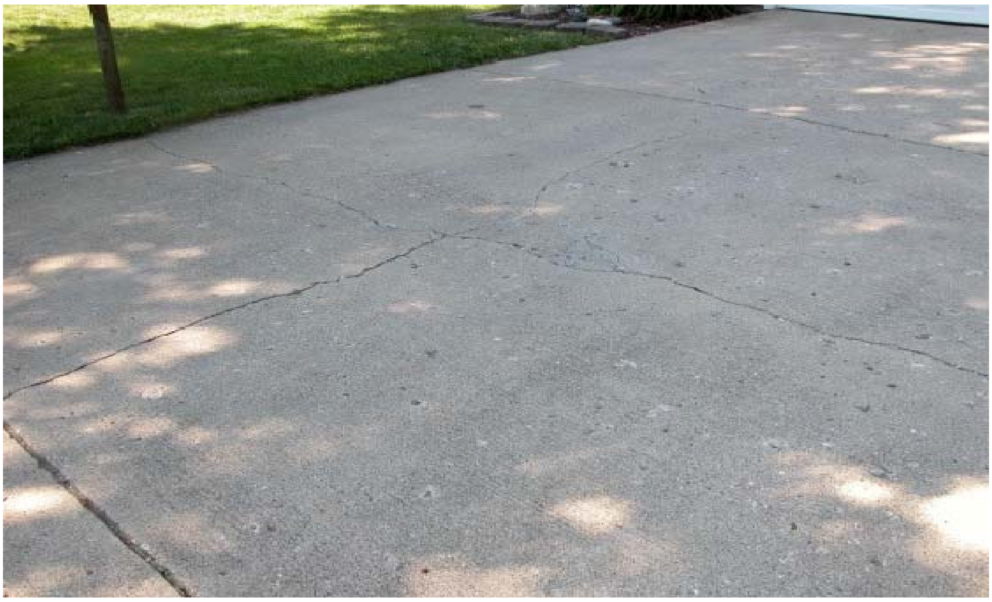


Figure ٥ Driveway cracks where jointsshould have been placed

Another reason that concrete cracks is expansion. In very hot weather a concrete slab, like anything else, will expand as it gets hotter. This can cause great stress on a slab. As the concrete expands, it pushes against any object in its path, such as a brick wall or an adjacent slab of concrete. If neither has the ability to flex, the resulting force will cause something to crack.An **expansion joint** is a point of separation, or isolation joint, between two static surfaces. Its entire depth is filled with some type of compressible materialsuch as tar-impregnated cellulose fiber,closed-cell poly foam, or even lumber See Figure ٦). Whatever the (compressible material, it acts as a shockabsorber which can "give" as it is compressed. This relieves stress on the concrete and can prevent cracking.

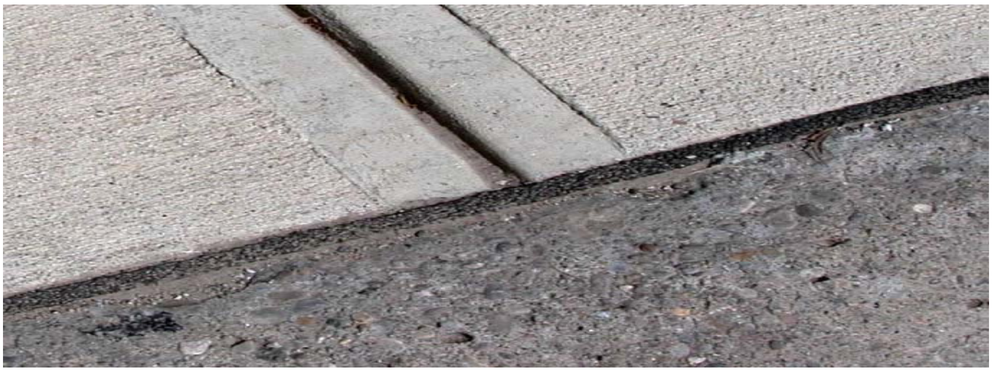


Figure ٦ Foam expansion joint separating driveway and

Expansion joint material can also prevent the slab from grinding against the abutting rigid objectduring periods of vertical movement. Duringthese times of heaving or settling, expansion jointmaterial prevents the top surface of the slab frombinding up against the adjacent surface andflaking off (See Figure ٧).

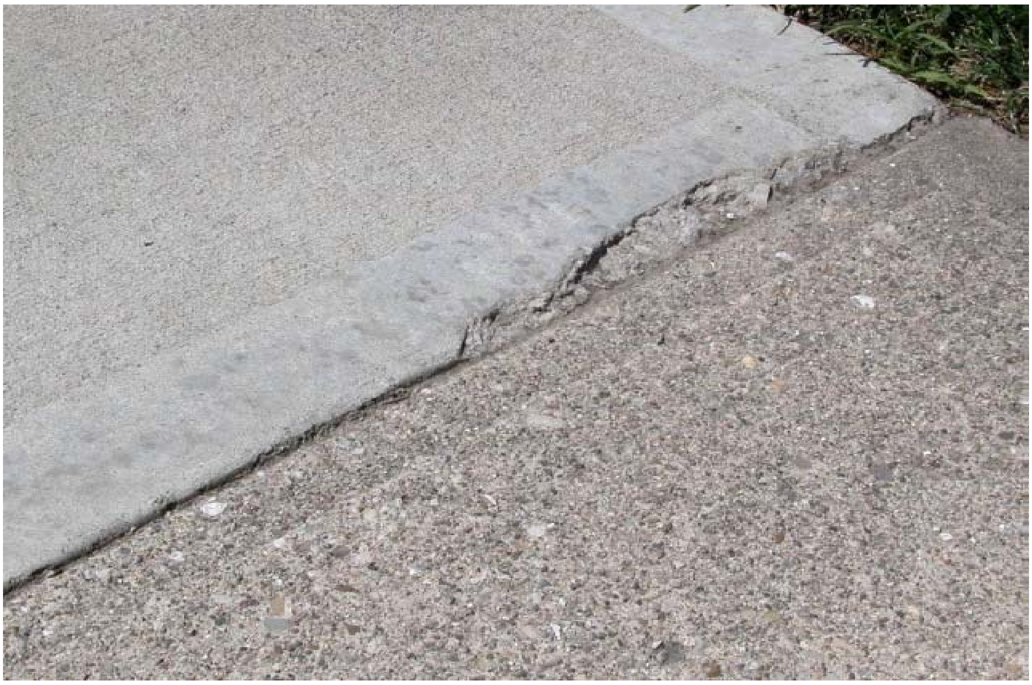
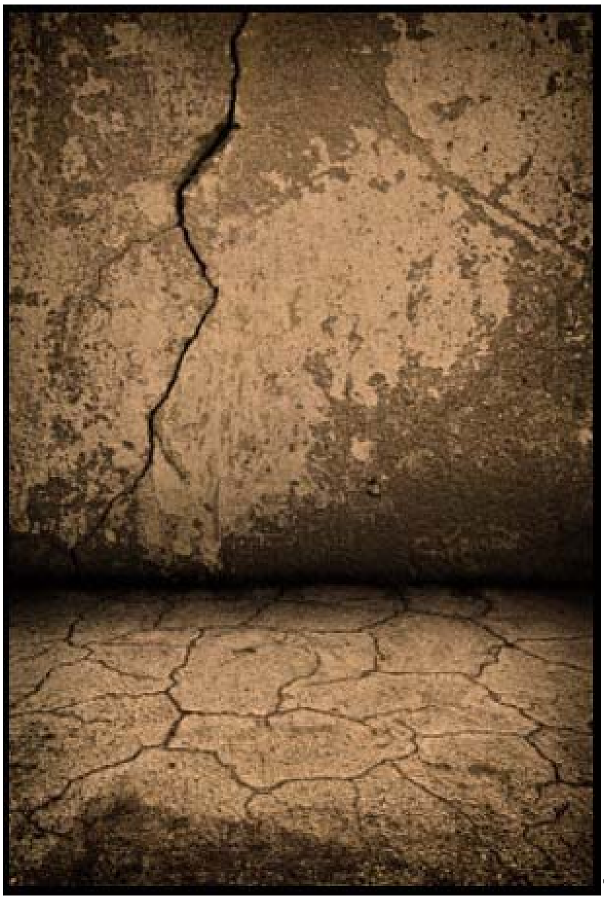


Figure ٧ Expansion joint between these slabs would have prevented chipping

How to prevent and fix concrete cracks

Concrete is one of the most durable and hardworking materials you can use. But producing long lasting, crack resistant concrete structures do not happen by accident. Here are the reasons why concrete cracks occur, what you can do to prevent the problem and if it is too late, fix the mistake before the situation increases in severity.

Why does concrete crack?


The problem: Excessive drying

A concrete slab that dries too fast has a significantly larger possibility of cracking. The chemical process that takes concrete from a liquid to a solid state requires water and this process continues for weeks after the concrete has initially set. A large number of concrete cracks are the result of rapid dehydration.

The solution: Curing

There are a number of ways concrete can be cured and they all serve two main purposes- to retain the moisture necessary for the concrete to reach its full strength and to delay drying shrinkage until the concrete is strong enough to resist cracking.

Technique #١: Water cure

Concrete can be mist sprayed, flooded or ponded. Water curing is the most effective method for preventing any water mix evaporation. Ideally a concrete slab should be water cured for ٧ days. Obviously, sometimes this is impractical and many construction professionals choose to water cure for ٣ days achieving ٨٠% of the benefit of a full ٧-day water cure.

Technique #٢: Plastic film seal

The waterproof plastic film seal should be applied to the concrete as soon as it is hard enough to resist any surface damage. This technique can cause discoloration so it is not advisable when appearance is a priority.

Technique #٣: Chemical membranes

The application of chemical curing should be made as soon as the concrete is finished. Be aware that chemical curing compounds may alter the adherence of resilient flooring.

The problem: Excessive water

As we know, water isadded to a concrete mix to make the concrete easier to work with. But the majority of concrete mix used in construction actually has too much water added to it. Not only does this excess water reduce the strength of the concrete it also is responsible for shrinkage, the main cause of cracking.

As concrete hardens and dries, it shrinks. This shrinkage is due to the evaporation of excess water used in the mixing process. Therefore, the wetter the mix, the greater the shrinkage will be. It is possible for concreteslabs to shrink as much as ١ inch per ٢٠٠ feet. Cracks are the inevitable result of this shrinkage.

The solution: Understand your water to cement ratios

Do not be tempted by a wet mix that is easier to produce. The appropriate mix will take longer to generate, but the long-term benefits will far outweigh the extra manpower required to pour a stiff mix.

Never exceed the .٥٠ water to ١ cement ratio. Water permeability increases when the ratio exceeds .٥٠. The correct water ratio will greatly improve the overall strength and durability of your concrete.

To arrive at the correct water to concrete ratio, divide the water in one cubic yard of your mix by the cement in the mix. So if one cubic yard contained ٢٥٠ pounds of water and ٥٠٠ pounds of cement- your mix ratio would be an acceptable .٥٠.

The problem: Lack of control joints

Control joints help you control where the concrete cracks. These are important because the planned cracks allow for the inevitable movements that will happen during temperature fluctuations and drying shrinkage.

The solution: Actively place control joints around your job

Space control joints appropriately. Control joints should be spaced (in feet) no more than ٢-٣ times the thickness of the concrete slab (in inches). For example, a slab ٥” thick should have joints spaced between ١٠-١٥ feet apart.

It is also important that the joints are cut deeply enough. They should be cut ٢٥% the depth of the slab. A slab ٥” thick should have joints ١.٢٥” deep.

In hot weather, joints should be cut within ٦-١٢ hours after finishing concrete. Ideally, a grooving tool will be used to cut the joints in fresh concrete. If this is not possible, then there are early-entry dry-cut saws that may be used immediately after finishing. These saws will cut up to ٣” deep depending on the model.

Control joints are an important part of concrete construction, yet a surprising number of plans do not have control joint spacing marked on them. If you leave this process to an external party, often cuts will be made in the most convenient place rather than the places that will benefit the strength and durability of your job.

The problem: Poorly compacted ground

The area below your concrete slab is critical to the success of your job. A slab on ground (or grade) is not intended to be self-supporting. The key to successful soil support is not strength but uniformity. If the subgrade is not compacted and the ground becomes saturated after consistently heavy rain, the plumbing and utility trenches could potentially collapse.

The solution: Compact the subgrade

There are two ways the subgrade (soil) can be compacted—by either vibratory or static force. Static force will be achieved by the weight of a heavy machine. Vibratory force on the other hand, uses vibration to reduce the friction between the soil particles, squeezing them together.

The type of soil and the type of job will determine whether static or vibratory force is necessary.

Cohesive soil will need to be sheared to achieve compaction and as a result, a machine with a high impact force will be necessary. For this job, a rammer is the preferred choice or a pad-foot roller for larger jobs.

Granular soil only requires the particles to be vibrated to move them closer together. For this job, vibrating plates or rollers are the preferred tools.

Reversible vibratory plateswork well on granular soil and granular-cohesive mixes. These machines are good value for money because of their versatility in the field. The vibration can be reversed to move the machine back or forth or stopped to compress a troubled soft spot.

Jumping jacksare perfect for compacting soil in a footing trench or on smaller areas because they provide high amplitude, low frequency force. These machines are not recommended for compacting granular soil.

The standard **vibratory plate** is ideal for compacting subbases and granular soils. The vibration of the plate is lower in amplitude and higher in frequency than a jumping jack. But they do not offer as much versatility as the reversible vibratory plate because the machine is balanced to only move forward.

What do I need to do to prevent cracks in my concrete?

When it comes to concrete, random cracking is unsightly. But, due to the fact that concrete shrinks, it is going to crack. Our best defense for concrete cracking is to try to control where the cracks occur.

Cracks will appear at any time and place where the stress within the concrete to pull apart exceeds the strength of the concrete to hold itself together. Concrete will shrink at a rate of approximately ١/٨ inch per ٢٠ feet, and while it shrinks it will crack randomly. We can control this random cracking by pre-determined location of joints in the concrete.

Some forms of joints are:

١. **ISOLATION JOINTS** (also called expansion joints) – These are placed wherever complete separation between the floor and adjoining concrete is needed to allow them to move independently without damage. These isolation joints are often made with an asphalt-based cork-like material.

٢. **CONSTRUCTION JOINTS**– These are placed in a slab where concrete operations are concluded for the day. However, if the concrete operation is interrupted long enough that a cold joint mayappear, you should install a construction joint regardless of planned joint layout.

٣. **CONTROL JOINTS** (also called contraction joints) – These are intended to create straight lines of weakness in the concrete that the cracks will occur along. They should be created to a depth of one forth the slab's thickness with a maximum joint spacing of ٢٤ to ٣٦ times the thickness of the slab.

   Control Joints can be formed with a jointer, also called a groover. They have a cutting edge or bit that makes narrow grooves in the slab. For a ٤-inch slab the depth of the cutting edge should be one inch, for a ٦-inch slab the edge depth should be ١.٥ in, and for an ٨-inch slab the edge depth should be ٢ inches. The radius at the top of the groove should be ١/٨ in. for floors and ١/٤ to ١/٢ in. for sidewalks, driveways or patios. Shallow groover tools should only be used for decorative applications.

٤. **SAW JOINTS** – These are control joints that are sawed in, straight as possible, clean lines about ١/٤ the thickness of the slab. Sawing should be done as soon as the concrete is strong enough to resist tearing or other damage by the saw blade. A slight raveling of the sawed edge is acceptable. It is important not to delay sawing too long because the concrete may crack before it is sawed, or it will crack ahead of the saw blade. Saw joints are usually preferred over joints with a groove tool on floors that will carry forklift traffic or other industrial vehicles.

Cracks in concrete cannot be entirely prevented, but they can be minimized and controlled with properly designed joints.