Types of Joints in Concrete Constructions

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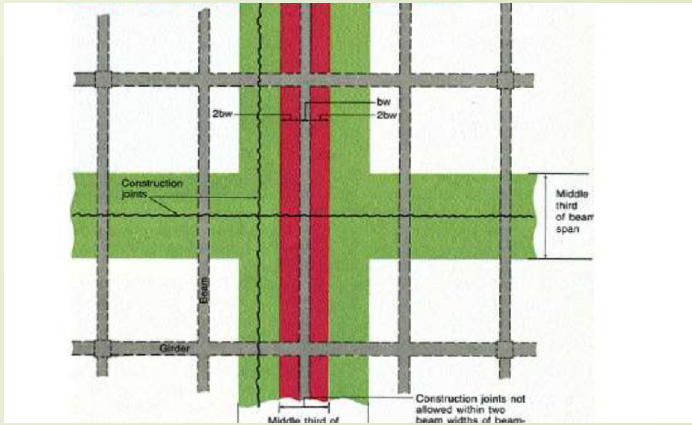
November-2021

- Concrete is subject to change in length, plane, and volume due to changes in its temperature, moisture content, reaction with atmospheric carbon dioxide and maintenance of loads.
- The effects may be permanent contractions to initial drying shrinkage, carbonation, and irreversible creep.
- Other effects are transient and depend on environmental fluctuations in humidity and temperature and may result in either expansions or contractions.



Movements in Structure

- The movements in hardened concrete that can cause cracking can originate from:

1. The Movements that are independent of the type of structure; these properties include shrinkage.
2. Movements depending on the type of structure and consisting of effects of all imposed loads such as self weight and lateral loads of wind and earthquakes. Such movements may be deflections, elastic strains, and strains due to creep caused by permanent loads.
3. Movements depending on the location of the structure caused by changes in temperature and humidity.
4. Movements due to the deferential soil settlement.

Different types of concrete joints are provided in construction depending on the nature of the construction and as required by the design.

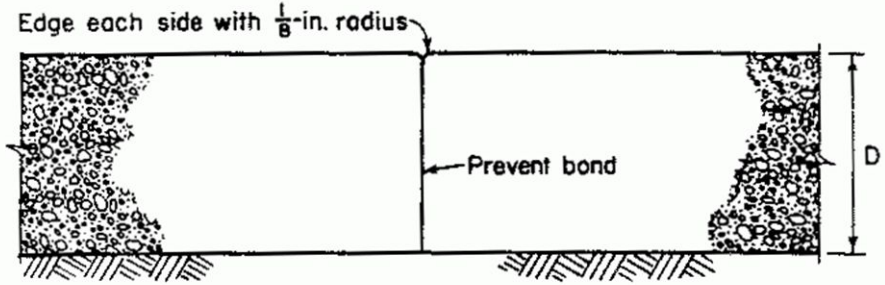
In general, there will concrete joints in most of the structures constructed as we cannot construct a structure by one casting step.

Depending on the nature of the structure and base on the construction requirements, the following types of concrete joints are provided in structures.

-Movement Joints
- Contraction Joints
- Expansion Joints
- Sliding Joints
- Construction Joints
- Temporary Joints
- Isolation Joints

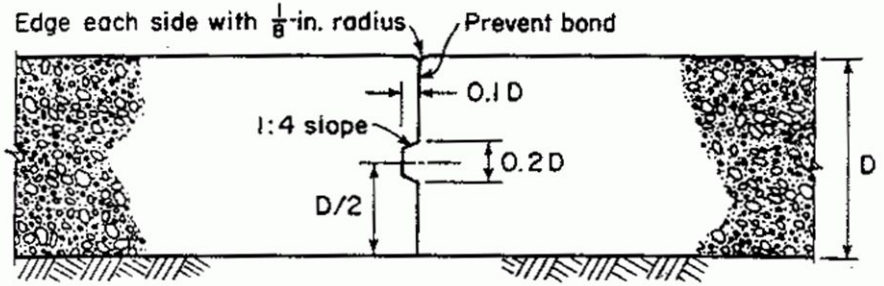
According to The ACI Committee 224 Joints will be designated by a terminology based on the following characteristics: resistance, configuration, formation, location, type of structure, and function.

- Resistance: Tied or reinforced, doweled, non doweled, plain.
- Configuration: Butt, lap, tongue, and groove.
- Formation: Sawed, hand-formed, tooled, grooved, insert formed.
- Location: Transverse, longitudinal, vertical, horizontal.
- Type of Structure: Bridge, pavement, slab-on-grade building.
- Function: Construction, contraction, expansion, seismic, hinge.



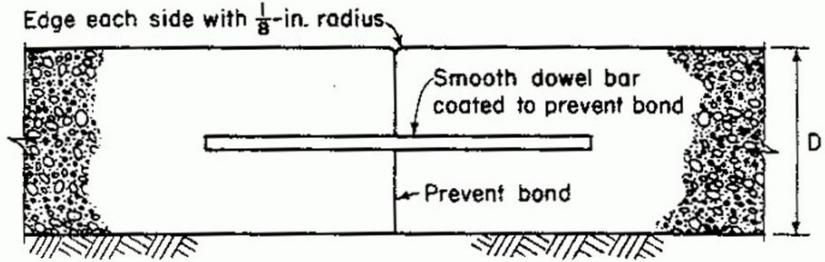
Butt-type construction joint

(a)



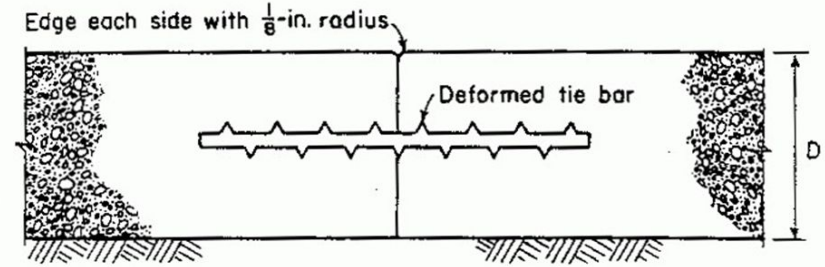
Tongue-and-groove construction joint

(b)



Butt-type construction joint with dowels

(c)



Butt-type construction joint with tie bars
(not a contraction joint)

Movement Joints

- Movement Joints in structures can be seen very commonly as they make the structure stable, constructible and reduce the cost of construction.

- Movement joints are provided in structures considering the behavior of the structure and the amount of movement that it could move.

- If the structures tend to move in any direction due to settlement, wind effect or any other reason, it is advisable to let the structure behave the way it intends to.

- Avoiding the movement will lead to the high cost of construction and structures could be crack or damage due to many reasons.

For example, in the event of an earthquake, building deflects laterally and if sufficient gap has not been provided when two buildings are adjoining, there could be damages to the structural elements.

That kind of event could lead to the failure of structures.

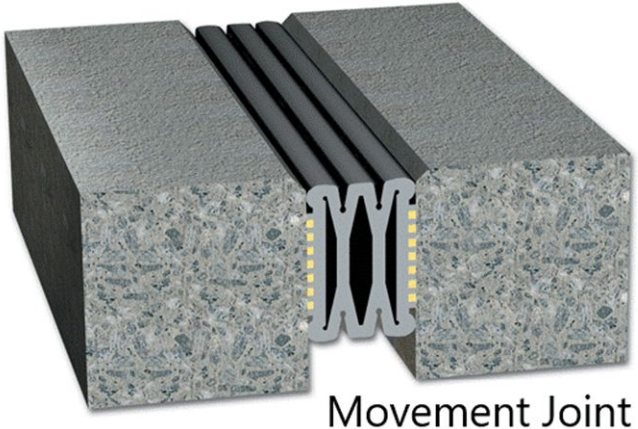
- when the gaps between the two buildings are considered, it should be more than the maximum design deflection. Maximum deflection may vary depending on the type of design.

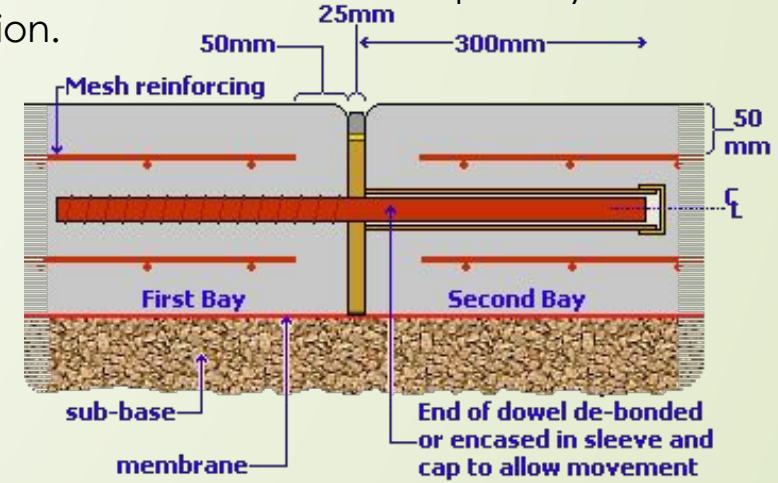
When the design for wind, deflection is calculated according to that particular code and if the structure is design for seismic events, values permit by the code shall be used.

-In addition, movement joints are provided for movements that occur due to expansion and contraction when the temperature is changed

Lateral loads on the structures

The lateral load could be earth pressure, water pressure, wind pressure, earthquake pressure.
When the lateral loads are applied structure could move permanently or temporarily.
The application of earth pressure, water pressure, could move the structure permanently.
However, wind pressure, earthquake load, etc deflect the structure temporarily when loads are
il position.

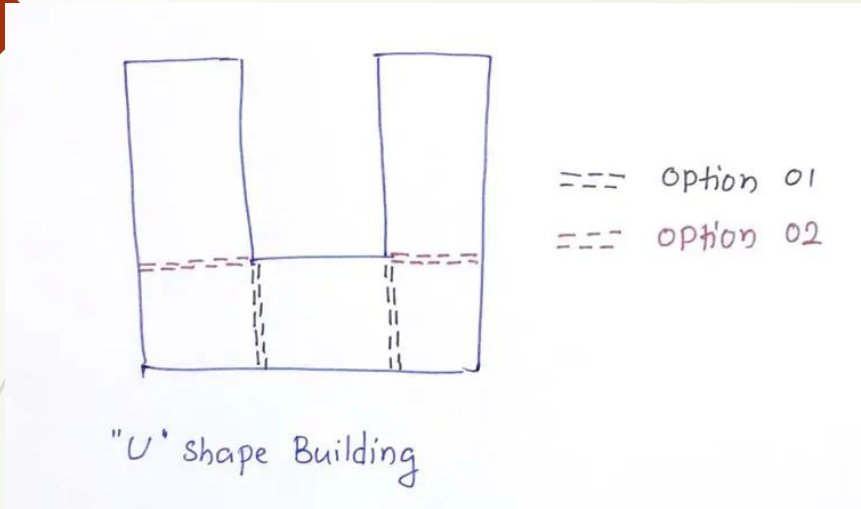




To accommodate the separation of Irregular structure

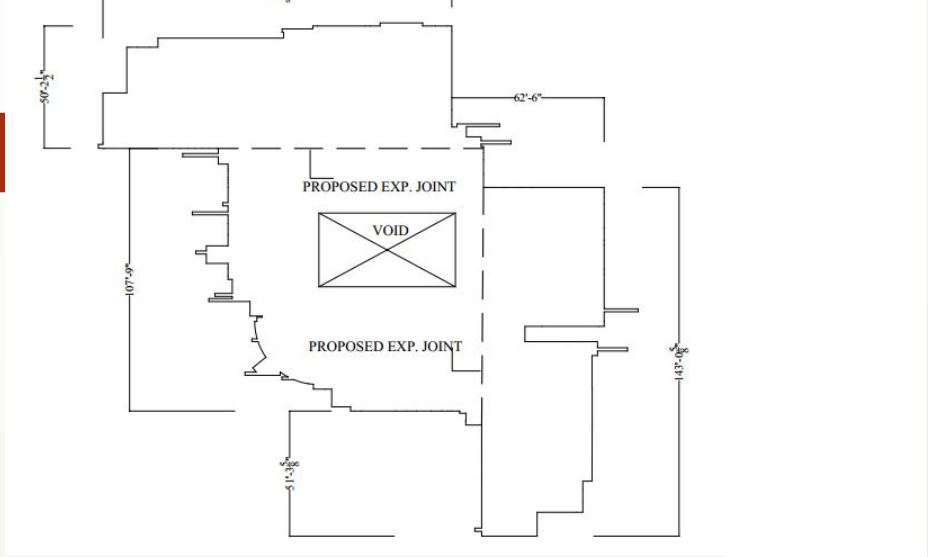
For example, when the building is in "U" shape in plan, it is advisable to have a separation joint in the building especially when it constructed on a shallow foundation.
There will be a different settlement in the structure due to the geometry of the structure. As a result, if the structure is built continuously, additional stresses will apply to the structure.
It can be avoided by operating the structure as indicated in the following figure.

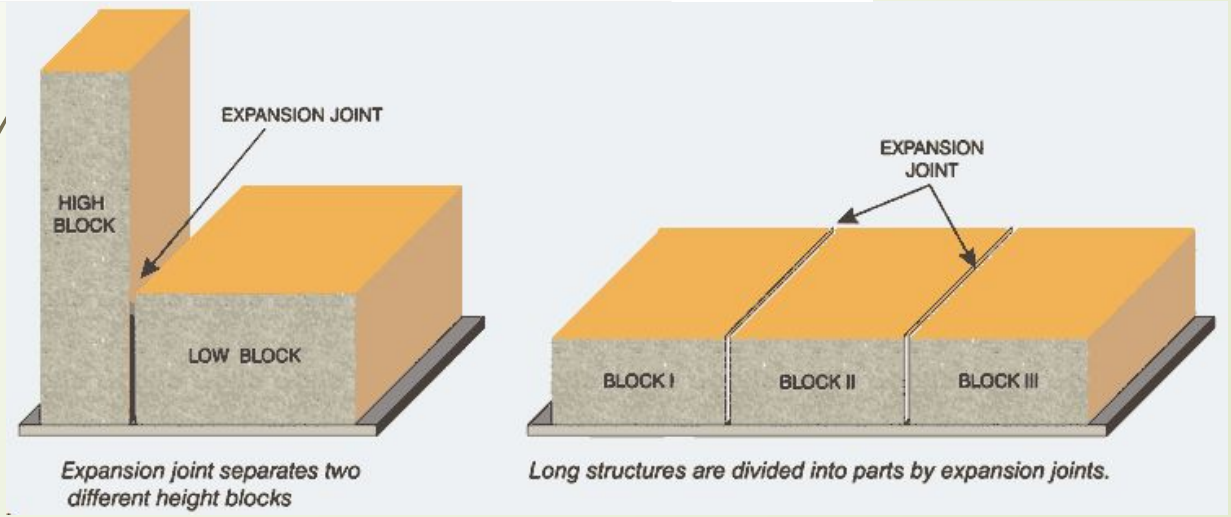
As indicated in the below figure, the movement joint can be constructed based on the preference of the structural engineer.



Movement joints are provided in different structures and the type of joint detail is different from the structure to structure. Further, the gap allowed in the joint will also be a function of the structure type and its use.

Movement Joints in Foundations
Movement Joints in Floor Slabs
Movement Joints in Beams
Movement joints in Bridges





Expansion joint separates two different height blocks

Long structures are divided into parts by expansion joints.

A. 20 ft (6m) apart in walls with frequent openings.
B. Never more than 20 ft (6m) apart, walls with no openings.
C. Within 10 to 15 ft (3 to 5m) of a corner, if possible.
E. In line with each joint at first-story level.
F. Joint lines are projected.

Fig. 3.1—Locations for contraction joints in buildings as recommended by the Portland Cement Association (1962).

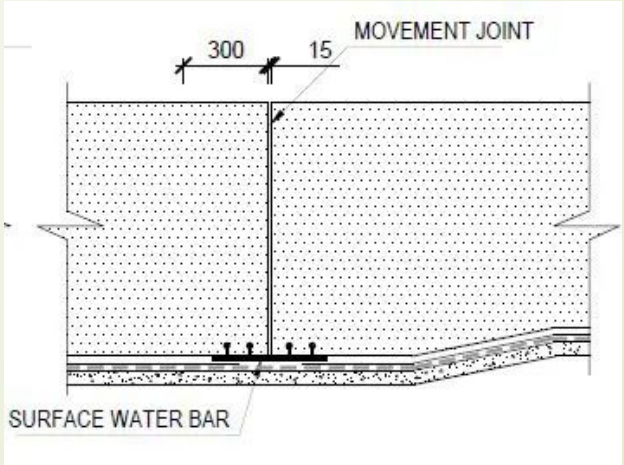
Movement Joint in Foundations

Many structural inputs are required for deciding these types of concrete joints. The location and nature of the movement joint to be provided in the foundation will be based on allowable movements in the structure.

In general, the width of the movement joint could vary between 10mm -25mm. However, on special occasions, this even can increase up to about 100mm.

Foundation movement joint especially when there are basements, needs to be water tightened to avoid movement of water through the joint.

When there is a movement joint in foundations such as a raft foundation, a surface water bar will be provided not allowing the penetration of water through the joint.



Movement Joints in Concrete Slabs

-When there is a movement joint in the foundation as discussed above, the same joint will be continued for the floor slabs as well. Further, the width of the joint could also follow the same.

-However, when the two blocks are separated by a movement joint for seismic even, it should be careful when deciding the width of the joint.

-Width of the movement joint shall be based on the outcome of the structural analysis for such lateral loads applied by an earthquake.

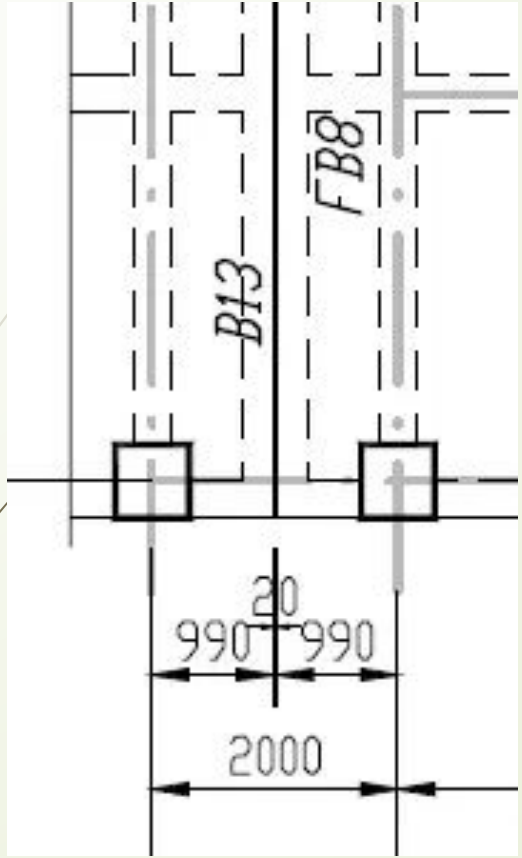
-The maximum deflection of the building shall be checked especially at upper levels where it critical, to finalized the width of movement joints on the floor.

-In general, there will be two columns nearby and either side of the movement joint, Both sides could be cantilever to have a movement joint in the floor.

-In addition, these movement joint sometimes identified as expansion joints. However, the function or the purpose of the joint shall determine the type.

-The construction joint details used for the expansion joints could also be used for the movement joints. It is only required to make sure that the joint can allow sufficient

Cracks developed due to expansion of concrete.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20
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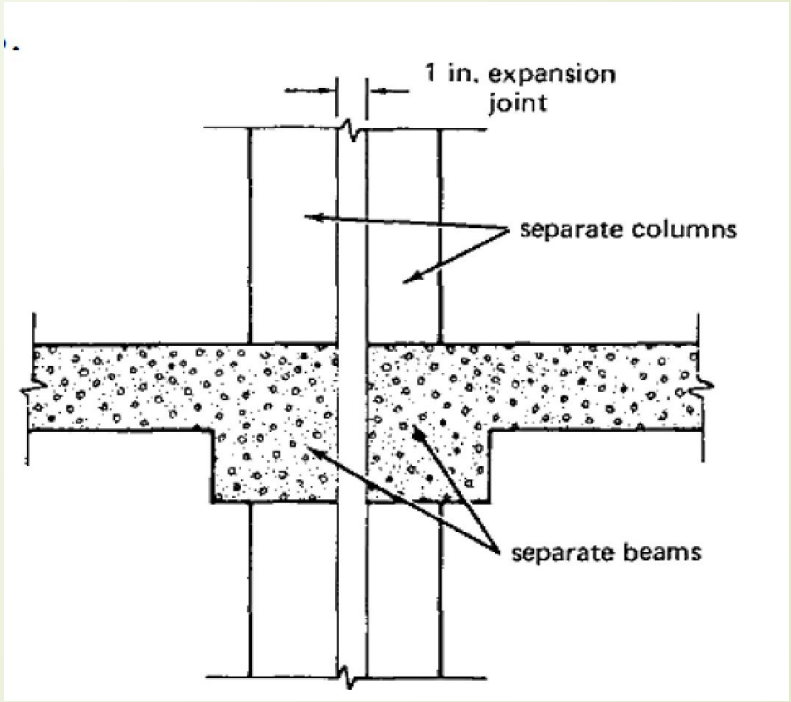
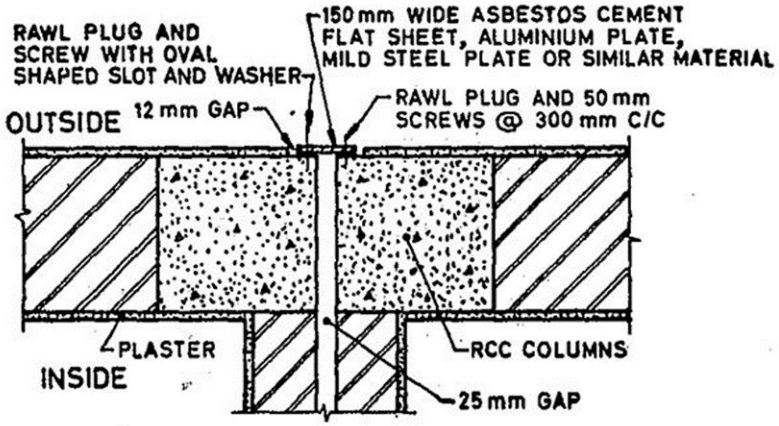
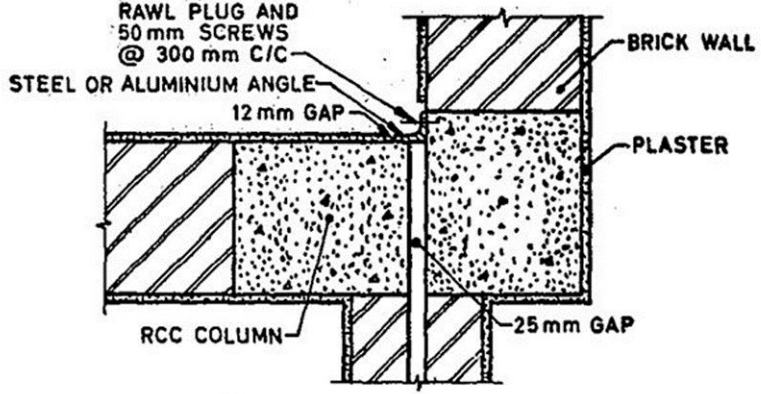

1 in. expansion joint
separate columns
separate beams

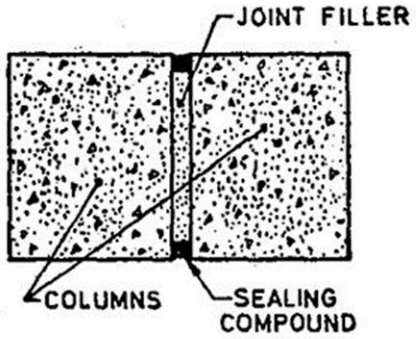
Movement Joints in Concrete Slabs



12A TYPICAL DETAILS OF EXPANSION JOINT
ON OUTER FACE OF COLUMNS



12B TYPICAL DETAILS OF EXPANSION JOINT
AT CORNER COLUMNS



12C TYPICAL DETAILS OF EXPANSION
JOINT AT ISOLATED TWIN COLUMNS

Joint Spacing

- Function of concrete thickness, coarse aggregate size and concrete slump

ACI Code recommends the joint spacing be 2 to 3 times (in feet) the concrete thickness (inches)

Example: a 5 inch slab would have joints spaced 10 to 15 feet

1- Construction joints

If concrete placement is stopped for longer than the initial setting time, the joint should be treated as a construction joint

Construction joints are necessary in most reinforced concrete construction. Due to their critical nature, they should be located by the designer, and indicated on the design drawings to ensure adequate force transfer and aesthetic acceptability at the joint.. Advance input is required from the designer on any additional requirements needed to ensure the structural integrity of the element being placed.

Construction joints are placed in a concrete slab ,concrete pavements and surface concrete constructions to define the extent of the individual placements, generally in conformity with a predetermined joint layout.

Construction joints must be designed in order to allow displacements between both sides of the object but, at the same time, they have to transfer flexural stresses produced in the member by external loads.

Construction joints must allow horizontal displacement right-angled to the joint surface that is normally caused by thermal and shrinkage movement. At the same time they must not allow vertical or rotational displacements. Fig.below summarizes which displacement must be allowed or not allowed by a construction joint.

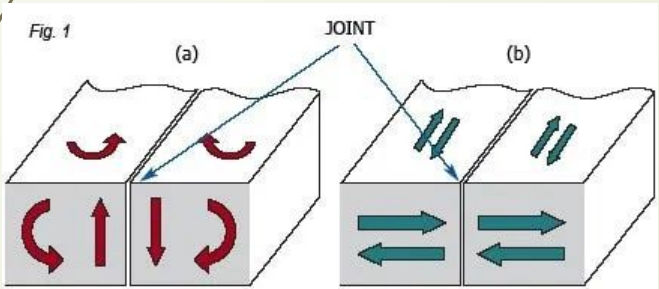


Figure 1 – Relative movements which must be (b) allowed and (a) not allowed by a con-struction joint for concrete slabs

Except for very small structures, it is impractical to place concrete in a continuous operation. Construction joints are needed in order to accommodate the construction sequence for placing the concrete. The amount of concrete that can be placed at one time is governed by batching and mixing capacity, crew size, and the amount of time allotted. Correctly sited and properly executed construction joints provide limits for successive concrete placements, without adversely affecting the structure.

For monolithic concrete, a good construction joint provides a well bonded watertight surface, which allows for flexural and shear continuity through the joint. Without this continuity, a weakened region results, which may serve as a contraction or expansion joint.

To achieve a well-bonded watertight joint, a few conditions must be met prior to placement of the fresh concrete. The hardened concrete must be clean and free of all laitance (ACI Committee 311 2019).

If only a few hours elapse between successive placements, a visual check is needed to be sure that

all loose particles, dirt, and laitance are removed. The new concrete will be adequately bonded to the hardened green concrete, provided that the new concrete is vibrated thoroughly over the area. Older joints need a little more surface preparation. Cleaning by means of an air-water jet or wire brooming can be done when the concrete is still soft enough that any laitance can be removed, but hard enough to prevent aggregate from loosening. Concrete that has set should be prepared using a wet sand blast or ultra-high pressure water jet (ACI Committee 311 -2019)

ACI 318 states that existing concrete should be moistened thoroughly prior to placement of fresh concrete. Green concrete will not require any additional water, but concrete that has dried out may require saturation for a day or more. No pools of water should be left standing on the wetted surface at the time of placement.

Joint Location

The final consideration is placing the construction joint in the right place. Assuming an adequate production capacity, construction joints should be located where they will least affect the structural integrity of the element under consideration, while at the same time being compatible with the building's appearance. Placement of joints varies, depending on the type of element under construction. For this reason, beams and slabs will be addressed separately from columns and walls

Beams and Slabs—

From the point of view of strength in beam and slab floor systems, desirable locations for joints placed perpendicular to the main reinforcement are at points of minimum shear or at points of contraflexure. Typically, joints are located at mid-span or in the middle third of the span, but locations should be verified by the engineer. In beam and girder construction, where a beam intersects a girder at the point of minimum shear, ACI 318 states
that the construction joint in the girder should be offset a distance equal to twice the width of the

Horizontal construction joints in beams and girders are usually not recommended. Common practice is to place beams and girders monolithically with the slab.

Flexural continuity is achieved by continuing the reinforcement through the joint with sufficient length past the joint to ensure an adequate splice length for the reinforcement. Shear transfer is provided by shear friction between the old and new concrete, or dowel action in the reinforcement through the joint

Columns and Walls—

It is general practice to limit concrete placements to a height of one story. Construction joints in columns and bearing walls should be located at the undersides of floor slabs and beams, and at the top of floor slabs for columns continuing to the next floor. Column capitals, haunches, drop panels, and brackets, should be placed monolithically with the slab.

The placement of fresh concrete on a horizontal surface can affect the joint. Common practice has been to provide a bedding layer of mortar, of the same proportions as that in the concrete, prior to placement of new concrete above the joint. The ACI Manual of Concrete Inspection (ACI committee 311 2019) recommends using a bedding layer of concrete with somewhat more cement, sand, and water than the design mix for the structure. Aggregate less than 3/4 in. can be left in the bedding layer, but all aggregate larger than 3/4 in. should be removed. This mix should be placed 4 to 6 in. deepn and thoroughly vibrated with the regular mix placed above

Contraction Joints

- Contraction joints in concrete are provided at regular interval to from a weak plane, so that cracks are formed at the joints but not in undesired places.
- Contraction joints are provided in concrete pavements, slabs, walls, floors, dams, canal linings, bridge, retaining walls etc.
- When concrete is placed, due to shrinkage, creep and thermal movement concrete tends to reduce in size due to which small cracks are formed in the concrete at weak zone.

Need of Contraction joint in Concrete

- Concrete tends to shrink or reduce in size when it starts hardening. This shrinkage of concrete creates tensile stresses in the concrete which develops the minute cracks at the weak plane.
- These cracks are restricted and prevent the formation of large cracks due to the presence of reinforcement in the concrete. But if its unreinforced concrete, the small cracks tends to develop into a large cracks at irregular interval
- To prevent such cracks, contraction joints must be installed at appropriate intervals. It is also recommended to install these joints in reinforced

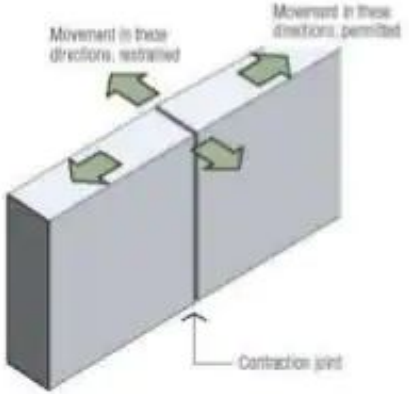


Fig 2 : Forming of vertical contraction joint

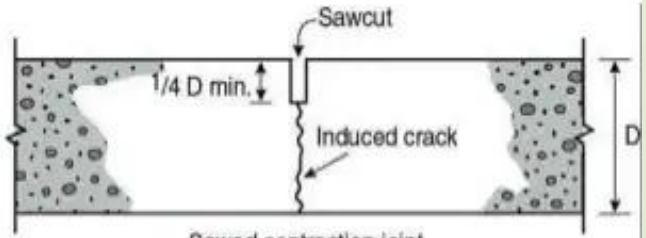


Fig 3: Sawed contraction joint.

Thank you