HIGHWAYS DEPARTMENT

GUIDANCE NOTES

ON

PANELLING DESIGN & JOINT CONSTRUCTION

OF CONCRETE SLABS

Research & Development Division

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1. Introduction

The correct layout and the correct construction of joints are important determinants of the long term performance of concrete pavements. This Guidance Note aims to produce information on which consistent design and construction practice can be based.

2. Panelling Design

2.1 Overall design considerations

a) Avoid stress concentration

The design of the joint layout for concrete pavements aims to avoid physically weak configurations or those which are likely to cause detrimental stress concentrations. Rectangular slabs are the ideal layout and joints should be positioned as far as possible to produce rectangular slabs. Non-rectangular slabs such as L, T, U or H shaped slabs shall be avoided.

b) Panels tied together by longitudinal joints move as a unit

One important point to bear in mind is that adjacent panels separated by a longitudinal joint do not move relative to each other. It follows that panels tied together by longitudinal joints move as a unit, not individually. As shown in Figure GN 020/01, the same direction of longitudinal movement should be allowed for adjacent panels separated by a longitudinal joint. This will be further discussed in paragraph 2.3.

c) On road sections with curved alignment

It is acceptable to curve the individual bays to follow the general alignment of the road. Theoretically two adjacent panels move relative to each other along the line joining the centroids of the two slabs. In practice it is acceptable to construct the transverse joints right angle to the centre line of the curve and to install the dowel bars right angle to the transverse joint (see Fig. GN 020/02)

d) Avoidance of acute-angled corners

In general corners with an internal angle of less than 80 should be avoided. Where a joint meets the kerb line, it may be necessary to modify the joint detail as shown in Figure GN 020/03 to avoid an acute-angled corner. However, the angle created should be as close to 180 as possible and in no case should the internal angle be less than 135. The realigned section shall be 450 mm long. Dowel bars shall be omitted from the realigned section to avoid constraining the movement at the joint.

2.2 Longitudinal Joints (LJ) (see H1107)

a) Design considerations

LJs are provided to reduce the slab width and limit stresses in the transverse direction. An increase in the slab width will yield an increase in the effective slab area for load transfer. Frequent LJs increase the number of construction operations so there must be a balance between the number of construction operations and the level of load to be transferred.

b) Dimensions to follow

Maximum width of slab	- unreinforced	- 4.5 metres
	- with mesh	- 4.5 metres (desirable)
		- 6.0 metres (with B503 mesh)
Minimum width of slab	- 1 metre	
Length/width ratio (unreinforced only)	- 1.6 desirable maximum - 2.0 absolute maximum	

c) Position and construction

LJs should not be formed in or near wheel tracks to avoid unfavourable loading condition. Ideally LJs should be provided between traffic lanes at or near lane lines, or alternatively in the centre of a lane. If necessary, a LJ can stop at any transverse joint and not carry through the other side of the transverse joint.

LJs should normally be formed. Poured-through LJs is not allowed unless the contractor uses a purpose-made regulating machine spanning the full width of the slabs concerned (details discussed in paragraph 3.4)

2.3 Transverse joints (TJ) in general

a) Transverse joints to continue across carriageway but not staggered

A TJ can be an expansion joint, a contraction joint or an isolation joint. TJs must continue across the full width of the carriageway, they should never stop at a LJ or be staggered. As shown in Figure GN 020/04, a TJ not continuing through an adjoining slab will create tensile stress in the adjoining slab and cause cracking in line with the transverse joint. The exception to this requirement is box-out joints for manholes or utility covers where it is only required to bring one side of the box-out joint across the width of the carriageway (discussed further in paragraph 2.6).
TJs shall continue through kerbs, edgings and their foundation and backing if

the concrete slabs are cast against the kerbs and edgings (GS 10.35(2)).

b) TJ to be straight across the width of the carriageway

As shown in Figure GN 020/01, an angled TJ with all dowels bars perpendicular to the joint will effectively become a fixed joint as it will not allow movement in any direction. A TJ should be straight across adjoining panels (unless separated by an isolation joint) as adjoining panels tied together by LJs move together as a unit. An exception is when a TJ meets the kerb line of the edge of the carriageway where a change in direction can be allowed to avoid an acute-angled joint. As discussed in paragraph 2.1(d), the realigned section shall be 450 mm long and the internal angle of the section shall not be less than 135. Dowel bars must be omitted in this realigned section to avoid constraining movement at the joint.

2.4 Expansion joints (EJ) (H1105)

a) Spacing

The primary function of an EJ is to allow expansion movements in the longitudinal direction. However, EJs are the most expensive type of joints to construct and maintain. The relatively large joint width makes an EJ more vulnerable to spalling damage. It is relevant to note that the longer the slab the wider the joint. The number of EJs should be reduced as far as possible. Spacing of EJ depends on several factors including the temperature at which the concrete is placed, the frictional restraint of the subgrade/subbase and the slab thickness. The recommended maximum spacing is as follows-

- 40 metres for mesh reinforced slabs;
- 60 metres for unreinforced slabs.

b) An EJ is not a solution for conflicting movements

An EJ allows movement only in one direction and shall not be used as a solution where there are conflicting movements across a joint such as at road junctions. In such situation isolation joints shall be used. Please refer to paragraph 2.6.

2.5 Contraction joints (CJ) (H1106)

a) Spacing

The primary function of a CJ is to allow contraction movement in the longitudinal direction. Similar to EJs, the number of CJs should be reduced as far as possible to minimise maintenance commitment. However, sawn-through CJs are of narrow width and therefore less susceptible to damage, in addition they do not require to be sealed thus reducing maintenance requirements. The recommended maximum spacing is as follows-

- 20 metres for mesh reinforced slabs;
- 5 metres for unreinforced slabs.

b) Position

Besides separating a road pavement into slabs of convenient lengths, CJs should be located where severe concentrations of tensile stresses are expected to occur. An example is where an abrupt change in cross section occurs such as in an L-shaped pavement and a CJ should be provided to separate it into two rectangular slabs. Another example is the boxing out of an opening as discussed in paragraph 2.6 below.

2.6 Isolation Joint (IJ) (H1107)

a) Functions

Isolation joints are joints across which no dowel bars or tie bars are installed for load transfer. They are used to prevent induced cracking which may result from misaligned joints by permitting slabs to move against each other transversely and longitudinally. An example is at a major road junction where it is not possible to continue a TJ on a road through the slabs of the side road. Isolation joints are also used around manholes or utility openings for separation purpose.

b) Isolation joints at road junctions

It is a common problem for unreinforced slab construction. Because of the small length, there may be several CJs at a junction. It is often not possible to continue these CJs through the slabs of the side road. It is not satisfactory to join these CJs onto LJs of the side road because there cannot be any movement across the LJs. The solution as shown in Figure GN 020/05 is to terminate the CJs at an isolation joint separating the road slabs of the two roads. Where a main road is of mesh reinforced construction and it is not necessary to provide a TJ at the junction, the slabs of the side road can terminate at an EJ or a CJ.

c) Isolation joints around manholes or utility openings

Because of different supporting arrangement for manholes and utility openings, it is necessary to provide isolation joints around such openings for separation purpose. The typical layout of such box-out arrangement is shown in standard drawings No. H 1111 and H 1112. The box-out should be orthogonal to the road slab (rectangular and with sides parallel to the sides of the road slab). To avoid creating lines of weakness, two TJs (an EJ or a CJ) should be provided to extend the isolation joints in the transverse direction through the whole width of the slab as shown in Figure GN 020/04. Preferably both but at least one of these two

TJs should also be extended through all adjoining slabs across the whole width of the carriageway. Therefore the presence of manholes and utility openings will inevitably result in short panel lengths making unreinforced construction more favourable.

2.7 Construction Joint (H1108)

Construction joints should be avoided wherever possible. Although a construction joint aims at bonding the new concrete to the hardened concrete in such a manner that the concrete appears to be monolithic and homogeneous across the joint, in practice it is very difficult to obtain full adhesion, with the result that there is usually a plane of weakness at construction joints.

No construction joints shall be formed within 2.5 metres of an existing or planned TJ (GS 10.42). Since the maximum length of an unreinforced concrete slab is 5 metres, it follows that construction joints are not allowed in unreinforced road slabs.

3. Joint Construction

3.1 General considerations

Clearly joints should be constructed in such a way that movement of the slabs will take place in accordance with the design. It is necessary to pay particular attention to joint construction as slight deviations may create constraints in movement causing the slab to crack or spall under stress concentration. Malpractices aimed at facilitating slab construction may inadvertently create constraints in movement leading to cracking and additional maintenance requirements.

3.2 Tie bars

Tie bars should be straight and located at mid depth of a slab. It is important to check that anti-corrosive sleeves are provided in the correct position (H1107) as they serve as a physical separation to prevent future corrosion of the tie bars. Tie bars should be securely fixed in position through openings at the side forms before concreting. The temporary bending up of tie bars for LJs due to space limitation can be allowed provided they are bent back to a horizontal alignment before concreting of the adjoining slab (note that bending up of dowel bars is not permitted as discussed in para. 3.3(a) below).

3.3 Dowel bars

a) Correct alignment and position

Dowel bars are more important than tie bars as they are the moving parts linking adjoining slabs. Dowel bars shall be uniform in cross section and free from burrs on the ends. They shall be straight and free from bending. Any bent dowel bars shall be rejected and shall not be allowed to be re-formed or to be bent back into an apparently straight alignment for use in joint construction. The ends of dowel bars protruding out from end forms shall never be allowed to be bent despite space limitation.

Dowel bars shall be securely fixed in position and alignment before concreting. They shall be horizontal, perpendicular to the end forms and parallel to other dowel bars of the same set. For pour-through construction, dowel bars shall be securely fixed onto rigid cradle cages and the cradle cages shall be securely fastened onto the subbase.

b) Omission of dowel bars at end kinks of TJs

It may be necessary to realign a TJ at the end to avoid forming an acute-angled corner. Dowel bars shall not be provided in the realigned section as discussed in paragraph 2.1(d) to avoid creating a constraint in movement of the slab.

3.4 Formed joints

A formed joint is constructed by first concreting the slab on one side of the joint against temporary formwork. With this type of construction, it is easier to ensure that the joint is straight and that the dowel bars or tie bars are correctly aligned. EJs and isolation joints shall be constructed in this way. LJs also should normally be formed in this manner.

3.5 Pour-through and sawn joints

a) Points to note in concreting

Pour-through CJs are acceptable in particular for unreinforced construction. However, most of the elements are hidden after concreting and therefore checking before concreting is important. Particular attention should be paid to the following -

- dowel bars are straight, horizontal, parallel to each other and securely fixed in position and alignment onto rigid cradle cages which in turn should be securely fastened to the subbase layer;
- the alignment of a joint to be saw cut subsequently should be marked clearly such that the marks can still be seen after concreting;
- the midpoints of the dowel bars align with the joints to be formed;
- concrete near the cradle cages shall be carefully compacted to avoid dislocating the dowel bars.

b) Saw cutting of joints

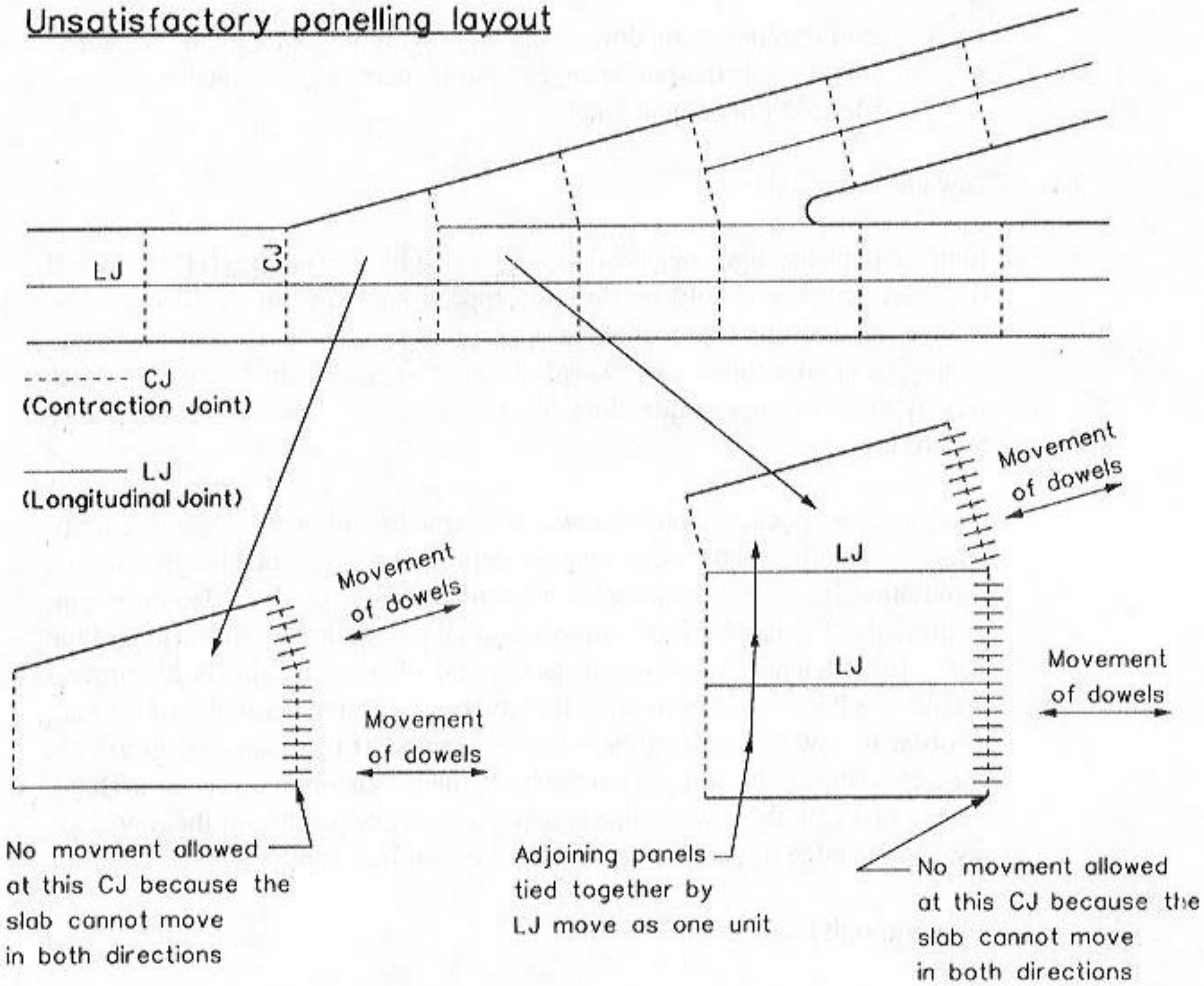
Joints in pour-through construction are formed by saw cutting (H1109 detail B). Saw cutting should be done at appropriate time to avoid cracking. Delayed saw cutting is probably the cause of most of the transverse cracks and shrinkage cracks found in finished slabs. Experience in Hong Kong has shown that the appropriate time for saw cutting is about 24 hours after concreting.

It is important to check that the saw cut is straight and reaches one quarter to one third depth. Insufficient saw cut depth may cause the slab to crack at some other location, not along the alignment of the cut. It is also important to check that the saw cut is of uniform depth throughout the entire width of the slab. Insufficient saw cut depth at the end of a sawn joint is a common problem as it is necessary to bring the saw blade outside the width of the slab in order to saw the ends to the adequate depth. If by special approval the concrete slab is to be cast against the kerb, the provision of a gap through the kerb in line with the saw cut line is required to allow passage of the saw blade beyond the edge of the concrete slab at the required depth.

c) Pour-through LJs

LJs should normally be constructed as a formed joint. It is easier to control the cross fall of the slab with a formed joint. Pour-through construction shall not be allowed unless the contractor uses a transverse purpose-made regulating machine spanning the full width of the slabs to be constructed which should be supported on a carriage (the level of which shall be controlled by the average level of not less than four points evenly spaced over at least 1.5 metre of the supporting rail, beam, slab or similar approved on each side of the slabs) and equipped with at least two oscillating-type transverse screeds.

Unsatisfactory panelling layout



An improved panelling layout

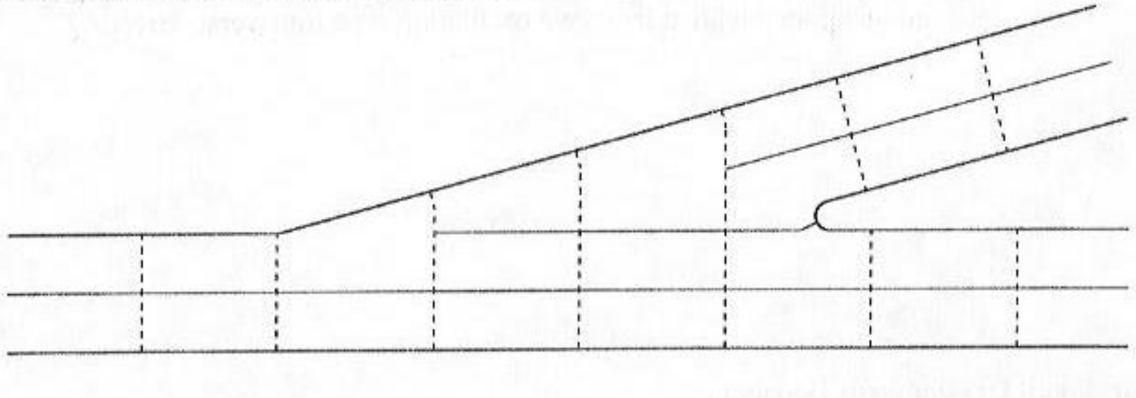


Figure GN/020/01 - Effect of non-straight transverse joints

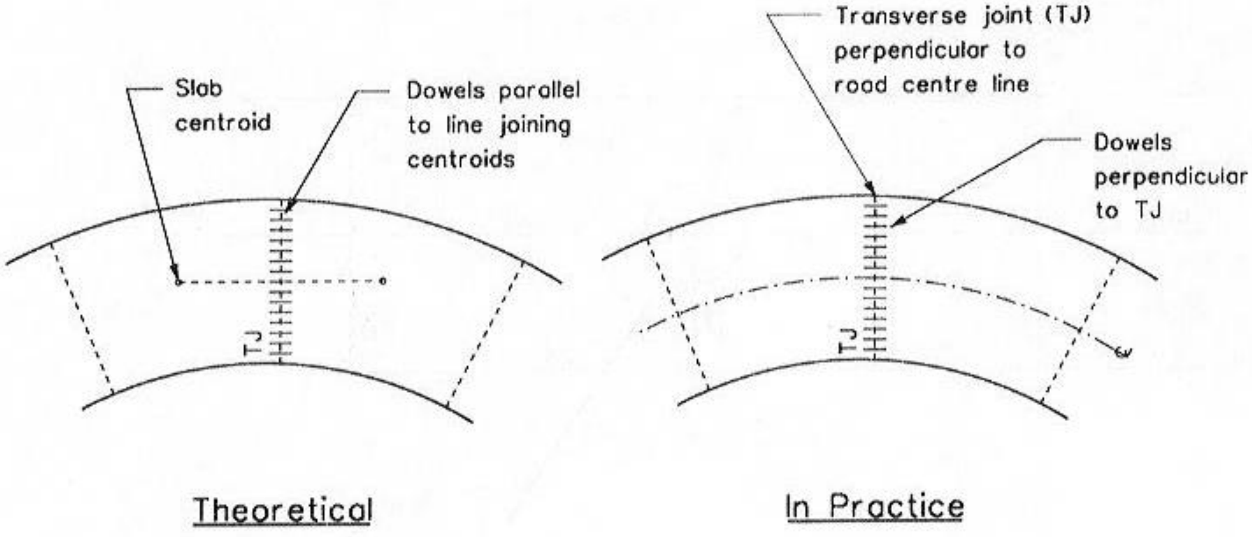


Figure GN/020/02 - Alignment of dowelbars for curved slabs.

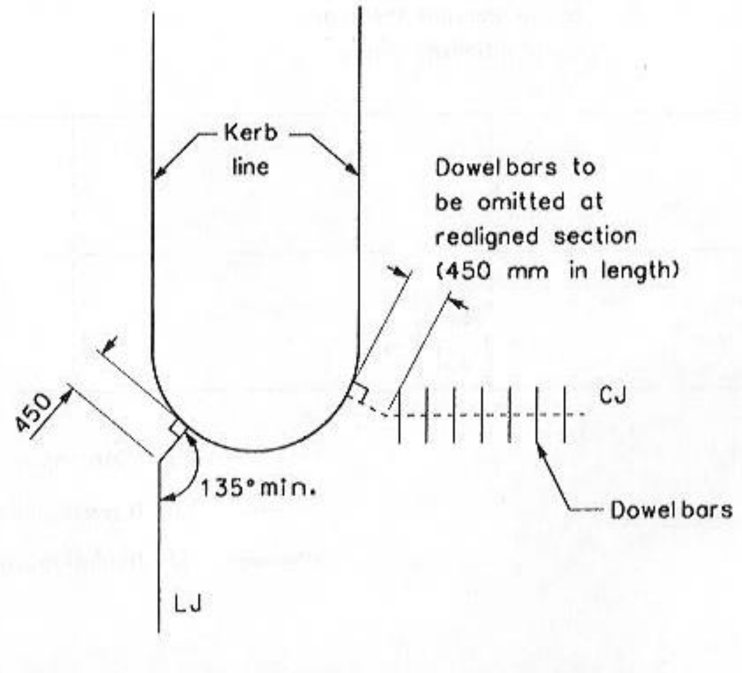


Figure GN/020/03 - Avoidance of acute - angled corners

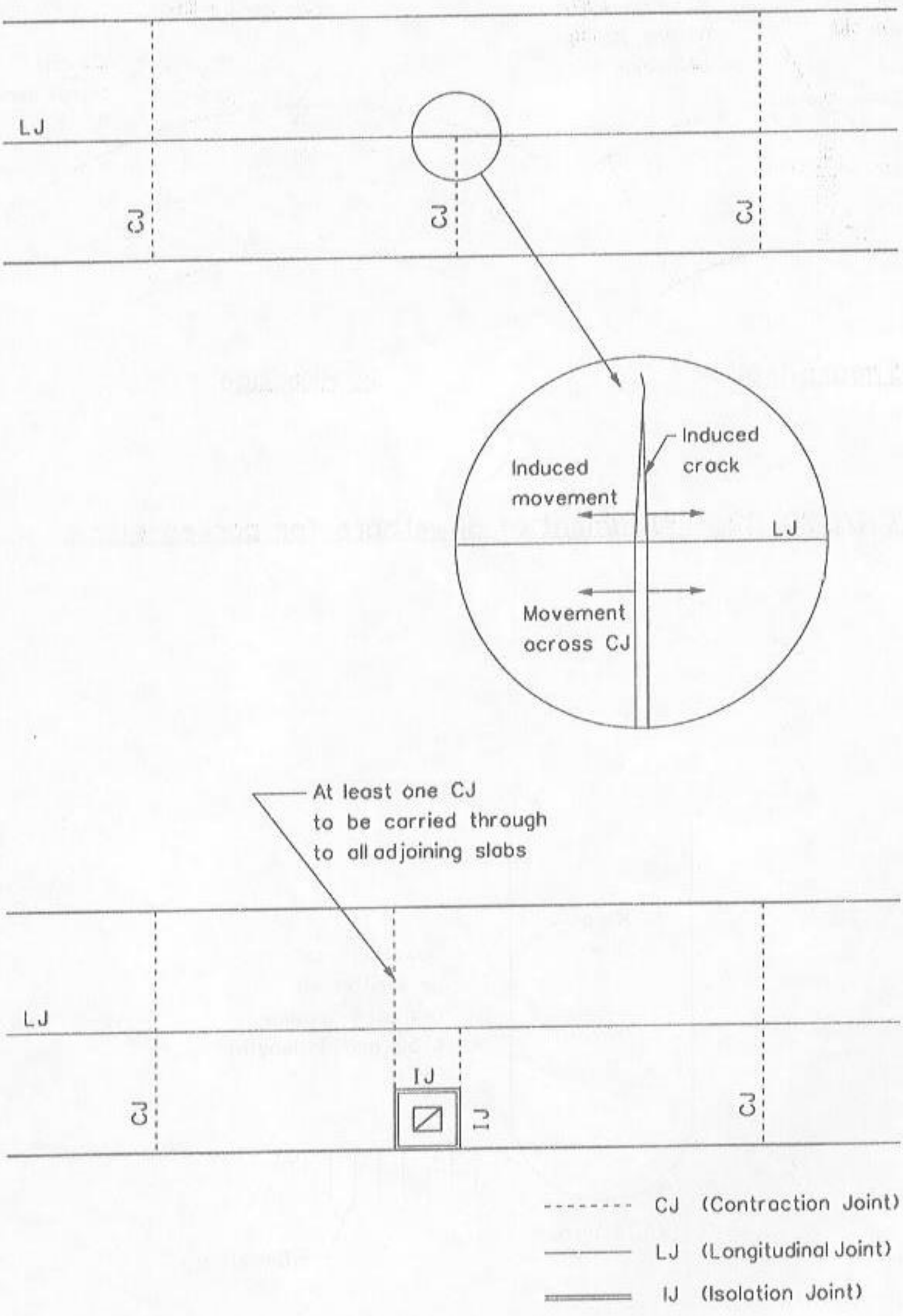


Figure GN/020/04 - Isolation joint around box-out slab

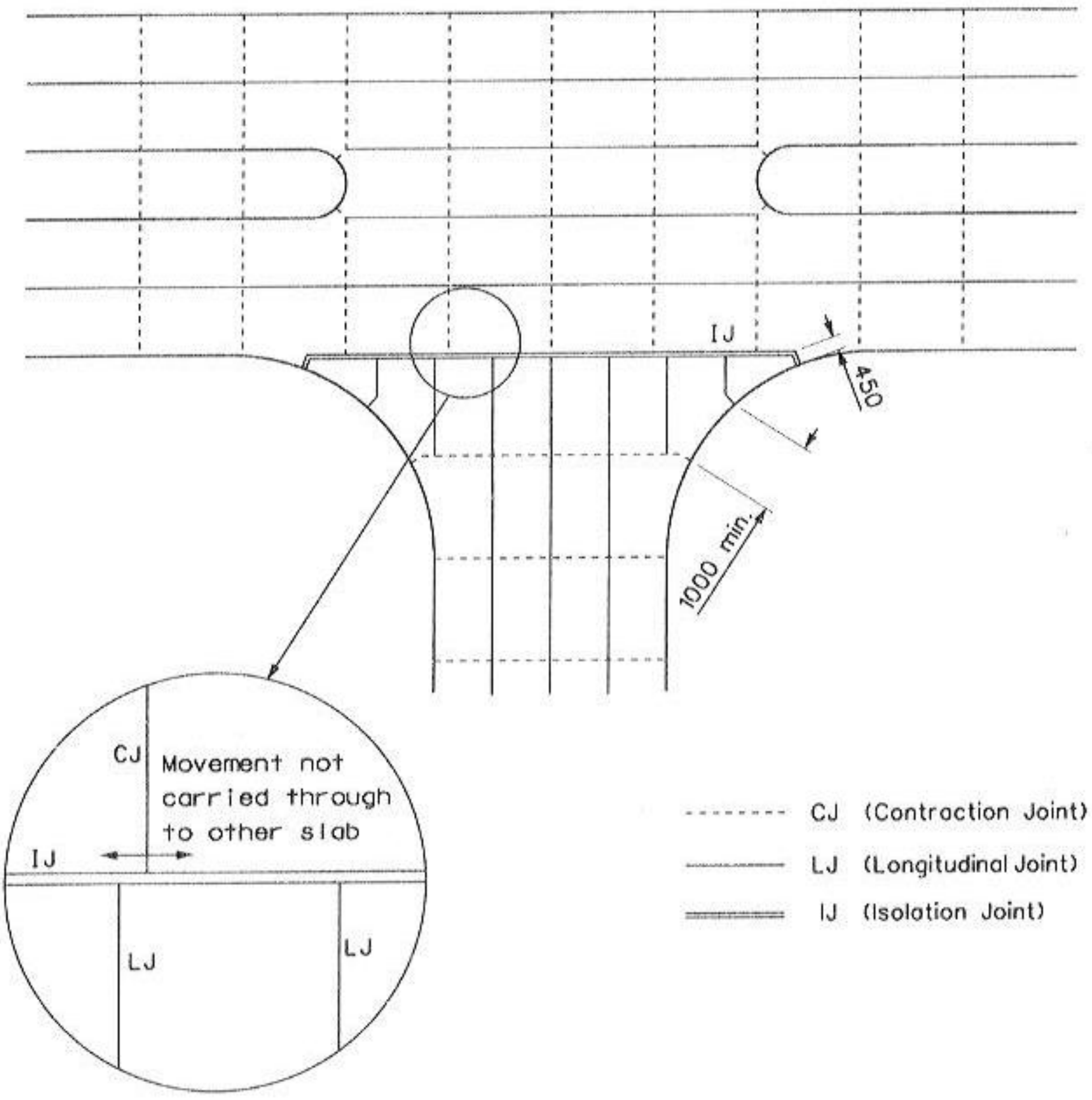


Figure GN/020/05 - Isolation joint at juction