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THE MYTH OF SAW-CUT JOINTS IN CONCRETE SLABS AND WALLS

MUANGSANGOP SENIWONGSE

Bermello Ajamil and Partners, New York, USA

This paper is concerned with the world-wide practice of providing shallow saw-cut joints or v-grooves at regular spacing, for structural purposes, in concrete walkway slabs, slabs-on-grade, and parapet walls. The primary purpose of this paper is to raise awareness among engineers that the practice is a myth and has no structural advantages, and for the engineers to *think* of a better and more positive/reliable approach to concrete crack control. The other purpose is to make aware the need for engineers to think and observe actual behavior of existing structures, and use that observation to improve future design, and not repeat unsound or useless practices. Elimination of useless saw-cut joints in future construction would save the whole world billions of dollars. The author demonstrates that the saw cuts have no structural impact by showing the pictures taken in New York of typical cracks seen on walkway slabs and parapet walls, and on garage floor slabs that were built with saw-cut joints. Note that this type of actual field observation is more representative than the crack observation on small concrete models tested in any engineering laboratories. For comparison, the author shows the examples of crack-free, maintenance-free garage floor slabs and parapet walls without any saw cuts that have been in service in Thailand for the past 30 years.

Keywords: Construction, Crack, Creep, Design, Reinforcing, Sequence, Shrinkage.

1 INTRODUCTION

This paper addresses the myth associated with the commonly adopted practice in USA of providing saw-cut joints in concrete slabs, slabs-on-grade and walls at some regular spacing, with the belief that these saw-cut or v-groove joints would prevent concrete cracks at other locations in the slabs or walls, and that cracks if formed would be neatly at and in line with the initiated saw-cuts. This paper presents opposing view based on years of observation of actual behavior of these structural concrete. In fact, cracks can be observed on concrete walkway slabs, slabs-on-grade in many parking garages and driveways, and on bridge parapet walls, all built with saw-cut joints. The occurrence of cracks in the mentioned slabs, some very extensive, is so common that it seems to be an acceptable local practice, and the saw-cut details are even promoted to be standard details by various agencies. The purpose of this paper is to bring to the attention of design engineers of the above observations. Examples of crack-free concrete slabs and walls without any saw cuts in two major projects are shown. This paper shows that saw-cuts in concrete can be eliminated from future design which would result in the saving of billions of dollars worldwide.

2 SAW- CUT JOINTS IN STRUCTURAL CONCRETE SLABS AND WALLS

Saw-cut joints in this paper refer to the shallow saw-cut joints and v-groove or u-groove joints on the faces of structural concrete slabs and walls. These are seen on almost all concrete walkway slabs, concrete driveway and garage concrete floors. The joints are seen at maximum spacing of six feet to ten feet in orthogonal directions as shown diagrammatically in Figure 1. Figure 2 shows concrete slab on ground: a) with saw cut of one-quarter of an inch deep and b) an imitation of saw cut using v-groove or u-groove of one-quarter of an inch deep.

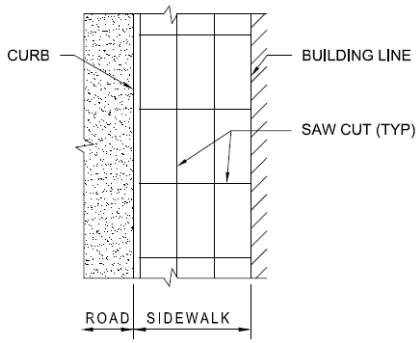


Figure 1. Plan view of example concrete slab on grade walkway with saw cut joints.

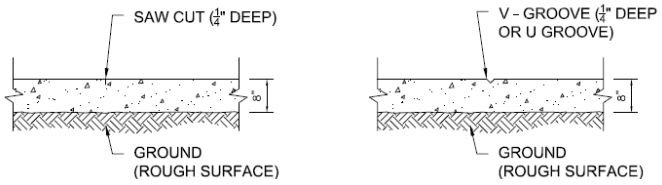


Figure 2. Typical concrete slab on grade with shallow saw cut at top surface.

The saw cuts are found in many sizes and variations. Some are seen to have wider groove (about half an inch) at very fourth or fifth saw cut lines (panels). These wider grooves are sealed with joint sealer.

Note that Figure 2 above indicates the slabs are on a rough ground surface intending to convey the message that the slabs in a) and b) are not free to slide but restrained from sliding by cohesion and friction between the bottom of the concrete slab and the ground surface.

Similar saw-cut joints or v-grooves are seen on structural concrete walls such as retaining walls, and parapets of highway bridges.

The concrete slabs thickness varies from 4 inches to about 15 inches for slab-on-grade or walkway. The amount of reinforcing steel depends on the individual design. For bridge parapet walls, they are either rectangular in cross section or of New Jersey's parapet type, and the reinforcement is designed for large lateral loads according to the AASHTO Bridge Design Specifications. It is noted here that there is no known correlation between the amount of reinforcement in the slabs and walls with the spacing of the saw cuts or v-grooves.

2.1 The Myth of Saw-Cut Joints

Having practiced and observed structural concrete behavior since 1970 in major projects in not less than 16 countries, the author cannot see any merits or structural advantages of providing

shallow saw-cut joints on concrete floors or walls. The reason or the myth why saw-cut joints are provided is the belief that concrete cracks would take place at and along the saw-cut joints in the form of deeper and wider joints, but all at the saw-cut locations, and less likely to crack at anywhere else on the slabs or walls. That is the wishful thinking. There is no creditable engineering mechanics that support concrete crack control using shallow saw-cut joints.

2.2 The Effects of Making Saw-Cut Joints

It will be evident in Section 3 that saw-cut joints have no structural advantages on the behavior and performance of the slabs or walls. The only effect - they are seen to be effective in trapping of dirt and cigarette ends on the walkways as shown typically in Figure 3.

(a) (b)

Figure 3 (a), (b). Cigarette ends trapped in saw-cut grooves in walkway slabs.

3 OBSERVATION OF CRACKS IN CONCRETE WITH SAW-CUT JOINTS

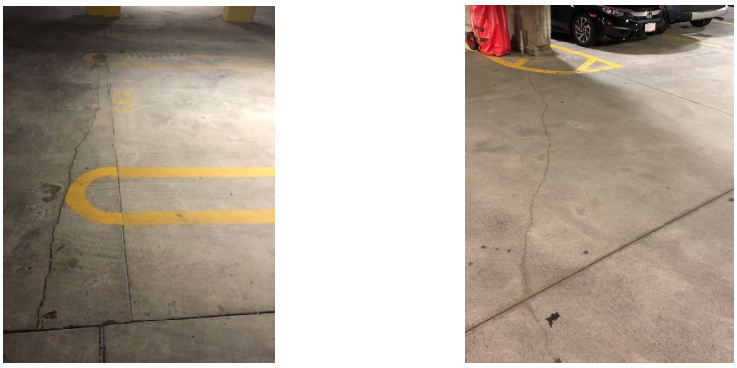
This Section shows typical concrete cracks commonly seen in concrete slabs and walls that incorporated saw cuts. All pictures were taken in 2018. Figure 4 shows concrete cracks in the sidewalk slabs. Figure 5 shows concrete cracks in the slab-on-grade parking garage floor in a six-month old apartment building in New York. Figure 6 shows cracks in concrete parapet wall of a bridge with v-grooves at about five to six feet spacing. The cracks are seen in this case at about one foot away from the groove joints.

(a) (b)

Figure 4 (a), (b). Cracks in sidewalk concrete slabs on Park Ave. in New York City.

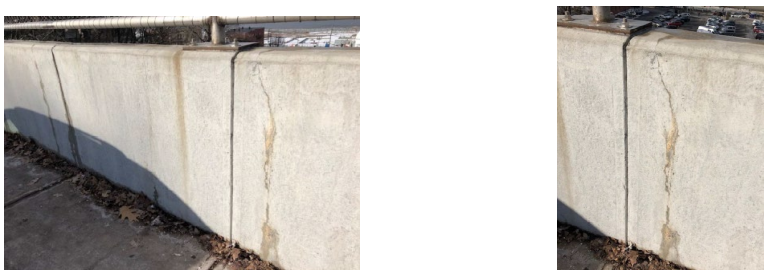
4 REPAIR AND MAINTENANCE OF SAW-CUT JOINTS

All joints require maintenance and repair, sooner or later. All pictures of repairing in this Section were taken on Park Avenue in New York in 2018. Figure 7 shows maintenance work on the grooves. Figure 8 shows the demolition of extensively cracked walkway and recast of new slabs.



(a) (b)

Figure 5. Cracks in slab-on-grade garage floors (a) condominium in NY, (b) shopping mall in Massachusetts.



(a) (b)

Figure 6 (a), (b). Cracks in NY bridge parapet walls with saw-cut joints.

(a) (b)

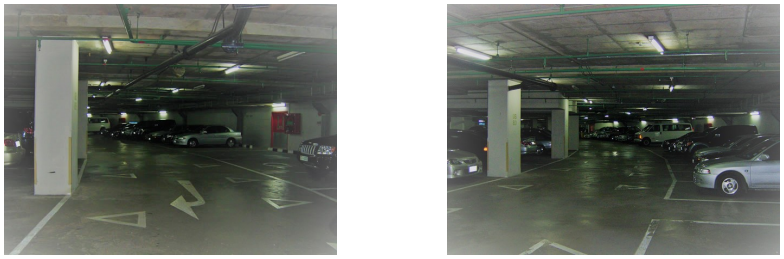
Figure 7. (a) Saw cutting grooves in walkway slab, (b) Taping saw-cut groove before applying sealant.

(a) (b)

Figure 8. (a) Removal of cracked walkway slab, (b) Recast walkway slab.

5 CRACK-FREE FLOORS AND WALLS WITHOUT SAW-CUT JOINTS

This Section shows examples of concrete garage floors and bridge parapet walls which have been in service since 1990s and are still in excellent conditions without any cracks. The concrete slabs and walls were designed and built conventionally without any saw cuts. The pictures in Figures 9 and 10 were taken in 2008, after some 15-20 years after the completion of construction of both projects. Figure 9 shows the underground bottommost basement garage floor of the United Nations' Conference Building in Bangkok, built in the early 1990s (Seniwongse 1991). Figure 10 shows the pictures of the parapet walls of 40-km long expressway bridges in Bangkok that was built around 1988-1991(Seniwongse 1989). The deck itself is continuous using innovative link slabs between spans (see Jointless Bridge (Seniwongse 1990)).



(a) (b)

Figure 9. Crack-free garage basement floor in UN-ESCAP Conference Building (Seniwongse 1991).

(a) (b)

Figure 10. Crack-free parapet walls on 40-Km viaduct in Bangkok (Seniwongse 1989).

6 DISCUSSION AND CONCLUSION

This paper intends to call upon engineers to exercise field observation and common sense in the design and construction of concrete slabs and walls. The pictures in Sections 3-5 are self-explanatory. Complicated computer programs and mathematical modeling do not always deliver good design and construction, but common sense and engineering intelligent always do. It is obvious that saw cuts in concrete are useless, and money is wasted in making the saw cuts, and later on the maintenance and repair. The cost of making the saw- cut joints (not the cost of slab/wall) is about $20 - $30 per linear foot of joints (Rhode Island, 1998). The cost of repairing of existing saw-cut joints is about $40 - $60 per linear foot (Appendix A). For an example city having a total 200,000,000 feet length of joints in walkways, the cost of making saw cuts would be 200,000,000 ft x $25 per foot = $5,000,000,000. That is the cost in one example city. The potential saving for the whole world would be billions of dollars, and the concrete would be just fine as shown in Section 5.

For crack-free concrete, design proper reinforcing steel, and construct using proper concrete pouring sequence to allow dissipation of concrete creep and shrinkage, using full face construction joints as shown in Figure 11. Fresh concrete is placed in alternate segments of say 10 ft. long. Allow the concrete to cure and shrink for a few days, then place concrete in the closure segments. In fact, the mentioned techniques were used in the two projects in Section 5. Other design techniques and concepts for crack-free concrete can be found in the references by Leonhardt (1988) and Seniwongse (1972, 1973, 1989, 1990, 1991, 2006, 2008, and 2010).

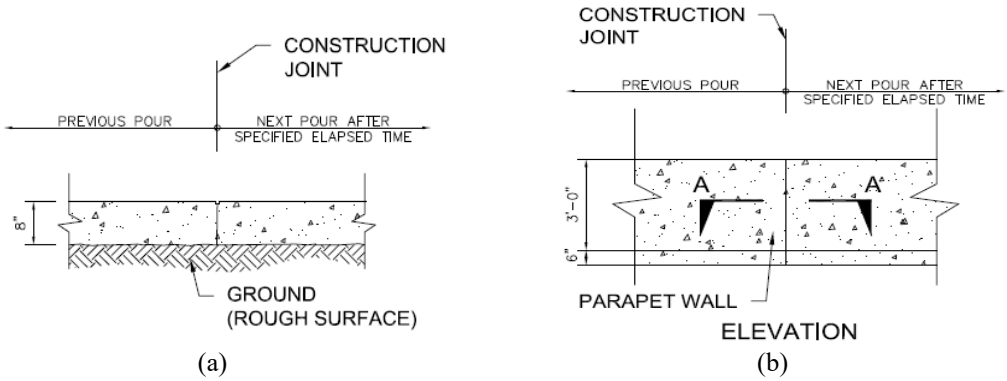


Figure 11. Full construction joint with proper concrete pour sequencing.

Appendix A. Estimate Cost of Repair of Saw Cut in Concrete

Assume, for example, it is required to repair a total 20 ft long saw cut joint on concrete walkway on Park Avenue in New York City, and the Contractor is in White Plains in New York. Two technicians driving from White Plains to Park Avenue and back after work would take 6 hours, and actual setting up time, saw-cutting concrete and cleaning up would take 3 hours. The cost of the car and concrete saw is $ 500 per day. The direct cost would be $(2 x 20 x 9 + 500) = $ 860. Applying 15 percent insurance and profit, the total cost would be $(1.15 x 860) = $989 for 20 ft saw cut. Estimate cost for 1 ft. is $989/20 = $49.45, rounded to $50/ft.

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