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Precast Concrete Whitetopping for Commercial Entrances (Modular Pavement Systems)



2017 Concrete Paving Workshop

The Motivation!

- Commercial facility
 - Historically known for its fried chicken
 - Limited entrances (2)
- Moderate traffic
- District 1 Wanted to do concrete overlay, but...
- Owner "knows people" (This is Illinois)
- Project died







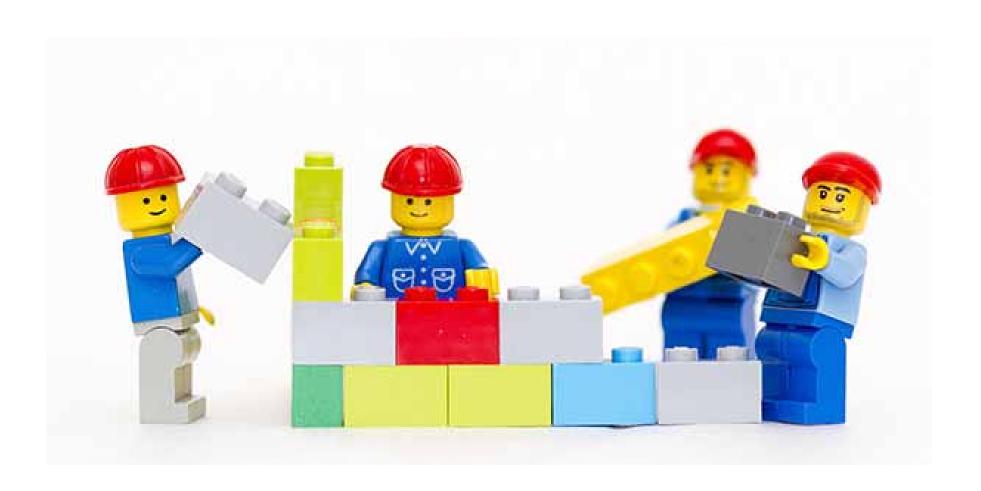
Speed of Execution!

Concrete's Last Remaining Barrier

- We need quick fixes
- Keep facility disruptions to a minimum
 - Fast & overnight if necessary
 - Enable conventional paving where possible
- Increase speed of completion where there are conflicts
- Combine best technologies

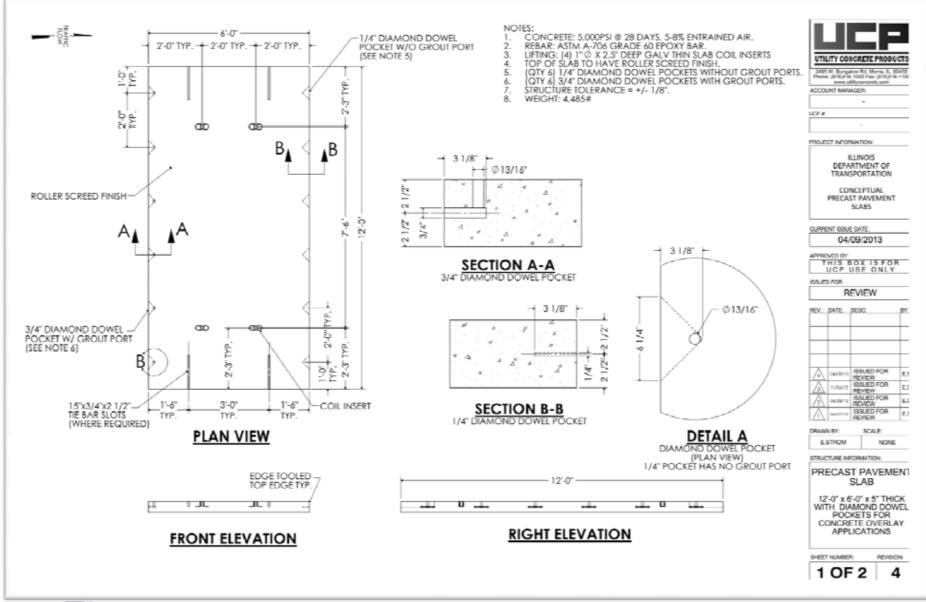


Keep it Simple!



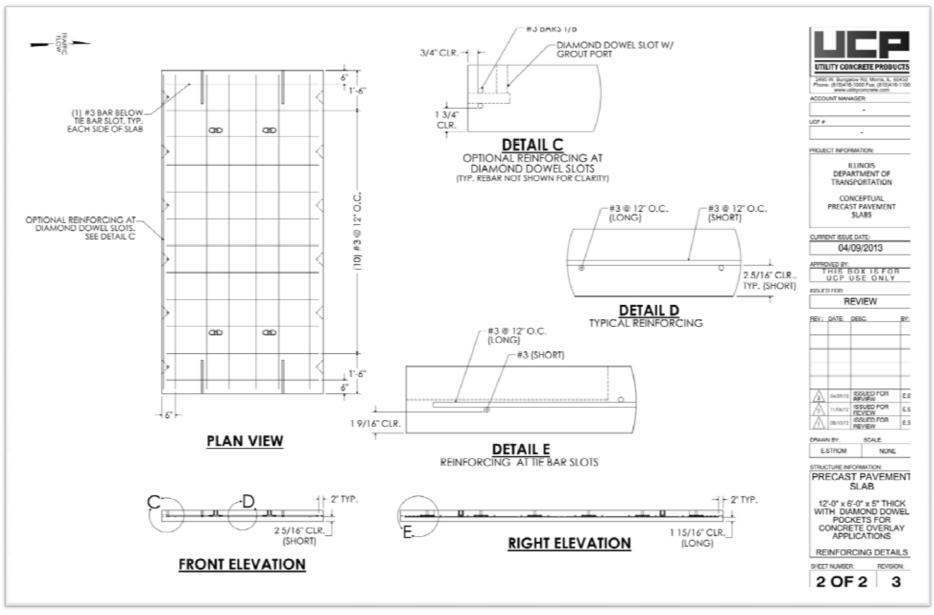


Plan Sheet 1



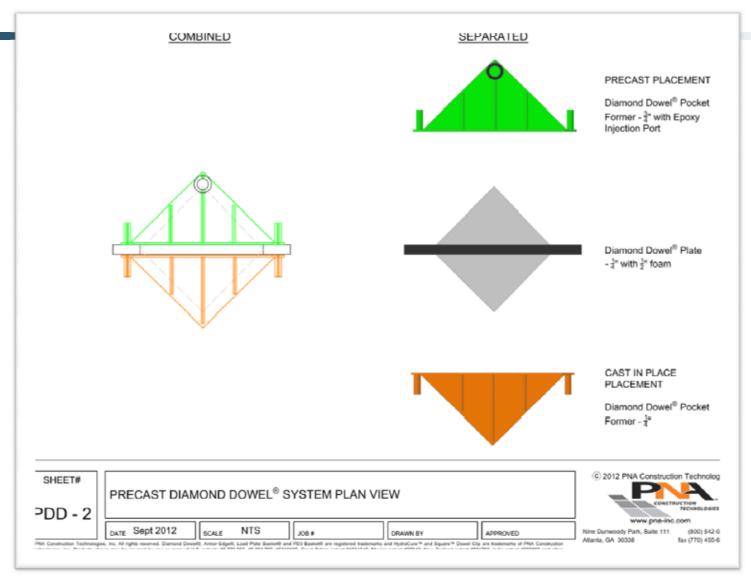


Plan Sheet 2



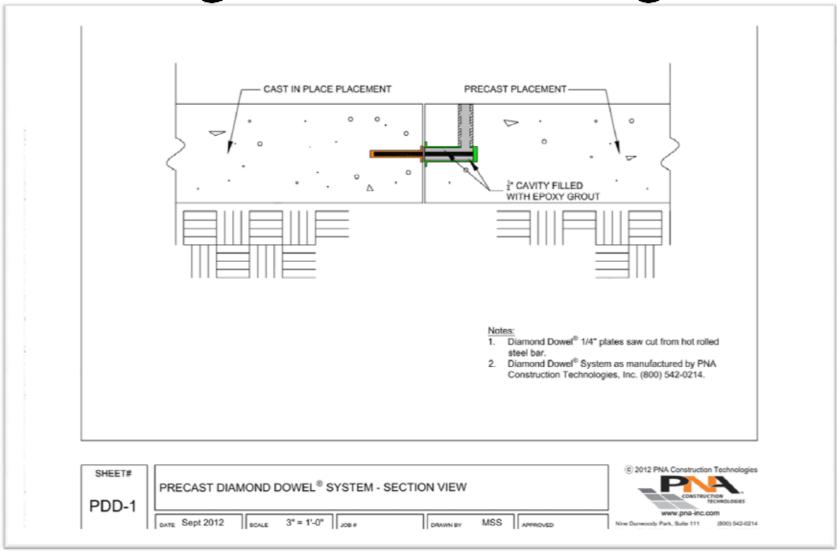


Diamond Dowel Modifications





Dealing with Lack of Alignment





Assembly in Position Top View



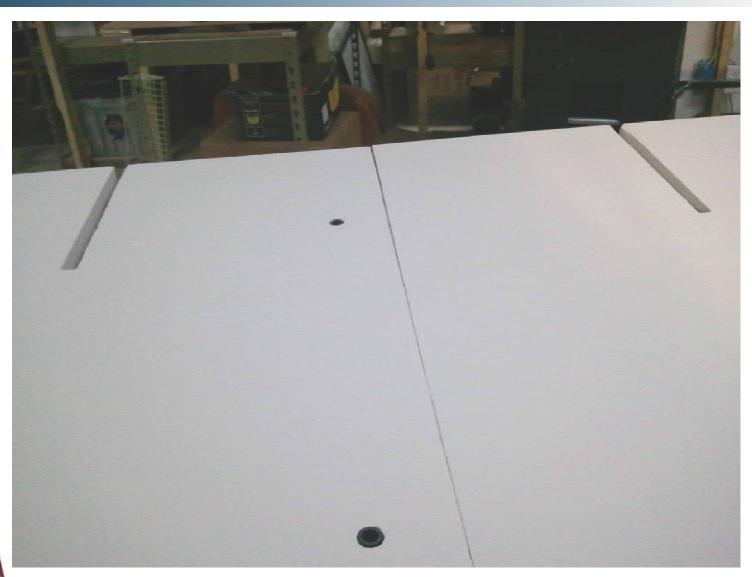


Assembly in Position Side View Slight Gap for Pre Positioning



Self Aligned as Pushed In

(I had to take the gasket out due to the Styrofoam not being adequate)





Longitudinal Joint Bar





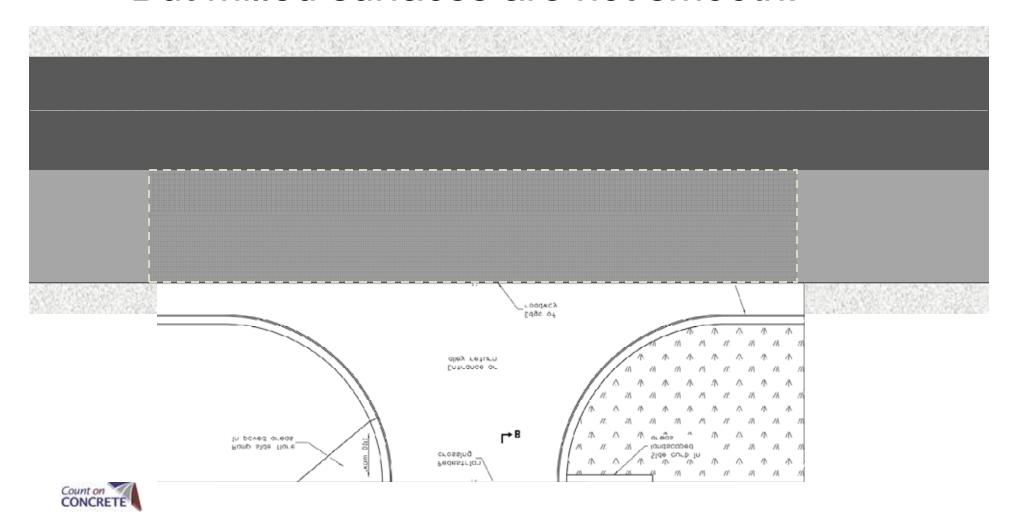
Alignment from Opposite End





Construction Sequence Step 1 - Milling

But milled surfaces are not smooth!









The Original UTW Project – Flowable Shoulders



Winnebago County Shoulders Low-Grade Material

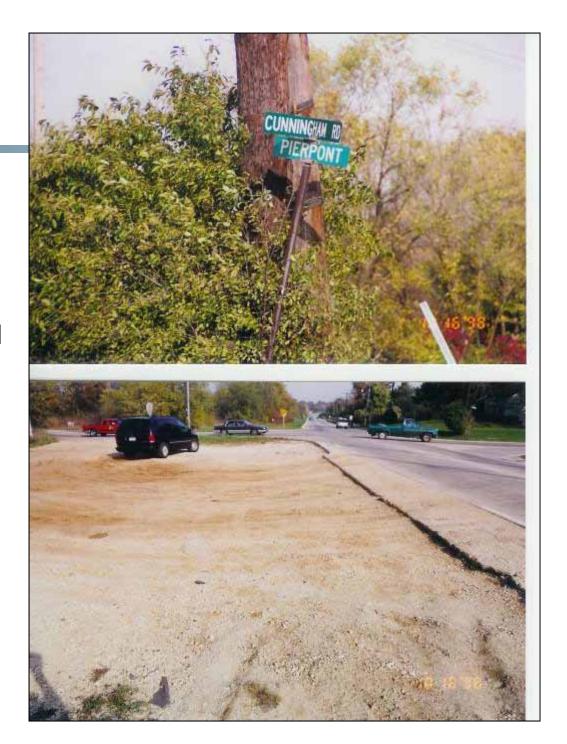
- These experimental shoulders were put into place in November of 1994. They were intended not as full-time traveled pavement, rather as a maintenance eliminator for the county. Blading up of the shoulders after rains has not been significantly reduced.
- This is a significant safety enhancement as runoff-the-road accidents are much less likely since errant vehicles don't get caught in the edge ruts. The shoulders were originally intended to go adjacent to concrete pavements similar to the UTW projects, but the first project we build of this type happened to be adjacent to an asphalt pavement.
- We have used similar materials to fill potholes prior to placement of UTW in the commercial market. The idea is to emulate the elastic properties of the adjacent asphalt. So far, (the oldest was built in '98) in one of the ready-mix yards we first placed this material you cannot tell where the asphalt ended and the low-grade material began.





Project Location

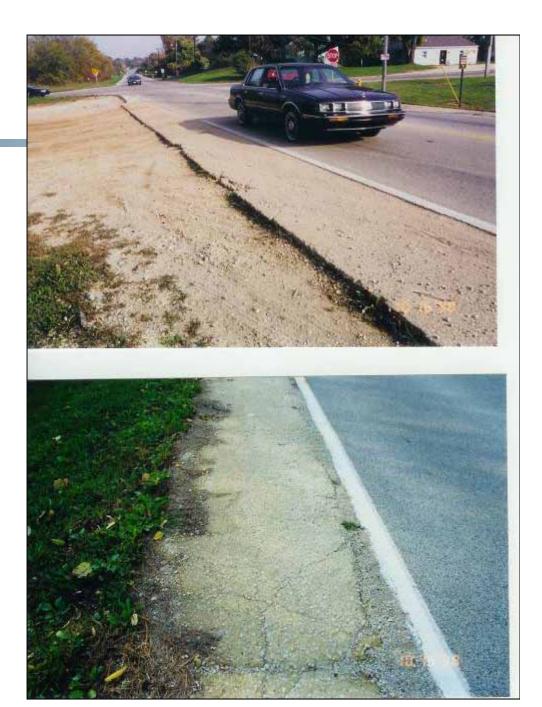
- Located at Cunningham and Pierpont west of Rockford in Winnebago County.
- Construction was in mid-November and it was cold. I suspect that temperatures reached freezing or below that night, but did not seem to hurt things.





Surface Condition in '98

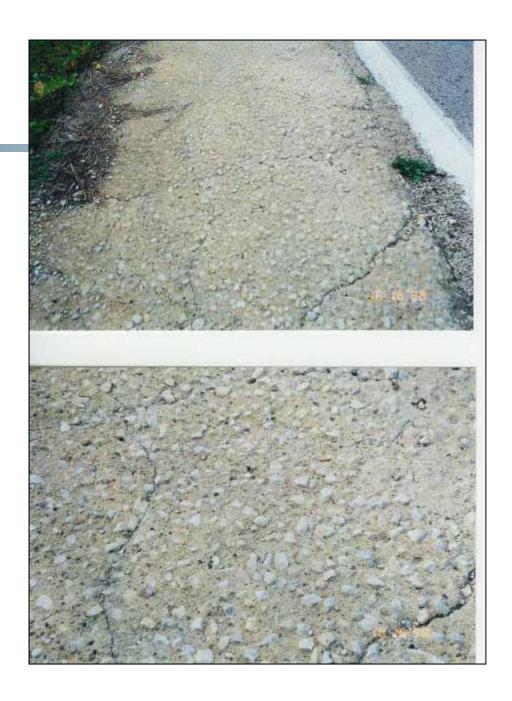
- The original concept was to create an inexpensive material to eliminate the repeated need to blade up the granular shoulder next to the pavement after a rainstorm.
- It was not intended to be a true concrete shoulder. This totally eliminated the edge rutting problem.



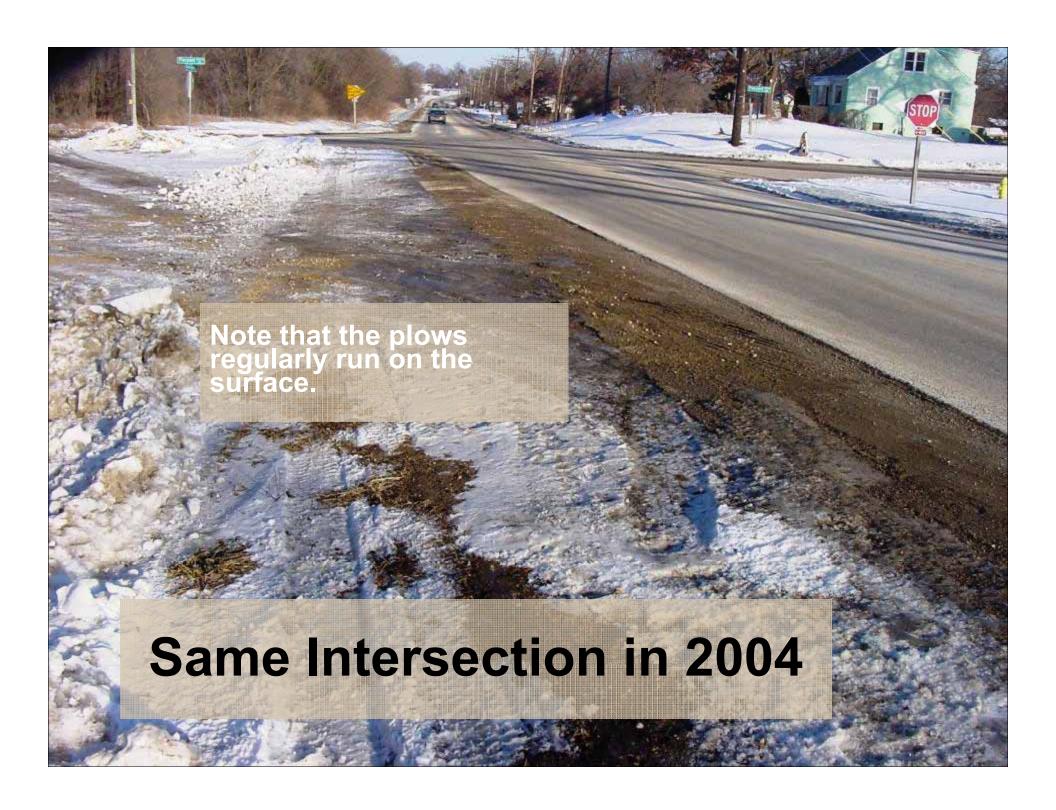


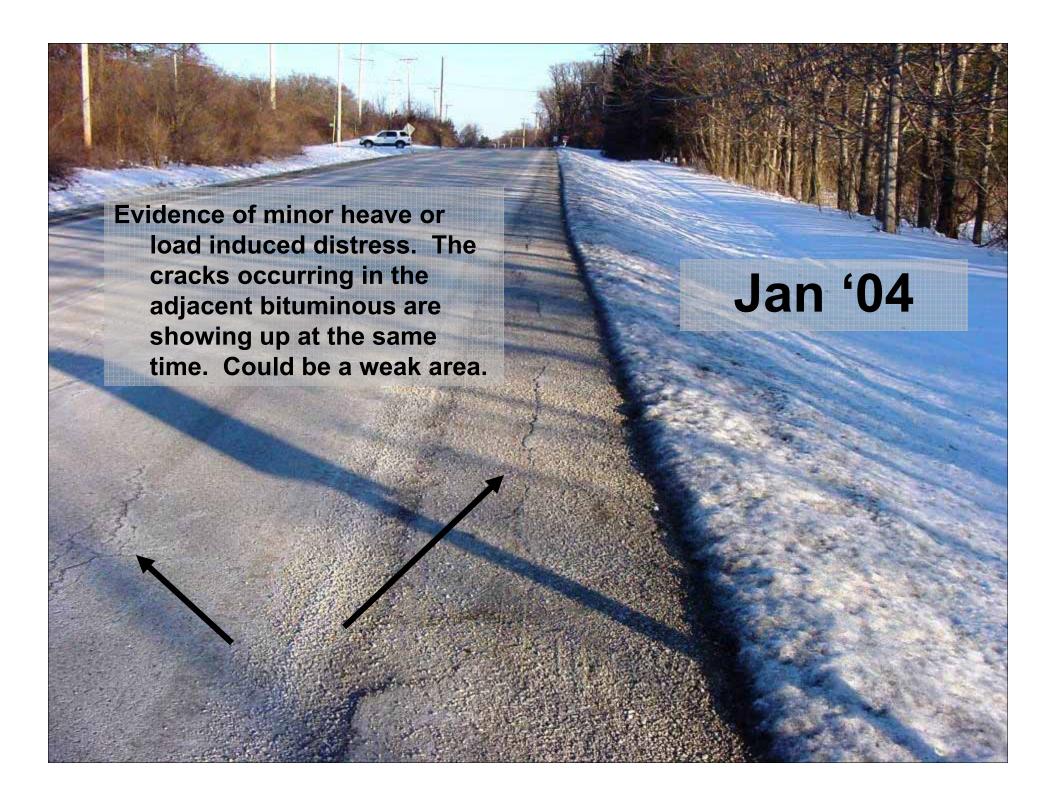
More '98 Surface Shots

- Remember, this is not supposed to be concrete. There are no joints, and I can't remember for certain if they even put curing compound on it as there was plenty of free water in the mixture.
- It was placed next to a rebuilt asphalt section.









September 2009



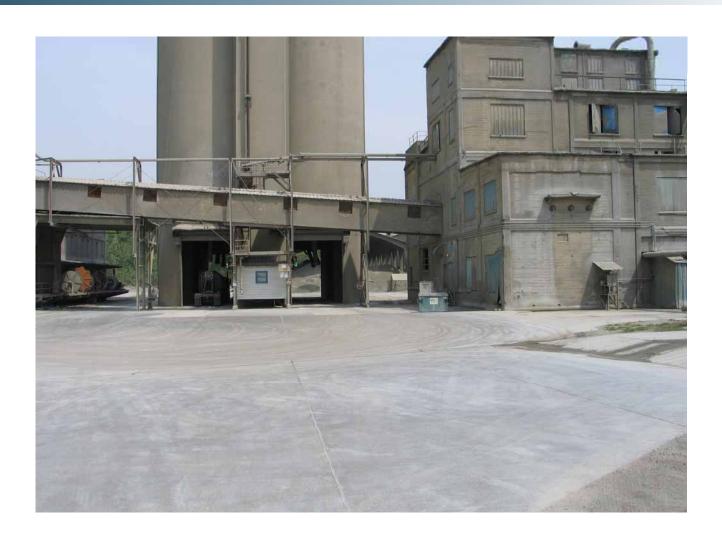




SCC Quick Base & Patching Material 2005

by Randell Riley



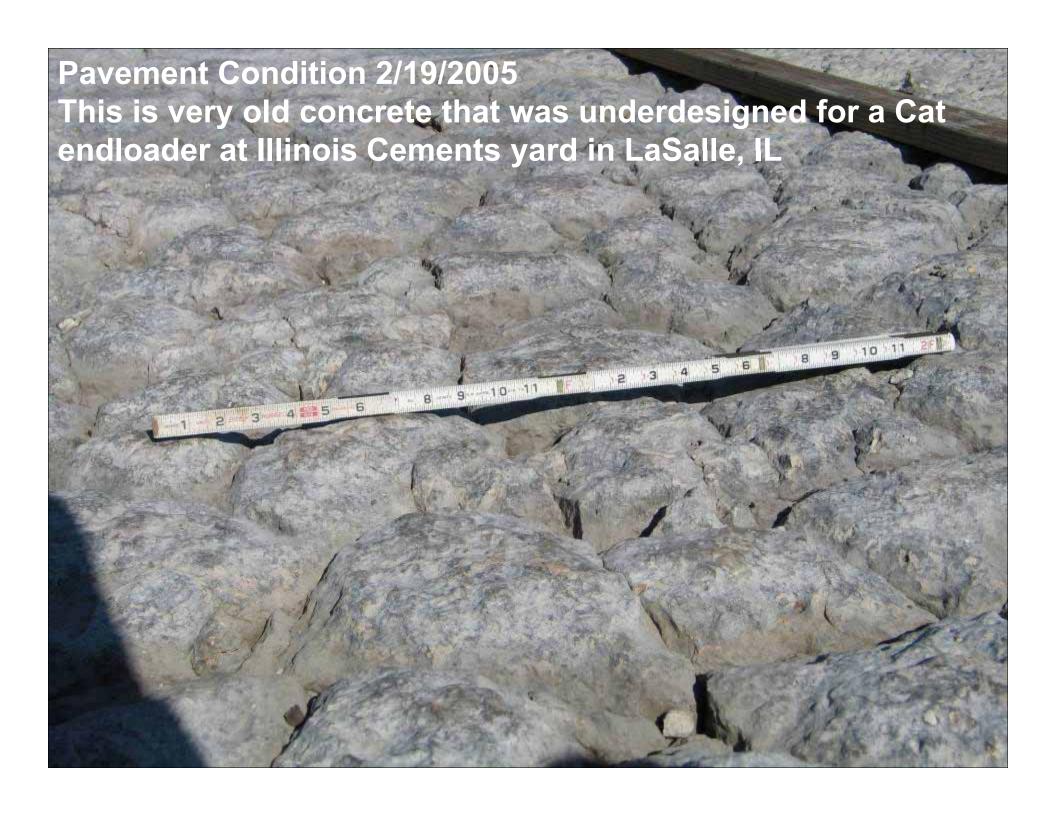


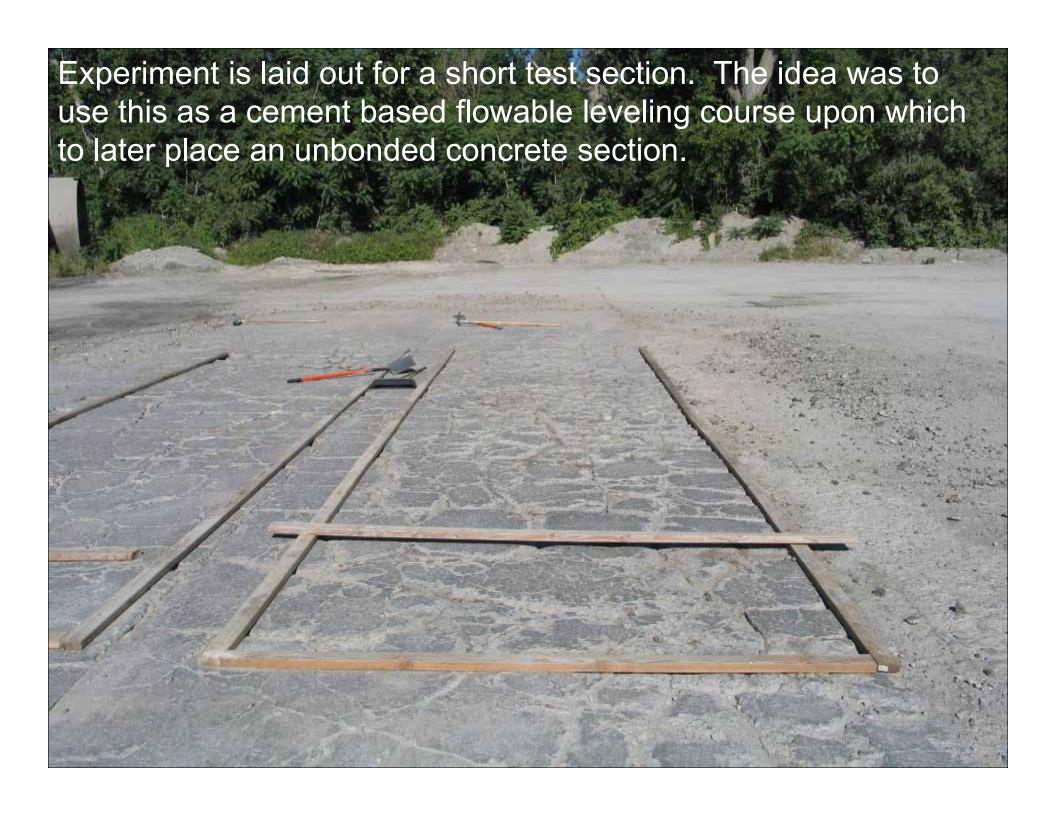


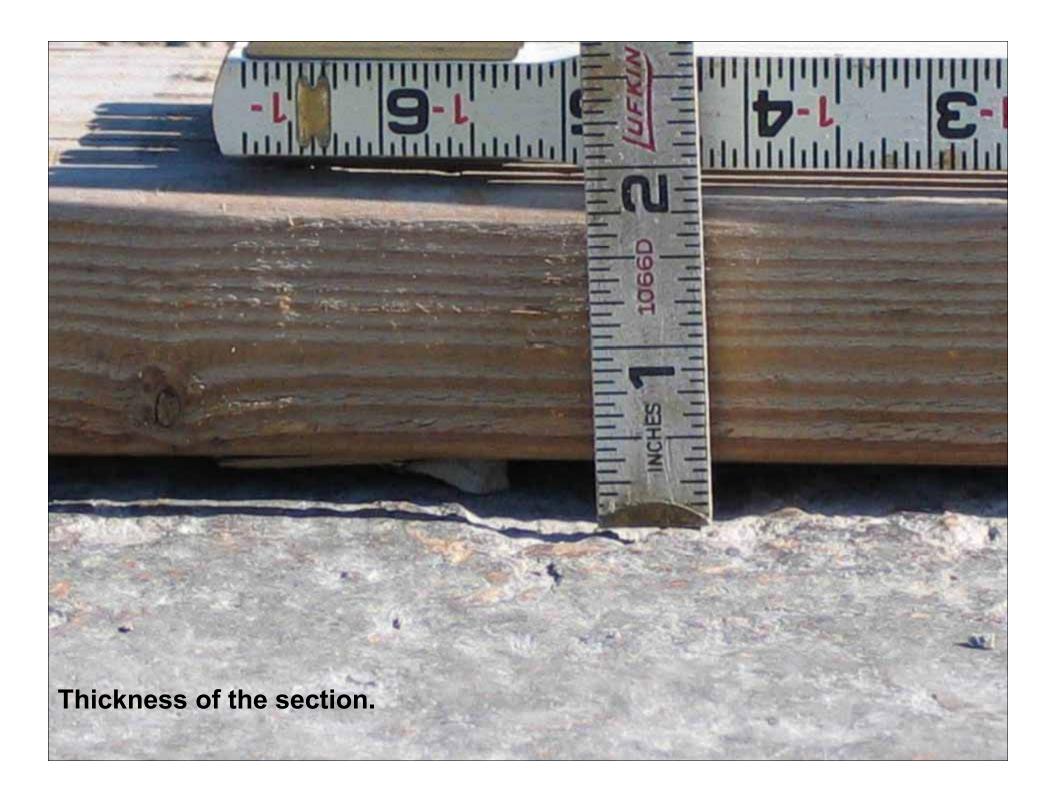
Cat 988G

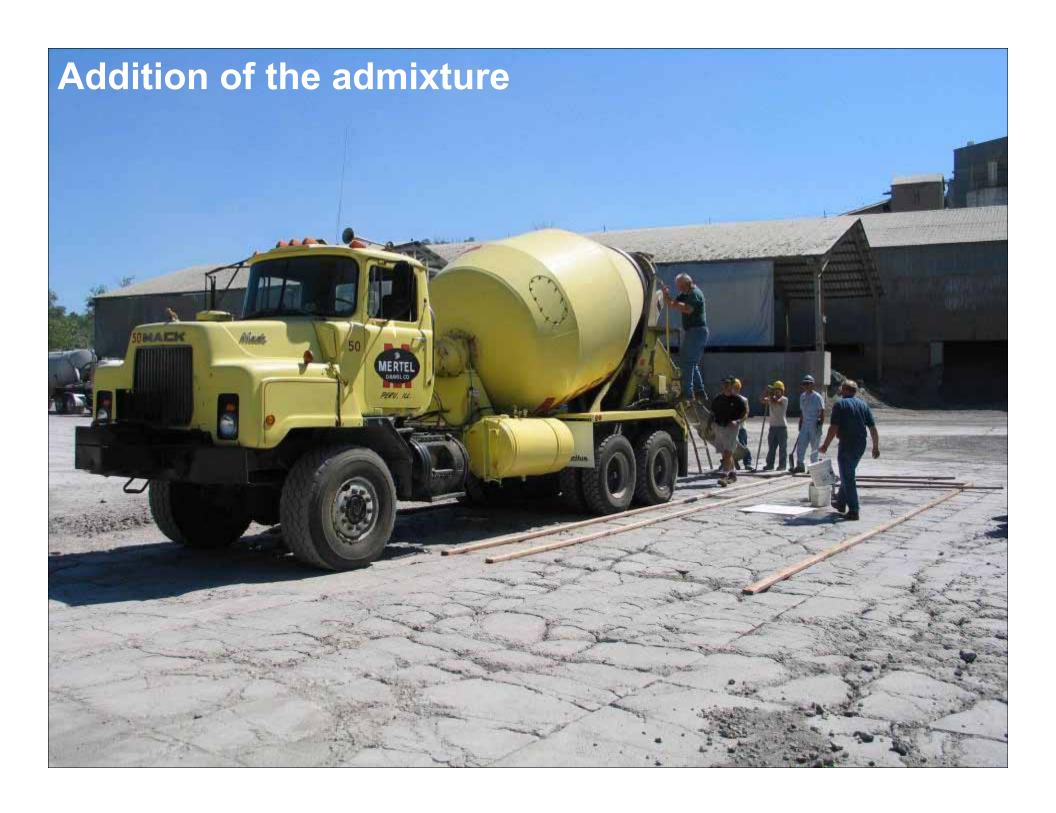














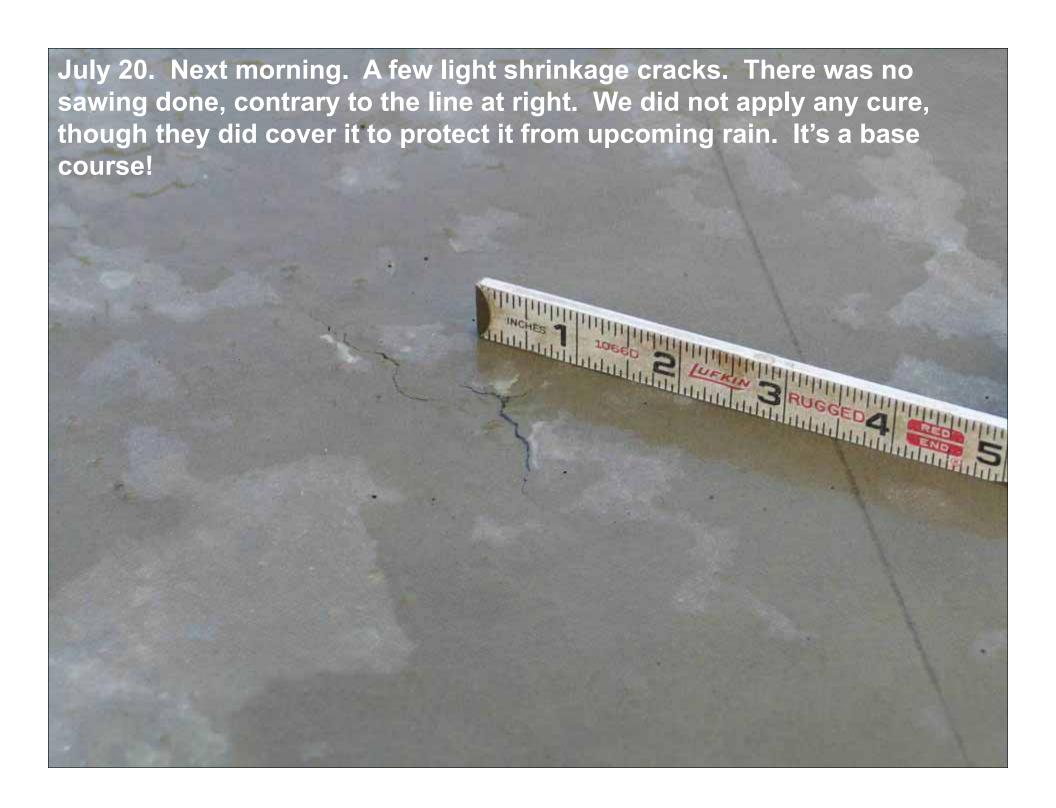






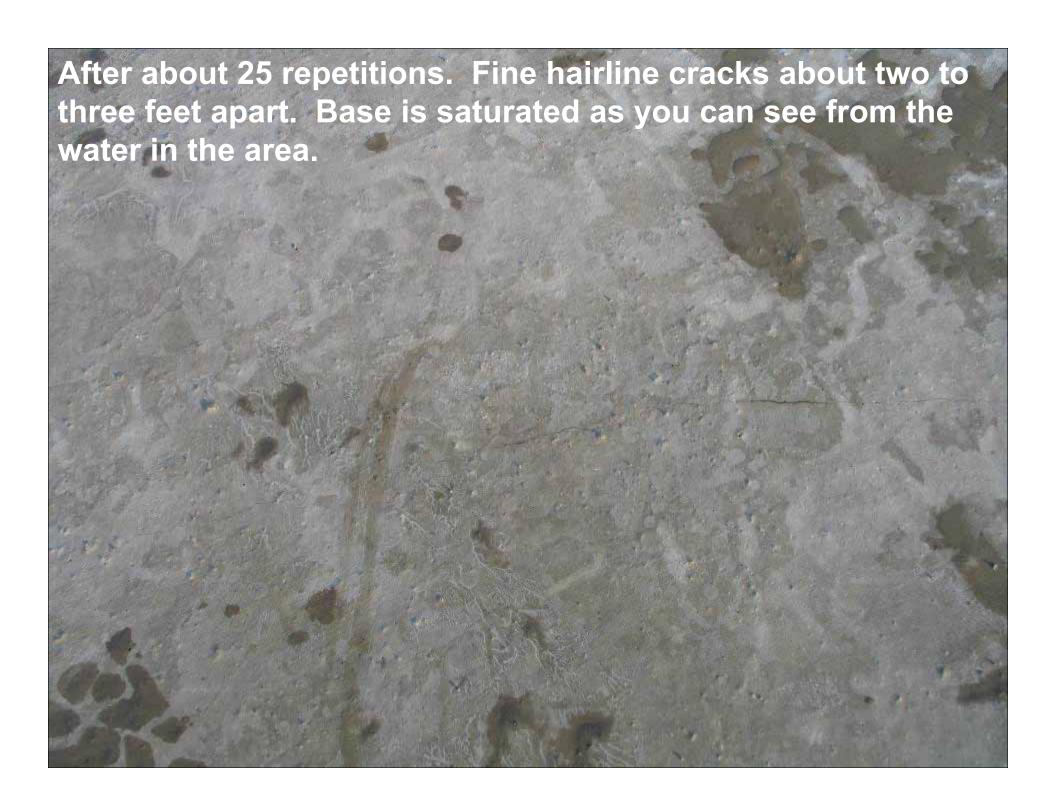




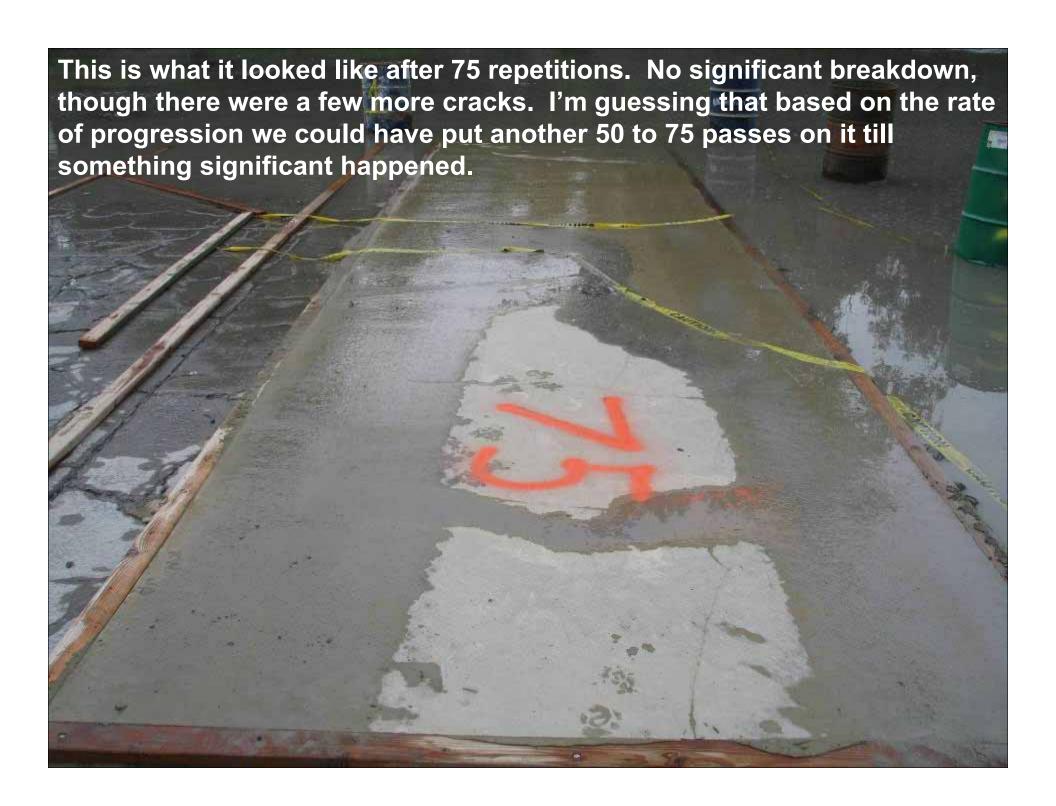




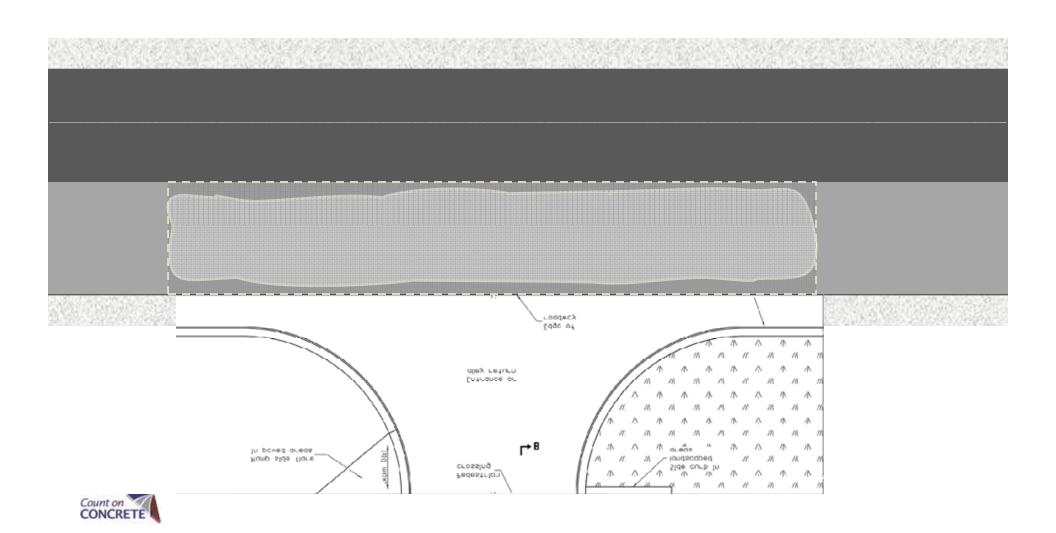
25 passes with no little or no breakdown. Just supposed to be there long enough to act as a base course to be protected by the concrete.



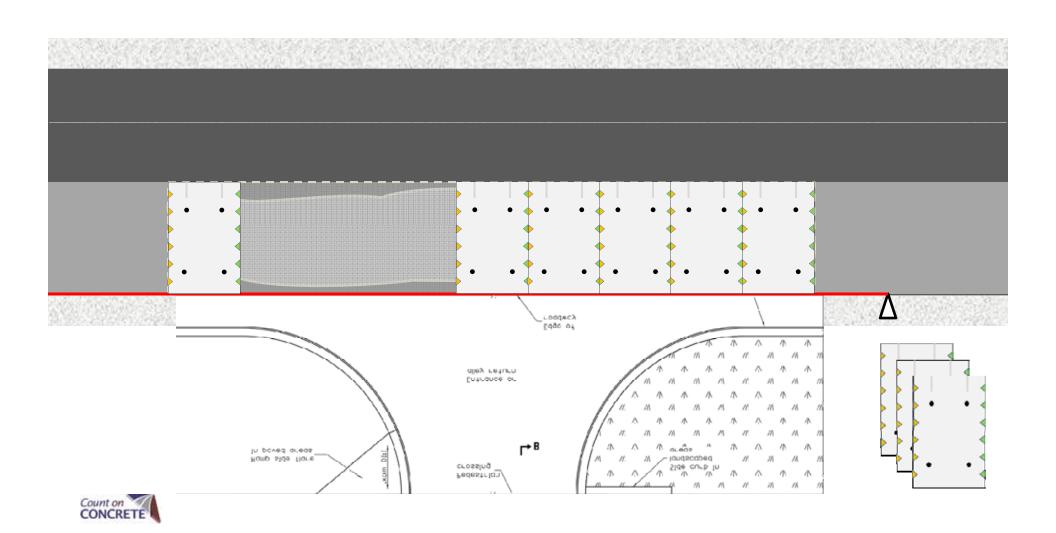




Construction Sequence Step 2 – Grout Placement

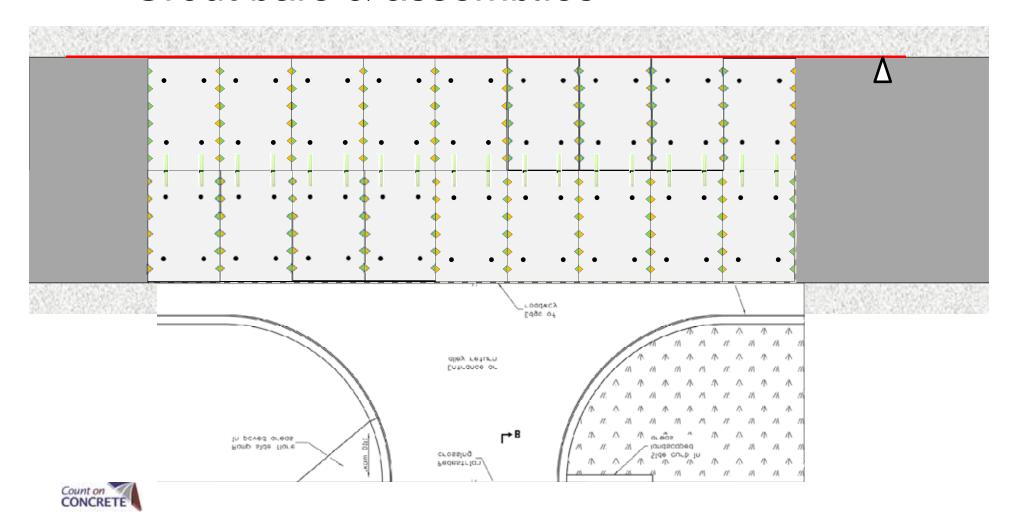


Construction Sequence Step 3 – Align & Place Slabs

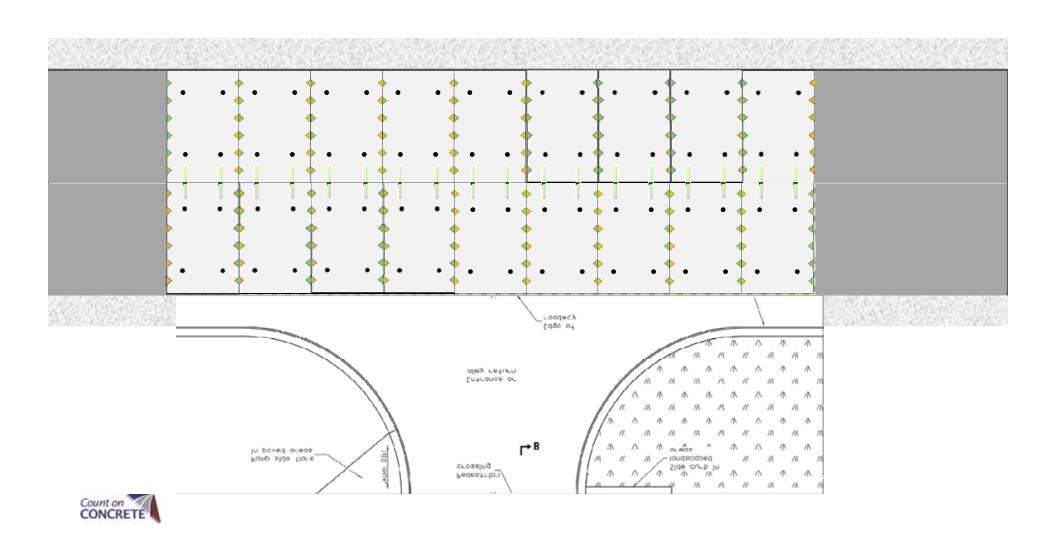


Construction Sequence Step 4 –Other Lane if Necessary

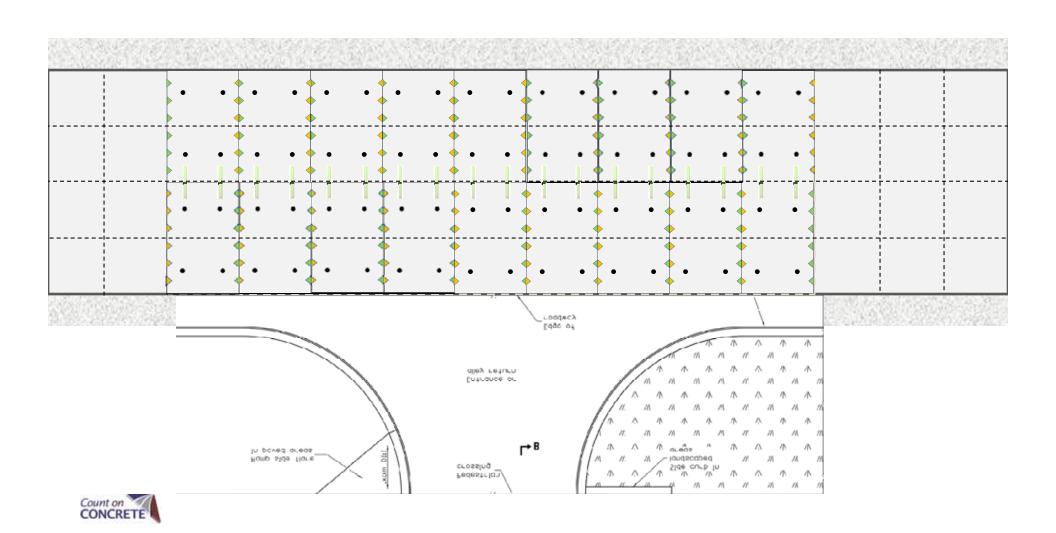
Grout bars & assemblies



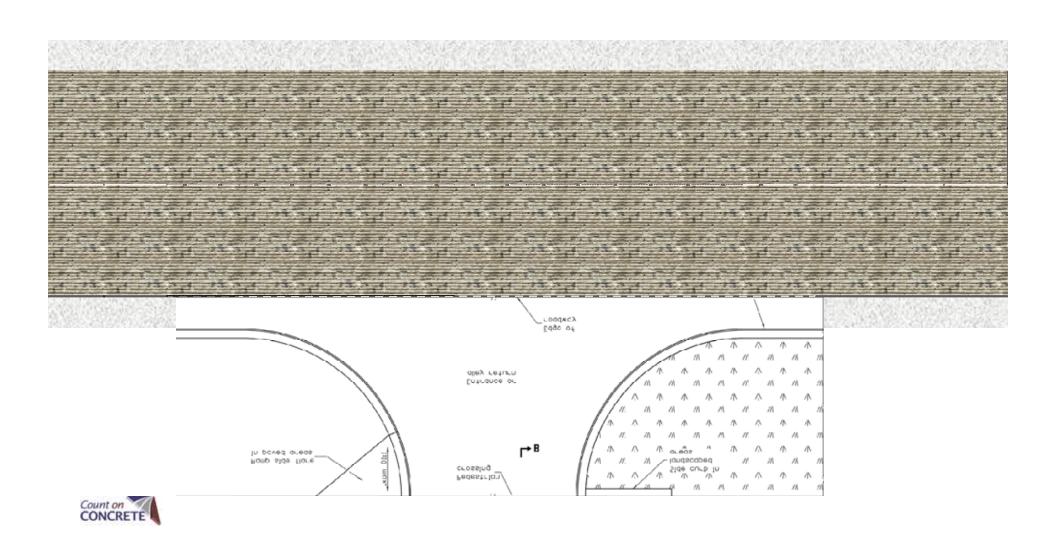
Construction Sequence Step 5 – Pave 1 or both lanes



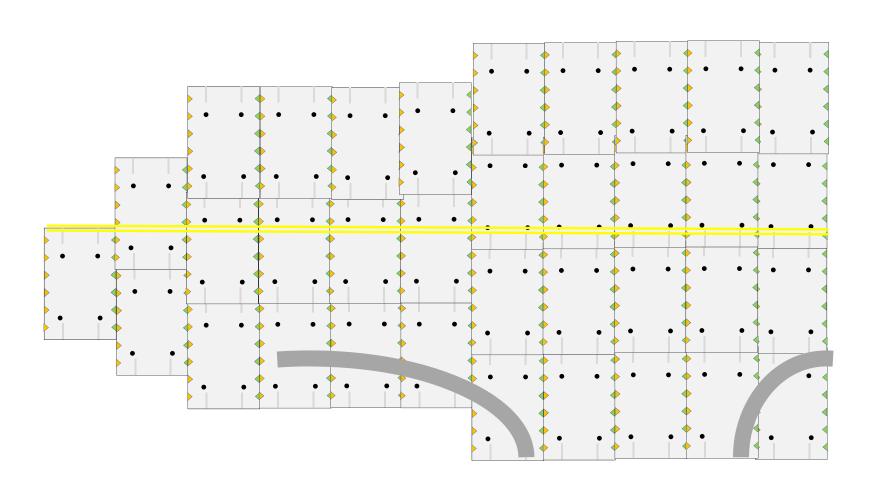
Construction Sequence Step 6 – Cut Joints



Construction Sequence Step 7 – Grind for Smoothness



Complex Areas





Others are Having the Same Idea



Theoretical and experimental studies on Precast Ultra-Thin Whitetopping in Singapore



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Introduction

Concrete pavement is used at junctions to prevent severe rutting effects. However, user delay cost caused by the replacement of concrete pavement is as high as 5 times the construction cost (NguyenDinh et al. 2016). Moreover, there is a complicated transition pavement to connect concrete pavement and asphalt pavement (Figure 2).



Figure 2: Complex transition structure to connect asphalt and concrete pavement according to Standard Details Of Road Elements (LTA, 2015)

Research objective

To develop an alternative pavement system for concrete pavement at junctions that can

- he constructed fast
- eliminate the transition pavement

Precast Ultra-Thin Whitetopping (PUTW) concept



ure 3: Precast concrete pavament Figure 4: Ultra-Thin Whitetopping (UTW)

Figure 5: Precast Ultra-Thin Whitelopping

Precast PUTW stab

New or good condition asphalt

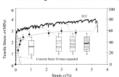
PUTW is the pavement system that is fabricated off-site in a plant, transported to the project side and installed bonded on prepared asphalt based. Once installed, PUTW behaves like a bonded

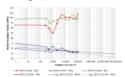
Engineered Cementitious Composite (ECC) for PUTW slab

PUTW slabs have to be durable enough to withstand the construction loads, traffic load as well as environment loads. However, the slabs are so thin to accommodate any reinforcement meshes. Therefore, Engineered Cementitious Composite (ECC) is used.

ECC is a unique type of high performance fiber-reinforced cementitious composite. The most distinctive characteristic of ECC is high tensile ductility which is achieved by the formation of multiple micrograds (Figure 6). The flexive strength of ECC in this study is more than 10 MPa.

For pavement skid resistance, the use of CORUNDUM aggregate in ECC mixture significantly increases surface skid resistance. Based on the tests using wheel tracking machine and Britle Pendulum tester, the surface skid resistance is expected to last for the whole pavement lifetime without any further intervention (Figure 7). The upwards tendency of dry BPNs can be explained by the amount of fines and fibers on the surface after wheel tracking tests, however these were removed during wet skid resistance tests, therefore, BPN curve goes down as usual.



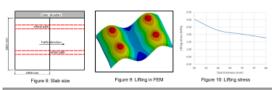


cal unlaxial tensile stress-strain curve Figure 7: Long-term skid resistance performance of ECC with corundum

PUTW pavement development

PUTW Slab size

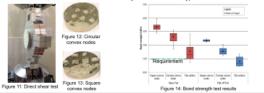
PUTW slab size is chosen based on overall pavement system performance and slab handling. Lifting stresses calculated using FEM are far below the ECC flexure strength (figure 10). Therefore, PUTW slab size is chosen to be 3600 mm (one lane width) x 2400 mm (restricted by transport vehicle size in Singapore).



Interface bonding in PUTW

There are two bonding interfaces in PUTW: PUTW slab – grout and grout – asphalt. The interface grout – asphalt is very similar to fresh concrete bonding to asphalt in UTW, where the required bond strength (1 MPa) is achievable in good UTW practices.

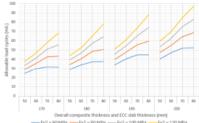
Based on the laboratory tests, the bond strength requirement for the interface PUTW slab – grout is fulfilled by any types of slab's bottom surface. However, due to the inconsistency of samples with a flat surface, it is recommended to use only the converse for PUTW slabs.



PUTW performance analysis

Calibrated nonlinear three dimensional 9 slab multilayer FEM is used to evaluate the performance of PUTW taking into account both traffic and environment loads.

Maximum possible stress of 4 MPa in PUTW slab under combined traffic and environment loads is far below the flexure strength of ECC. Therefore, the overall PUTW performance is dependent on asphalt laver.



Ey2 = 60 MPa — Ey2 = 80 MPa — Ey2 = 100 MPa — Ey2 = 120 MPa Figure 15: Allowable load cycles of PUTW in relation with slab thickness, composite thickness and support layer's equivarient modulus

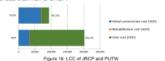
Life cycle cost analysis (LCCA) of PUTW

The alternative pavement for LCCA is Jointed Reinforced Concrete Pavement (JRCP) used in Singapore context.

With the help of the state of the art microscopic traffic simulation tool, user delay cost was estimated for a selected case study area.

PUTW has higher initial construction cost however due to rapid installation, its user cost is far less than the cast-in-place candidate.

The LCC of PUTW is less than half of JRCP.



PUTW fabrication and construction

The PUTW slab fabrication and construction is similar to common practice in precast concrete pavement without any steel reinforcement and load transfer devices. Asphalt surface preparation is similar to Ultra-Thin Whitetopping practice.

Results and Conclusion

- ECC is a high performance material for PUTW slab. And with the use of corundum in the mixture. ECC also provide high long term skid resistance performance.
- PUTW slabs with convex nodes at the bottom fulfills the requirement for interface bonding
- Overall performance of PUTW is at least about 25 years under Singapore traffic condition.
- · PUTW can be much more economics solution compared to conventional concrete pavement

The research focused on developing the PUTW pavement system in Singapore. The results show that PUTW is a cost effective, quickly constructed and durable pavement system that can help to tackle the current issues about long lane closure time and complicated transition pavement at heavy traffic junctions.

Full-scale field trial plan

JTC Corporation (JTC) Singapore will sponsor a three year project for full-scale laboratory testing and field trial

Full scale study will focus on construction techniques, quality of construction work, and parameters such as weather conditions and their impact on pavement performance especially interface bond performance and long term ioint performance.



Figure 17: PUTW at junction

References

LTA, 2015. Standard Details Of Road Elements (SDRE). Singapore: LTA.

Nen NguyenDinh, Teron Nguyen, En-Hua Yang, Bernhard Lechner, 2016. Life Cycle Cost Assessment of Engineered Cementitious Composite (ECC) Precast Pavement in Singapore. In 11th International Conference on Concrete Pavements

Acknowledgement

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Things TBD

- Is it actually doable?
 - Precast patching is becoming an alternative in IL. Yes!
 - Cost is high relative to conventional paving, but meets a particular need
- Can we build it smooth w/o grinding?
- Is this a solution looking for a problem?
 - Maybe we don't need it
 - Open to better ideas, but this one may have a place



Conclusions

- Speed of execution is the last big hurdle for concrete pavement
- Commercial entrances are manageable using other "hardware" solutions
- Combining the best of precast and slipform paving solutions may provide opportunities for concrete solutions to those problems
- We just need to think different about our business!





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Thank you for your time!



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Graphic Element Working Slide

