

SWIFT- CAPTG 2012

**BEST PRACTICES IN AIRFIELD CONCRETE
PAVEMENT MAINTENANCE**

PARTIAL AND FULL DEPTH PATCH REPAIRS


*Hakan Ekim
Teknika Inc., Toronto*

September 18, 2012
Banff, Alberta




Requirements

- Quick Repairs with no or minimum closures or operational delays
- High Quality and long lasting patch repairs. They do not wish to return to the repair in a very near future
- No premature failure . FOD !



Major Challenges

- Proper education of the maintenance personnel to ensure work is done as per manufactures specs.
- Not having enough data or successful case histories.
- Lack of mutual understanding in between various parties involved >> Communication??



Common denominator

It is widely accepted that effective repairs will become increasingly important as many airports may not receive the funds needed to carry out major rehabilitations or re-construct distressed pavements



Engineering and maintenance managers can utilize a variety of pavement repair options to extend the useful life of their pavements.

There is already enough knowledge and experience to perform proper pavement repairs.

Available materials and techniques are well established and proven but yet somehow not adapted.

Transport Canada Survey

Report No: AARMEC/ C-02-04 Revision, Nov.2002

Survey was made to produce :

"Pavement Preservation Catalogue for Canadian Airfields"

This extensive work was based on literature survey and review of pavement preservation practices of Canadian Airports based on the results and repair practices survey



No field performance studies issued by or for Canadian Airports were located

Only 26 out of 70 operators responded



Recommendations of Transport Canada

- The content of the Catalogue should be enhanced by the inclusion of additional technical and engineering reports that could not be located, and by the inclusion of new reports as they become available. The content of the Catalogue should also be enhanced as new pavement preservation technologies are developed and additional technical information is uncovered.
- To obtain additional technical reports and information from Canadian airport operators and from the Canadian engineering consulting industry will require considerable effort.

We do need to overcome these managerial issues and difficulties.

We are facing a great challenge which is not only the maintenance of the assets but also the necessity to use existing facilities beyond their design lives simply due to economic and environmental conditions.



Transport Canada ERD 121 (no longer updated)

Type of defects are well defined .

Defects are rated as Low, Medium, and High severity

Extent of repairs classified in between 0 and 4
(4 being extreme worse case)

Condition Rating is obtained

(PCN,LCN,Friction Values not included not a full assesment)



Transport Canada Defect Classifications(ERD 121)

- Panel Cracking
- Corner Cracking
- Edge Cracking
- Scaling and spaling
- Joint faulting and sealant failure
- Surface Cracking
- D cracking
- Pumping
- Compression buckling



Panel Cracking (L)



Corner Cracking (M)



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Edge Cracking (L,H)



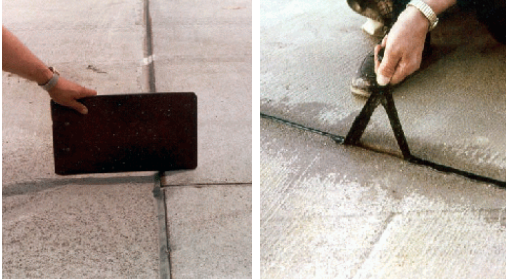
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Scaling/Spaling



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Joint Faulting(M)/Sealant Failure(M)



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Surface Crazing (M)



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“D” Cracking



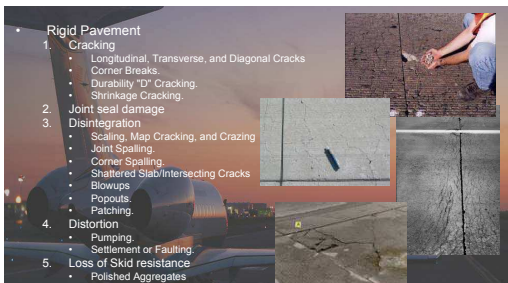
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Pumping (M) / Buckling(H)



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FAA AC 150/5380-6B Chapter 3 Rigid Pavement Distresses (2007)



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The Keys to success of patch repairs of PCC pavements

MUST HAVE GOOD AND SOUND PAVEMENT MANAGEMENT SYSTEM IN PLACE

- 1- Understand the cause of the problem,
- 2- Have realistic expectations,
- 3- Correct selection of materials and methods according to operational conditions,
- 4- Surface preparation,
- 5- Application and supervision

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Selection of the repair material depends on:

- Ambient temperature
- Time required for early trafficking, return to service
- Size and depth of repair
- Product performance
- Compliance with specified properties
- Previous good experience
- Cost effectiveness and delivery
- Technical support from the manufacturer

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Selection of appropriate repair materials

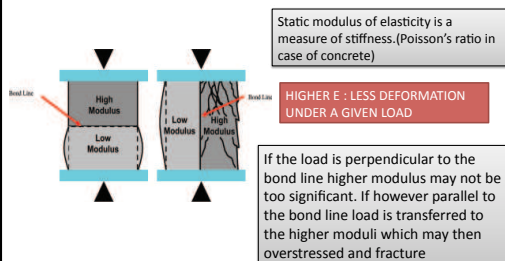
The perfect repair product should have physical, chemical and mechanical, properties, similar to the parent concrete.

Dimensional compatibility of repair material is very important.

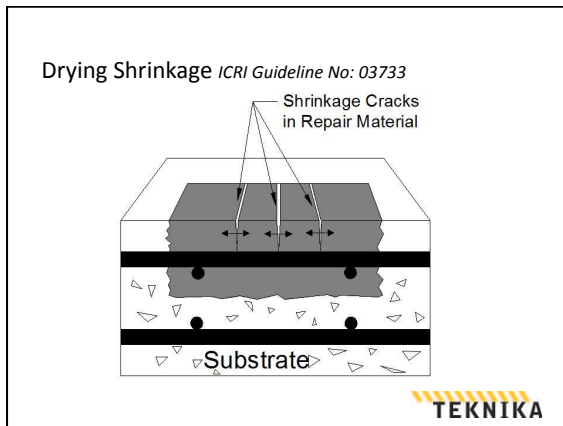
- The ideal repair should have a modulus just lower than the parent concrete
- The repair should have thermal expansion similar to the parent concrete
- The repair should have shrinkage lower than the parent concrete
- The repair should have strength just greater than the parent concrete

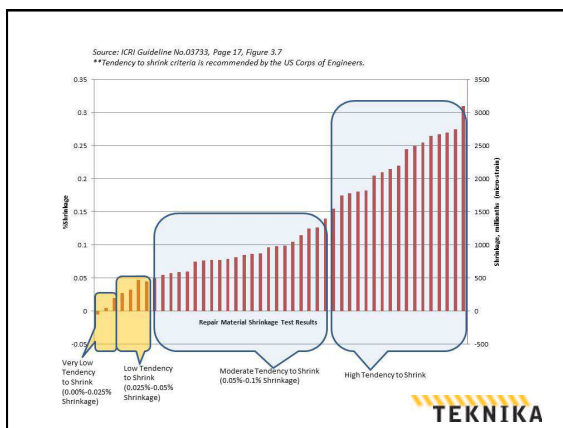
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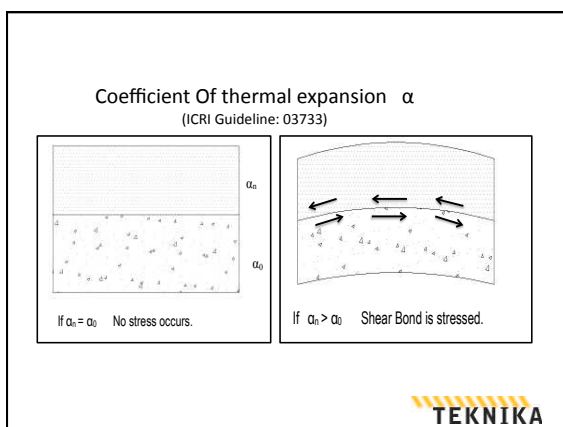
Importance Of Modulus of Elasticity







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Performance Requirements	Undesirable Response (results if wrong material is selected)	Desirable Properties
Ambient temperature changes	 Cracking in repair material due to thermal contraction stresses	Thermal coefficient similar to that of substrate
	 Spalling due to thermal expansion stresses in substrate	Thermal coefficient similar to that of substrate
Temperature changes within repair material at early ages	 Deformation due to thermal expansion from high exotherm	Low exotherm during cure
	 Cracking due to thermal contraction stresses in repair material	

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Coefficient of thermal expansion for concrete is $11 \times 10^{-6}/^{\circ}\text{C}$.

ACI 503R → Polymeric Materials → Coefficient of Thermal Expansion is 4–11 times greater than Concrete

Therefore polymeric materials will expand/contract more than the substrate.

When movement is restrained stress is induced at the bond line

Very Important especially for large patch repairs (>2m²)

PROBABLY THE MOST IMPORTANT CRITERIA WHEN SELECTING PATCH REPAIR MATERIALS

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Texas A&M University System, Project 0-5110-S
Best Practices for Concrete Pavements (Ref :10)
Dan Zollinger, David W. Fowler, Anal Mukhopadhy

Looked at 10 different materials commercially available materials.

Modulus is the larger influence on strain due to temperature change. The thermal stresses induced at the interface between the concrete and repair material should be compared to the bond strength which resists the stress.

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Selection of patch repair method

If the damage is confined to the top 1/3rd of the slab, then **partial depth patch repairs** can be OK



If the damage goes deeper than the top 1/3rd of the concrete slab, or reaches dowel bars, then **full depth patch repairs** must be carried out

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Available Repair Materials

• Cementitious Materials

Portland Cement Concrete with an accelerator

Calcium Aluminate Cement

Magnesium Phosphate Cement

Latex Modified Cement or PMC

• Hot Mix

Resin Based

Epoxy based mortars

Polyurethane based mortars

MMA (Methyl Methacrylate) mortars

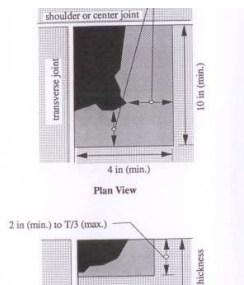
Polyester based repair mortars

Polyurea's and Vinyl Concrete

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Partial depth repair of concrete pavements (1)

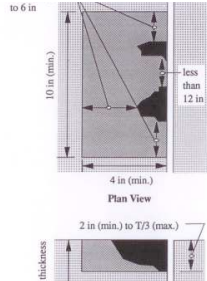
- Remove all deteriorated and/or delaminated concrete as shown by survey and indicated by paint lines in accordance with preferred method of removal
- Ensure size of repair is at least 50mm beyond damaged areas
- The perimeter of the repair should have a vertical face and should not be feather-edged.
- This can be done by saw cutting (preferable method) or milling.
- Joint preparation including an appropriate bond breaker is required at joint/crack edges



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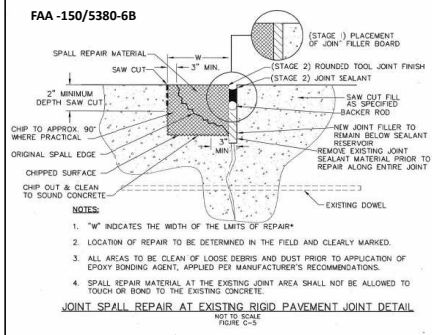
Partial depth repair of concrete pavements (2)

- Clean concrete surface by water jetting or high pressure air blast
- Mix the repair material using a forced action mixer
- Apply the repair material in accordance with manufacturers instructions
- Compaction of repair material
- Finishing the repair, providing skid free surface by steel tine brush
- Cure the repairs with a curing membrane with min 90% curing efficiency
- Partial depth repairs at joints must include sealing joints when finished



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FAA -150/5380-6B



NOTES:

1. "W" INDICATES THE WIDTH OF THE LIMITS OF REPAIR*
2. LOCATION OF REPAIR TO BE DETERMINED IN THE FIELD AND CLEARLY MARKED.
3. ALL AREAS TO BE CLEAN OF LOOSE DEBRIS AND DUST PRIOR TO APPLICATION OF EPOXY BONDING AGENT, APPLIED PER MANUFACTURER'S RECOMMENDATIONS.
4. SPALL REPAIR MATERIAL AT THE EXISTING JOINT AREA SHALL NOT BE ALLOWED TO TOUCH OR BOND TO THE EXISTING CONCRETE.

JOINT SPALL REPAIR AT EXISTING RIGID PAVEMENT JOINT DETAIL
NOT TO SCALE
FIGURE C-3

Full depth repair of concrete pavements (1)

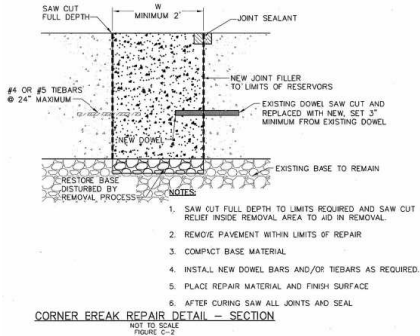
- Remove all deteriorated and/or delaminated concrete as shown by survey and indicated by paint lines in accordance with preferred method of removal
- Ensure size of repair is at least 100mm beyond damaged areas
- The perimeter of the repair should have a vertical face and should not be feather-edged.
- This should be done by saw cutting
- Joint preparation including an appropriate bond breaker is required at joint/crack edges
- Check the sub-base for soundness and if necessary, compact with a vibrating plate

Full depth repair of concrete pavements (2)

- Provide dowels or other load transfer mechanisms at edges
- Mix the repair material using a forced action mixer or use ready mixed concrete
- If using a prebagged material, use good quality aggregates for bulking out in accordance with manufacturers instructions.
- Apply the repair material in accordance with manufacturers instructions
- Compaction of repair material
- Finishing the repair, providing skid free surface by steel tine brush
- Cure the repairs with a curing membrane with min 90% curing efficiency

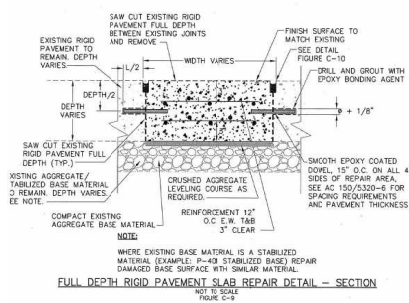
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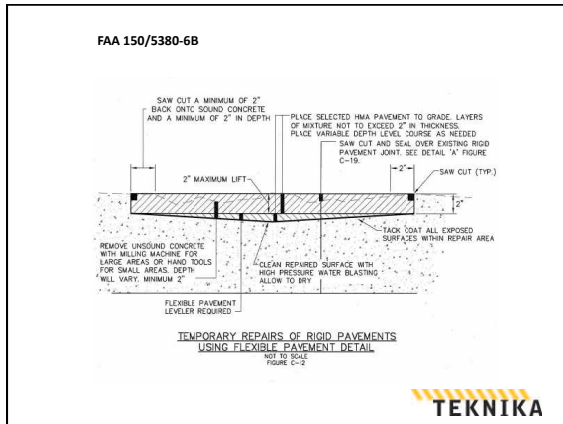


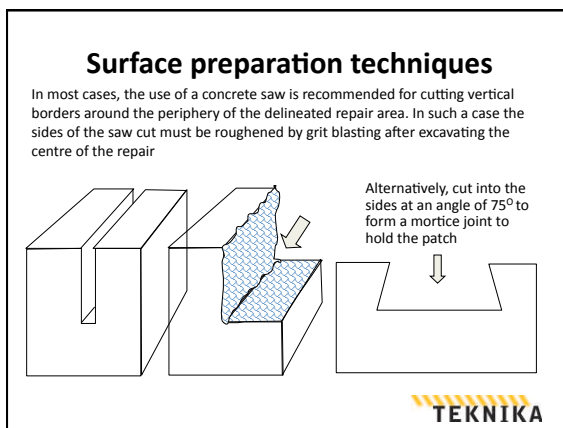
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Surface preparation techniques

- For partial depth repairs, the use of jack-hammers are NOT recommended. The impact causes micro-cracking in the concrete and shattering of aggregate. This results in poor bond and may lead to delamination of the repair.
- Jack-hammering may be used for full-depth repairs provided that the repair area is isolated by saw cutting.
- Ultra high pressure water blasting is the preferred method for partial depth repairs. There is no vibration to damage the freshly exposed concrete surface and key is better.
- Cold-milling is a good method for removing large areas of concrete but if the concrete is weak, the aggregates may be pulled out of the bonding interface and weaken adhesion.

This is not surface preparation !!



NO !!!

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Expedient Spall Repair Methods and Equipment For Airfield Pavements

Michael I. Hammons & Athar Saeed

Document No : AFRL-RX-TY-TP-2009-4552

Airforce Research Laboratory, Airforce Materiel Command, Tyndall Airforce Base FL

Selected equipment and procedures were evaluated to expedite repair of spalls with rapid setting materials. The objective was to develop one or more methods to excavate and prepare a 2-foot-wide by 2-foot-long by 4-inch-deep spall for placement of a rapid-setting repair material in 15 minutes or less. A secondary objective was to correlate various excavation methods with a relative life expectancy of the repair. For five excavation methods, 2-foot-wide by 2-foot-long by 4-inch-deep spalls were excavated in triplicate. The spalls were subsequently repaired using a commonly-used rapid-setting cementitious repair material.

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Findings of *Hammons and Saeed*

- Most efficient method was the Cold Planer. 58% more efficient than jack hammers.
- Second efficient method was gang saw
- Only Cold Planer was able excavate 2'x2'x4" area in 15 minutes
- GREATEST MEAN PULL OFF STRENGTH WAS FOR THE COLD PLANAR (IN BOTH PRE AND POST TRAFFICKING .
- OTHER METHODS WERE 1/3 OF THE COLD PLANAR



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Surface preparation techniques



High pressure water blasting



Milling machine and drum

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Abrupt Slope changes must be avoided
 Reference: Dept. of the Air Force.,Engineering Technical Letter ETL 07-08






Figure 7. Repair with Abrupt Slope Change
 (Not Recommended)

Figure 8. Repair without Abrupt Slope Change

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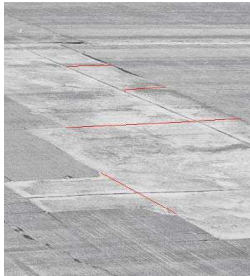
Ensure size of repair is at least 50mm(2") beyond damaged areas. ??????






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Large repairs, red lines added where saw cuts should have been made
 Reference: Dept. of the Air Force.,Engineering Technical Letter ETL 07-08

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National Concrete Pavement Technology Centre
Guide For Partial Depth Repair of Concrete Pavements
April 2012
Iowa State University Publication







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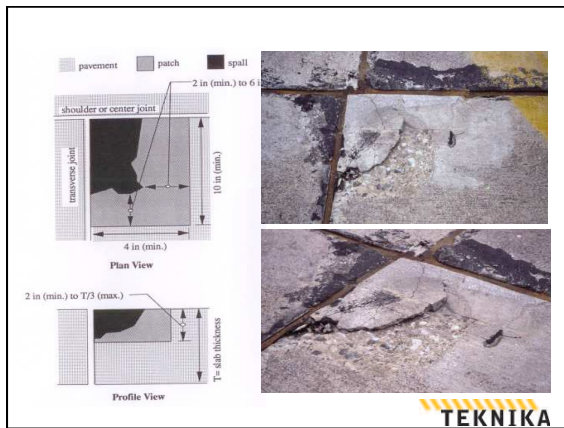


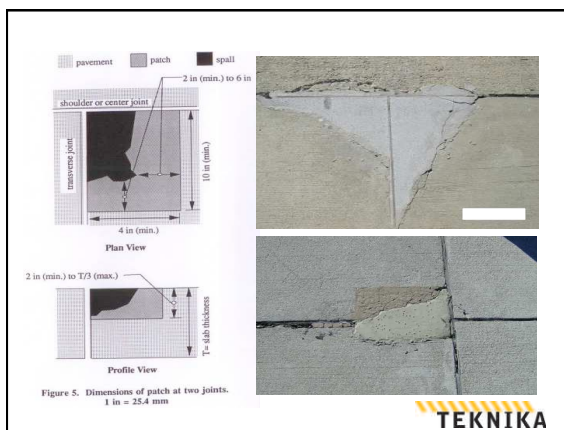
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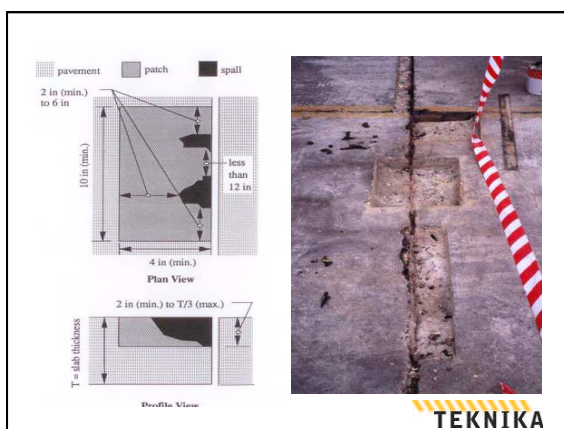


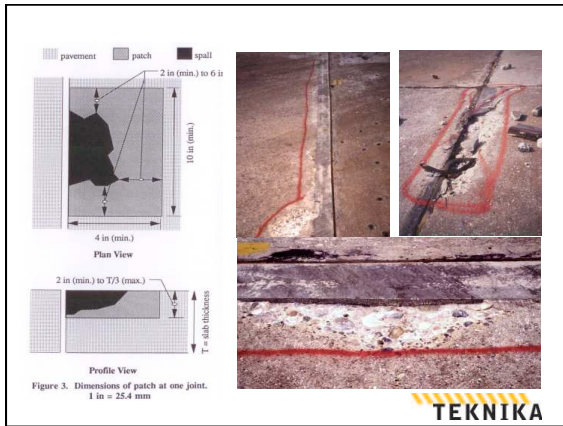
This could only be temporary repair and needs to be monitored closely to prevent FOD

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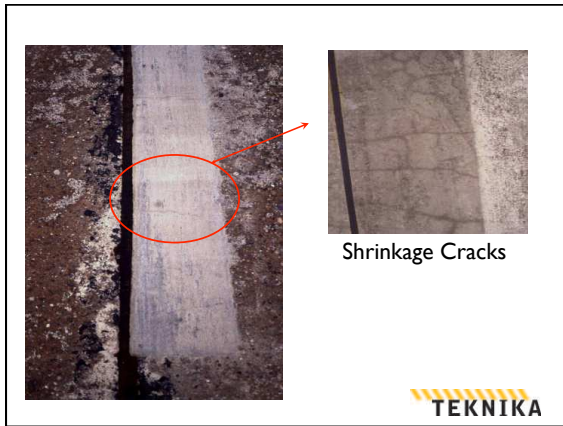
















Some recommended repair techniques



Coring is an excellent technique for preparing patch repairs



Cored corners of patch repairs



Popout cored and filled

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Proper Mix Consistency



Patched repair



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Patch Size?



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**NEW ICRI GUIDE
& EUROPEAN REPAIR GUIDE**

Guideline for Inorganic Repair Material Data Sheet Protocol.
Guideline : 320.3R-2012

EN 1504 -2006 : European Repair Specification

Resources

1. *Guide for Selecting and Specifying Materials for Repair of Concrete Surfaces*
ICRI ,International Concrete Repair Institute,
Technical Guidelines, Guideline No:03733
2. *Guidelines and Procedures for Maintenance of Airport Pavements.*
FAA Advisory Circular,AC No: 150/5380-6B-2007,
3. *Expedient Spall Repair Methods and Equipment for Airfield Repairs*
Michael I Hammons,Air Force Research Laboratory and Athar Seed,Applied Research
Associates.
Airbase Technologies Division, Air Force Research Laboratory, Air Force Material Command,
Tyndall Air Force Base FL.
4. *Engineering Technical Letter 07-08:Spall Repair of PCC Airfield Pavements in Expeditionary
Environments,*
Department of The Air Force,
AFCESA/CEO,Tyndall AFB, FL



Resources

5. *Guide for Partial Depth Repair of Concrete Pavements*
National Concrete Pavement Technology Centre,IOWA State University, Institute for
Transportation . April 2012
6. *Pavement Preservation Catalogue for Canadian Airfields.*
Report No: AARME/C-02-04
The Technical Evaluation Engineering Division
Aerodrome Safety Branch
Transport Canada, Ottawa, Ontario, November 2002
7. *Guidelines Respecting Airport Pavement Structural Condition Surveys*
Engineering Reference Document ERD 121 January 2004
Transport Canada, International Aviation & Technical Programs Branch, Engineering Division
Ottawa, Ontario.
8. *Maintenance and Repair of Airport PCC Pavements*
Engineering Reference Document ERD 125-02, November 2004,
Transport Canada, International Aviation&Technical Programs Branch, Engineering Division
Ottawa,Ontario.



Resources

9. *Materials and Procedures for the Repair of Partial Depth Spalls in Concrete Pavements*
Concrete Pavement Repair Manual of Practice
Strategic Highway Research Program, SHRP-H-349
National Research Council
10. *Investigation of Spall Repair Materials for Concrete Pavement:Summary Report*
Report No :0-5110-5 May 2006
Dan G.Zollinger,David W.Fowler,Anal Mukhopadhyay
Texas Transportation Institute,The Texas a&M University System



THANK YOU


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