Joint Filler Separation on RETAILER Colored Slab Projects

- *Causes of Separation and Current Control Attempts*
- *Intent of Current Specification vs. Experiences in the Field*
- *Results of Case Study Involving Separation Repair*
- *Recommended Changes for Handling on Future Projects*

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Introduction

From the inception of the RETAILER Exposed Slab Store Program, the potential for joint filler separation and its correction has presented a major challenge with no easy solution. Joint filler separation, as with many elements in the exposed slab project, presents dual concerns over both floor durability and aesthetics. Accepting the fact that under ideal conditions the joint filler will always be installed "too early" on the store projects, and recognizing that no construction program of this magnitude can be expected to achieve "ideal" conditions on every project, we feel the only practical option is to accept that filler separation will likely be the rule rather than the exception and address the issue accordingly. We hope to provide all parties involved in this program with a better understanding of the challenges faced and the possible solutions based upon our knowledge of joint fillers and their behavior and based upon the actual project experiences of our field personnel and our approved filler applicators.

Cause(s) of Joint Filler Separation

Joint filler separation is a result of saw cut contraction and construction joints "opening" beyond the filler's lateral movement capability during the slab shrinkage process, as excess moisture leaves the slab mass. This joint opening process occurs primarily within the first year after slab placement. Semi-rigid joint fillers are formulated to be moderately rigid in order to avoid deflecting under load and exposing joint edges to impact from vehicle wheels. Because these fillers are moderately rigid, their lateral movement capability is limited. If the control/contraction joints open in excess of the lateral extension capability of the filler, the filler will break bond or separate either adhesively (filler-to-concrete) or cohesively (within the filler itself). Semi-rigid fillers are formulated with low to moderate adhesive strength and tensile strength in order to avoid "welding" or restraining the slab panels and tearing concrete during the shrinkage process.

The following excerpts from ACI Report, 302.1R-04 address this issue:

> *If the joint should be filled before most of the shrinkage has occurred, separation should be expected between the joint edge and the joint filler, or within the joint filler itself.*
>
> ……
>
> *Earlier filling will result in greater separation, and will lead to the need for more substantial correction; this separation does not indicate a failure of the filler.*
>
> *ACI 302-1R-04 Page 61*

Minimizing the Occurrence of Joint Filler Separation

Accepting the fact that some degree of joint filler separation is likely on most projects, the goal is to work to minimize the extent of the separation rather than to attempt to eliminate it all together, as such efforts are likely going to prove fruitless and cost prohibitive. The three key areas to consider when attempting to minimize the occurrence of separation are as follows:

A. *Joint Spacing*

Reducing the spacing between saw-cut joints will reduce the amount of anticipated opening which will occur within each joint as a result of slab shrinkage. The joint spacing has already been reduced during the RETAILER construction program in an effort to minimize separation. While further reducing joint spacing could lead to a further reduction in anticipated separation, this would lead to increased costs in the slab construction and the cost/benefit ratio of such a revision may not be favorable. Additionally, further reductions in spacing would not guarantee the complete elimination of separation if other factors cannot also be tightly controlled, such as filler installation timing and the guarantee that every saw-cut joint functions as designed.

B. *Filler Installation Timing*

The American Concrete Institute recommends that joint filler installation be delayed 60-90 days, or as long as possible, after slab placement to allow for slab shrinkage and to allow the joints to open to their ultimate dimension. ACI further recommends an absolute minimum slab cure of 30 days and that the room be stabilized at ultimate operating temperature for a minimum of 7 days prior to installing joint filler. The current RETAILER specification calls for a minimum 30 day slab cure and 14 day temperature stabilization, but our experiences in the field and through interviewing installers show that these minimums are rarely achieved, at least throughout the facility, on a majority of store projects due to construction scheduling conflicts or other considerations. Meeting or exceeding the specified minimum slab cure on the store projects prior to filler installation commencement is probably the single most effective method available towards reducing filler separation occurrence, but again we recognize that multiple considerations and cost/benefit formulas come into play on this issue on any given project.

C. *The Use of a More "Flexible" Filler*

Note: We do not consider this a viable option in the RETAILER store construction program as the trade-offs are likely to be very unfavorable and this is only being addressed here as it is a theoretical method of reducing separation and because we understand that the possibility has been considered at various times during the program.
The two semi-rigid fillers currently specified range in Shore hardness from A90 to A100+. ACI recommends that joint fillers used in concrete floors subject to wheeled traffic have a minimum hardness of A80+. While in theory the use of a filler with a lower Shore A hardness (i.e. "softer" than the current fillers) could lead to less separation, we believe the anticipated reduction in separation which would be achieved would be negligible, even when moving all the way down the hardness scale to an elastomeric "sealant" rather than a filler.

The main reasons we feel that this approach is not viable are:

a. Semi-rigid joint fillers with a marginally lower hardness would not likely provide meaningful gains in lateral movement capability, and potentially would not provide adequate joint edge protection, the primary goal of the joint filler.

b. Elastomeric-type "sealants," despite their substantially lower hardness and increased flexibility, can only achieve meaningful gains in lateral movement capability when installed at the proper aspect ratio (i.e. ½ depth of width over backer rod), and installation of these products in a standard saw cut joint on these projects is impractical as the joint dimensions do not allow for proper installation. Further, the elastomeric "sealant" would provide no structural joint edge support or load deflection capabilities so joint edge deterioration would likely occur.

Treatment of Filler Separation and its Repair in the Current Specifications

Because separation occurs to some degree on virtually every project, we feel it needs to be addressed more comprehensively in the initial construction specifications. In summary, the current specification stipulates only the following in relation to joint filler separation:

- *Filler separation should be repaired 7 days prior to grand opening*
- *Filler separation should be repaired by the joint filler installer*
- *Filler separation should be repaired with a low viscosity version of original filler used or a color matched semi-rigid polyurea from filler manufacturer*

Based upon extensive applicator interviews, project experience, and separation repair material sales, our strong belief is that separation repair/refill actually being performed on a store project is by far the exception rather than the rule. We estimate that truly comprehensive separation refill occurs on perhaps 10% or fewer of the store projects, whereas some degree of separation probably occurs on 100% of these projects.

The main reasons we believe filler separation is not being performed as specified include:

A. *"Filler separation" is not defined in the specification.*
The current specification indicates that separation voids should be refilled 7 days prior to grand opening. But "separation voids" and what constitutes "correctible" separation voids, are not defined, potentially leaving judgment of what should be repaired in the hands of multiple parties with no clear final authority. On some projects applicators have been told that separation only needs to be fixed if it exceeds 1/32" in width. On other projects applicators have been told to refill "hairline" separations that could not practically be refilled. The current specification does not indicate what constitutes filler separation, what determines whether it needs to be refilled (i.e. specific width, locations, etc.) …or who determines whether it needs to be refilled (i.e. GC or RETAILER PM, etc.).

B. *Timing of separation repair is not practical based on store construction schedule.*
The current specification indicates that the repair/refill take place 7 days prior to grand opening. Our experiences to date have shown that on most projects:

- Too many other construction activities are occurring at this time to make repair practical. Often the store is being racked or stocked and the densifier applicator is also performing work. The activities of these other trades and the urgency of preparing the store for opening prohibit the installer from effectively repairing substantial portions of the floor.

- Repairs performed with the previously specified "LV" fillers required that other trades stay off joints for 8-12 hours, which was often impractical given the other operations taking place prior to opening. The addition of polyurea fillers as a repair option has improved this access issue, but the awareness of this option and/or its reflection in the project specifications on any given store are only now being seen and will still require cooperation from all other building trades during the repair process.
- The timing of the separation repair called for is often too close to the timing of the last slab pour and/or the original joint filling installation to provide much long-term performance benefit. While the planned project schedule should have the joint filling completed 30 or more days prior to grand opening (and thus 21 days or more prior to scheduled separation refill), on many of the projects we've been involved the filling work is being completed within 2 weeks or fewer prior to grand opening, leaving little time for the filler to separate prior to "scheduled" filler separation repair. As a result, there is often no separation to repair until several weeks later…after the store is open.

- On many projects, the general contractor has released the filling applicator from his responsibility to repair separation in exchange for the applicator agreeing to install filler prior to the required 30 day slab cure. We do not know whether this is done with the consent of the RETAILER project authorities or not but do know it happens somewhat routinely.

C. *Many general contractors do not understand separation and its causes and as a result do not appropriately assign value to separation repair when awarding the filler contract.* In speaking with our applicators, they believe that most general contractors they bid to have little or no knowledge that separation is to be corrected as part of the contract. Thus, they assign little or no value to this aspect of the applicator's bid. This means that many well intentioned applicators, who rightfully allocate money in their bid intending to repair separation, get overlooked simply because their bid is higher than an applicator who does not allocate for this contingency. Applicators who do not allocate money for separation repair either are not bidding per specification or may well be taking a calculated risk based upon past experience in knowing that the GC will expect or know that the repairs should be performed.

D. *Some applicators refuse to perform separation repair or perform only minimal repair because the separation results from circumstances beyond their control, such as:*

- GC requests filling work to take place too early, sometimes as early as 7 days after slab placement, leading to extensive separation.
- Separation occurs as a result of slab curl or other structural issues, such as improper joint activation, etc.
- GC or other project authorities will not provide applicator access to areas which require repair or assist in keeping other trades off repair areas.

E. *Separation Repair Method is Not Defined*
This in part goes back to the issue of separation not being defined and the specification merely calling for "separation voids to be refilled." Separation repair is generally best performed in two main ways:

a. Gravity feeding material into the voids
b. Re-sawing/removing the top ¼" - ½" of existing filler and refilling joint

Generally the most successful repair method is removing and replacing material, but it is also the most time consuming, and if not done properly, risks damage to the joint edges during re-sawing. The best method on any given project will be determined by the type and degree of separation, but currently the specifications give no guidance on this issue. Also not addressed within the specification is whether a stain prevention film needs to be re-applied prior to separation repair to prevent possible slab staining from repair material.

Case Study – Various Separation Repair Methods Utilized and Monitored

Because we feel that joint filler separation and its repair is a critical long term challenge faced within the joint filling scope of the RETAILER Store Construction Program, we have conducted a comprehensive six-month study on an actual RETAILER Store project to test and monitor various separation repair products and repair methods to determine their likely short-term and long-term success. We feel that the project where this case study was conducted represents a "typical" RETAILER Store project.

Our primary goals in conducting this case study were to:

1. Determine Ideal Separation Repair Timing
2. Determine Ideal Separation Repair Method
3. Determine Ideal Semi-Rigid Separation Repair Material

Project Name and Location: RETAILER Store #5540 Clackamas, OR

Project Conditions:

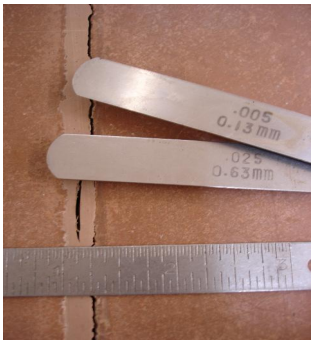
Approximate Slab Cure at Time of Filler Installation: **43 Days in test area**
(Note: other areas had 30 days or less, we chose 43 day area to reflect an area consistent with the schedule specified.)
Approximate Slab Cure at Time of First Separation Repair: **80 Days**
Approximate Joint Spacing: **12'**
Unusual Joint Conditions Noted: **Some Degree of Minor Curling**

Separation Repair Timing

For the purpose of this case study and for practical reasons, we elected to perform the separation repairs at the specified time (approx. 7 days prior to opening). Both the timing of the filler installation and the separation repair represented a project that was being constructed within the bounds of the schedule called for in the specification.

Separation Void Details

The separation voids which occurred on this project were fairly standard, but represented the most noticeable separation in the project and were wider than many other voids observed. The voids occurred both cohesively (within material) and adhesively (filler-to-joint wall) and had an average width of .030" (approximately credit-card width and the standard that has been sited as requiring correction on previous projects we've encountered). Average joint width was 3/16"-1/4", again fairly typical. *See photo at right.*



Typical separation void to be repaired was .030" wide +/-

Note: A project with 10' joint spacing would be expected to exhibit slightly narrower voids and joint width.

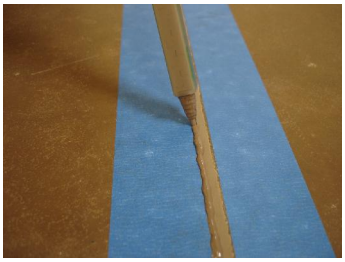
Separation Repair Method One – Gravity Feeding

For this trial, we performed separation repair by gravity feeding two lower viscosity semi-rigid materials currently specified for correction into the separation voids: *Mocha MM-80 LV (Epoxy)* and *Mocha Spal-Pro RS 88 (Polyurea).* This is the most widely reported method used on the projects where our applicators have refilled separation voids. We used removable tape to prevent potential slab staining and to measure approximate material spread and usage during the repair.

Edges Taped to Avoid Staining

Advantages of Gravity Feed Repair:

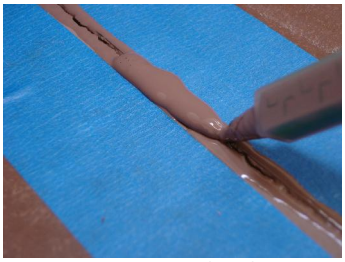
- *Minimal defect preparation required (assuming voids are relatively clean and dry).*
- *Minimizes risk of damage to floor slabs*



Spal-Pro RS 88 Mocha Polyurea is gravity fed into the voids.

Disadvantages of Gravity Feed Repair:

- *Requires reasonable void width for optimal filler penetration and long term success (.020 or greater)*
- *Because of the random pattern of separation, production is minimal if attempting to follow and fill narrow void.*
- *Material penetration can be inconsistent depending upon void dimension and cleanliness, so voids may require continual monitoring and some of the applied material is "wasted" through overfill.*
- *If the LV Epoxy repair filler is utilized, a significant cure time, typically 8-10 hours, will be required before repair areas can be opened for traffic.*
- *Depending upon repair material and the age and color of original filler, contrasting colors may be noted between the materials, leading to potential aesthetic concerns.*
- *Void must be clean and free of debris for material to effectively penetrate and bond. Void cleaning methods are difficult and slow and could lead to dust issues in an open store environment.*



Multiple applications of the filler may be required as seepage occurs.

After RS-88's initial cure (approx. 15 mins) excess material is razored off.

Summary

Gravity feed refill may be a viable option in stores exhibiting clean, consistent patterns of moderate to wide separation and flush filler profile. It could be the first method of repair tested and could be abandoned in favor of removal and replacement method (noted later) if this method proves too slow, difficult, or if contrasting colors differences occur and are objectionable.

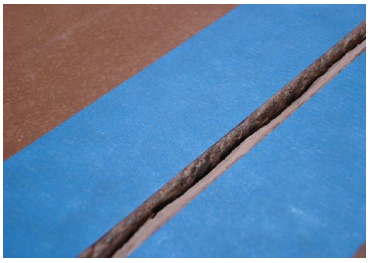
Finished repair after razoring

Separation Repair Method Two –
Partial Filler Removal and Replacement

For this trial, we performed separation repair by partially removing the installed, separated MM-80. We used a joint cleanout saw and a right angle grinder, both equipped with a tightly braided wire wheel, to remove the existing filler to a nominal depth of 3/8" to ½" below the slab surface. The newly created channel was then refilled with Mocha Spal-Pro RS 88 and shaved flush after cure.

Portion of existing filler is removed Using a dustless joint cleanout saw.

We consider the removal and replacement method the most effective method of ensuring a consistent, quality filler separation repair which offers the best chance of long term success, both aesthetically and functionally. *But*, the removal and replacement method may present challenges if performed in an open store environment due to equipment use. Also, this method presents a greater potential for joint edge damage if the removal of original filler is performed by an unqualified or inexperienced contractor.



Removal process creates new, clean channel for filling within the joint.

Advantages of Removal and Replacement Repair:

- *Maximum productivity is achieved by consistent filler removal assisted by power equipment and yielding a clean, consistent channel for refilling.*
- *Maximum consistency in performance and appearance of finished repair, no concerns with color differences between original and replacement material.*

Spal-Pro RS-88 is installed in as in new joint. Seepage monitored during cure.

Disadvantages of Removal and Replacement Repair:

- *Considerably more noise and a more "noticeable" operation in an open store than gravity feed method.*
- *Some potential for dust but manageable.*
- *Potential for joint edge damage during the filler removal process if performed by inexperienced contractor; also has potential to expose and widen inherently weak joint edges even in the hands of an experienced contractor.*
- *May require more material than gravity feed method.*

Finished repair after razoring

Summary

Removal and refill method is likely the only practical option on projects where voids are narrow (i.e. hairline or slightly larger) and frequent or where existing filler profile is low in addition to exhibiting separation. Interference to open store operations would have to be minimized through careful management of repair operation and work would likely have to be performed at off-peak hours.

Post-Separation Repair Monitoring in on Case Study Project
After performing separation repairs using the two methods previously discussed with both the MM-80 LV (epoxy) and Spal-Pro RS 88 (polyurea), the repaired areas were monitored over a period of 180 days to determine whether the original separation repair timing was appropriate and whether one repair method or product lead to distinctly greater success than the other.

Repair Method: Gravity Feed Separation Repair
Initial Filler Placement: 43 days after slab placement
Repair Timing: 80 days after slab placement
Repair Product Utilized: Mocha Spal-Pro RS 88

13 Days After Repair Performed (93 days after slab placement)	**70 Days After Repair Performed (150 days after slab placement)**
	
Observations: Separation repair area visually evident but repair is successful.	Observations: New separation voids occur despite nearly six month slab cure. Voids do not occur where original void repair was performed.

Repairs performed using both methods and materials appeared to yield similar results and appeared to be successful. But, a major limitation of the repairs was that they did nothing to mitigate the possibility of additional separation voids occurring in the repaired area, as the photo on the right shows. After nearly six months of slab cure, evidence of continual joint movement was detected in one of the repaired joints by the appearance of new separation voids. Through continual observation of this and other joints on the projects we have witnessed voids disappear and reappear at various times, perhaps resulting form changes in environmental conditions (i.e. humidity and rain) or as a result of many other possible issues. This may or may not be representative of a majority of store projects, and the likelihood of this phenomena may have been lessened by the reduced joint spacing present in newer store specifications. But it is also important to note that this project represented a project largely in compliance with the specified (i.e. ideal) schedule for joint filling and separation void repair to take place.

Based upon this case study and many other open store projects we've observed in the field, we would suggest that while the ideal methods and materials used for separation void repair may be different from project to project, the ideal timing for the repair to take place is similar to that for the initial filler placement – defer as long as possible for the best chance of achieving long term success.

Recommendations for Treatment of Separation Repair for Consideration in the RETAILER Store Construction Program

A. *Define "typical" separation voids and defects that do not constitute "separation."*
It is first important that "separation" be defined as outlined in the introduction (a void occurring from lateral joint movement" and that all parties understand what "typical" separation is and how to identify it. Concave filler profile, collapsed or "punched down" filler, or filler which has lost bond as a result of inadequate joint preparation are often called "separation," but truly may be deficiencies in the original installation work. It is critically important that all parties inspect and recognize the difference as any issue other than "normal" separation that results from poor installation work should be corrected by the joint filling installer prior to store opening, not corrected at RETAILER's expense at a later date.

In the same light, separation resulting from circumstances beyond the applicators control, such as improper saw-cutting or joint activation, slab panel curl, or the decision to install the filler before the specified slab cure is achieved should not necessarily become the responsibility of the applicator to repair. If separation occurs as a result of an avoidable circumstance perhaps the fiscal responsibility for its repair could be shifted to the party responsible for the circumstance. This might serve as a more powerful disincentive to overlook the importance of the filling portion of the construction program or allow for a truer cost-benefit analysis to be made should the decision be made to proceed with any work that does not meet the specification.

B. *Define "correctible" separation.*
Our common recommendation is that separation be corrected or considered for correction when it reaches approximately .032" in width, or about the width of a credit card. This is the standard that we also understand is used on some projects but nowhere do the specifications indicate this standard. This void width correction recommendation is made on a performance basis (i.e. joint edge exposure may be unacceptable at this width and edges may spall) rather than an aesthetics basis. Separation voids in a store may be a concern from both perspectives. Separation methods, materials, and timing should all be dictated by the primary concern on any given project or determined by RETAILER's overall separation management goal. If RETAILER views separation primarily as an aesthetics issue, then the timing of the repair should be delayed and the scope of repair methods and materials options will widen.

C. *Remove separation repair from the initial joint filler installer's scope of work or break it out as a separate bid package.*
Because the extent and nature of anticipated separation is truly unknown before the project commences, applicators cannot intelligently bid the work. Awareness and/or enforcement of the refilling requirement on the part of the GC is also minimal. For the most part, separation is not being refilled, which means by default that RETAILER is in some way specifying and possibly paying for something they are not getting, and even if they do get it, is not likely to provide any long term benefit.

D. *Define who is responsible for separation repair, both prior to and after store opening.*
Again, we would recommend that separation correction be treated as a separate scope of work from the initial filler installation. This is not to say that the original filling contractor cannot also be the separation repair contractor, but it is not necessarily a "natural" pairing, as ideally the two processes should take place months apart from each other. Because separation repair work requires great attention to detail, good equipment, and ideally maximum productivity to be practical, we feel that this work should be left in the hands of a specialty contractor who has established and has shown the ability to perform the work with maximum efficiency and minimum interference to construction or open store operations.

We recommend that a list of specialty contractors be established to perform this work, and that the "pool" of contractors is kept relatively small in order to maintain consistent quality and performance from project to project and in order to encourage the development of innovative ways of performing these repairs. Concentrating this work among a small group of qualified contractors may also create economies of scale and provide RETAILER with a more controllable source of responsibility and a more controlled finished product.

E. *Define realistic and optimal timing for separation repair work to be performed*
As previously outlined, the current scheduled separation repair timing (7 days prior to store opening) is not ideal for many reasons which have been noted. We feel that on most projects, optimal separation void repair will likely need to take place after store opening, and perhaps as long as six months after opening (or more depending upon environmental conditions), at least if aesthetics and the prevention of future separation is the primary goal. If repair is to continue to be performed prior to store opening, it should be done for performance reasons (i.e. to repair joints which open excessively) and should not be expected to provide a long-term aesthetics solution. Methods and materials used for refill will also have to be limited substantially to those least invasive and providing the fastest turnaround. As a last note, GC's will need to be provided with better guidance on the importance and priority of the repair process.

F. *Define acceptable repair methods and products for separation void repair, allowing for multiple methods depending upon project circumstances*
We have outlined the advantages and disadvantages of two repair methods previously. Each of these or both may be acceptable on any given project, but will likely lead to different costs. If the void repair is bid as a separate package, RETAILER or the GC could decide the best repair method for specific projects based upon scheduling, operational issues, and budget considerations. Repair contractors could be asked to provide unit prices per lineal foot for both repair methods so an intelligent decision can be made on each project as to the acceptable level of separation, how much should be repaired, and when.

Summary

We are currently working to develop alternative methods of repair and products to perform the repairs, but not enough information about the expected success of these alternative approaches is currently known. We expect that alternative methods of repair well may be available and would suggest that the specifications include a provision allowing for "approved equal" methods to be used and implemented quickly if proven successful and valuable to RETAILER.

Metzger/McGuire is committed to continually working to solve this problem in partnership with our applicators and all parties involved in the RETAILER Store Construction Program with the goal of provide RETAILER with long-term, cost effective solutions and we are always available to discuss ideas and possible solutions towards this goal. We appreciate the opportunity to be a part of this program and will continue to work diligently to ensure its long-term success.