A Report on Concrete Sealants

With Emphasis on Their Radon Blocking Capabilities

And

Their Green Values

Respectfully Submitted to Professor Paul Jackson

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By Daniel Schramm, Amanda Shamp, and Derek Zumbach

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Table Of Contents

Introduction

This report will analyze the nature and purpose of concrete sealants with a particular emphasis on sealants that protect against radon infiltration through concrete foundations into buildings and the environmental impact of these products. Concrete sealants used in building construction help maintain the longevity of the resources used in construction by insuring that they will not need to be frequently replaced. Because concrete is used in such large quantities in construction, it is essential that it be protected against deterioration as well as offer protection against outside substances that may be harmful to a building's inhabitants. For these reasons, concrete used in construction must maintain its structural integrity for the entire expected lifetime of the building. Concrete sealants serve two main purposes: they can be used to cure newly laid concrete so that it sets uniformly and forms a surface impenetrable by dust that is also ideal for gluing down tile or other flooring, and they can be used to actually seal the concrete from moisture, acids, and other chemicals (including radon) both to block these substances' entry into the building as well as keep them from weakening the concrete.

After exploring the nature of concrete porosity and the dangers it poses, we will look at how concrete sealants work, St. Olaf's use of concrete sealants, and then compare several sealants (including one that St. Olaf College has favored). An essential consideration in our evaluation of these sealants will be how environmentally friendly they are. As our guideline for this, we will use the "Environmental Impact Questionnaires" developed by Michael Braungart and William McDonough for use by companies interested in "green" design. Our final conclusion will be a recommendation of the product we believe excels the others in both greenness and utility.

Untreated Concrete: A Problem Waiting To Happen

Concrete is a porous material, which means that despite its seemingly impenetrable surface, liquids (and some gases, particularly noble gases) can move through it. This occurs by a process of capillary action. Thus, moisture and other substances in the ground outside a concrete foundation can seep through the walls and enter a building if proper precautions are not taken.

One problem that can occur has to do with a process known as "saponification." All concrete contains alkalis. These are broadly defined as compounds containing the alkaline metals (alkaline metals are almost always found as compounds due to their high reactivity). In concrete, the specific alkalis that can cause problems are potassium and sodium. These elements have a tendency to continually react within the concrete, breaking down the bonds formed and weakening its structural integrity. This process is exacerbated by the presence of moisture in the concrete, which aids the alkalis in the saponification process. Another problem related to concrete's porosity does not necessarily weaken the structural integrity of a building, but can be seriously detrimental to the health of its inhabitants.

Radon (Rn, 86) is one of the noble gases, so it is chemically inert. It is odorless, colorless, tasteless, and generally undetectable without the use of special instruments. As a form of radioactive decay from uranium (U, 92), radon is a naturally radioactive gas, released in rock, soil and water.[1] It has been known, and proven, to cause cancers, and more specifically, lung cancer. In fact, radon is the second known leading cause of lung cancer. It could potentially be very harmful to anyone exposed to it for a long period of time. The EPA and the US Surgeon General suggest that all homes get tested for radon, because nearly one in every fifteen homes

[1] EPA (U. S. Environmental Protection Agency). Updated Friday January 23, 2004. At the EPA homepage http://www.epa.gov/iaq/radon Accessed Wednesday January 28, 2004.

(and other buildings) has a high indoor radon level.[2] But how does radon get into homes and other buildings in the first place?

Radon is present in the ground at higher levels in various geographical regions. Often times, its presence is related to uranium mining that had been or is still going on. Because radon is a noble gas it is an extremely small atom (on the level of 10^{-10} meters wide). This allows it to move through materials that are impervious to all other substances. As we noted earlier, untreated concrete is porous enough to allow water in (a water molecule, for comparison, is somewhere around 3 to 4 angstroms wide), thus it is easily penetrated by radon gas. To complicate matters further, radon will mix with moisture from the ground and be transported through the concrete that way as well. When arriving on the indoor side of the concrete, the moisture and radon evaporate into the air, once again, creating an extreme IAQ hazard.[3]

Stopping Radon From Getting In

There are several ways of mitigating radon contamination in buildings. These can be grouped as either active or passive resistance techniques. The National Safety Council (NSC) lays out five major parts to a passive radon-resistant system:

1. A layer of gas-permeable material under the foundation (usually four inches of gravel)
2. Plastic sheeting over the gas-permeable material
3. Sealant and caulk on all openings in the concrete foundation floor
4. A gas-tight three- or four-inch vent pipe that runs from under the foundation through the house to the roof
5. A roughed-in electrical junction box for the future installation of a fan, if needed

[2] Ibid.
[3] Radon Mitigation, www.concretesealants.com/radon.htm (January 28, 2004).

"These features create a physical barrier to radon entry. The vent pipe prevents radon from entering your home by drawing the radon from below the house and venting it to the air outside where it then dilutes with the outside air."[4]

Installing a mechanical ventilation system (i.e., fan) is a form of active radon resistance in that it involves the ongoing physical removal of radon. But this can be expensive due to continuous electricity costs and will also require maintenance. In addition, should the ventilation system ever be shut off or break down, radon levels could build up rapidly without the building inhabitants' knowledge. Thus the passive system, with anti-radon concrete sealants as its cornerstone may be the most optimal form of radon mitigation. Many concrete sealant companies have developed radon sealants. According to these companies, radon sealants need to be applied only once to stop radon contamination for the lifetime of the concrete.[5]

But before we move on to an analysis of how radon sealants (and concrete sealants in general) function and our analysis of several of those sealants, we should acknowledge two significant considerations that cast doubts on the efficacy of radon sealants. Despite the claims of radon sealant manufacturers that their products only need to be applied once, the EPA has issued an "Important Consumer Notice"[6] stating "what occurs after using one of these [radon sealants] is a temporary reduction in radon levels which gives the homeowner a sense of false security. Years later when the owner tests his home again . . . he finds that the radon concentration has returned to the level observed prior to the application of the sealant, and that the home's occupants had probably been exposed to this level for many years." The manufacturers claim their products need only be applied once, but the EPA suggests that they actually are not effective for the lifetime of the concrete—in fact, they become worthless after several years. The

[4] NSC (National Safety Council), www.nsc.org/ehc/radon.htm (January 29, 2004).
[5] Basement Waterproofing and Radon Mitigation Made Easy, www.radonseal.com (January 29, 2004).
[6] Important Consumer Notice, www.state.me.us/dhs/eng/rad/Rnnotice.htm (January 28, 2004).

EPA recommends a fan-based ventilation system (the active resistance technique) as the most effective method to reduce radon contamination, despite the relatively high energy and maintenance costs compared to the sealants. (The other elements of a passive radon resistance system—plastic sheeting and a layer of gravel under the foundation—reduce radon levels somewhat on their own, but are not entirely successful at blocking it and tend to become less so over time. They are most effective when coupled with either a ventilation system or the use of radon sealants.)

A final consideration to keep in mind if thinking about choosing a radon sealant is that other conventional concrete sealants designed simply to dustproof concrete or slow down the deteriorating effects of saponification also help protect against radon to a certain extent simply by providing waterproofing qualities to the concrete. Remember, by blocking the capillaries through which the water "wicks," you also block a certain amount of radon traveling in the water. Of course, if radon levels are extremely high in a particular building, normal concrete sealants probably should not be trusted to block the radon.

Concrete Sealants And The Power Of Acrylics

The active ingredients in most concrete sealants are petroleum-based acrylics that are suspended in either a water or oil solution. When the sealant is applied to the concrete, it seeps into the pores and capillaries and reacts with the alkali and calcium ions in the concrete to form a gel. This gel will harden over a period of several months, pushing foreign matter out of the concrete in the process. If the sealant has been properly applied, it will successfully bond to the concrete blocking all the capillaries through which substances might move, making it a solid mass that is no longer porous.[7] These acrylics are active over a long period of time, because the

[7] Basement FAQ Sheet, www.concretesealers.com/basement.htm#What_can_I_do (January 29, 2004).

polymer chains that compose them will keep bonding to each other, forming extremely long chains that become even more impenetrable over time.

The primary difference between ordinary sealants that protect against water infiltration and saponification and radon sealants is the size of the capillaries in which the acrylics form barriers.[8] In ordinary sealants, the acrylics are not capable of forming total barriers in the smallest capillaries, meaning that radon, which as noted earlier is an extremely small atom, can still move through those capillaries even when an ordinary sealant has been applied. The ordinary sealant will probably block some of the radon by filling in the larger capillaries, but will by no means block all of it. The acrylics used in radon sealants, however, will bond into even the smallest capillaries, blocking all routes of radon penetration.

St. Olaf's Use of Concrete Sealants

According to Pete Sandberg, Director of Facilities at St. Olaf College, radon testing done on the buildings has revealed no significant radon contamination on the campus proper. Two radon "hotspots" were located below the Hill, but these were improved to well below threatening levels years ago. St. Olaf, therefore, has not been particularly concerned about radon mitigation in choosing the concrete sealants it uses.[9]

Sandberg says the college will probably continue to choose concrete sealants for construction projects (such as the new science building currently under planning) based on requirements identical or very similar to those found in the recently constructed Dittman Center's *Construction Specifications Booklet*. Under Section 03250, Part 2 – "Products," 2.1b of this booklet, "Concrete Curing/Sealing Compounds," concrete sealants must be liquid acrylic based, minimum 30% total solids, non-yellowing membrane forming compounds conforming to

[8] Basement Waterproofing and Radon Mitigation Made Easy, www.radonseal.com (January 29, 2004).

[9] Personal e-mail correspondence, January 15, 2004.

TTC-800a, an industry standard. There are four concrete sealant products that fall within these parameters: Sonocrete Building Products: Kure-N-Seal #30, Mater Builders: Master Kure, L&M Construction Chemicals: Dress and Seal #30, and Euclid Chemical: Super Rez-Seal.

Sandberg also noted that "spec" writers tend to choose products based on personal experience, and the college will also have preferences or requirements that contractors must take into account. In the case of concrete sealants, contractors have used the Sonocrete product on both the Buntrock Commons and Dittman Center construction projects and are likely to use it again in future projects.[10] For this reason, we have chosen to focus on the Sonocrete product as an example of the type of concrete sealant St. Olaf currently uses.

Comparison Of Four Sealants: Greenness and Utility[11]

The EIQs or Environmental Impact Questionnaires that we have used as the model for evaluating the "greenness" of the four sealants were designed for companies to evaluate their products to determine how "environmentally friendly" they were. (The actual EIQs can be found in a separate attachment.) The EIQs address everything from potential health hazards to environmental hazards and impact on endangered species to what harmful chemicals go into a product. These questionnaires need not be filled out in full to get a general idea of how effective a product is at being environmentally friendly. It is easy to pick out which products are better for the environment than others when EIQs are compared. The four products we chose to look at are: Sonocrete Kure-N-Seal 30, 1000 Conseal, Radon Seal, and Radon Loc.[12]

The concrete sealer that St. Olaf College uses, the Sonocrete Kure-N-Seal 30[13], is by far the worst product for the environment out of the four. Not only is this product highly

[10] Personal e-mail correspondence, January 23, 2004.
[11] Charts comparing these values can be found in a separate attachment.
[12] Images of these products can be found in a separate attachment.
[13] Kure-N-Seal 30, http://www.chemrex.com/productCatalog/detailpage.asp?prodId=82 (January 29, 2004).

combustible in heat or flame, but it contains stronger skin irritants than the other products and is more harmful to human health. The Sonocrete Kure-N-Seal 30 contains harmful products including xylene, Napha-light aromatic, 1,2,4-trimethyl benzene and cumene. Not only are these products harmful in to general health, but the benzene is suspected to be a carcinogen and the xylene vapor can cause corneal injury and damage to red blood cells. Inhalation of the vapors can also result in death or permanent damage to the kidneys, liver and the mucous membrane. Aside from health issues, if this product is released into the environment, it can cause serious damage. Because this product is highly flammable, it is important that it be stored carefully and in a cool place away from all sources of ignition. If this product is released into the environment, the most important thing is to contain the liquid, put into a chemical waste container and prevent it from becoming water run-off and getting into ditches and storm sewers. This product is strictly prohibited from being reused, in fact it is stated in the MSDS that the reuse of the plastic pail is forbidden and the pail should be properly disposed of in the nearest hazardous waste location. Finally, unlike the other three products, this one does not protect against radon (although, admittedly, St. Olaf does not have a radon problem). Overall, this product is the least environmentally friendly out of the four products.

1000 Conseal[14] is also not as environmentally friendly as the last two products. 1000 Conseal is non-toxic, meaning it is a water-based chemical that is not flammable or explosive, and it does not emit any harmful fumes. In this respect, Conseal is much more environmentally friendly than Kure-N-Seal 30. However, because of the high pH level of this sealer (12.1) if this liquid got into any water stream, it has the potential to be highly toxic. The base nature of this product does not affect air quality, but if someone ingests this product, they will likely have

[14] 1000 Conseal, http://www.wetsealers.com/CONSEAL1000.html (January 30, 2004).

serious health issues due to the high pH level. 1000 Conseal is significantly friendlier to the earth than Kure-N-Seal, but two other comparable products are even better to the environment.

Radon Seal[15] and Radon Loc[16] are almost the same products, and both are relatively environmentally safe. They are both non-toxic, not flammable, and they do not affect the indoor air quality of a space too much. Both products are odorless, colorless or turbid liquid colored and they are both water-soluble. The pH of both products is neutral, measured at about 7.9 (cured for the Radon Loc and for the RadonSeal) and a pH of about 7.0 for the Radon Loc when it is not cured. As far as health issues go for these products, the only possibility is of minor throat, skin or eye irritation, all of which are treatable. These two products are almost identical in make-up and so they have the same impact on the environment, which is less significant than both the 1000 Conseal and the Kure-n-Seal 30. These two products, the RadonSeal and the Radon Loc have a smaller impact on the environment, and are therefore better for the environment.

Aside from the purported "greenness" of the products in question, the ability to perform within certain categories of utility are also extremely important. As St. Olaf College has communicated there is little need for a radon blocking sealant on our particular campus. But the categories of waterproofing, hardening, dustproofing, and the creation of a vapor barrier in combination with cost remain important enough to merit to evaluation previous to making a sealant choice.

The college's primary choice, Sonocrete Kure-N-Seal 30, is indeed quite cheap in cost. Measuring in at a mere $89.83 for a 5-gallon pail and an extremely low $909.94 for a 55-gallon drum it is indeed the most cost effective. But what of its performance in comparison to its more

[15] Basement Waterproofing and Radon Mitigation Made Easy, www.radonseal.com (January 29, 2004).
[16] RadonLoc Product and Technical Information, http://www.radonloc.com/product.html (January 29, 2004).

expensive rivals? Aside from not blocking radon, having not mentioned hardening effect or vapor locking capability, Kure-N-Seal 30 claims to "reduces liquid penetration" in place of a waterproofing declaration. The only extra reported benefit touted by Kure-N-Seal is the fact that it functions as a dustproofer, an important attribute that will be discussed more thoroughly later. The rivals do indeed cost quite a bit more: Radon Seal is $149.00 for their standard product in a 5-gallon pail, 1000 Conseal $124.95 per 5-gallon pail, and Radon Loc is the most expensive at $159.00 per 5-gallon pail of their standard product. This does pose a formidable disincentive but when one observes the many benefits of the rivals' additional properties it sets things into perspective and makes the case for change more evident.

Radon Seal, 1000 Conseal, and Radon Loc all share the ability to seal out radon gas but also have hefty waterproofing claims which will protect the building in question from damaging seepage of ground water. Depending on the expected lifetime of the construction the hardening and dust proofing qualities of all three alternatives should be important to note. Hardeners and dustpoofers prolong the life of the concrete and prevent harmful carcinogens from being kicked up from a deteriorating, well-traveled, concrete floor. Thus making such qualities essential for any building whose concrete foundation is expected to last many years of wear and tear. Radon Seal stands alone as the only product that claims to contain a vapor barrier. A sealant that acts as a vapor barrier blocks indoor water vapor from escaping through crack in unsealed concrete and condensing on walls, insulation, and the underside of roofs and damaging them during the winter months. Since this is a problem exclusive to cold climates it would seem to be an obvious property to be considered on the St. Olaf campus.

As is obvious from the above line-up, St. Olaf's choice for concrete sealant is indeed the cheapest but, as one might suspect, has the least amount of extra benefits. Though St. Olaf does

not have a radon problem it would seem advantageous to choose a product whose properties would prolong the life of the concrete with hardeners and water sealers.

Resource Management

Not much information is available about the manufacturing procedure of these products. However, we know that producing concrete itself is not exactly environmentally friendly. The process of making concrete, including the dirty job of quarrying the silicates and stones and drying the manufactured cement in the kilns, is a long and environmentally detrimental process. Manufacturing the cement produces mass amounts of carbon dioxide because the components of the cement need to dry and set. The only way to get the cement hot enough to dry completely is to supply enough fossil fuels so that the cement gets hot enough. This use of fossil fuels in cement manufacturing is a significant contributor to air pollution today. Because concrete sealants do much to extend the lifespan of concrete by protecting it from various degrading forces, and thus significantly reduce the amount of new concrete that has to be produced, they can be considered to be very environmentally beneficial as a group of products.

Another important aspect of resource management relating to concrete sealants is the type of solvent in which the active acrylics are suspended. These solvents can be either water or petroleum based. Water based solvents in concrete sealants represent a far more responsible management of resources for two reasons. First, they are less toxic because they contain less petroleum compounds, meaning that any improper disposal or leakage of the product into the natural environment will incur less severe damage. Second, they conserve fossil fuel resources better relative to petroleum-based solvents, because not as much petroleum is necessary to make them.[17]

[17] Special thanks to Prof. Jackson for information on this point.

However, in general, more could be done to find alternative chemicals to the active ingredients (the acrylics) being used in sealants at this time, which are, after all, still petroleum based and by that fact potentially degrading to the environment.

Conclusion

The criteria that we have used to evaluate the four concrete sealants (their utility as well as their environmental friendliness) leave one product ahead of the rest: Radon Seal. Although it is the second most expensive product, it is the only one that works as a radon sealant, waterproofer, hardener, dustproofer, and vapor barrier. Furthermore, compared to the other products we considered, it is very "green:" it uses a water-based solvent, is nonflammable, has a fairly neutral pH, contains only silicates as carcinogens, and is nontoxic if not brought into inappropriate contact with the body. In addition, it is $10 cheaper per 5 gal pail than Radon Loc, which has similar properties. The Sonocrete product is perhaps the worst of the four, both with respect to utility and environmental friendliness. We should point out, however, that St. Olaf does not have a radon problem, and the Kure-N-Seal 30, at a relatively cheap price, may provide all the functions St. Olaf really needs in a concrete sealant. Nonetheless, it would seem that this product does fall short of other available products with regard to its environmental values.