Analysis 3 – Floor Covering for Clean Rooms

Background

The primary purpose of the LSM Facility is to produce and store large amounts of pharmaceutical products. There are specific rooms containing specialized pharmaceutical equipment that are designated for mixing chemicals to create these pharmaceutical products. These rooms are called "clean rooms", which are defined as a manufacturing and inspection area that is temperature and humidity controlled and has continuously filtered air specifically designed to reduce particulate contamination.

Clean rooms differ from containment rooms in that they are intended to keep particles out of the room instead of containing them inside. Clean rooms are given a class depending on the particle count that is specified for the room. The clean rooms in the LSM Facility are a Class 10,000. This means that there exist no more than 10,000 particles larger than 0.5 microns in any given cubic foot of air. For example, in a Class 100 there exist no more than 100 particles larger than 0.5 microns in any given foot of air. In order to achieve this, the air in a clean room is repeatedly filtered to remove dust particles and other impurities that can damage the production of highly sensitive technologies.

Along with keeping the air clean, a major issue with clean rooms is keeping the floor surface clean. In order to prevent particles to become stuck to the floor, the surface needs to be smooth and joint free. Depending on what types of chemicals and products being used in the rooms, the floor must also be resistant to certain chemicals.

This is a very delicate matter because these floors are required to be highly durable to reduce the amount of cracks and nicks in the floor. These damages could retain dust and particles, which can contaminate the equipment or all of the products being produced.

In the LSM Facility, HGS chose to use a quartzite epoxy flooring system. This system is installed in 3 different coats: a primer coat, a base coat, and then a finish coat. The epoxy system is very common in pharmaceutical buildings, but it is a very expensive system to use. There is also a lot of time allotted to the installation because each layer requires a day to cure, and it must be kept relatively clean. I plan on researching different floor systems that could possibly reduce the installation time and or cost of the project. Some other types of floor coverings are terrazzo, epoxy terrazzo, or a plain epoxy floor.

Description of Floor Coverings

Quartzite Epoxy Flooring

Description:

For all of the clean rooms in the LSM facility Epo-Rok Quartz (Figure 7), a product manufactured by the Valspar Corporation, is specified to be the floor covering. The Valspar Corporation has been in business for over 80 years, and the Epo-Rok Quartz is just one of the products they manufacture for industrial purposes.

Figure 7 – Epo-Rok Quartz

The Epo-Rok Quartz flooring system is a 100% solid decorative floor resurfacer. It was designed to be used in light duty areas where slip resistance, and ease of maintenance and cosmetics are of a major consideration. This system is ideally suited for applications in hospitals, research and educational facilities, and pharmaceutical facilities. A unique feature of this system is that it is seamless, which makes it ideal for areas where sanitary needs are required.

This specific system is only ¼" thick, and is installed in three different layers. An epoxy shop floor resurfacer is applied directly to the concrete, which serves as the base coat. The next layer consists of the aggregate, which is the quartz aggregate. This can come in various colors, and the color used in the LSM can be seen above in Figure 7. The final layer of the system is a heavy coat epoxy resurfacer, which serves as the top coat. Each layer of the system requires 24 hours to cure, and must be protected from all traffic whether it be foot or equipment. On top of that, the existing concrete that the system is to be applied to must be no less than 60 days old to prevent cracking of the epoxy floor covering. The only temperature requirements for the system are that it must be applied between 60°F and 90 °F. This could cause some problems if the building is not enclosed and maintained at a constant temperature or provided temporary heating.

Advantages:

Epoxy floor systems are the most widely used in pharmaceutical and health care facilities and in most cases are the most beneficial. Located in Figure 8 is an example of a finished product in a pharmaceutical facility. These floors provide a seamless surface that is very resistant to chemicals, damage, slip, and dust collection. These are all very important attributes of the system because of the nature of the rooms in which they are used. As stated earlier in this analysis, cleanliness is a very important issue since pharmaceutical drugs are being produced in

these rooms and can not be contaminated in any way. They also possess a compressive strength around 9,000 psi., which makes the surface very durable and hence requires very little maintenance.

Figure 8 – Example of finished product

Disadvantages:

There are no physical disadvantages to the system itself. Only if the surface was damaged, which would require a lot of force, the area would need to be sanded down and then reapplied. There would be some visible distinction between the original floor finish and the new, but it would be very minimal. The only issue with the system is related to its application time. Each layer needs to be applied no earlier than 24 hours before the previous. This could lead to delays in a project if contractors need to get into that area to work. This can be avoided with proper coordination by the contractors and the Construction Manager. This floor covering is also more expensive than most other coverings, but many of these other coverings do not possess the same attributes as the epoxy.

Bonded Conductive Terrazzo

Description:

Along with the epoxy system, terrazzo can also be a type of seamless floor coating depending on the floor slab below. Terrazzo is typically used in health care facilities, lobbies, educational facilities, retail, and hotels. Terrazzo is known traditionally as an expensive decorative floor covering that is very durable. Figure 9 shows a simple example of what a finished terrazzo floor looks like in a pharmaceutical building in Rockville, MD. This floor is not located in a clean room, but rather displays the aesthetic value of terrazzo. There are many different types of terrazzo floor systems including: precast, structural, monolithic, epoxy, conductive, and bonded. In this section, bonded conductive terrazzo will be analyzed further for reasons to be explained.

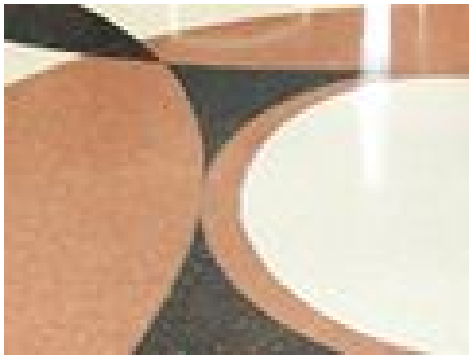

Figure 9 – Genetic Therapy Bldg.

Terrazzo is a composite material which is typically poured in place. It consists of a cementitious binder, instead of epoxy, and an aggregate which is spread throughout the mix creating at heterogeneous coating. The aggregate can be marble, quartz, granite, or glass. The terrazzo is then cured, ground down, and then polished and sealed to a smooth finish. Terrazzo is one of the thickest floor coatings due to the aggregates used in the bonding material. The average thickness of a terrazzo floor is 2", with the terrazzo topping being roughly ½". If terrazzo is used, it must be taken into account during the design phases of the project because the floor slabs will need to be recessed to account for the thickness of the terrazzo system.

Due to the fact that this floor is going to be used in a manufacturing facility, many things need to be taken into consideration. First is the fact that cleanliness and resistance to chemicals is a primary concern of Human Genome Sciences in the clean rooms, and this is the reason why conductive terrazzo must be used. Conductive terrazzo will conduct electricity within prescribed resistance levels. It eliminates the buildup of static electricity and is therefore a safe floor for use in areas subject to explosive hazards. Another issue is that there are a large number of floor drains within the building that require the floor to be sloped. This will require the floor covering to be bonded to the concrete floor slab, hence bonded terrazzo must be used in comparison to monolithic which requires a flat surface.

Advantages:

There are numerous advantages to bonded conductive terrazzo flooring. This flooring is very resistant to impact damage and daily wear and tear. It is also resistant to many chemicals due to its conductive nature. Terrazzo has always been known as a very decorative floor covering depending on the type of aggregate used in the binder. The cost of terrazzo is also very comparative to all other floor systems when maintenance cost is taken into effect instead of just initial cost.

Disadvantages:

Terrazzo can also become a very expensive product when areas need replaced. It can become difficult to get the same exact mix or a mix relatively close to the original. Also, depending on the aggregate, there can be a long lead time to get the appropriate materials. This can also become an issue during initial application. If the wrong amount is ordered, the schedule could fall behind if more material needs to be ordered. Another issue with terrazzo is that it is not 100% resistant to liquids. If proper maintenance is not taken on the surface it

could retain some chemicals causing issues with flammability. One major issue with all terrazzo floor systems is the need for dividers to prevent cracking. Typically the dividers are placed over control joints located on the buildings concrete floor slabs, but they can also be placed in areas to separate different terrazzo mix designs. This would not be an issue in the LSM facility because the floor slabs are so thick and highly reinforced that there are no control joints throughout the slab. There is simply one main control joint running east to west in the southern portion of the building, and there is no need for special flooring in that section of the building.

Conductive Epoxy Terrazzo

Description:

The epoxy terrazzo floor system is a smooth seamless floor covering which is much thinner than your typical terrazzo. Epoxy terrazzo has taken more than 70% of today's terrazzo market due to its thin application, multicolor ability, and greater durability. Figure 10 shows an example of an epoxy terrazzo floor with an aesthetic design. This system is very comparable to that of the quartzite epoxy flooring. The main difference is in the aggregates used.

Figure 10 – Epoxy Terrazzo

Epoxy terrazzo floors are typically installed in a ¼" thickness, and in two different layers. The first layer is just an epoxy primer that takes no less than an hour to cure. The epoxy system is then set into place and trowel finished. Once the floor is allowed to cure for a little, the surface is then grouted with an epoxy terrazzo grout to fill in all of the voids. The final step is to then polish and seal the surface like typical terrazzo floors.

Advantages:

The advantages of the epoxy terrazzo floor are quite similar to that of the quartzite epoxy floor. This modern-day terrazzo is excellent for multicolored patterns and designs because the epoxy resin matrix can be pigmented, like paint, to achieve an unlimited spectrum of colors. And it can accommodate a wider variety of richly colored aggregates, including chips of marble or granite, recycled glass, mother of pearl, and various synthetic materials. Epoxy terrazzo offers outstanding durability and wear, making it tough enough for use in high-traffic commercial

and industrial environments. Because the binder is 100% epoxy, the finished floor surface provides greater resiliency, chemical resistance, compressive strengths, and flexibility than cement-based systems.

Disadvantages:

This is one of the most expensive floor systems in the market today. This would be a big issue to Human genome Sciences because cost is a major factor in constructing the LSM facility. Though it has many attributes that are required for a clean room, the quartzite epoxy floor coating has the same attributes, so the added cost would not add any extra value to the facility. This system has only one physical disadvantage, and that comes into play if the floor is damaged. There can be a lot of time and cost associated with replacing the damaged section of the floor. There can be a lead time associated with the marble or granite aggregate used in the terrazzo mix. If it is a rare stone or a high demand stone there could be high costs and schedule delays to get the proper stone chips in time.

Cost and Schedule Comparison

In order to compare the impacts of each floor covering on the LSM project, an estimate was performed using the appropriate materials for each system. In order to obtain cost and duration values for the quartzite epoxy, bonded conductive terrazzo, and the conductive epoxy terrazzo, values were obtained from the R.S. Means Assemblies Estimate and Building Construction Costs Data books.

Located below in Table 2 are the overall cost and duration values for each of the floor coverings. A detailed estimate can be found in Appendix F.

Table 2 - Analysis of Floor Coverings		
Quartzite Epoxy		
Description	Total Cost	Total Weeks
Epoxy with quartz chips	$450,500	22
Total	$450,500	22
Bonded Conductive Terrazzo		
Description	Total Cost	Total Weeks
Bonded Conductive Terrazzo	$742,000	118
Total	$742,000	118
Conductive Epoxy Terrazzo		
Description	Total Cost	Total Weeks
Conductive Epoxy Terrazzo	$617,450	53
Total	$617,450	53

These values obtained from the R.S. means are only approximations. As you can see the value for the total weeks varies greatly. This can be manipulated by adding extra crews which in turn would increase the labor cost of the product. By looking at the values obtained, it would be useless to perform this action.

The values for total cost and total weeks clearly show that the quartzite epoxy floor covering is the most beneficial system. Below is a cost and schedule relationship between the proposed quartzite epoxy and the other two systems. (+ is more, - is less)

Bonded Conductive Terrazzo:

Cost impact: +$291,500

Schedule impact: + 96 weeks

Conductive Epoxy Terrazzo:

Cost impact: +$166,950

Schedule impact: + 31 weeks

The only system that closely compares to the quartzite epoxy flooring is the conductive epoxy terrazzo. The only way to have the values more closely resemble each other would be to increase the crew size. This would change the total duration to 27 weeks, which would still impact the schedule by 5 more weeks. It would also add an additional $118,720 to the total cost.

By analyzing the cost and schedule impacts of all of the floor systems, the proposed quartzite epoxy flooring is the superior system.

Conclusion / Recommendation

The LSM Facility consists of multiple "clean rooms" in which pharmaceutical products will be produced. These rooms have a Class 10,000 rating which means that there exist no more than 10,000 particles larger than 0.5 microns in any given cubic foot of air. In order to keep this condition there needs to be an extensive HVAC system as well as a floor that is resistant to collecting dust and particles that could contaminate the pharmaceutical products being produced.

For all of the "clean rooms" a quartzite epoxy floor covering was specified. This floor covering is installed in three coats and each coat takes 24 hours to cure. This type of flooring is required due to its resistance to chemicals, durability, and relatively smooth surface.

Three different systems were researched in this analysis, including the specified floor covering, a bonded conductive terrazzo floor, and a conductive epoxy terrazzo floor. In terms of durability and chemical resistance all of the floor coverings are relatively the same. Each floor system has one disadvantage, and that is related to damage to the product itself. It can take a lot of time as well as money to replace a section of flooring depending on how it is damaged.

In terms of cost and schedule impact, the quartzite epoxy terrazzo floor is superior. The other two systems not only cost more money but they also will take more time to install. It is evident that for "clean room" applications a quartzite epoxy floor is the premier floor covering to use. It is not only aesthetically pleasing, but it is durable, resistant to chemicals, cheap, and takes less time to install than its counterparts.