



# ADVANCED FLOORING MATERIALS AND THEIR LIMITATIONS WITH SPECIAL REFERENCE TO CASTING AND PHARMACEUTICAL INDUSTRIES

Manjusha Shinde<sup>1</sup>, Dr.Madhav Kumthekar<sup>2</sup>

<sup>1</sup> Post Graduate Student, S.P.S.M.B.H's College Of Architecture, Kolhapur, Maharashtra, India

<sup>2</sup> Professor, Department of Civil Engineering, Dr.Daulaotrao Aher College Of Engineering, Karad, Maharashtra, India

*Abstract:* Maintaining the uninterrupted production operation of the company while performing corrective maintenance of the floor is a major challenge making it necessary to invest in floors that are durable, resistant, and require less or zero maintenance. There are new advanced materials available in the market which can be cost-effective as well as improve the performance of the flooring by overcoming its limitations. Even though the new flooring materials are available in the market people are still going for the conventional flooring material due to a lack of information about the new flooring materials attributes as well the cost benefits. This paper deals with new advancements in flooring materials for casting and pharmaceutical industries.

*Index Terms* – Advanced Flooring Materials, Cost Benefits, Less Maintenance, Types of Flooring, Durable and Resistant.

## I. Introduction

Globalization and liberalization have made the world market fiercely competitive due to which performance of the industry the backbone of any economy has become very difficult. The growing emphasis is on consistent quality and zero maintenance, with the optimum cost, are the key drivers of trends in the flooring industry. Customers need Quality, functionality and lasting performance, that to at a competitive price. Therefore, there is a need to use floors that are easy to clean, maintain and have good abrasion resistance.

Conventionally the concrete flooring was commonly used almost for all the industries however there are lot of limitations to this flooring materials, as the loads coming on the flooring are increasing day by day due to huge capacity machines or the equipment which are operating and moving on the floor. This leads to cracking of the flooring causing frequent maintenance. However when the industry is operating, the management cannot take the shutdown for this type of maintenance with disturbed production cycle. Similarly, for pharmaceutical industry, even though the loads are not high but the conventional concrete flooring will not meet the purpose, as these industries require highest quality of sterile and hygienic conditions. Hence it is a need of the time to go for the new flooring materials and techniques which will meet the requirements of these industries, enhance the efficiency by reducing the problems related with flooring.

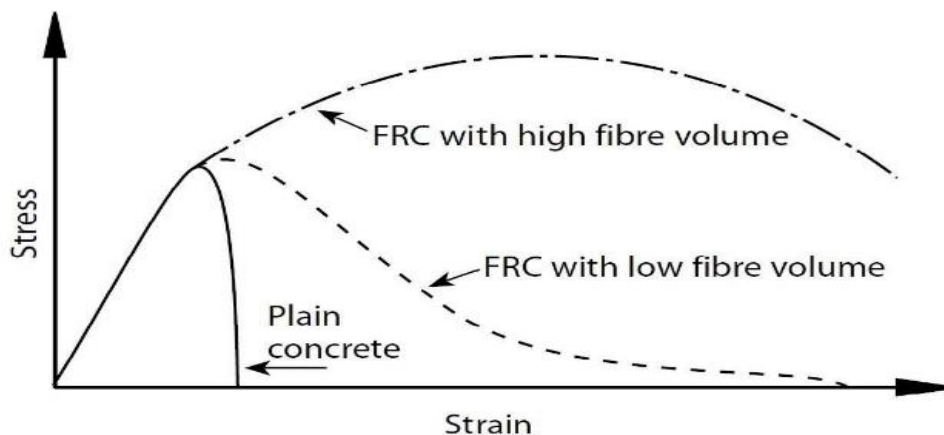
In the present scenario lot of work has been done on problems related with industrial flooring .New materials and techniques have been established to meet the changing industrial flooring requirement. Eg.High-performance concrete, fibers such as steel, polymers, glass, carbon and other different artificial materials which can be blended with concrete. There are lot of advancement in materials and these new industrial materials prove to be useful for providing better load carrying capacity, abrasive resistant, hygienic conditions and safety that too at the reduced overall cost. As there are variety of materials available for industrial flooring, it is crucial task for the Architects or Engineers to choose appropriate flooring material which will meet the standards and at the same time should be cost effective.

**II. ADVANCED INDUSTRIAL FLOORING MATERIALS**

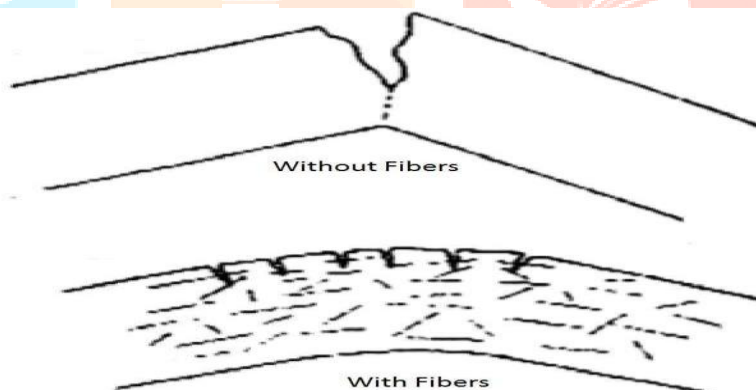
The type of material used to make the floors determines how they are classified. Each has unique aggregates and finishes that will give the finished product distinct qualities. This section aims to aid in understanding what may be expected from floorings and to assess the importance of specific aspects that might be seen on a finished floor. Floors are provided to provide a platform for the production of goods, movement of the machineries and equipment and the activities of workers. Industrial floors should be able to withstand tensile, compressive, and bending forces, as well as impact and abrasion. It should also be resistant to harmful physical activities and chemical reactions.

**2.1 FIBRE REINFORCED CONCRETE**

Fibres play an important role in obtaining a floor with good properties. The fibre reinforced concrete will withstand compressive and bending pressures, as well as impacts and abrasion. The industrial flooring is a crucial structure because of its impact on product quality, worker comfort, and health issues. It should be capable to withstand extremely strong mechanical impacts, abrasion and should have the dust-free property; and it must meet specific thermal comfort standards.



*Fig: 1 Stress strain diagram for the plain concrete and FRC*



*Fig: 2 .Failure mechanism of concrete members with and without fibres.*



*Fig. 3 Laying process of FRC flooring*

**i) Process of manufacturing FRC**

Steel fibres are frequently used in industrial flooring. Fibre into concrete can be applied in one of three ways as shown in fig.4.

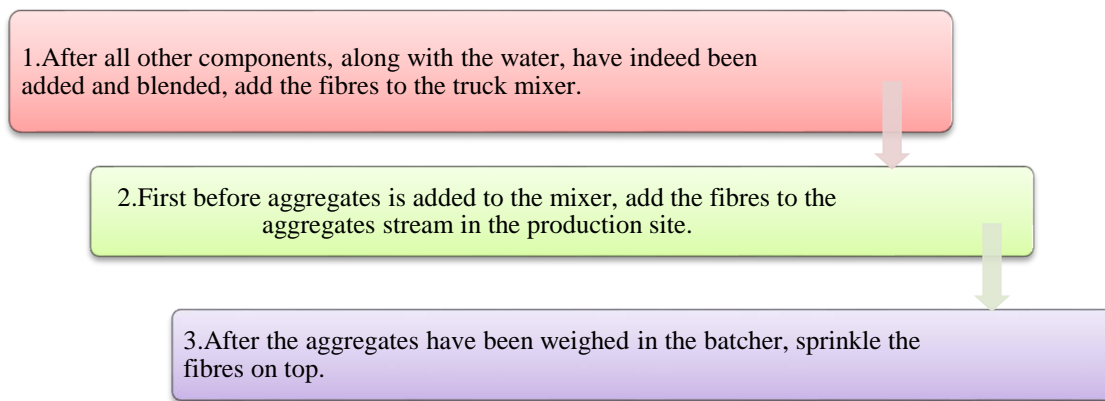


Figure: 4. Process of manufacturing FRC

**ii) Various forms of fiber-reinforced concrete is shown in the figure 5.**



Figure.5. Illustrates various forms of fibre-reinforced concrete

iii) Relationship between volume of the fibre and toughness and strength is shown in the fig.6.

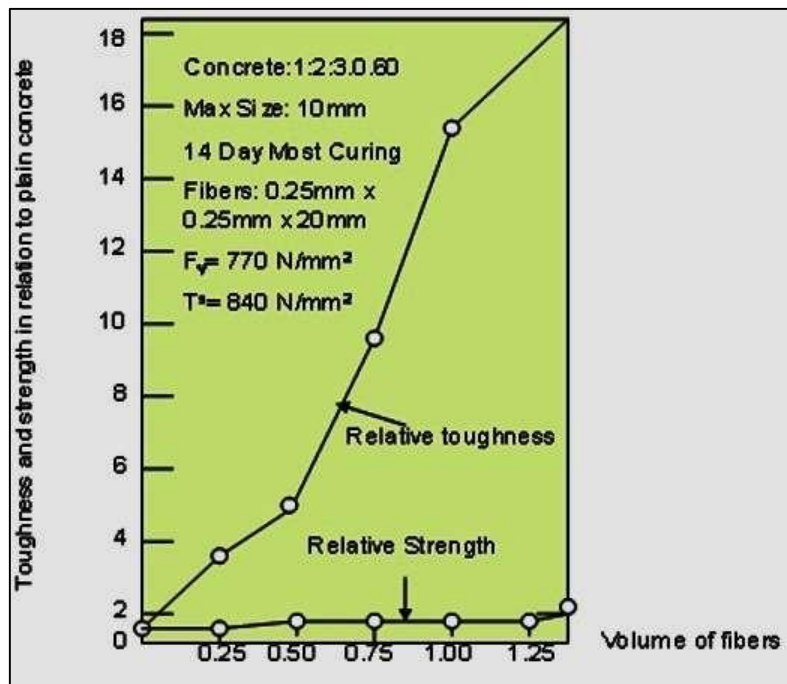


Figure 6 .Relationship between the volume of the fibre and toughness and strength

#### iv) Advantages of FRC

The following major advantages and limitations of FRC are given as under:

1. The addition of fibre to concrete won't seriously impact gains in compressive strength (0 to 15 percent).
2. As the fibre concentration rises, the elastic modulus of FRC marginally rises. It was determined that the elastic modulus increases by 3% for every percentage point increase in the amount of fibre.
3. The flexural strength will be 2.5 times greater when 4 percent of the volume is made up of fibres.
4. FRC is 10 to 40 times harder than regular concrete.
5. The splitting tensile strength of mortar increases by roughly 2.5 times when 3 percent by volume of fibre is added.
6. Tensile strength: For every 2% increase in total fibre volume, a 30–40% increase in strength is seen in direct tension. When the fraction of steel fibres in FRC is increased, the flexural fatigue strength increases significantly. The increased utilization of steel fibres has resulted in a nearly one-and-a-half-times improvement in fatigue strength. When the total amount of fibre is doubled, the split tensile strength increases by 10 to 45 percent in addition to 3 percent.

#### v) The limitations of FRC are as given below:

The following major advantages and limitations of FRC are given as under:

1. Workability decreases. The loss of workability in concrete is based on the volume concentration of fibres. The larger aspect ratio had an impact on workability as well.
2. Steel fibres must be inserted in adequate amounts if the expected improvements are to be realized. Corrosion of the surface is another issue that might affect the surface's look.

Hence the FRC can be effectively used as the new flooring material for the casting and pharmaceutical industries.

### III.POLYURETHANE FLOORS

Industrial flooring made of polyurethane is considered as attractive since it comes in a variety of colours and has a pleasing appearance as shown in the fig.7. It basically lies on top of the concrete foundation and is chemically resistant. They are frequently employed in the textile, chemical, and pharmaceutical sectors. Polyurethane floors are unique in these types of enterprises since they are hygienic and waterproof, preventing the build-up of dust and the development of germs.



Figure.7 Polyurethane concrete flooring

#### i) Major Advantages of Polyurethane Flooring Systems

- 1. Flexibility of polyurethane:** polyurethane has been found to last longer because it flexes under impact and does not abrade as other materials.
  - 2. Alkali and solvent resistance:** Like epoxy, polyurethane materials are just less affected by some chemical interactions. Polyurethane is the ideal material for regions that come into touch with oils and chemicals.
  - 3. Curing time:** In most cases, polyurethane cures more quickly. This is one benefit polyurethanes offer when doing time-sensitive tasks or when a mission-critical application requires the resin.
- Tolerance for harsh temperatures: A polyurethane coat's elasticity has another advantage when the resin rapidly transitions from hot to cold.
- 4. Life cycle costs:** An important advantage of polyurethane flooring systems is the possibility to renew the topcoat without complete removal of the flooring system – a process called “retopping”. As compared to other flooring systems that have to be replaced when reaching the end of their lifetime. Polyurethane flooring systems are especially advantageous in the case of long-term usages of 40 years. Within this period, most of the comparative flooring systems have to be replaced at least once.

#### ii) Limitations of Polyurethane

1. Very sensitive to humidity, can affect its ability to cure properly.
2. Prone to gouging, not as resistant to heavy industry traffic as epoxy surfaces.

### IV EPOXY FLOORING IN PHARMA INDUSTRY

Numerous concentrated chemicals and dynamic organic compounds are frequently used in pharmaceutical research, and the flooring system in many areas must be resilient enough to withstand the spillage of potentially dangerous and/or corrosive substances. Many conventional flooring systems can be harmed by the organic solvents that are frequently used to clean pharmaceutical industry equipment. Epoxy floor coatings that are resistant to corrosion and other resinous concrete floor coating systems as shown in the fig.8 are made to endure contact with these materials and reduce the chance of absorption while guarding against structural damage to the concrete foundation.



Figure 8 Epoxy flooring

### i) Pharmaceutical flooring that follows cGMPs

Every food or pharmaceutical manufacturing plant concerns about adhering to the FDA's cGMP (current Good Manufacturing Practices) regulations. These standards define the mechanical, chemical, and impact resistance of the flooring systems and include detailed instructions for production lines, laboratories, packing systems, and storage rooms. Static control flooring can help to lessen the risk of explosions or fires in places that contain volatile chemical compounds or powders, while seamless epoxy and urethane flooring can help to lessen the risk of biological contamination. These flooring systems may be significantly simpler to effectively clean than other more conventional flooring options by minimizing tough cracks, seams, or creases where debris and contaminants can accumulate, enabling a safer and more hygienic environment for pharmaceutical research and manufacturing.

### ii) Types of Epoxy Flooring

Epoxy floors are smooth, appropriate and relevant, and may be manufactured in a variety of colours, designs, effects, and decorative alternatives. They are appropriate for use in industrial and commercial settings due to these qualities. There are a number of standard varieties of epoxy flooring, including:

1. Epoxy Flake Coating
2. Epoxy Floor coatings
3. Epoxy Self-Levellers
4. Antistatic Epoxy Flooring
5. Epoxy Screeds
6. Epoxy mortar floor

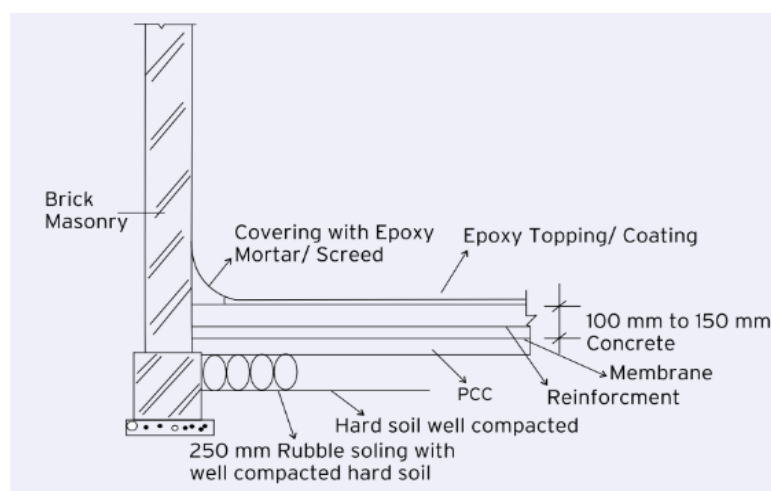


Figure 9. Systematic diagram of epoxy flooring

### iii) Epoxy flooring has many benefits to match a number of unique characteristics as given under:

- a) Aesthetics** - Epoxy flooring can be installed in a variety of colour and variations, as well as different gloss levels. Metallic coatings and the use of coloured microchips are further design options.
- b) Maintenance**- Epoxy is a seamless flooring choice, as the substrate is shielded from contaminants including chemicals, mud, liquids, and other foreign substances. Because of this, waxing or polishing is not required, and all that is needed to clean the floors is a walk-behind scrubber or regular cleaning with a general-purpose cleaner. Epoxy flooring are a fantastic long-term value option because they only need thorough maintenance and minimal upkeep.
- c) Durability**- Epoxy flooring can withstand a range of workloads, including vehicle and forklift usage. This type of industrial flooring can resist regular assault from a wide range of tools and production procedures. Epoxy flooring fits the durability requirements of the majority of industrial firms since it is an abrasion- and chemical-resistant material.
- d) Installation** - It is essential to have a qualified flooring contractor supervise the process. A poor installation will hasten the coating's fading and cracking. Before applying any coating, the substrate must also be properly prepared. Depending on the project's thickness and size, installation times vary.
- e) Cost** - Prices will vary depending on size, style, and layout, but generally speaking, they range from 2800 to 5600 per square metre. Epoxy floors typically have lower lifecycle costs because to its low maintenance requirements, longevity, and durability, which result in inexpensive installation costs.
- f) Applications:** Epoxy flooring is excellent for the pharmaceutical, food production, healthcare, and other industries because it is one of the most adaptable flooring solutions.

### iv) The following are the limitations of Epoxy Flooring

#### a) Powerful Applicator Fumes

Wet epoxy gives off an unpleasant stench when it is being applied. Employees who work with epoxy protect themselves by donning masks and safety goggles because the fumes can be toxic in addition to having an unpleasant odour. But once the epoxy has fully hardened, the scent disappears until the coating is further sanded, which releases epoxy resin particles into the surrounding air.

#### b) Prolonged Curing

Depending on the type of epoxy coating used and the scope of the project, epoxy flooring systems could take several days to cure entirely. Applications typically need 72 hours to fully dry and cure. Epoxy application, however, might only take 24 hours in smaller pharmaceutical facilities.

#### c) Water Makes It Slippery

Epoxy is non-porous, which means that when it gets wet, it can become quite slippery.

## V CONCLUSION

There has been a lot of progress in materials, and these new industrial materials have proven to be useful for providing better load carrying capacity, abrasion resistance, hygienic conditions, and safety, all at a lower overall cost. Considering the variety of materials available for industrial flooring, it is responsibility of an architects or engineers to select appropriate flooring materials that meet standards while maintaining cost effective.

## REFERENCES

- [1] Balázs Nagy, Salem Georges Nehme, Dóra Szagri “Thermal properties and modelling of fibre reinforced concrete.” Energy Procedia 78 (2015), ISSN: 1876-6102, P.P 2742 – 2747. June 2015.
- [2] Bryan Barragán, Luca Facconi, Olivier Laurence1, Giovanni Plizzari, “Design of Glass Fiber Reinforced Concrete Floors according to the Fib Model Code 2010”, FRC ACI-Fib International Workshop Conference Paper · July 2014
- [3] Dipen Kumar Rajak, Durgesh D. Pagar, Pradeep L. Menezes and Emanoil Linul, “Fibre-Reinforced Polymer Composites: Manufacturing, Properties, and Applications.” Polymers 2019, 11, 1667, October 2019.
- [4] Chowanec A., Ostrowski K., Epoxy resin coatings modified with waste glass powder for sustainable construction, Technical Transactions, Vol. 8/2018, pp. 99–110.
- [5] Hesham Alsharie, “Applications and Prospects of Fibre Reinforced Concrete in Industrial Floors.” Journal of Civil Engineering, 2015, 5, P.P 185-189, June 2015.
- [6] <https://www.pharmaguideline.com>.