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Study of the adhesion of UV-cured resin on stone

Mehrnaz Afkari[1], Ali Moazen[1], Behzad Shirkavand Hadavand[2]

[1]Research and Development Center, Sadra Atiyeh mahour Ltd, Tehran, Iran
[2]Department of Resin and Additives, Institute for Color Science and Technology, Tehran, Iran

Abstract

UV-cured epoxy-based coatings are widely used for their superior mechanical properties and resistance to environmental factors. This study examines the adhesion of UV-cured epoxy and polyester resins on White Crystalline Marble and Pietra Gray Marble. Samples were prepared by cleaning, sanding, and applying coatings, followed by UV curing using LED and halogen lamps. Adhesion strength was evaluated through pull-off tests. Results indicated that adhesion is highly dependent on the substrate's porosity and surface texture. White Crystalline Marble, with its low porosity and smooth surface, exhibited moderate adhesion, requiring surface roughening or priming for better bonding. Pietra Gray Marble, with a rougher and more porous structure, showed improved adhesion, particularly with epoxy resin. Epoxy demonstrated superior adhesion to both stone types compared to polyester, which had weaker bonding and higher brittleness. The study highlights the importance of substrate selection, surface preparation, and resin choice in optimizing adhesion performance. Proper treatment, such as surface roughening and priming, enhances the durability and effectiveness of UV-cured resin coatings on different stone substrates. These findings provide valuable insights for applications in construction, decorative stone installation, and structural repairs, where strong and durable adhesion is required.

Keywords: Adhesion, Epoxy resin, Polyester, Crystalline Marble, Pietra Gray Marble

Introduction

Stone adhesive is a highly strong and durable material used for bonding various types of stones, ceramics, concrete, and construction materials. This adhesive is typically made from epoxy or polyester resins and, once dried, offers high resistance to pressure, moisture, and temperature changes. It is widely used in construction, cladding, installing decorative stones, and even structural repairs. Its key features include strong adhesion, resistance to environmental conditions, and fast drying time, making it an ideal choice for civil and construction projects [1].

Crystalline Marble is a type of marble with a crystalline and transparent structure, composed of fine or coarse calcite crystals. Due to metamorphic processes, this stone has high density and a uniform structure, which reduces porosity and increases its resistance to water absorption [2]. Its surface can be easily polished, providing a high gloss, making it an ideal choice for interior decoration, sculpture, and luxury flooring. Because of its low porosity, this marble has high resistance to liquid penetration, making it less prone to staining compared to some other types of marble [3].

Pietra Gray Marble, also known as "Gray Marble," is a type of marble with a dark gray background and white veins. It is composed mainly of calcite with small amounts of other minerals and has a relatively higher porosity than some lighter-colored marbles. This porosity makes it more susceptible to water absorption and staining if not properly treated. Therefore, resin coatings are often applied to reduce porosity and enhance surface durability. Due to its unique color and elegant texture, this stone is widely used in modern designs, interior facades, and luxury flooring [4].

Experimental

Materials

In this study, unsaturated polyester and epoxy acrylate were prepared industrially. The optical initiator 2,4,6-trimethylbenzoyl diphenylphosphine oxide (TPO) was prepared from IGM Resins and benzophenone was prepared industrially. Epoxy was purchased from TENAX Italy and styrene was prepared industrially. Fumed Silica was prepared from China.

Method

Both polyester and epoxy acrylate resins were diluted with styrene solvent in a ratio of 65:25. Then 2% by weight of TPO and 1.5% by weight of benzophenone were added to it.

Epoxy and hardener were also mixed in a ratio of 1:3. Also, to prepare mastic with a similar formulation, 6% by weight of Fumed Silica was added to the samples. Next, films of 120-micron thickness were applied to crystalline marble and Pietra Gray marble from each of the six samples using a film-puller, and

the samples were cured with UV light using LED and halogen lamps.

Results and Discussion

The adhesion of epoxy resin and polyester resin to White Crystalline Marble and Pietra Gray Marble is affected by various factors such as porosity, surface roughness, and surface preparation process. Epoxy generally performs better on stones due to its strong chemical structure and high adhesion to a wide range of surfaces. White Crystalline Marble has average adhesion to epoxy due to its high density and low porosity. To improve adhesion, surface preparation such as roughening or priming is recommended. Pietra Gray Marble has medium porosity, which can increase epoxy adhesion. Its rougher surface helps resin absorb better, but primer may be necessary to prevent excessive penetration.

Polyester resin is generally less adhesive than epoxy and is more brittle. White Crystalline Marble has a smooth, low-porosity surface, making it difficult for polyester to adhere to this stone and is more likely to peel off. Pietra Gray Marble has slightly better adhesion to polyester than to White Crystalline Marble due to its higher porosity, but it will still be weaker than epoxy.

Conclusion:

Overall, epoxy has better adhesion than polyester, especially to Pietra Gray Marble which has a more porous texture. To improve adhesion on both stones, proper surface preparation (such as roughening and cleaning) and in some cases the use of a primer is recommended.

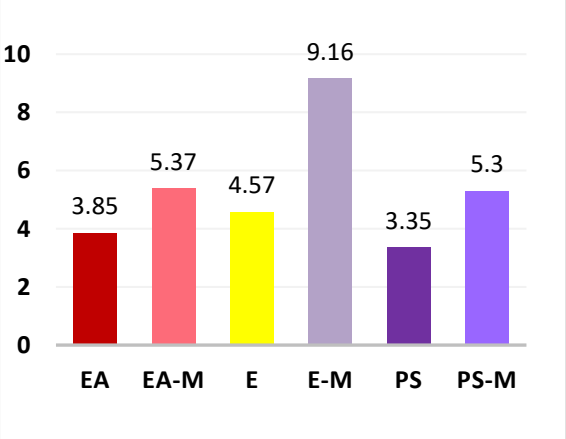

Figure 1. pull-off test result for Crystalline Marble stone

Epoxy Acrylate (EA), Epoxy Acrylate mastic (EA-M), Epoxy (E), Epoxy mastic (E-M), Polyester (PS), Polyester mastic (PS-M)

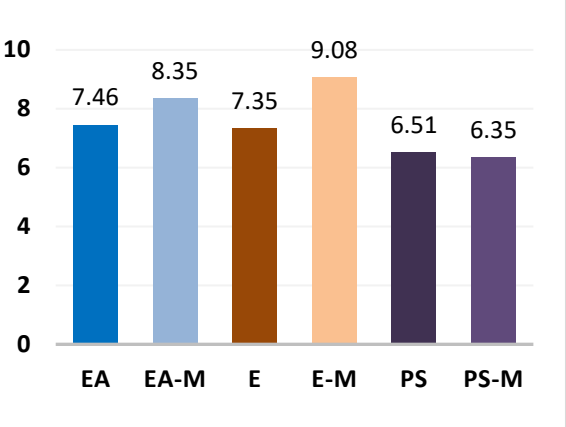

Figure 2 . pull-off test result for Pietra Gray Marble stone

Conclusion

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