

# THE INFLUENCE OF SURFACE ROUGHNESS ON THE OPTICAL REFLECTANCE CHARACTERISTICS OF GYPSUM-BASED COATINGS

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## Abstract

This study aims to systematically investigate the effect of surface roughness on the optical reflectance behavior of gypsum-based wall coatings within the framework of existing literature. Surface topography is one of the fundamental parameters determining the optical performance of materials, and the interaction of light with a surface varies depending on surface roughness and microstructural characteristics. However, it is observed that this relationship has been addressed in a limited and fragmented manner in the literature, particularly with respect to gypsum-based coatings.

Within this scope, the relationships between surface roughness (Ra), surface morphology, and optical reflectance components (diffuse and specular reflectance) were comparatively evaluated based on studies conducted on mineral-based coatings, ceramics, and other surface materials. The findings in the literature indicate that as surface roughness increases, specular reflectance decreases, while diffuse reflectance increases, resulting in a more homogeneous distribution of light on the surface. Furthermore, it is understood that not only the average roughness value but also the surface geometry and the distribution of microstructural irregularities play a decisive role in light scattering.

This study presents a holistic approach to the relationship between surface roughness and optical reflectance behavior by reinterpreting findings from different material groups within the context of gypsum-based coatings. The results indicate that the optical performance of gypsum surfaces can be directed through the control of surface microstructure and provide a conceptual framework for future experimental studies in this field.

**Keywords:** surface roughness, gypsum-based coatings, optical properties, diffuse reflectance, specular reflectance, surface topography, microstructure, light-surface interaction

## 1. Introduction

Surface roughness has been a significant research topic in the field of material science as one of the fundamental parameters determining the physical and optical behavior of materials. In particular, the interaction between surface topography and light plays a critical role in defining optical properties such as reflection, scattering, and absorption. The literature demonstrates that with increasing surface roughness, light is distributed over wider angles across the surface, leading to a decrease in specular (mirror-like) reflectance and an increase in diffuse reflectance, as reported in numerous studies [1], [2].

The surface-light interaction is not only governed by average roughness values but is also directly

related to microstructural irregularities, pore structure, and the continuity of surface geometry. In particular, irregularities at the micro-scale cause light to scatter in multiple directions, significantly altering the optical behavior of the surface [3]. Therefore, the effect of surface roughness on optical performance should be evaluated not only through macroscopic parameters but also within the context of microstructural characteristics.

Studies conducted on different material groups indicate that the effect of surface roughness on optical reflectance behavior varies depending on the material type. Research on ceramic, metal, and polymer-based surfaces demonstrates that controlling surface roughness through surface treatment techniques is an important tool for tailoring optical properties [4], [5]. However, most of these studies focus on industrial materials, and it is observed that research on building materials—particularly gypsum-based coatings—remains limited.

Gypsum-based coatings are among the widely used mineral-based materials in interior surfaces and can be produced with varying levels of surface roughness depending on finishing techniques. Despite this, the relationship between the roughness characteristics of these surfaces and their optical reflectance behavior has not been systematically addressed in the literature. Existing studies generally focus on mechanical performance, adhesion, and application techniques, while evaluations related to optical behavior remain limited.

## 2. Materials and Methods

In this study, a literature review method was employed to evaluate the effects of surface roughness on the optical reflectance behavior of gypsum-based coatings. Within the scope of the research, peer-reviewed scientific articles, technical reports, and academic studies published at both national and international levels on surface roughness, surface characterization, and light–surface interaction were comprehensively examined. In particular, studies addressing the effects of surface topography on optical reflectance components across different material groups were analyzed and evaluated.

Within the scope of the study, the following steps were followed:

- During the literature review process, existing academic studies related to surface roughness and optical reflectance behavior were systematically examined, and publications directly relevant to the research topic were selected.
- Different material groups, including ceramic, metal, polymer, and mineral-based surfaces, were evaluated, and their roughness characteristics, microstructural behaviors, and light interaction mechanisms were comparatively analyzed.
- The effects of surface roughness on light reflectance behavior were classified, and changes in diffuse and specular reflectance components were evaluated based on the obtained data.
- Parameters related to surface characterization ( $R_a$ ,  $R_z$ , surface morphology, microstructural irregularities) were considered, and their effects on light scattering were analyzed.
- Since studies specifically focused on gypsum-based coatings are limited, research on mineral-based materials with similar physical properties was also included within the scope of the evaluation.
- Based on the findings obtained, a general evaluation framework was developed regarding the relationship between surface roughness and optical reflectance behavior.

As a result of these analyses, it has been understood that surface roughness is one of the fundamental parameters determining the optical performance of materials, and that reflectance behavior can be directed through the control of surface microstructure.

Within this context, the data obtained throughout the study were evaluated through a systematic approach, and a conceptual framework for the optical behavior of gypsum-based coatings was established.

### *2.1. Material Analysis*

Gypsum-based coatings are mineral-based materials widely used on interior surfaces and can be produced with varying levels of surface roughness depending on application techniques. The surface properties of these coatings vary according to the material composition, application method, and surface finishing techniques.

In gypsum surfaces, roughness is characterized by an irregular surface topography consisting of microscopic peaks and valleys. These irregularities directly influence the interaction of light with the surface, thereby determining reflectance behavior. As surface roughness increases, light is scattered over wider angles, whereas surfaces with lower roughness exhibit more directional (specular) reflectance.

The microstructural properties of gypsum-based coatings are defined by parameters such as crystal structure, porosity, and surface continuity. These characteristics directly influence the absorption, reflection, and scattering behavior of light on the surface. In particular, a porous structure causes multiple internal reflections of light within the surface, thereby increasing the diffuse reflectance component.

In this context, the effects of surface roughness and microstructural properties of gypsum-based coatings on optical reflectance behavior were analyzed in an integrated manner. These analyses demonstrate that the optical performance of gypsum surfaces depends not only on the material type but can also be directed through the control of surface topography.

### *2.2. Surface Roughness Parameters and Classification*

Surface roughness is a fundamental characterization parameter used to quantitatively describe surface topography, representing the deviation of a material's actual surface from an ideal (geometrically smooth) surface. These deviations appear as irregularities composed of microscopic peaks and valleys and directly influence the mechanical, tribological, and optical behavior of the material [6].

One of the most commonly used parameters in the characterization of surface roughness is the average roughness value,  $R_a$ .  $R_a$  is defined as the arithmetic mean of the absolute deviations of the measured surface profile from the mean line and represents the overall roughness level of the surface. However, the  $R_a$  parameter alone is not sufficient to fully describe surface topography. Therefore, parameters such as  $R_z$ , which represents the maximum peak-to-valley height difference on the surface, also play an important role in surface characterization [7].

Surface roughness parameters are generally classified into three main groups: amplitude parameters ( $R_a$ ,  $R_z$ ), spacing parameters, and hybrid parameters. Amplitude parameters describe the height of surface irregularities, while spacing parameters define the distribution of these irregularities across the surface. Hybrid parameters, on the other hand, evaluate both height and distribution characteristics together, providing a more comprehensive approach to surface topography [8].

The classification of surface roughness varies depending on the intended use of the material and performance expectations; however, it is generally expressed as low, medium, and high roughness levels. Surfaces with low roughness exhibit a smoother and more continuous structure, whereas surfaces with high roughness display more pronounced irregularities, significantly affecting the physical and optical behavior of the surface.

From an optical perspective, surface roughness is a critical parameter that determines the manner in which light interacts with a surface. On surfaces with low roughness, light is reflected in a more directional

and orderly manner (specular reflectance), whereas on surfaces with high roughness, light is scattered in multiple directions, exhibiting diffuse reflectance behavior. Therefore, surface roughness is not only a geometric property but also a fundamental factor determining the optical performance of a material [3], [5].

In gypsum-based coatings, surface roughness varies depending on the application method, equipment used, and surface finishing techniques. In particular, plaster application techniques determine the nature of microstructural irregularities formed on the surface, thereby directly affecting the level of roughness. In this context, accurately defining the roughness characteristics of gypsum surfaces is of critical importance for understanding their optical behavior.

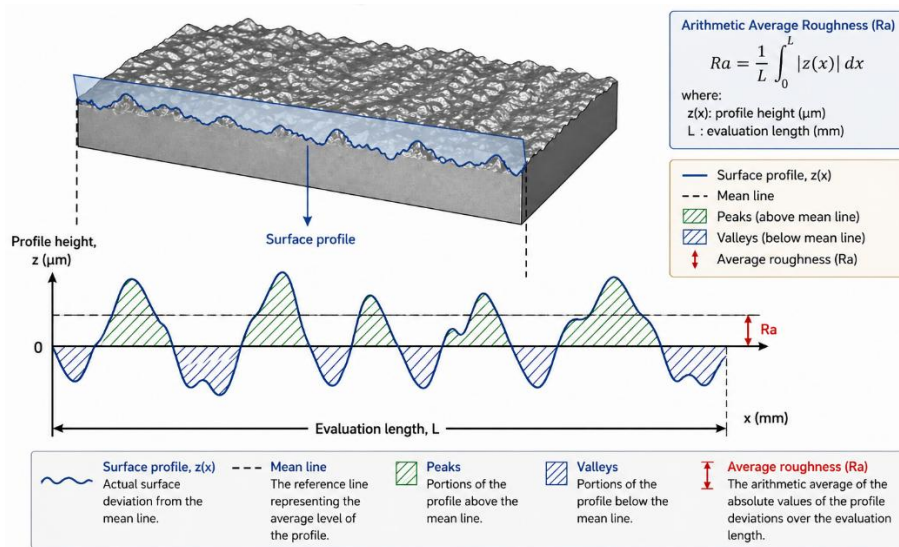


Fig. 1. Schematic representation of surface Roughness (Ra) and surface profile.

### 2.3. Optical Reflectance Mechanisms

The optical behavior of a surface is determined by the processes of reflection, scattering, and absorption that occur as a result of the interaction between incident light and the surface. This interaction is significantly influenced not only by the optical properties of the material but also by surface roughness and microstructural irregularities [9]. In particular, micro-scale irregularities in surface topography are considered one of the fundamental factors determining the reflectance characteristics, as they cause light to be distributed in different directions across the surface.

The light-surface interaction is generally explained by two main reflectance components: specular (mirror-like) reflectance and diffuse reflectance. Specular reflectance is observed on ideally smooth surfaces and is based on the principle that light is reflected at an angle equal to the angle it makes with the surface normal. This occurs when surface irregularities are negligible relative to the wavelength of light [10].

In contrast, as surface roughness increases, light is scattered in multiple directions due to microscopic peaks and valleys on the surface, resulting in diffuse reflectance behavior. Diffuse reflectance refers to the multidirectional distribution of light on rough surfaces, and such surfaces tend to approach Lambertian behavior [11]. In this case, the intensity of the reflected light from the surface exhibits a more uniform distribution in different directions.

In real surfaces, optical reflectance behavior generally emerges as a combination of these two components. In other words, a surface may exhibit both specular and diffuse reflectance characteristics,

and the proportion of these components varies depending on surface roughness, material type, and surface processing techniques [12]. It is widely accepted in the literature that as surface roughness increases, the specular component decreases while the diffuse component becomes dominant.

Another important factor in understanding optical reflectance mechanisms is the relationship between surface irregularities and the wavelength of light. When surface roughness is comparable to or larger than the wavelength, scattering effects become more pronounced and diffuse reflectance behavior increases. In contrast, when surface irregularities are much smaller than the wavelength, specular reflectance becomes dominant [13].

When evaluated specifically for gypsum-based coatings, surface roughness and microstructural properties play a critical role in determining optical reflectance behavior. The porous structure of gypsum surfaces and the surface irregularities formed depending on application techniques cause multiple scattering of light across the surface, thereby increasing the diffuse reflectance component. This indicates that the optical performance of gypsum-based coatings depends not only on material composition but also on the control of surface topography.

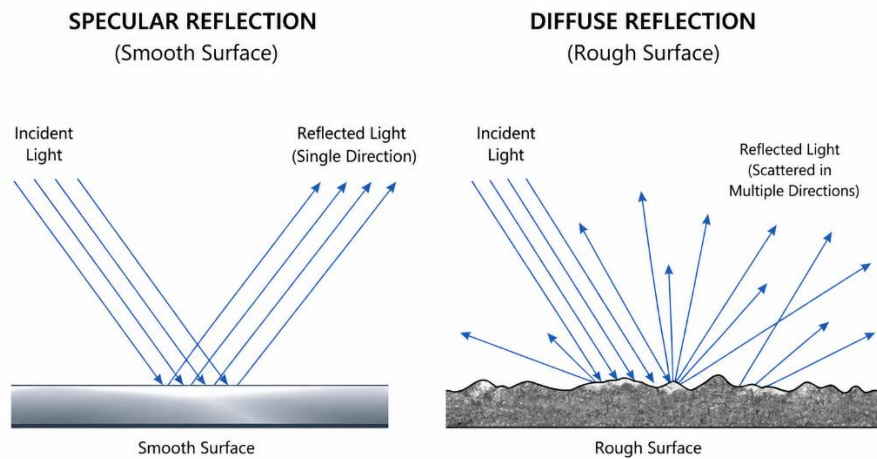


Fig. 2. Specular and diffuse reflection from smooth and rough surfaces.

### 2.3. Evaluation of Surface–Light Interaction

The surface–light interaction is one of the fundamental processes determining the optical performance of a material and requires the integrated evaluation of surface topography, microstructure, and material properties. This interaction is analyzed through the effects of surface roughness on the reflection and scattering behavior of light [9].

In the evaluation process, surface roughness parameters ( $R_a$ ,  $R_z$ ), along with surface morphology and microstructural irregularities, were considered as the main determining factors. The literature indicates that with increasing surface irregularities, light undergoes multiple scattering across the surface, which enhances the diffuse reflectance component. In contrast, on smoother surfaces, light is reflected in a more directional manner, and the specular component becomes dominant [14].

Another important factor in the evaluation of surface light interaction is the statistical distribution of surface roughness. Not only the average values of surface irregularities, but also their distribution characteristics and orientation affect the scattering behavior of light. In particular, random roughness structures on the surface cause light to disperse in multiple directions, thereby increasing optical homogeneity [1].

In addition, the effect of surface roughness on optical behavior should be evaluated together with the spectral properties of the surface. The interaction of light with the surface varies at different wavelengths, indicating that the influence of surface roughness on optical performance is wavelength-dependent [9]

When evaluated specifically for gypsum-based coatings, it is observed that variations in surface roughness resulting from finishing techniques directly affect the light–surface interaction. The porous structure and microstructural irregularities of gypsum surfaces cause multiple internal reflections of light, thereby increasing the diffuse reflectance component. This indicates that the optical performance of gypsum-based coatings depends not only on the material type but also on the control of surface topography.

### **3. Findings**

In this section, the effects of surface roughness on optical reflectance behavior were comparatively evaluated based on literature findings from different material groups. The obtained data reveal that surface topography plays a decisive role in the reflection and scattering mechanisms of light.

#### *3.1. The Effect of Surface Roughness on Optical Reflectance Behavior*

Surface roughness is one of the fundamental parameters determining the optical reflectance behavior of a material. The microscopic peaks and valleys present in surface topography directly influence the interaction of light with the surface, thereby defining reflection and scattering mechanisms. The literature generally agrees that as surface roughness increases, light is distributed over wider angles across the surface, and the directional nature of reflectance decreases [1], [9].

The optical effect of surface roughness depends not only on the magnitude of surface irregularities but also on their distribution and their relationship with the wavelength of light. When surface irregularities are small relative to the wavelength, the surface behaves optically smoother, whereas with increasing roughness, scattering effects become more pronounced [9].

In this context, the effect of surface roughness on optical reflectance behavior is primarily evaluated through two different reflectance components: diffuse and specular reflectance.

##### *3.1.1. Diffuse Reflectance Behavior*

Diffuse reflectance is an optical behavior observed in cases of high surface roughness, characterized by the distribution of light in multiple directions from the surface. This type of reflectance arises as a result of microscopic irregularities on the surface scattering light in various directions. On surfaces exhibiting diffuse reflectance, the reflected light does not have a specific direction, and the surface presents similar brightness values to the observer from different viewing angles [11].

On rough surfaces, light strikes peaks and valleys and undergoes multiple directional changes, resulting in a more homogeneous distribution of light. For this reason, diffuse reflectance is typically dominant in matte surfaces with low gloss. In addition, the porous structure and microstructural irregularities of the surface allow light to partially penetrate and scatter again within the material, further strengthening the diffuse component [15].

##### *3.1.2. Specular Reflectance Behavior*

Specular reflectance is a directional type of reflection that occurs when the surface is optically smooth and light is reflected at a specific angle. This type of reflectance is based on the principle that the angle of

reflection is equal to the angle of incidence with respect to the surface normal. When surface roughness is low, the irregularities on the surface are negligible relative to the wavelength of light, and thus the reflectance exhibits predominantly specular characteristics [10].

Specular reflectance is characterized by high brightness and clear reflected images and is particularly evident on metal and polished surfaces. However, as surface roughness increases, this directional reflectance behavior is disrupted, and light is distributed in multiple directions, leading to a reduction in the influence of the specular component [12].

In real surfaces, both diffuse and specular reflectance components are generally present, and the proportion of these components varies depending on surface roughness. Therefore, surface roughness is considered a critical parameter in determining optical reflectance behavior.

### *3.2. The Relationship Between Surface Roughness and Reflectance in Different Material Surfaces*

The effect of surface roughness on optical reflectance across different material groups should be evaluated together with parameters such as refractive index, absorption coefficient, porosity, and surface topography. The literature shows that as roughness increases, the specular component weakens while diffuse scattering is enhanced; however, the intensity of this trend varies depending on the material type [1], [4]. In particular, the statistical distribution of random surface irregularities is an important factor determining the angular distribution of scattering [1].

#### *3.2.1. Ceramic and Mineral-Based Surfaces*

Ceramic and other mineral-based surfaces exhibit strong diffuse scattering behavior due to their porous microstructure and heterogeneous surface topography. As surface roughness increases, light is distributed over wider angles through multiple internal reflections and scattering. This results in a more matte and optically homogeneous appearance of the surface [15]. Additionally, microporosity in mineral surfaces allows light to partially penetrate into the surface and scatter again, which increases the total diffuse component and suppresses the specular peak.

#### *3.2.2. Polymer-Based Surfaces*

In polymer-based surfaces, optical behavior depends not only on surface roughness but also on the degree of translucency and refractive index contrast of the material. While specular reflectance is dominant at low roughness levels, increasing roughness leads to a combined increase in surface scattering and volumetric (subsurface) scattering, resulting in a matte appearance [11]. The statistical distribution of micro-asperities and whether the surface is oriented (anisotropic) determine the angular distribution of reflectance and reduce the observed gloss.

#### *3.2.3. Metal Surfaces*

Metals exhibit intrinsically high reflectivity due to their high free electron density and produce strong specular reflectance at low roughness levels. However, an increase in surface roughness leads to the formation of surface elements with different orientations, as described in the microfacet model, causing the reflectance to spread over wider angles [12]. This process results in the broadening of the specular peak and a reduction in overall gloss. Reducing surface roughness through surface treatments (such as polishing or coating) enhances the specular component once again.

### *3.3. Surface Roughness and Optical Behavior in Gypsum-Based Coatings*

Gypsum-based coatings are mineral-based materials widely used on interior surfaces and can be produced with varying levels of surface roughness depending on application techniques. In these coatings, surface roughness is not only an aesthetic feature but also a critical parameter determining light-surface interaction. Although studies on the optical behavior of gypsum surfaces are limited in the literature, evaluations based on similar mineral-based materials reveal the decisive role of surface topography in reflectance mechanisms [16].

#### *3.3.1. Microstructural Properties of Gypsum Surfaces*

Gypsum-based coatings possess a heterogeneous microstructure composed of calcium sulfate dihydrate ( $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ ) crystals. During application, these crystals form random orientations, creating an irregular surface topography. This constitutes the primary microstructural source of surface roughness [16].

Porosity in gypsum surfaces originates from the voids between crystals, allowing light to partially penetrate into the surface and scatter back. This multiple scattering mechanism contributes to an increase in the diffuse reflectance component. In addition, pore size and distribution directly affect the propagation of light within the surface and are among the key parameters determining optical behavior [16].

#### *3.3.2. Formation Mechanism of Surface Roughness*

In gypsum coatings, surface roughness is largely formed depending on the application process and surface finishing techniques. The equipment used during plaster application (such as trowels and sponges), application pressure, and surface smoothing operations play a decisive role in shaping the surface topography.

Steel trowel applications performed to obtain a smooth surface reduce surface irregularities, thereby lowering roughness and creating a more compact structure. In contrast, surface treatments carried out using a sponge or similar techniques increase microscopic irregularities on the surface, resulting in a higher level of roughness. This process can be explained by the reorganization of the crystal structure on the surface and the increased formation of micro-scale peaks and valleys.

Additionally, the water-to-binder ratio of the gypsum mixture, the drying process, and environmental conditions are among the important factors influencing the formation of surface roughness. These parameters directly affect microstructural development, thereby determining the final surface topography [16].

#### *3.3.3. Evaluation of Optical Reflectance Behavior*

In gypsum-based coatings, optical reflectance behavior arises from the combined effect of surface roughness and microstructural properties. On gypsum surfaces with low roughness, the specular reflectance component becomes more pronounced, whereas with increasing surface roughness, diffuse reflectance becomes dominant. This behavior is explained by the scattering of light in multiple directions due to microscopic irregularities on the surface [11].

The porous structure and crystal irregularities cause light to undergo multiple internal reflections within the surface, increasing scattering behavior and resulting in a more optically homogeneous appearance. Therefore, the optical performance of gypsum coatings depends not only on surface roughness but also on the control of microstructural properties.

## 4. Analysis of the Relationship Between Surface Roughness and Optical Behavior

The relationship between surface roughness and optical reflectance behavior is evaluated within the framework of the effects of surface topography on the reflection and scattering mechanisms of light. Findings in the literature indicate that surface roughness is not merely a geometric property, but also a fundamental parameter that determines whether light is distributed in a directional or multidirectional manner [9]. In this context, the relationship between surface roughness and optical behavior is analyzed through diffuse and specular reflectance components, as well as microstructural properties.

### 4.1. Relationship Between Roughness and Diffuse Reflectance

Diffuse reflectance is a behavior that becomes more pronounced with increasing surface roughness and is characterized by the multidirectional scattering of light from the surface. Microscopic irregularities on the surface cause incident light to strike at different angles and change direction at each point of interaction. This process leads to a more uniform distribution of light across the surface, thereby increasing the diffuse reflectance component [11].

With increasing surface roughness, the surface tends to approach Lambertian behavior, and the angular dependence of reflectance decreases. Especially in surfaces with porous and heterogeneous structures, multiple internal reflections of light further enhance the diffuse component. For this reason, surfaces with high roughness are generally associated with low gloss and a matte appearance [15].

### 4.2. Relationship Between Roughness and Specular Reflectance

Specular reflectance is a directional type of reflection that becomes dominant when the surface is optically smooth, with light reflected in a specific direction. When surface roughness is low, the irregularities on the surface are negligible relative to the wavelength of light, and thus the reflectance exhibits predominantly specular characteristics [10].

As surface roughness increases, the specular reflectance component weakens. Micro-scale peaks and valleys alter the orientation of local surface normals, causing light to be reflected at different angles and leading to the dispersion and reduction of specular reflectance [12]. This process results in a decrease in optical gloss and a transition of the reflectance behavior toward a more diffuse character.

### 4.3. Effect of Microstructure on Light Scattering

The effect of surface roughness on optical behavior is not limited to macroscopic roughness values alone and should be evaluated together with microstructural properties. The crystal structure, porosity, and distribution of microstructural irregularities on the surface directly determine the interaction of light with the surface [11].

Microstructural irregularities cause light to undergo multiple scattering on the surface, thereby broadening the angular distribution of reflectance. In particular, in porous materials, the penetration of light into the surface and its subsequent re-emergence through scattering is considered a key mechanism that enhances the diffuse reflectance component. This leads to a more optically homogeneous appearance and a less directional reflectance behavior.

In this context, considering surface roughness together with microstructural properties enables a more accurate and comprehensive understanding of optical reflectance behavior. Findings in the literature indicate that these two parameters cannot be evaluated independently and that surface topography should be examined at multiple scales.

Therefore, approaches to surface characterization that address both macroscopic and microscopic levels are of critical importance in determining the optical performance of materials.

## **5. Evaluation and Implications for Gypsum-Based Coatings**

A holistic evaluation of the literature findings indicates that the optical reflectance behavior of gypsum-based coatings is governed by the combined effects of surface roughness and microstructural properties. In gypsum surfaces, crystal morphology, porosity, and surface topography are the primary parameters determining the interaction of light with the surface. Therefore, in assessing optical performance, not only average roughness values (Ra, Rz) but also the continuity of surface geometry and microstructural distribution should be taken into consideration.

### *5.1. Effect of Surface Finishing Techniques on Optical Behavior*

In gypsum coatings, surface finishing techniques directly affect optical reflectance behavior by determining the final surface topography. Compaction and surface smoothing processes carried out with a steel trowel reduce surface irregularities, creating a more compact structure with higher continuity. In such surfaces, the limited presence of microscopic irregularities leads to a more pronounced specular reflectance component.

Techniques such as sponging, brushing, or trowel finishing (trifil) create controlled micro-irregularities on the surface, thereby increasing the level of roughness. On these surfaces, light is scattered in multiple directions, leading to an increase in the diffuse reflectance component. This variation in surface topography demonstrates that optical behavior changes depending on the surface finishing method.

### *5.2. Control of Surface Roughness and Application Methods*

In gypsum-based coatings, surface roughness is considered a controllable parameter depending on the application process. Mix design (water-to-binder ratio), application thickness, number of layers, surface finishing time, and the equipment used play a decisive role in the formation of surface topography.

A low water-to-binder ratio and appropriate curing conditions contribute to the formation of denser surfaces with lower porosity and are associated with reduced roughness levels. In contrast, high water content and rapid drying conditions increase void formation in the microstructure, leading to more pronounced surface irregularities. Application pressure and surface finishing time during the process also affect the degree of surface compaction, making them important parameters that influence the level of roughness.

Considering the relationship between surface roughness and optical reflectance components, it is observed that variations in application parameters influence both specular and diffuse reflectance behaviors. This indicates that optical behavior can be directed through the control of surface topography.

### *5.3. Evaluation in Terms of Design and Application*

The optical behavior of gypsum-based coatings is explained through the combined evaluation of surface roughness and microstructural properties. The control of surface topography is among the key parameters determining the interaction of the material with light and is therefore taken into account in the assessment of optical behavior.

Different levels of surface roughness affect the distribution of light on the surface, thereby influencing surface gloss and reflectance uniformity. This demonstrates the role of surface finishing techniques and application parameters in determining optical behavior.

When the relationship between surface characterization parameters and application techniques is considered together, it is evident that surface roughness in gypsum-based coatings is directly related to optical reflectance behavior. This relationship provides an evaluation framework demonstrating that optical performance can vary through the control of surface topography.

## **6. Recommendations for Future Studies**

It is observed that studies on the optical reflectance behavior of gypsum-based coatings are limited in the literature, and further research in this area is expected to contribute to a more detailed understanding of the relationship between surface roughness and optical properties. In particular, experimental investigations examining the relationship between roughness parameters ( $R_a$ ,  $R_z$ ) and optical reflectance components (diffuse and specular reflectance) on gypsum surfaces are of great importance for addressing the existing gaps in the literature.

The use of advanced measurement techniques for surface characterization (such as profilometry, atomic force microscopy, and optical surface analysis methods) can enable the multi-scale evaluation of the relationship between microstructure and optical behavior. Such approaches allow surface topography to be examined at different scales, thereby contributing to a more comprehensive understanding of optical scattering mechanisms.

Systematic investigation of the effects of application parameters in gypsum-based coatings—such as the water-to-binder ratio, surface finishing techniques, and curing conditions on surface roughness can support the development of new approaches for controlling surface topography. Such studies are important for generating data that link material performance with the application process.

Investigating the effect of surface roughness on spectral reflectance behavior through optical measurements conducted at different wavelengths can contribute to a more comprehensive evaluation of surface light interaction. In this context, performing measurements across the visible and near infrared regions would enable the analysis of the optical performance of gypsum surfaces under varying conditions.

## **7. Conclusion**

The relationship between surface roughness and optical reflectance behavior is directly linked to the surface topography and microstructural properties of materials. Findings in the literature indicate that as the level of roughness increases, specular reflectance decreases while the diffuse reflectance component becomes more pronounced. This trend is explained by the influence of surface irregularities on the scattering behavior of light.

The effect of surface roughness on optical behavior is not limited to average roughness values alone, but should be evaluated together with parameters such as the continuity of surface geometry, the distribution of microstructural irregularities, and porosity. This necessitates a multi-scale approach to surface characterization.

Evaluations specific to gypsum-based coatings indicate that surface roughness in these materials is directly related to application techniques and microstructural properties. Surface finishing methods and application parameters determine surface topography, leading to variations in optical reflectance behavior.

The comparison of literature findings across different material groups reveals that surface roughness is a decisive parameter in determining optical performance and demonstrates that this relationship is also valid in the context of gypsum-based coatings. Within this framework, approaches aimed at controlling surface topography emerge as an important area of research for understanding and evaluating the optical behavior of materials.

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