

Coat of paint at the Dresden Zwinger – background and conservation method

Barevné provedení drážďanského Zwingeru – historie a konzervační metoda

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The use of colored coatings to design and protect stone architecture at the Dresden Zwinger followed a common tradition and goes back to the ensemble's creation in the early 18th century. The appearance of the facades over time has been documented in paintings, written sources, and photographs. Furthermore, all paint layers are researched and scientifically evaluated through numerous small remnants on the building itself. More recent investigations confirm four different paint layers between 1713 and 1898. After an overview of the historical color schemes, the talk will pay particular attention to the restoration history of the early 20th century. The removal of all paint layers from the stone surfaces at that time significantly changed the Zwinger's appearance and, in the long run, caused damage phenomena that still pose conservative challenges for restorers today. From this starting point, a conservation concept has been developed over the past decades that takes into account the particular erosion and patination behavior of Elbe Sandstone and the dimensions of the Zwinger ensemble with its roughly 500 exposed weathered sculptures. Part of the current concept is the sustainable protection of weathered stone surfaces with a silicone resin paint. The lengthy development process of this method and the protective function of the paint will be presented in the talk. The application of color on historic buildings is always accompanied with debates about the appearance of the object. The aesthetic problem of patinated Elbe Sandstone and its solution, illustrated by the Zwinger, is also a topic of the discussion.

Použití barevných nátěrů k výzdobě a ochraně kamenné architektury bylo v drážďanském Zwingeru běžnou tradicí a sahá až do doby vzniku komplexu na počátku 18. století. Vzhled fasád v průběhu času je zachován na obrazech, v písemných pramenech a fotografiích. Kromě toho jsou všechny vrstvy barev zachovány na četných nálezech na malých zbytcích samotné budovy a vědecky vyhodnoceny. Novější výzkumy potvrzují čtyři různé nátěry mezi lety 1713 a 1890. Po přehledu historických barevných provedení se přednáška zaměří zejména na historii restaurování na počátku 20. století. Tehdejší odstranění všech barevných vrstev z kamenných povrchů výrazně změnilo vzhled Zwingeru a mělo dlouhodobé škodlivé účinky, které restaurovům dodnes přináší konzervační výzvy. Na základě této výchozí situace byl v průběhu posledních desetiletí vyvinut konzervační koncept, který zohledňuje zvláštní erozi a patinování elbejského pískovce a rozměry komplexu Zwinger s přibližně 500 exponovanými sochami vystavenými povětrnostním vlivům. Součástí současného konceptu je trvalá ochrana povrchů kamene vystavených povětrnostním vlivům pomocí silikonové pryskyřičné barvy. V přednášce bude představen dlouhý proces vývoje této metody a ochranná funkce barvy. Použití barvy na historických budovách je vždy spojeno s debatami o vzhledu objektu. Estetická problematika patinovaného elbeho pískovce a její řešení na příkladu Zwingeru jsou rovněž předmětem úvah.

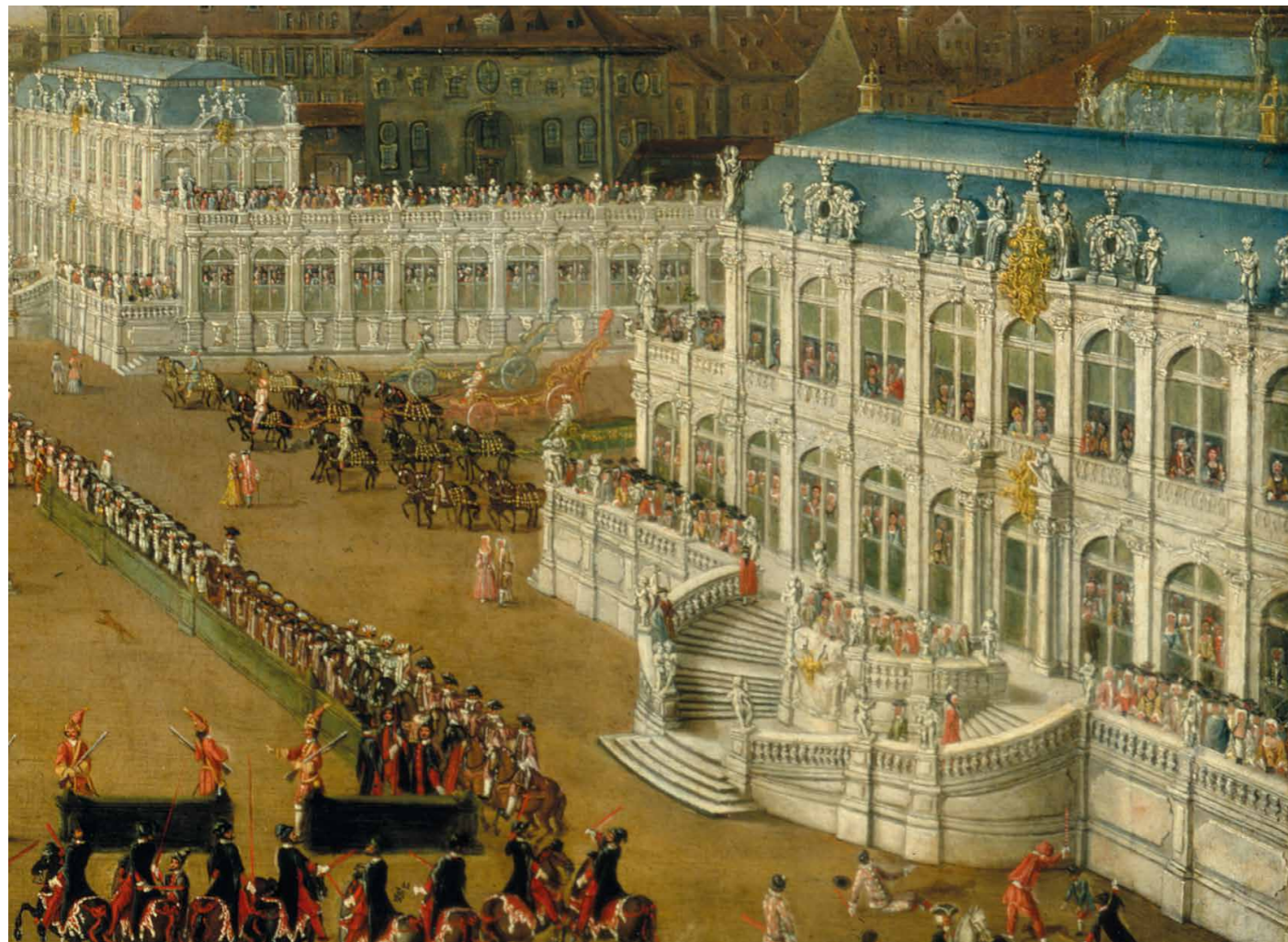


Fig. 1 Johann Alexander Thiele: "Carroussel Comiques" Rennen im Zwinger (Detail), 1722. [Gemäldegalerie Alte Meister, Staatliche Kunstsammlungen Dresden, Gal. Nr. 3603]

Since well before the 18th century, colour was used to decorate and protect stone buildings. Coloured coatings were based on a very common craft tradition. In the baroque era, Dresden's architecture was characterized by plastered buildings, mostly coloured in light ochre tones. Prestigious courtly stone buildings such as the Zwinger and the Catholic Court Church (Hofkirche) were given extensive colour schemes. The exterior of the Frauenkirche was planned to be coloured as well.^[1] Consistent with baroque elegance, the coatings served to conceal the joints and differences in stone material and the visual enhancement of Elbe sandstone, which was the mandatory building material, in favor of the plastic effect of the overall architecture. The use of white colour, for example, was intended to imitate scarcely available materials of higher quality like marble. On the other hand, the protective function of coating must also have played at least a secondary role, as the susceptibility of fine-grained varieties of Elbe sandstone to weathering was known. These colour coatings on baroque buildings can be verified by various sources.^[2] If preserved, in Dresden these representative baroque buildings mostly show natural stone facades today.

1 Remus, T.: Instandsetzungs- und Restaurierungsarbeiten bis 1942, in: Die Frauenkirche zu Dresden – Werden Wirken Wiederaufbau; Dresden 2005, Pg. 101.

2 Marx, H.: Der Zwinger und die Farbe – der Zwinger und die Malerei. in: Jahrbuch der Staatlichen Kunstsammlungen Dresden, vol. 14, 1982. Pg. 9.

Historical coating systems at the Zwinger

The history of the Dresden Zwinger is marked by constant changes in its appearance of facades over time which have been captured in literary sources, paintings and photographs. Since its construction around 1710 the Zwinger's facades were continuously coloured until the early 20th century, which means that the building has been completely covered with colour for most of the time.^[3] Over these about 200 years, four layers of paint consecutively accumulated on the facade of the Zwinger. Numerous small remnants of paint have been found and binder systems have been evaluated by recent diagnostic tests. Microscopic examinations now provide us information about the pigments used in the facade coatings.^[4]

An authentic, albeit somewhat idealized, impression of the earliest appearance of the complex is shown by two paintings by the court painter Johann Alexander Thiele, dated 1722. The facades are entirely coloured in an off-white hue. Heraldic elements with surrounding cartouches were gilded, which contrasts elegantly with blue-coated copper roofs. (Fig. 1) This original white facade coating was probably a calcareous oil paint. In the accurate Zwinger vedutas painted by Thiele's successor court painter Bernardo Bellotto in the early 1750s, traces of this colouring can be seen and the gildings are still visible. The subsequent colour scheme, applied between 1783 and 1795, was again in an off-white shade, but this time using an oil bound lead white colour. Cross-sectional analysis revealed a distinct layer of dirt, followed by a third, ochre colour scheme from around 1860. This was replaced between 1880 and 1898 by an oil-based gray colour scheme, whose dark hue can still be seen in numerous black-and-white photographs.

The changes from white to ochre to dark gray colouring that took place during the 18th and 19th century can be explained by the later extension buildings that completed the Zwinger complex from the mid-19th century. When the Gemäldegalerie designed by Gottfried Semper closed off the northwest side of the Zwinger courtyard in 1855, its monumental natural stone facade stood in contrast to the baroque Zwinger in its aged second white coating. The only way to match the colour of the baroque architecture to the newly built neo renaissance stone facade was to recoat the baroque buildings in an ochre sandstone-like hue. However, the appearance of the freshly laid sandstone is not permanent, but rather weathers slowly and imperceptibly in a long period over the decades, turning over gray to black. After twenty-five years, the darkened natural stone 19th century extension buildings once again contrasted with the painted architectural elements toward the end of the 19th century. A dark gray was now chosen to match the baroque complex to the darkly patinated extensions.

The coatings served not only to harmonize the colour of the entire Zwinger structure. Later, paint was also necessary to cover various repair materials, mostly cement-bound, which were often used extensively in combination with corrosive iron clamps and reinforcements around the mid-19th century onwards. Over the following decades, these heterogeneous substrates formed a disastrous material combination with the sealing oil coating: The completely different strength and expansion properties of sandstone and cement-bound supplements initially led to stress cracks. In addition, the aging oil paint tended to crackle. Moisture that penetrated the cracks could not diffuse out of the stone again through the oil-based coating. Prevented moisture diffusion accelerated the decomposition processes of the stone underneath the colour layers. Corrosive expansion of iron clamps also got intensified and caused enormous damage.^[5]

The incompatible combination of materials and negligent maintenance led to a steady deterioration in the structural condition of the entire complex during the second half of the 19th century. Conservationists called for the long-term preservation of the Zwinger as an important

3 Marx, Pg. 7.

4 Archiv Zwingerbauhütte, Fassungsuntersuchung, Trentzsch/Hoblyn 2013.

5 Hoferick, F./ Siedel, H.: Die Ablaugung von Ölfarbanstrichen am Dresdner Zwinger – Geschichte und Folgeschäden, in: Denkmalpflege in Sachsen. in: Arbeitsheft des Landesamtes für Denkmalpflege Sachsen, Dresden 1999. Pg. 80–88.

architectural testimony to the baroque period. The growing awareness of the monument's value finally led to a restoration phase in 1911, which was interrupted by the First World War. After foundation of the Zwingerbauhütte in 1924, the restoration work was able to continue until 1936 with a craft-oriented restoration concept and a baroque design intention. The restoration concept was led by a paradigm shift away from mortar additions with colour coating toward a purist craftsmen like material approach with piecework and copies made exclusively from "the best stone."

"Never again paint on the Zwinger!"

The measures conducted between 1924 and 1936 were in line with the aesthetic preference of the early 20th century for a natural stone tooled appearance, justified by the obvious stone damage, which was incorrectly attributed solely to the sealing oil paint.¹⁶¹ Thus, the credo "never again paint on the Zwinger!" became popular. All facades and sculptures were to be stripped of their colour layers and the entire complex appeared completely with a natural stone surface for the first time in its history. During this restoration phase from 1924 to 1936, a strongly alkaline paste, later known as "Zwinger paste," was used to leach all the sculptures and the entire facade surface. (Fig. 2) The paste consisted of caustic soda, slaked lime and soap, among other ingredients. After a reaction time of up to 24 hours, it was removed along with the layers of paint and rinsed off with plenty of water, whereby the active agents were unintentionally carried deeper under the stone surface and deposited there. Immediately after drying the substances became noticeable, particularly on the exposed stone sculptures, in the form of efflorescence, which was mainly due to reactions with the caustic soda solution. The following reactions are related to the sulfur dioxide-containing air that prevailed at the time due to coal combustion in households and industry: When the sodium hydroxide came into

contact with the CO₂ in the ambient air, it initially converted to sodium carbonate, which caused long term reactions with the flue gases and sulfuric acid rainwater (SO₂) to form sodium sulfate.¹⁷¹ This sulfate compound is known as one of the most harmful stone damaging salts. By leaching the entire facade of the Zwinger, the sodium sulfate accumulated in the whole stone structure. Until today the salt is particularly noticeable in the form of spalling due to high pressure of periodic salt crystallization. Thus, with the best of intentions to protect the stone from rapid decay, another, no less fatal cause of damage was created.

Issues of stone conservation have been suddenly pushed into the background after the partial destruction of the Zwinger in 1945 in view of the extent of damage. During reconstruction, stone replacement in the form of piecework and copies was once again used, waiving any coating. In 1963, the reconstruction was completed and the Zwingerbauhütte was dissolved. Nevertheless, in the further decades, the enormous pollution of the air accelerated the stone damaging processes. High contents of fine particulate matter, soot, and sulfur dioxide intensified



Fig. 2 Leaching of colour layers from the sculpture Hermes at Kronentor attic. [H. Ermisch, Landesamt für Denkmalpflege Sachsen, 1925]

6 Kiesewetter, A.: Zur Konservierung und farblichen Aufhellung des Figureschmucks am Dresdner Zwinger, Ausstellungsbeitrag des Landesamtes für Denkmalpflege Sachsen, Dresden 2012, Pg. 101.

7 Hoferick / Siedel, Pg. 7.

the aforementioned salt-induced damage, the formation of gypsum crusts and also the typical black patina on Elbe sandstone. Although the incompatible oil paint had been removed, it now became apparent that the unprotected Elbe sandstone was exposed to rapid erosion and patination. Without continuous maintenance, critical conditions developed again over the course of the 1970s and 1980s, particularly in the stone substance of the most weather exposed architecture – the attic, balustrades, and sculptures – which necessitated the development of a comprehensive conservation concept

Conservation necessity

As early as in the mid-1980s, ambitious investigations and series of experiments were carried out under the direction of the building department of the State Art Collections in order to conserve about 700 sculptures, vases and decorations in an efficient and sustainable manner.¹⁸¹ The State Monument Office pushed for the conservation of the endangered building, but also asserted an aesthetic requirement specifically concerning the Zwinger: The blackening of the Elbe sandstone had progressed to such an extent that the patinated components heavily weighed like black unrecognizable piles on the brighter, rain protected facades, detracting from the cheerful design intent. (Fig. 3) In addition, the harmonious proportions of the facade architecture were disrupted by the sharp colour differentiation. In the meantime, petrographic analyses had led to the conclusion that the black patina on the Elbe sandstone could not be removed or cleaned without reducing and destroying the tooled surface, as it consists of an iron oxide deposit that can reach a depth of several millimeters.¹⁹¹



Fig. 3 Wallpavillon and black patinated balustrade sculptures. [Zwingerbauhütte, 1992]

8 Kiesewetter, Pg. 105.

9 Heidelmann, H.: Die Restaurierung von Sandsteinfassaden am Beispiel des Dresdner Zwingers, in: Arbeitshefte des Landesamtes für Denkmalpflege Sachsen, Dresden 1992, Pg. 41.

Based on the investigations of the patina and testings of new conservation materials, experiments were conducted on individual sculptures to lighten them using bright coatings. In 1986, lime and lime casein coatings were tested, which were to be applied as a sacrificial layer that would need to be renewed regularly. Experiments with silicate paint on individual sculptures were also carried out in 1990. Both binder systems proved to be insufficiently weather-resistant, but the application of paint already demonstrated the positive influence on the visibility of the sculptural details.¹⁰ During a construction phase at the crown gate (Kronentor) in 1989, silicone resin paint was tested for the first time as a surface coating for the attic architecture. After ten years, it turned out that the sculptures at the crown gate treated with silicone resin paint showed no new weathering damage. The binding agent system seemed to be proving its worth and testing was continued.

In 1990, the Zwingerbauhütte was reestablished within the state building administration. In the following years, lively discussions continued about how to deal with the exposed stonework and the future appearance of the Zwinger. The aim was to bring hundreds of exposed sandstone sculptures, which were at risk, into a condition that could be preserved and maintained in the long term. Material science investigations into consolidation, waterproofing, and coating methods were carried out. The conservation concept was optimized by the Zwingerbauhütte in collaboration with the State Monument Office, manufacturers, and testing laboratories.

Current conservation concept

The current conservation concept consists of many object-specific individual measures. Yet two main objectives are usually pursued: desalination and moisture protection. Desalination is necessary to prevent the salt-induced stone damage, mostly caused by the described leaching paste used in the early 20th century. Moisture protection prevents the further erosion of sandstone. Both measures are preventive and have been optimized since the 1990s to address the specific damage patterns at the Zwinger. The interaction between the two conservation methods will be described in more detail below, using the example of a sculpture conservation.

Vases and sculptures can be removed and transferred from the building to the Zwingerbauhütte workshop. In preparation for the conservation, the black patina surface of a sculpture is thinned by blasting it with glass powder. The air pressure is kept low at three bar to prevent abrasion of the tooled surface. In the careful process the patina film is thinned solely on the exposed tops of the surface quartz grains. (Fig. 4) Why does the patina have to be thinned first?

Over decades up to centuries of formation, the patina creates a near-surface compaction with far lower water permeability than the unpatinated brighter stone surfaces. On objects exposed to rain, completely different sorption behaviors occur often within the same object. Thus, the purpose of powder blasting is not cleaning, but preparing the sculpture for the water bath desalination. With this method, the sculpture is placed in a bath of demineralized water. The water dissolves and extracts the salt from the stone. Since the compacted patina areas on the sculpture was thinned beforehand, an equal charge balance in the water bath process is improved. The increasing salt content of the water is measured using conductivity. Based on the salt concentration of the water, the salt amount extracted from the stone can be calculated. After two weeks, the salt containing water is exchanged. The process can be repeated in up to five cycles until the salt content in the stone is reduced to a harmless level.

¹⁰ Kiesewetter, A.: Zur Konservierung und farblichen Aufhellung des Figureschmucks am Dresdner Zwinger, Ausstellungsbeitrag des Landesamtes für Denkmalpflege Sachsen, Dresden 2012, Pg. 105.



Fig. 4 Low pressure glass powder blasting in order to carefully thin compacted patina areas. [Zwingerbauhütte, 2016]

Properties of silicone resin paint

The greatest potential for damage of Elbe sandstone are various moisture-induced erosion processes. That means that the most important protection for Elbe sandstone would be a water repellent and water evolving surface. Therefore, silicone resin paint is used as an important part of the conservation concept.

Silicone resin paint works by fillers interacting with two types of binders: It contains approximately 60 % fillers, mainly calcium carbonate and titanium dioxide, and 5 % each of acrylate binder and the eponymous silicone resin binder. The filler content is so high that the pure acrylate has no film-forming properties, but instead forms a microporous structure during the drying process.¹¹ The microporosity provides a high diffusion ability for water in the gaseous state. Diffusion ability characterizes the essential difference to film-forming systems such as pure acrylic or oil paint. The silicone resin as the second binder component coats the pore cavities and stabilizes the structure without clogging the pores, thus ensuring the long-term stability of the paint layer.

The microporosity is fine enough to prevent capillary absorption of liquid water by up to 79 % and open enough to still allow water to diffuse in the vapor phase.¹² This prevents moisture from entering the stone, same as waterlogging beneath the paint layer. A two-layer application further improves the water-repellent effect of the silicone resin paint without visually impairing the surface texture of the stone by clogging the stone pores. Application with brushes achieves a paint thickness of approx. 0.4 mm. The high filler content gives a matt surface. High frost-thaw resistance was confirmed in laboratory weather simulation testing, with paint samples showing no changes or damage after one month of 92 cycles of temperature

¹¹ Hilbert, H: Farbfassung von Natursteinen im Silikonfarbsystem. In: Farbe in der Steinrestaurierung. Fassung und Schutz. 2. Workshop des Instituts für Bauchemie Leipzig e.V., Kloster Nimbschen, 11.–12. Juni 1999, published by Andreas Boué. Stuttgart 2000.

¹² Rubin, C.: Die Anwendung des Silikonharzfarbsystems auf Elbsandstein am Beispiel des Dresdner Zwingers. Diploma thesis FH Köln 2008, Pg. 79.

changes from -18°C to 50°C .^[13] Since no hydrophobic depth impregnation is used prior to application in order to ensure vapor diffusion openness, the hydrophobicity is limited to the paint layer. The non-invasive application also ensures the reversibility of the entire protection system. (Fig. 5) Reversibility plays a decisive role since the paint layer must be renewed at regular intervals of 10 to 20 years, depending on weather exposure. The paint layer can be removed from the stone surface using steam jet or low-pressure sand blast method.

The coated sculptures are regularly inspected and maintained. Wet cleaning can be used to easily remove dirt and biogenic growth from the paint layer. Small imperfections should be retouched. Depending on the rain exposure of the sculptures, the thickness of the paint layer may be reduced by chalking off over a period of 10 to 20 years to such an extent that a complete renewal of the paintwork may be necessary. To this end, the entire surface is cleaned, imperfections in the paintwork are filled, and a new single-layer paintwork is applied.



Fig. 5 Reversible silicone resin paint layer, removed in steam jet method before regularly renewal. [Zwingerbauhütte, 2005]

Appearance and aesthetics

The overall conservation goal at the Zwinger is to preserve and protect the entire stone structure. However, protection should not anymore take the form of colouring the entire building. The coating with silicone resin is limited to the few areas (in relation to the entire building) where the sandstone is exposed to intense weathering: in the attic areas of the pavilions and on 516 weather exposed sculptures. Prior to the coating measures up to the early 2000s, these areas stood out sharply from the rest of the facade surfaces due to their black colouration. Viewed from a distance, in front of the copper roofs or the sky, they appeared merely as two-dimensional silhouettes without any perceptible plastic details. In addition to the conservation goal, the coating also fulfills the aesthetic requirement of making the rich detail of the sculptural decorations visible.

13 Rubin, Pg. 91.



Fig. 6a, b Facade proportions influenced by patinated architecture, below: restored attic and balustrade sculptures. [Zwingerbauhütte, 1999 / 2025]

In terms of painting technique, the coating does not aim to create the appearance of a new glaze, but rather to match the black patinated areas to the light natural stone colour of the facade surfaces.^[14] The decisive factor is the exact reproduction of the various colour hues of aged but not patinated sandstone, which appear on the building in warm ochre tones with subtle nuances of red, gray and brown. To counteract the monotony of a new coat of paint, individually blended hues are applied to larger pieces such as vases and sculptures, fading into one another without creating an illusionistic imitation of sandstone. By adjusting the hues, transitions from coated to uncoated surfaces can also be created on individual sections of the facade, which merge imperceptibly into one another when viewed from a distance. This method harmonizes the overall architecture and reveals the intended proportions of the facades. (Fig. 6) It is not the colour, but the plasticity of the architecture that should come to the fore, so that the Zwinger reapproaches the design intention of a cheerful baroque architecture.

14 Kiesewetter, Pg. 106.