



Thesis
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The influence of material usage on the perception of memorials

The influence of tangible materials on the
perception of different public historical and
trauma-related memorials



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Preface

I am writing this thesis as part of my master's in architecture, urbanism and building sciences at the Technical University Delft. I am very intrigued by the subjective perception of design. Since material usage has a great influence on the emotional response, I chose this as the subject for my thesis. I chose the research field of memorials because the evocation of emotions is especially apparent in memorials and is extremely important.

The results of the research can be used by designers and others interested from different sectors. For example, architects, interior designers, product designers, furniture makers and artists.

Finally, I would like to thank my tutor Sabina Tanović for her input and support during the development of this thesis.

Robin Simons

Amsterdam, 15 April 2021

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1 Introduction

1.1 Motive, subject and relevance of the research

Designs in the form of a building, an infrastructural object, a work of art, a memorial or an interior object encourages with all the senses of the human body a different perception on the observer. This subjective perception is influenced by the form effect, the use of materials, the light, the passage of time and the history. All these aspects strongly influence the personal experience of the design. For example, round objects often give off a positive feeling of softness and satisfaction. Former psychologist and artist Gaetano Kanizsa explained that this might be caused by the gradual bending of the shape which makes the circle continuous. He further suggested that round objects seem to be soft to the touch (Kanizsa, 1979). On the other hand, neuroscientists Moshe Bar & Mital Neta describe that angular objects create a negative feeling of threat. This is endorsed by neuropsychological evidence. In an experiment, they measured the brain activity that occurs when looking at different shaped objects. They found that the amygdala - the part of the brain that reacts to danger - showed more activity with angular objects compared to round objects (Bar & Neta, 2007). It is fascinating that the built environment can have such a big influence on how we perceive a particular design. For this reason, I want to increase the knowledge in this area.

How and which materials are used in a particular design is of immense importance. This is supported by researchers Nicholas Watkins, Frances Cole & Sue Weidemann. They emphasise the significance of carefully composed design elements, including their materiality, to trigger a certain feeling. For instance, they mention that the use of materials could arouse curiosity or attention, invite touch and make the visitor feel present (Watkins, Cole & Weidemann, 2010). For this reason, I investigate the effect of tangible materials on the subjective perception of memorials dedicated to tragic events. Tangible materials are materials that can be touched, experienced and seen like concrete and wood. Intangible materials are materials that are not physically present such as materials used in digital visualisations. Many different tangible materials are available. The materials could be divided by material properties such as colour, texture, transparency, reflectivity, and weight. The properties have a strong influence on perception and are therefore chosen for investigation. Especially in the design of public historical and trauma-related memorials, the choice of material can contribute to the intended perception of the design and thus lead to arousing certain emotions. Therefore, it is interesting to see what the most frequently used materials in contemporary memorials are.

Currently, little scientific research has been conducted on the perception of tangible materials. Naz Kaya, an artist and researcher at the University of Georgia, conducted research on the effect of colour (Kaya, 2004). Furthermore, psychologists and professors Susan Lederman & Roberta Klatzky researched the effect of texture on human feelings (Lederman & Klatzky, 2004). However, the research was conducted on a single aspect of the material property obliterating other properties of a tangible material. This implies that there is relevance to look at the material properties from a wider research perspective to make statements about a characteristic and the emotional response to it. Knowledge about the effect of materials on perception helps designers in the material choice of their designs to achieve a certain perception on the part of the spectator. In this way, designs become stronger and the aim is better embodied.

1.2 Research approach

The current problem is the ignorance about how the perception of materials works. With this knowledge, designers will be able to make well-considered design choices.

To overcome this problem the research objective is to gain insight into the effect of materials on the perception of a memorial.

To achieve this goal, the following main question is formulated:

Which materials are most used in memorials and what is the spectator's expected emotional response to their material properties?

First, the contemporary need for a physical memorial is examined. This question will be answered by means of qualitative literature study. Second, I am going to find out which materials are frequently used in memorials and what functional reasons lie behind them. This question will be answered through qualitative literature study and observational research. The literature will be obtained from websites and internet articles. The observational research will be done online by studying the most famous Western contemporary memorials. After this, online books and scientific articles will be consulted to explain the functioning of the perception of materials. These questions will be answered based on a quantitative and qualitative literature study. Following this, the findings will be examined in the case studies. For this purpose, the materials used in the case studies will be analysed and compared by means of self-made drawings, analytic sketches, and photographs. Also, additional information about the design will be studied.

To do this, we will look into three different public historical and trauma-related memorials where different materials have been used. The first one is The National Slavery Monument in the Oosterpark in Amsterdam made by Erwin de Vries in 2002. This is a public historical memorial commemorating the dark history of Dutch slavery and the birth of freedom (Municipality of Amsterdam, 2018). The second one is The Auschwitz monument made by Jan Wolkers in 1993 - a public trauma-related memorial located in the Wertheimplantsoen in Amsterdam. It was created to commemorate the horrific events that took place during the Holocaust and to ensure that they are remembered forever (Joods Cultureel Kwartier, n.d.). And finally, my concept design of The Jewish Memorial Forest in Apeldoorn (2020), designed to commemorate the tragic events of the Jewish community in Groot Schuylenburg, including firings, executions, and deportations.

Chapter 1: Necessity and materiality of memorials

1.1 The form, subject and need of memorials

Memorials dedicated to tragic pasts have been part of our society for much longer than most people think. The origin of memorials goes back to prehistoric times, when events were commemorated by piling up large unprocessed rocks (Netten & Te Brake, 2009). Some theories indicate that the dolmen in the East of the Netherlands are an example of commemorative graves (Couwenbergh, 2020). Later, events and important figures were immortalized by statues, obelisks, and carved tablets. Think of the tombs of the Greek and Roman emperors. From the 19th century, Natural elements were used. These include parks, gardens, and trees. Later, a combination of natural elements and objects followed. A well-known example is the MH17 National Memorial in Vijfhuizen the Netherlands, made by Ronald A. Westerhuis and Robbert de Koning in 2017. This is a commemorative forest where a physical remembrance object is located in the middle of a ribbon of trees (Stichting Vrienden van Nationaal Monument MH17, n.d.). In recent decades, technological instruments have also made their appearance in remembrance culture. Photographs, sound fragments, stories and interviews are instruments that are used for this purpose. These instruments can serve as a temporary or permanent basis for remembrance. (Netten & Te Brake, 2009)

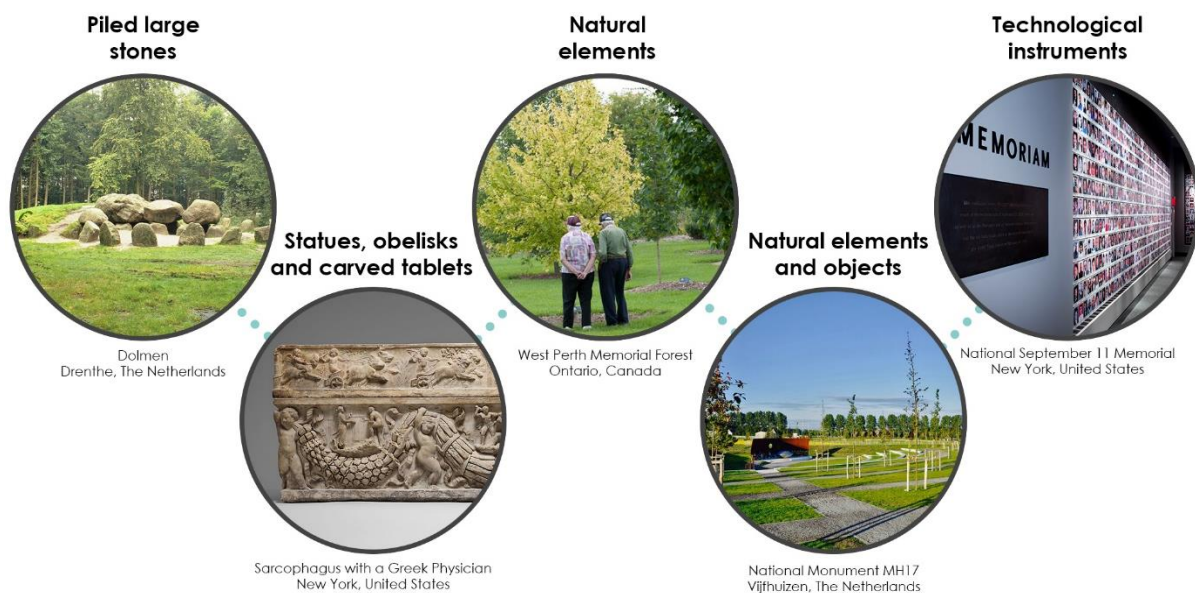


Figure 1: Simons, R. S. (2021, April 6). The changing shape of memorials

Not only the form of the memorial changed through time, also the reason why a memorial is created modified (Netten & Te Brake, 2009). Many memorials are related to wars (Imperial War Museum, n.d.). In this way, the fallen soldiers and civilians are commemorated. Besides, certain groups in society who have endured tremendous suffering during wars. An example of this is the in 2020 designed Jewish Memorial Forest in Apeldoorn, which commemorates the Jewish community who suffered during the Second World War. This memorial will be thoroughly analysed in section 3.3 The Jewish Memorial Forest. Another memorial that is linked to war and can be found in many counties is the memorial to the Unknown Soldier. These memorials were created to honour, mourn and remember the actions of unidentified soldiers. This memorial usually contains the body of an unidentified person, which symbolises all unidentified deceased. Memorials are also being designed to commemorate the victims of disasters. The sort of disasters can vary widely, from natural disasters, anthropogenic disasters, cultural disasters or humanitarian disasters. The monument of the Third Angel designed by Anatoly Haidamaka in 1995 is an example. This monument serves as a tribute to the ones who died as a result of the nuclear disaster in Chernobyl, Ukraine (Meandering Wild, 2021). Another type of memorials are those based on a shared experience, such as the Tuin

voor Bezinning designed by Poelmans Reesink in 2006 located in Warnsveld, The Netherlands. This memorial commemorates and honours the police officers who lost their lives in the line of duty (Politie, n.d.). There are also memorials commemorating individual life drama, such as a collision or suicide. There exist numerous reasons why we build memorials, an act that can take place immediately after a tragic event or later, depending on the context. (Netten & Te Brake, 2009)

Psychologists Josée Netten & Hans te Brake do research for *Impact*, a consultancy centre for post-disaster psychosocial care. They describe the importance of physical memorials and the ceremonies accompanying them. They state that a memorial has several functions. First of all, a memorial reminds us of an event or person that should be part of the general memory. A memory that is thereby transferred in a tangible way to future generations (Netten & Te Brake, 2009). Professors from Tilburg University, Paul Post, Albertina Nugteren, and Herbert Zondag describe a second function; the object is the base for expressing emotions (Post, Nugteren & Zondag, 2002). This happens because a physical memorial draws the observer's attention through her senses to what is being commemorated and evokes an emotional response. It also forms the starting point of a conversation. The emotions include negative emotions such as anger and sadness, but also positive feelings such as pride, respect, and recognition. In addition, Netten and Te Brake describe that a memorial can be an important part of the healing process by reflecting again on an event. Finally, they mention three ways memorials establish a connection. First, it allows different time occasions to come together. Past events are remembered and evaluated with a focus on the future to prevent similar events from happening again. Second, it creates a connection between relatives and non-relatives. Thirdly, a connection between young and old is realized (Netten & Te Brake, 2009).

Unfortunately, wars, disasters, shared experiences, and personal tragedies are something that continues to happen. The mentioned functions show the impact of a physical place of remembrance. We will continue to build memorials to make this possible.

1.2 Materiality of memorials

To answer which materials are commonly applied in contemporary memorial spaces. Observational research is conducted into the materiality of well-known Western contemporary memorials. Various internet articles were consulted. This includes an article written by Josephine Minutillo published in *Architectural Record*, in which she named the most famous memorials from around the world (Minutillo, 2018). This revealed the prominent role of these materials: granite, marble, sandstone, limestone, iron, weathering steel, bronze, concrete, and glass.

The list contains both natural and non-natural materials. However, the reason why these materials were chosen is still unclear. We will look at the functional motivations behind the choice of these materials.

Material	Variants	Lifespan	Weather resistance	Toughness
Granite	Many	Long	Good	7,0 Mohs
Marble	Many	Long	Bad	3,0 Mohs
Sandstone	Many	Long	Good	2,5 Mohs
Limestone	Many	Long	Bad	3,0 Mohs
Iron	Few	Average	Bad	4,0 Mohs
Weathering steel	Few	Long	Good	4,5 Mohs
Bronze	Average	Long	Good	3,0 Mohs
Concrete	Many	Long	Average	5,0 Mohs
Glass	many	Long	Good	6,5 Mohs

Table 1: Simons, R. S. (2021, 20 February). *Frequently used materials in memorials and their properties*

Table 1 shows the functional properties of the commonly used materials. The materials are generally available in many variants. In addition, the technical lifespan is relatively long. Granite can last for more than 100 years. The weather resistance of the materials varies greatly. This also applies to the moisture and acid resistance of the materials. For example, glass resists weathering, causing it to have many applications and functions. Finally, the toughness of the materials is examined using the Mohs hardness scale, the value indicates how scratch-sensitive and hard a material is. A high value indicates a hard and unscratchable material and a low value indicates a soft and scratchable material. The toughness is average, except for sandstone that scores a bit lower. In conclusion, the most used materials have many variants, a relatively long lifespan and generally have an average toughness.

Chapter 2: The perception of materials

2.1 The influence of colour

To gain more insight into the psychological effect of colour, the basics of what colour is and how it is formed scientifically will be explained first. Afterwards, the emotional influence of colour is discussed.

Colour is one of the properties of light, colour is determined by the wavelength composition of electromagnetic radiation (Tilley, 2020). These wavelengths vary from gamma rays (from 0.1 nm) to radio waves (from over 100m). Figure 2 shows that the visible light is located at a wavelength of 380 nm (violet) to 740 nm (red). The surface colour is determined by the light within the visible spectrum that is reflected by the surface. Thus, a surface that reflects all the light within the spectrum is perceived as white by the human eye. Contrary, a surface that absorbs all the light is perceived as black. For example, if the surface absorbs the blue and green waves, the red light is reflected, causing us to perceive the colour as red. Colour perception is a collaboration between the human eye and brain: the light falls on the eye receptors (called 'cones') and is transmitted via synapses into the brain, where it will be processed. The sensitivity of the eye varies slightly from person to person but a large difference exists comparing us to animals or insects. Humans can distinguish small differences in wavelengths, causing us to be able to see a total of a million colours (Hadhazy, 2015). The three basic colours (called 'primary colours') are red, green, and blue. All colours can be created by changing the quantities of hue (colour shading), saturation (liveliness) and intensity (brightness). (Tilley, 2020)

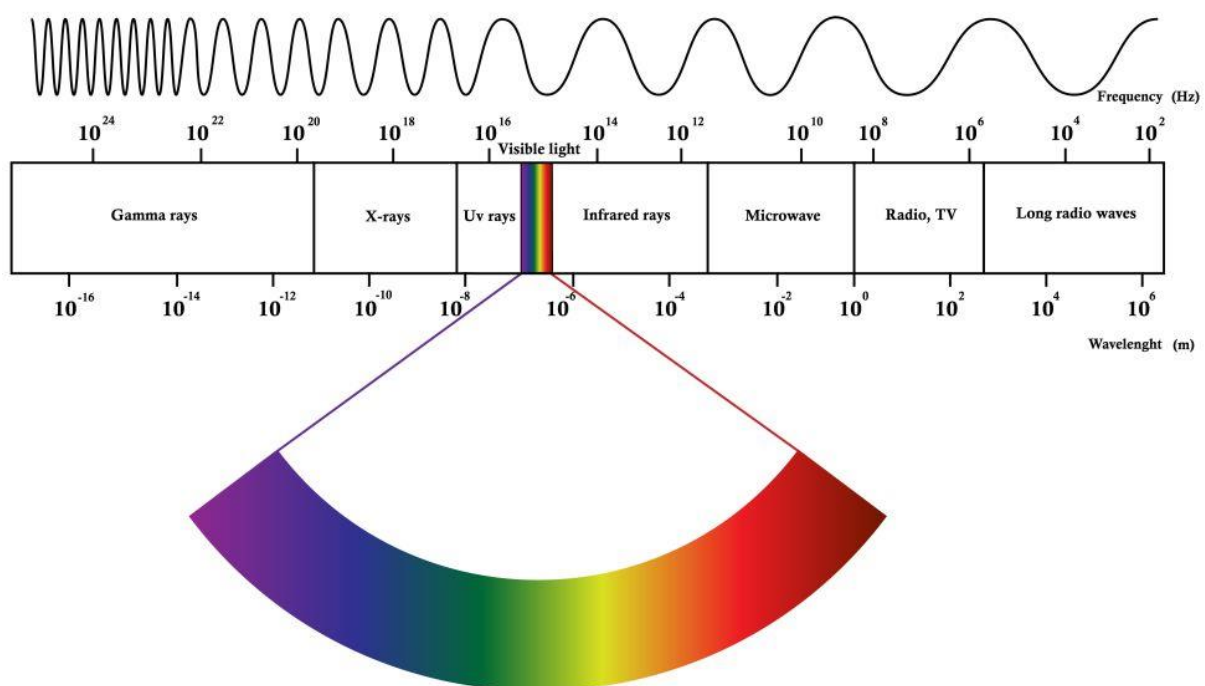


Figure 2: Lucas, J. (2015, 13 March). [Different wavelengths of electromagnetic radiation]

Researchers Marcel Lucassen, Theo Gevers and Arjan Gijsenij describe an increasing interest in understanding human emotion as a reaction to perceiving a particular colour or coloured object. This phenomenon refers in psychology as 'Colour emotions' (Lucassen, Gevers & Gijsenij, 2010). Professors Li-Chen Ou, Ronnier Luo, Andrée Woodcock and Angela Wright are specialized in colour and believe that colours play a major role in determining what we like and dislike. Colours evoke a complex psychological response and thus a certain feeling (Ou, Luo, Woodcock & Wright, 2004). David Simmons of the University of Glasgow researches perception. He states that there are three possible ways of generating an emotional colour response. The first way is the stereotypical

association; When colour is observed, it is unconsciously associated in the brain with different emotions. A second possibility is a personal association, in which perception is linked to a memory and a related emotion is aroused. A final option is a non-visual response, in which colour evokes an unforeseen signal (Simmons, 2011). Researchers at the University of Georgia, Naz Kaya and Helen Epps, support this theory. They contemplate that colour symbolism has a clear relationship with emotion, but it is mainly dependent on personal preference and experience (Kaya & Epps, 2005). Simmons states that despite individual influence a reliable emotional colour association can be achieved (Simmons, 2011). However, cultural differences may occur. Psychophysical researchers Ou, Luo, Woodcock and Wright studied colour emotions. In their study, 31 participants were shown a single colour and were asked to pick which of the two words they related the colour to. This study used ten emotional scales. No gender differences were found. However, a small difference existed between Western and non-Western participants. It concerned a difference on the emotional scales like-dislike and tense-relaxed. This could be explained by the different associations in the culture. For example, the colour red in China is often associated with happiness and pride, whereas in Western culture this colour is associated with anger and aggression (Ou et al., 2004). Kaya conducted an experiment among 98 participants in a Western culture, with an average age of 21 (Kaya, 2004). The participants described the experienced feelings when looking at a certain colour. The most frequently mentioned emotions are visible in Figure 3. The research showed that the colours with the most positive emotional associations were green (95.9%), yellow (93.9%) and blue-green (81.6%). The colours with the most negative association are grey (89.8%), black (78.6%) and green-yellow (71.4%). (Kaya, 2004)

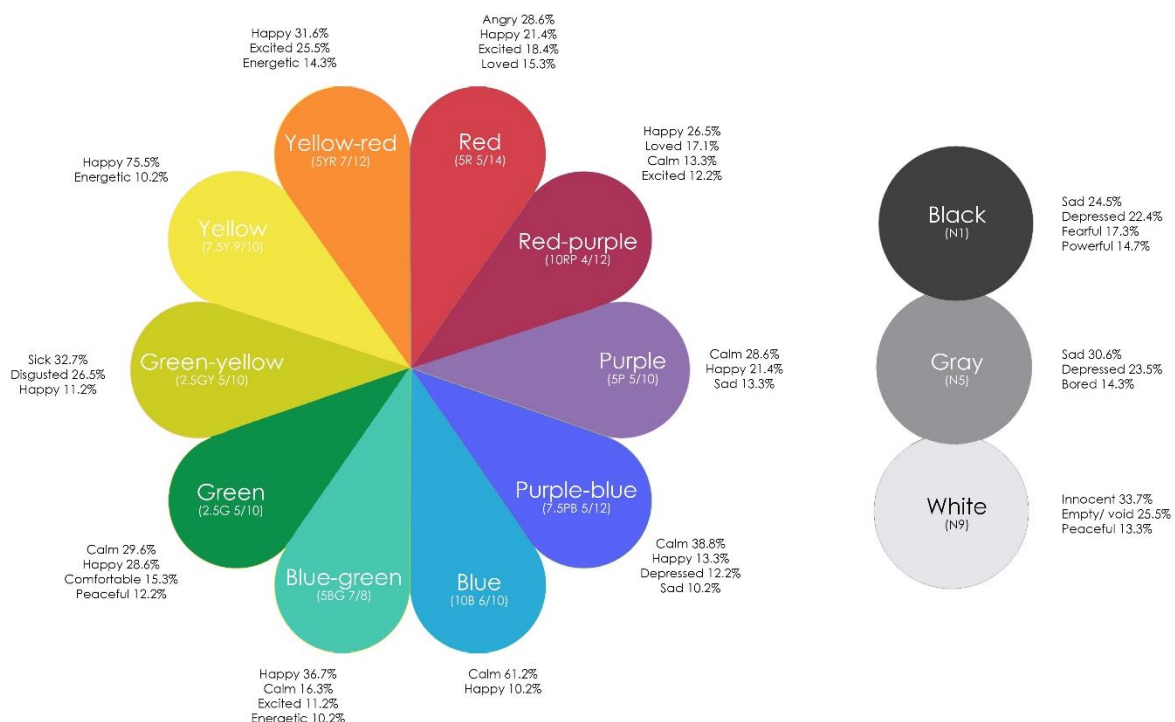


Figure 3: Simons, R. S. (2021, March 5). Colours and their emotional response

This shows that colour influences the perception and the choice of colour can guide this to achieve the desired emotional result.

2.2 The influence of texture

To understand how the texture of the material can influence perception, it is necessary to get a general idea of what texture is and what aspects are relevant.

Surface texture or finish is the local deviation of a surface from a flat surface (Barnes, Childs, Henson & Southee, 2004). The texture strongly influences the way the light is reflected by the surface and thus the appearance of the material. The surface texture has three properties, including lay, roughness and waviness, which Figure 4 shows. Lay is the dominant direction of the surface. For example, a wooden board has a vertical fibre direction. Other directions include horizontal, radial, circular, and isotropic. The roughness refers to the unevenness of the surface. An example of this is concrete, which has a low height and small spacing of the peaks and troughs, creating a high roughness. Waviness is similar to roughness, but it concerns a larger distortion. For instance, the wavy shape of corrugated sheets. In the profile the waviness and roughness come together. The texture of a material can be created in many ways: it is the raw texture of a material, the texture is the result of the production processes or the texture has developed over time under the influence of weathering. (Barnes et al., 2004)

In addition to texture, a material is tactile. This represents the touch ability of the surface and is determined by the softness, smoothness, and suppleness of the material. Note the difference in touch between a woollen rug and a concrete floor. (Barnes et al., 2004)

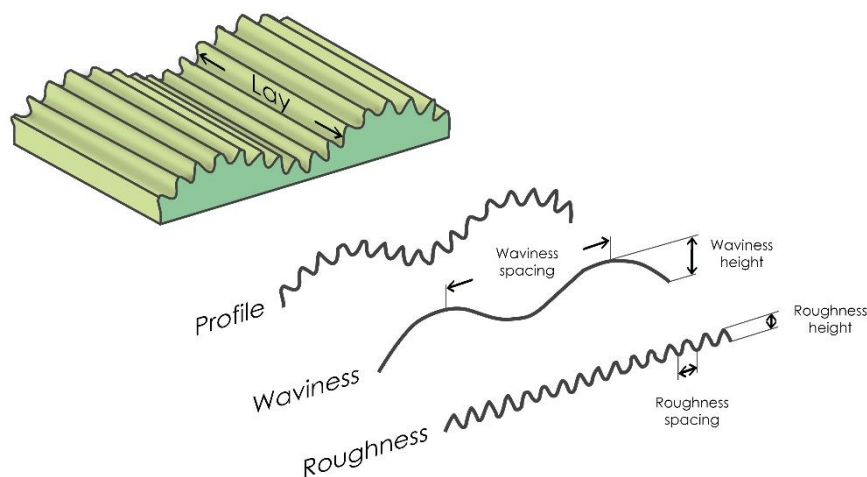


Figure 4: Simons, R. S. (2021, March 9). Surface texture and its properties

Each material has a texture. These textures change with the observation distance. The closer to the object the more details and idea of texture. Therefore, a concrete wall looks like an even grey mass from a distance. However, as one approaches the wall, the pores and roughness of the material are noticeable. Research shows that designers especially look at information about the tactile properties of materials in their design (Lederman & Klatzky, 2004).

Elvin Karana, Owain Pedgley and Valentina Ragnoli are professors from different universities and research materials in design. They suggest that texture is perceived and assessed by multiple senses: vision, touch, and sound. In some cases, smell and taste are added. They say that the assessment of a texture differs substantially from person to person. Besides, they state that the senses all work at the same time, making research into how texture works a complicated process. Especially perceiving texture through touch is difficult. This is because the manner of touch influences perception. A touch can be static or dynamic, it can occur with a difference in pressure and speed, and it can involve different parts of the body (Karana, Pedgley & Ragnoli, 2013). Professor and researchers Hengfeng Zuo, Mark Jones and Tony Hope, despite the complicated process, researched the perception of texture through touch. They found that roughness is one of the most important factors influencing people's emotional response to texture. They stated that a low roughness, i.e. a smooth surface, corresponds to a cold, humid, sticky, and glistening perception. A high roughness gives a feeling of warmth, dryness, non-sticky and non-glistening (Zuo, Jones & Hope, 2003). Researchers Lisa Wastiels, Hendrik Schifferstein, Ann Heylighen and Ine Wouters confirmed this. They researched among twenty students at the Vrije Universiteit Brussel, what the influence of colour and texture

had on the temperature perception of the material. The results showed that the roughness, independent of colour, influenced temperature perception. They saw that rough surfaces are perceived as warmer than smooth surfaces (Wastiels, Schifferstein, Heylighen & Wouters, 2012). Interior designer Kristine Bonnici mentions another effect of texture. She explains that a rough texture absorbs light and reflects it more interestingly (Bonnici, 2018). This brings out the visual qualities of the material and creates a restful effect. Smooth surfaces reflect light, making material properties less noticeable. She also mentions the importance of texture contrast. It arouses interest in an object or space and remains in the memory (Bonnici, 2018).

A fitting example is the Memorial des Martyrs de la Déportation in Paris, France. Designed by Georges-Henri Pingusson in 1962, this memorial commemorates the 200,000 French victims who died in various Nazi concentration camps between 1941 and 1944 (Minutillo, 2018). The memorial looks like a rough concrete bunker finished with a layer of gravel plaster (Ministère des armées, 2018). The front is closed off from the inside by trellis. At the back, narrow steep stairs lead to the inner courtyard, where a room is placed. Here, a long narrow corridor is visible, in which a glimpse of the outside appears through a narrow hole. The walls in this corridor are made of cement inlaid with glass balls and have a horizontal lay and a high wavy waviness. This texture generally gives a warm and dry feeling. The floor is made of a smoother natural stone, which overall feels cold and humid. The light from the ceiling and floor strikes the rough walls. The walls absorb and reflect the light highlighting the visual quality of the material. The contrast between the textures of the floor, ceiling and walls makes the room interesting and memorable. (Ministère des armées, 2018)



Figure 5: Clod, J. (2020, June). *Mémorial des Martyrs de la Déportation*

This shows that texture, and in particular the roughness of the texture, can influence the experience of the object.

2.3 The influence of transparency and reflectivity

Due to processes of transparency, reflectivity and refraction, materials behave differently depending on how it interacts when in contact with light. This is illustrated in Figure 6.

The notion of transparency and reflectivity is complex and needs some general explanation first. Transparency is the degree to which one can see through a material (Crowell, 2010). This aspect depends on the material properties, including the capacity with which the material transmits, absorbs, and reflects light. Furthermore, the amount of transparency depends on the wavelength.

For example, a material lets red light through and absorbs the other wavelengths. If the material allows little or no light radiation through, the material is called 'opaque'. If the material allows light to pass through but fades, this is called 'translucent'. Material is transparent if the light is fully sharp after leaving the material. (Crowell, 2010)

Reflection is the degree to which the material reflects light (Crowell, 2010). This phenomenon occurs due to the difference in wave resistance. Roughly speaking, two types of reflection can be distinguished. First, specular reflection, in which the light is reflected what results in a sharp image. Second, diffuse reflection, in which the light is reflected, and a blurred image is visible. One aspect does not necessarily exclude the other. For example, a material can be transparent and at the same time have a certain reflection on it. Refraction is the optical phenomenon where transparency and reflection meet. The light is refracted and leaves the medium in a different direction. The angle of incidence and the refractive index of the material determine the strength of refraction. A good example is a pair of glasses that use refraction to compensate for the refractive error of the eye to create a sharp image for the viewer. (Crowell, 2010)

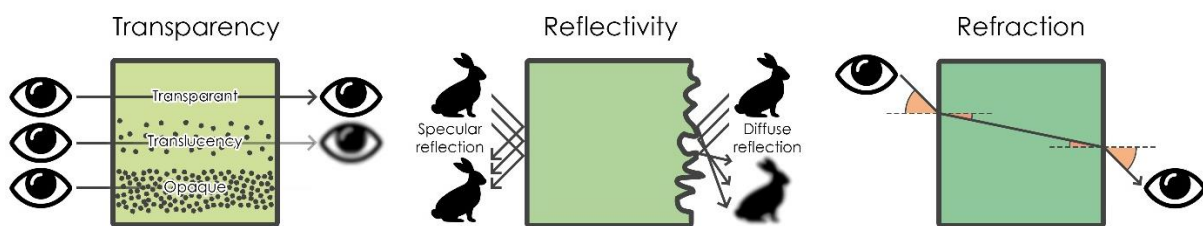


Figure 6: Simons, R. S. (2021, March 9). Transparency, reflection, and refraction visualised

Karana, Pedgley and Ragnoli describe transparency as a sensorial optical property and hence potentially affecting the emotional perception of the material. They state that transparent materials are generally perceived as breakable (Karana et al., 2013). Arguably, this is mainly because people link with glass, which is generally known as breakable. Furthermore, research by professors at the Delft University of Technology Elvin Karana, Paul Hekkert and Prabhu Kandachar show that transparency is related to the concept of 'sexy' (Karana, Hekkert & Kandachar, 2009). It is possible to look through a transparent material, which can create a special effect in combination with refraction. As earlier mentioned, the human eye is capable of perceiving small differences in colour and contrast. For this reason, a slight reflection on a surface can already be considered distracting (Gulnick, 2019).

A suitable reference is the Field of Empty Chairs at the Oklahoma City National Memorial in Oklahoma, United States. The memorial, designed in 2001 by Hans and Torrey Butzer and Sven Berg, commemorates the 168 victims of the 1995 bombing of the Federal Building (Minutillo, 2018). The memorial consists of 168 bronze chairs with granite seats and translucent glass bases, on which the names of the deceased are inscribed (Oklahoma City National Memorial Museum, n.d.). Wherein the glass demonstrates the vulnerability of the victims. The chair is a recognizable and therefore powerful object that represents the loss and absence of each individual. During the night, the feet of the chairs are illuminated, see Figure 6. The bubbles in the translucent glass reflect the light in all directions, illuminating the chairs and surroundings. This special effect is a vivid reminder of the victims. (Oklahoma City National Memorial Museum, n.d.)



Figure 7: Oklahoma City National Memorial Museum. (2018, August 15). Detail from the Oklahoma City National Memorial & Museum

A reflective surface, whether specular or diffuse, can also add value to an object. Architectural firm Ashleigh Clarke Architects states that a reflective surface can have many functional purposes (Ashleigh Clarke Architects, 2020). On the one hand, a reflection can add value by creating a memorable experience, giving the memorial a special place in the built environment. A reflective surface creates a dynamic image, which is perceived different from every angle and varies with time. A reflection can arouse curiosity and interest and thus attract attention, although it can also be unnoticeable because the surroundings gradually blend in. Also, it can be used to accentuate something. The shape of the object can also increase, decrease, or bend the reflection (Ashleigh Clarke Architects, 2020). On the other hand, a reflection can have a symbolic meaning. It can reflect what has happened.

A good example of a reflective object is the Space Mirror Memorial at the John F. Kennedy Space Centre in Florida, United States. The memorial was designed by Holt Hinshaw Pfau Jones and Wesley Jones in 1990. It commemorates the astronauts who died during space activities (Louie, 1988). This memorial consists of a large reflective granite surface on which the names of the deceased are inscribed. The pure reflection of the sky creates a unique and dynamic image. The names seem to float in the air, which for some is an appropriate image.



Figure 8: Kennedy Space Centre. (n.d.). Space Mirror Memorial

2.4 The influence of mass

Professors at the Dokkyo Medical University and Simon Fraser University, Satoru Kawai, Paul Faust and Christine MacKenzie conclude that previous research showed that several factors, including size, shape, pressure, slipperiness, inertia, colour, temperature and especially density, influence the perceived mass (Kawai, Faust & MacKenzie, 2012). Since physical memorials do not move or cannot be lifted. This research only looked at material-related properties, a few factors were not taken into account. The colour, temperature, density and perceived mass will be carefully examined.

Professor at Pembroke College Mike Payne researched the influence of colour on perceived mass. With his research, he concluded that objects that are equal in size and weight but differ in colour,

are not perceived equally in weight (Payne, 1958). He states that the difference in perception arises from the hue and brightness. He proposes that bright colours are perceived as lighter, while dark colours are perceived as heavier (Payne, 1958). Illustrated in Figure 9.

In depth investigation into colour observations can be read in paragraph 2.1. Determining the colour hue and brightness can be done through observation. Hue is about the tone of colour, such as red, green, blue and all intermediate tones. For brightness, a value of 0 (black) to 100 (white) is used in the Hue, Saturation and Brightness (HSB) colour system. Former psychologists and researchers Joseph Stevens and Janet Hooper, following previous research, investigated the effect of an object's temperature on its perceived weight. They established that cold objects felt significantly heavier than objects with a neutral temperature and warm objects were perceived as slightly heavier (Stevens & Hooper, 1982).

However, the temperature of the material will always want to adjust itself to the ambient temperature (Yang, 2004). Therefore, materials exposed to the same environmental temperature have the same temperature. However, one material may feel warmer or colder than another. This is due to the temperature difference between the human body and the material. Due to the difference in thermal conductivity (λ) of a material, the degree to which a material can transfer energy, a transfer of heat or cold will occur. If the thermal conductivity is high, the heat transfer will take place more quickly and the material will be perceived as hot or cold sooner. (Yang, 2004)

Finally, the estimation of the density (ρ , mass per volume) of a material is predominantly based on experience. For example, we know that stone weighs more per unit than fabric. Therefore, a material with a high density is considered heavier.



Figure 9: Simons, R. S. (2021, March 23). Material properties that influence the perceived mass

According to Karana, Pedgley and Ragnoli, perceived mass can provoke an emotional response, which they believe is influenced by 'embodied metaphors'. These are phrases to which an emotional value judgment is unconsciously attached (Karana et al., 2013). This theory is also supported by professors at the University of Twente and Delft University of Technology Thomas Rompay, Paul Hekkert and Wim Muller. Their research shows that language influences emotional judgments. For example, mass is unconsciously related to statements such as heavy news, heavy weather or heavy-headed & light-footed and light entertainment. In language, mass is thus related to the importance and a certain feeling (Rompay, Hekkert & Muller, 2005). As a result of these embodied metaphors, a heavily perceived object will predominantly be experienced as important and, as result, evoke heavy feelings. On the other hand, a light object will usually be perceived as less important and bring along lighter feelings.

Certain material properties that influence the perceived mass. This is visible in the memorials below



Figure 10: Rodriguez, V. (2020, February 26). Steilneset Memorial - Vardø, Norway



Figure 11: Long, H. (2018, April 23). [The National Memorial for Peace and Justice - Montgomery, United States]

Chapter 3: Case study analysis

The earlier discussed aspects will be now examined in both built and unbuilt memorial projects. For each case study, the initial cause and the designer's reasoning behind it will be discussed. Subsequently, the theoretical knowledge will be applied to the analysis of the used materials. Finally, the theoretical emotional response based on material usage will be compared with the designer's intent.

3.1 The National Slavery Monument



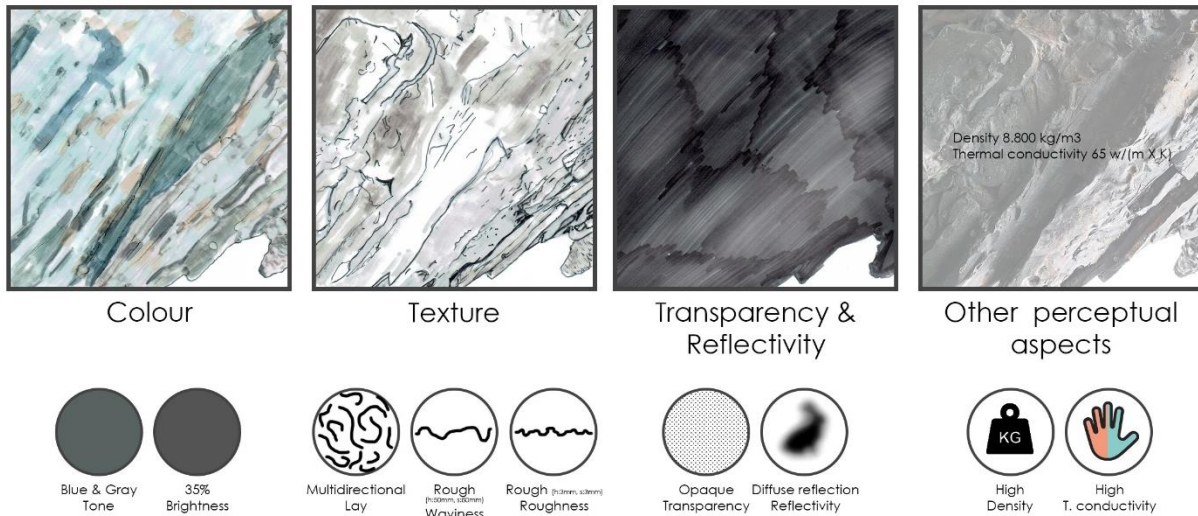
Figure 12: Simons, R. S. (2021, February 26). *Impression of The National Slavery Monument*

The National Slavery Monument is a sculpture made by the Surinamese artist Erwin de Vries (Sophiedela, n.d.). It is located in Amsterdam since its completion in July 2002. This date was not chosen by chance, because in July 1863 slavery was abolished in the Kingdom of the Netherlands. The memorial commemorates the dark period in which slavery took place. The memorial consists of ten rough bronze statues placed on a concrete base. (Sophiedela, n.d.)

According to the Municipality of Amsterdam, the sculpture Erwin de Vries designed represent three phases: the past, the present and the future (Municipality of Amsterdam, 2018). The past is depicted by a group of severely trampled slaves chained at the wrists and necks. The present is represented by a person with stretched out arms, stepping through a gateway referring to breaking the silence. The future is represented by a large woman who stands with her arms wide open, letting herself fall forward. This represents the desire for freedom and a better future. (Municipality of Amsterdam, 2018)

The materials used are bronze and concrete. An analysis of the materials is given in Figure 13.

Bronze



Concrete

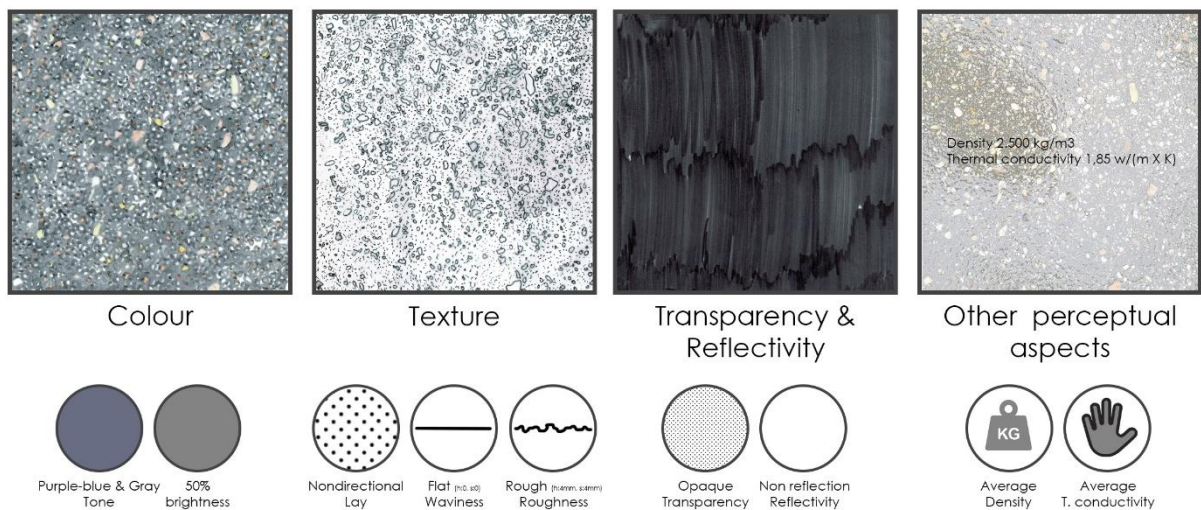


Figure 13: Simons, R. S. (2021, February 26). *Material analysis of the National Slavery Monument*

The analyses show that bronze consists of blue and grey tones, and concrete has purple-blue and grey hues. According to 'colour emotions' research from Kaya, the feeling that is experienced can be summarized as calm, sad and depressed (Kaya, 2004). Both textures can be experienced as rough. Research into the perception of texture by vision and touch supports the feeling of warm, dry, non-sticky and non-glistening (Zuo et al., 2003; Wastiels et al., 2012). Besides, the roughness does provide visual quality and has a calming effect (Bonnici, 2018). Both materials are opaque, and a slight diffuse reflection may occur on the bronze. However, this is hardly noticeable when it is not polished. The perceived mass is therefore determined by the brightness, thermal conductivity, and density of the material (Kawai et al., 2012). The bronze is reasonably dark with a brightness of 35%. It has high thermal conductivity (65 w/(m X K)), and a high density (8,800 kg/m³). Because of this, bronze will generally be perceived as heavy. The theory of 'embodied metaphors' substantiates that heavy object brings a sense of importance and evokes heavy feelings (Rompay et al., 2005; Karana et al., 2013). The concrete scores average on all these properties, which is why it is also experienced as moderately heavy.

The memorial reminds us of the dark period of slavery. Material that evokes sadness and sorrow is appropriate here. The colour, perceived weight, transparency and reflectivity are fitting. In contrast, a smoother texture that evokes a cold, humid and sticky feeling would have been more appropriate

(Zuo et al., 2003; Wastiels et al., 2012). As a result, the use of materials and the emotional response are partly in line with the thoughts behind the design.

3.2 The Auschwitz Monument



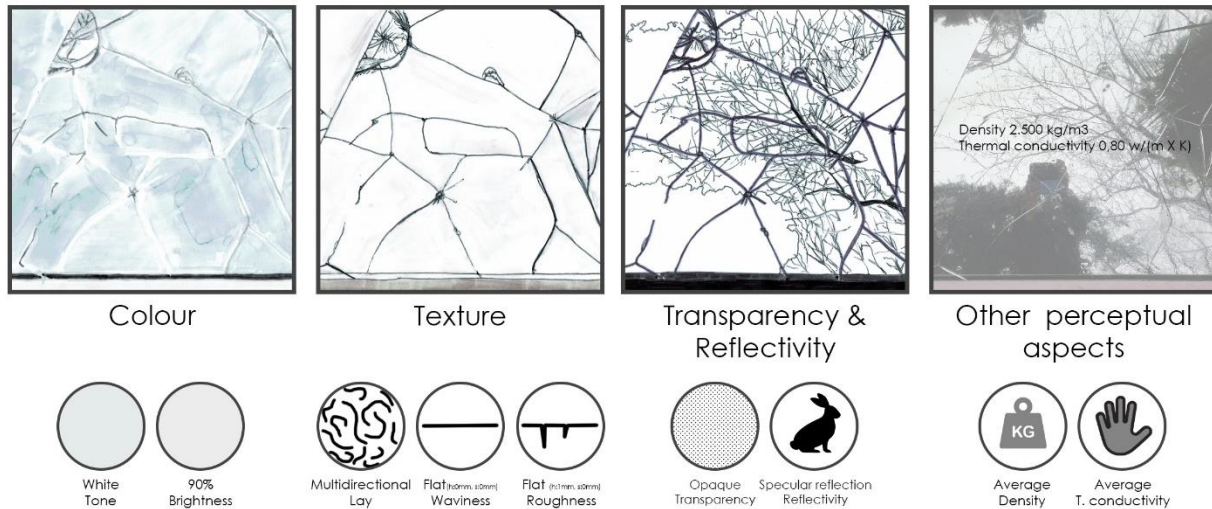
Figure 14: Simons, R. S. (2021, February 26). Impression of The Auschwitz Monument

The Auschwitz Monument is a memorial designed by the Dutch writer and visual artist Jan Wolkers (Joods Cultureel Kwartier, n.d.). Since 1993, the memorial is situated in Amsterdam. The memorial is a place of remembrance, mourning, and reflection on the atrocities committed against the Jewish community, including the deportation and murder of Jews in concentration camps. In the Second World War, 107,000 Jews were deported from the Netherlands of whom only 5,200 survived in the camps. The two largest camps were Auschwitz and Sobibor. The memorial consists of a mirror glass floor, in which cracks disrupt the reflection. Underneath the memorial, the urn of those who were killed in the concentration camp is placed. This urn is not visible. Behind the memorial stands a glass panel with written text in glass “Nooit meer Auschwitz” which translates to “Never again Auschwitz”. “Auschwitz” symbolizes the destruction of the Jewish people in the Netherlands and all over the world. On 27 January, the Russians liberated Auschwitz concentration camp. For this reason, on that date an annual ceremony of remembrance is held at the memorial. This moment can be appreciated in the impression sketch Figure 14. (Joods Cultureel Kwartier, n.d.)

In 2017 the Auschwitz Monument got an addition: the Holocaust Memorial of Names, which commemorates each Holocaust victim by name (Dutch Holocaust Name Monument, n.d.). The memorial gives 103,000 victims their own grave in the form of an engraved brick. This memorial is also located in Amsterdam, designed by the Polish-Jewish architect Daniel Libeskind. (Dutch Holocaust Name Monument, n.d.)

The Netherlands Auschwitz Comité declares that the designer intended the broken mirrors to represent the sky that could never be seen undamaged at any time in the future. Because of the great suffering that goes against all that is human (Nederlands Auschwitz Comité, n.d.). The materials used are mirror and transparent glass. Unfortunately, these materials have been repaired several times after being destroyed. Also, directly showing the weakness of glass. An analysis of the materials is given in Figure 15.

Mirror glass



Transparent glass

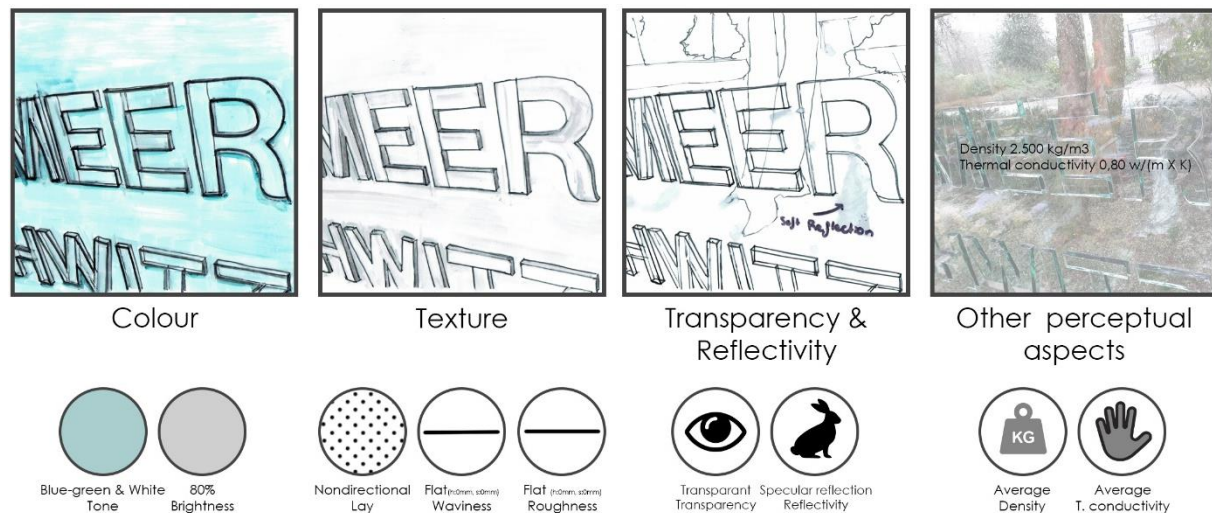


Figure 15: Simons, R. S. (2021, February 26). Material analysis of The Auschwitz Monument

The analyses show that mirror glass has a white tone and transparent glass blue-green and white tones. According to 'colour emotions' research performed by Kaya, a white tone evokes a feeling of innocence, emptiness and peacefulness. Furthermore, blue-green gives a happy, calm, and exciting feeling (Kaya, 2004). Moreover, both materials have a flat texture. Based on vision and touch experiments on the perception of texture, this texture communicates a cold, moist, sticky, and glistening feeling (Zuo et al., 2003; Wastiels et al., 2012). The cracks in the glass catch the eye. However, the height difference is extremely small, so the roughness is not affected. The theory of 'embodied metaphors' substantiates that transparent glass is generally perceived as fragile (Karana, Pedgley et al., 2013). Research on sensorial properties of materials shows that transparency is linked to 'sexy' (Karana, Hekkert et al., 2009). In addition, the glass has a specular reflection that can be seen as disturbing (Gulnick, 2019). The mirror glass is opaque and has a specific reflection. This

reflection gives the memorial value, and the experience makes it memorable (Ashleigh Clarke Architects, 2020). The reflectivity creates a dynamic image that changes with the viewing angle and over time. Besides, behind the broken mirror lies a strong symbolic meaning. Both materials have light colours with a brightness of 90 and 80%. The thermal conductivity is moderate ($0.80 \text{ W}/(\text{m} \times \text{K})$) as is the density ($2,500 \text{ kg}/\text{m}^3$). Because of these properties, the materials are considered just below average weight. The 'embodied metaphors' theory describes that the perceived mass evokes lightweight feelings (Rompay et al., 2005; Karana et al., 2013).

The idea was that the mirror would resemble a sky that could never be seen undamaged because of the terrible events (Nederlands Auschwitz Comité, n.d.). Emotions such as sadness and innocence would be appropriate. The texture and perceived mass suit the object by evoking appropriate emotions, as do the white colour tones. However, the blue-green tone gives a positive and calming feeling that is less matching, whereby a glass panel with a grey tone, that evokes feelings as sadness and depression, would have been more fitting (Kaya, 2004). The reflection of the mirror glass with the symbolic meaning is maybe a good way to evoke an emotion of innocent. The result is that the use of materials and the emotional response are largely in line with the thoughts behind the design, but optimisation is possible.

3.3 The Jewish Memorial Forest



Figure 16: Simons, R. S. (2021, February 26). Impressions of The Jewish Memorial Forest

The Jewish Memorial Forest is a 2020 designed memorial in Groot Schuylenburg, Apeldoorn. It is an unrealized design, but the materiality and the reasoning behind it make it an extremely suitable case study. The memorial commemorates the Jewish community of Groot Schuylenburg, during the Second World War in which many deceased. Groot Schuylenburg was a renowned Jewish psychiatric institution known for its 'active therapy', a therapy that combined care, relaxation, and work. The German occupiers fired the staff, deported the children and staff and carried out executions (Herinneringscentrum Apeldoornsche Bosch, n.d.).

The design consists of a large Star of David in which a tunnel is placed made of curved weathering steel plates. Displayed in Figures 16 and 17. The panels gradually come closer together, making the tunnel darker, quieter, and more unpleasant. The sharp tunnel slightly gives the spectators the same feeling that the victims must have had - a feeling of disorientation. This feeling is reinforced by the figures in the tunnel of children walking the same irreversible path. One can see through the cracks in the panels the terrible events depicted in the corners of the Star of David. At the end of the dark

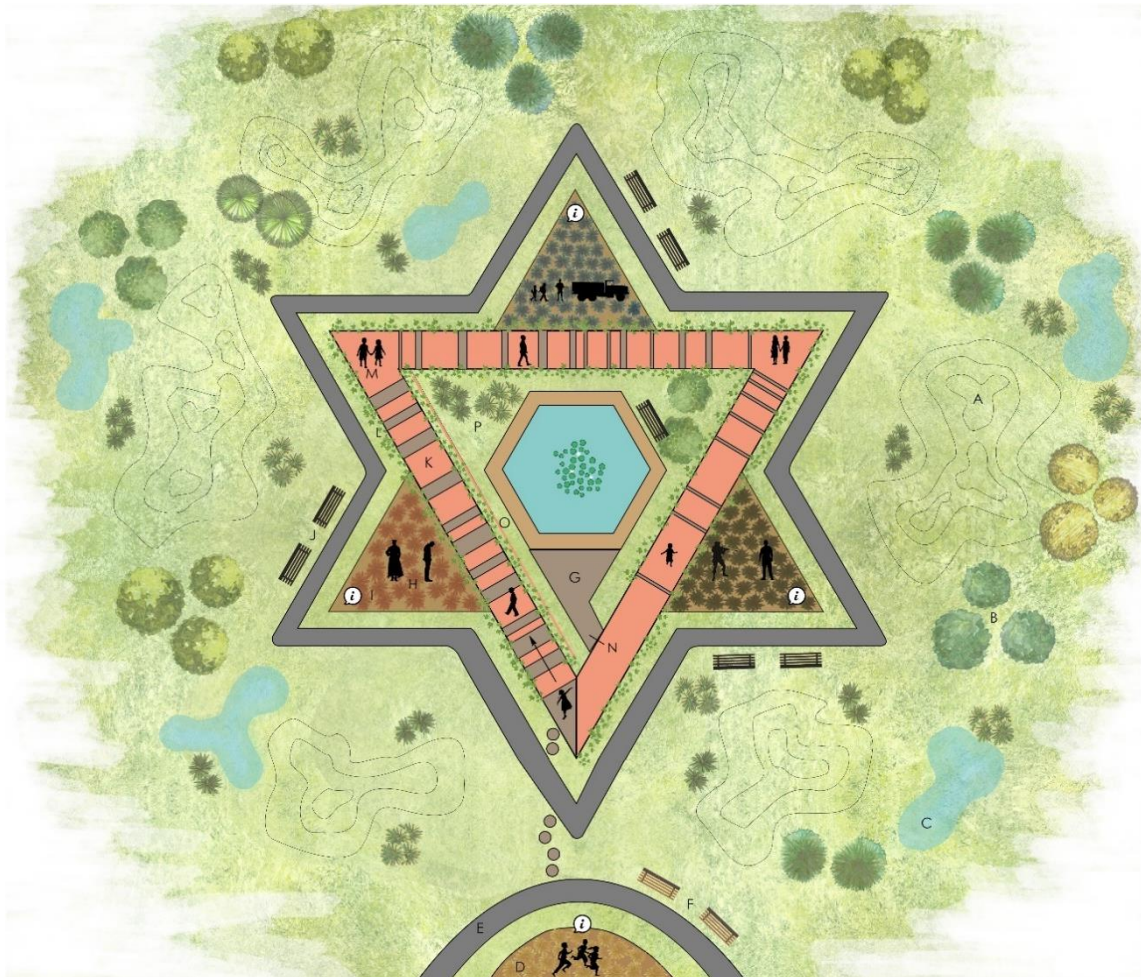


Figure 17: Simons, R. S. (2021, February 26). The layout of The Jewish Memorial Forest

tunnel, there is a door from which light emerges. Once through that door, one enters an open and empty inner space, where it is once again light and warm, and one can hear the sounds of the environment. Next to the pond is a weathering steel plate, in which the names of all 1,250 victims have been inscribed. This symbolizes the empty space that remained after the terrible events. Therefore, weathering steel is used. An analysis of this material is given in Figure 18.

Weathering steel

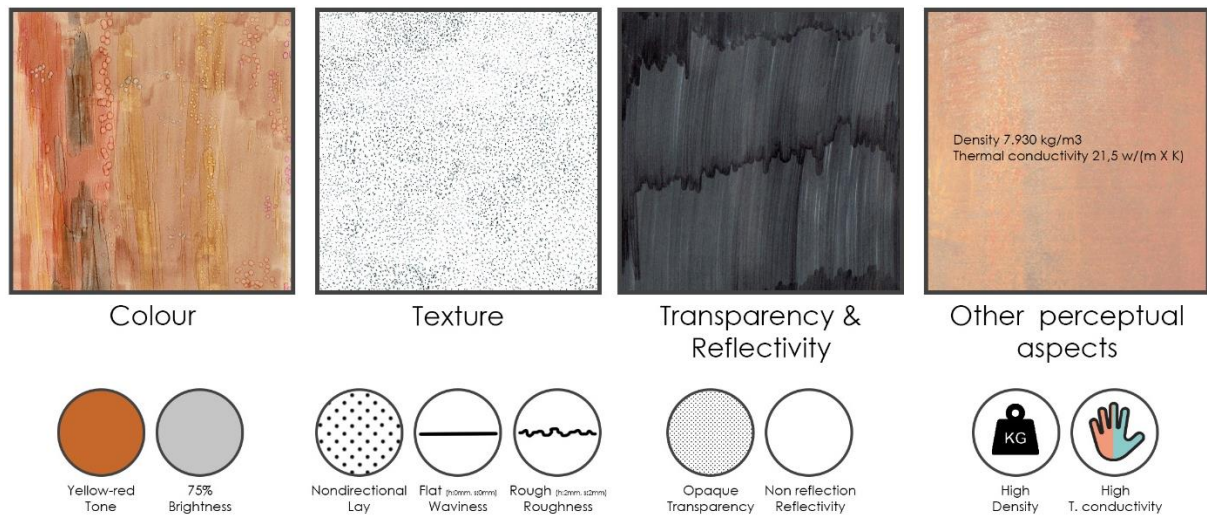


Figure 18: Simons, R. S. (2021, February 26). *Material analysis of The Jewish Memorial Forest*

When looking at the analysis of weathering steel, one can see that the material has a yellow-red tone. Pursuant to 'colour emotions' experiments this colour gives the viewer a feeling of being happy, excited, and energetic (Kaya, 2004). The roughness of the material is relatively unequally distributed, which, based on vision and touch experiments on the perception of texture, evokes a feeling of warmth, dryness, non-stickiness, and non-glare (Zuo et al., 2003; Wastiels et al., 2012). In addition, the roughness provides visual quality and has a calming effect (Bonnici, 2018). The material has no reflections and is opaque. The material is quite light in colour with a brightness of 75%. The thermal conductivity is high (21.5 w/(m X K)), just like the density (7,930 kg/m³). For this reason, the perceived mass is considered reasonably heavy. The 'embodied metaphors' theory says that a heavy object brings a sense of importance and evokes heavy feelings (Rompay et al., 2005; Karana et al., 2013).

The memorial is a place of remembrance and mourning for the tragic event experienced by the Jewish community of Groot Schuylenburg, where the tunnel is supposed to arouse feelings of fear and sadness. The perceived mass, transparency and reflectivity possibly match these feelings. Conversely, the light colour and rough texture may evoke opposite feelings. A material with a darker colour, such as black, which can evoke feelings such as sadness, depression, and fear, would be a more appropriate choice (Kaya, 2004). Additionally, a smoother texture that gave off a cold feeling is more suitable (Wastiels et al., 2012).

The natural weathering of weathering steel should also be taken into account. Over the years, weathering steel changes colour from yellow-red to black. However, this can be a very long process. Besides, the tunnel will become darker due to the increasingly limited light, which will also make the weathering steel appear darker.

4. Summary and discussion

4.1 Summary

The central question in this study is: Which materials are most used in memorials and what is the spectator's expected emotional response to their material properties? The research shows that memorials dedicated to tragic events are part of society since prehistoric times and the reason to build memorials have changed greatly over time. The importance and necessity of a physical memorial remains, which is why memorials will continue to be designed.

Granite, marble, sandstone, limestone, iron, weathering steel, bronze, concrete, and glass proved to be the most used materials in current memorials. These are generally materials that are available in many varieties, have a long life span, and have average toughness. The material properties that have a major influence on the emotional response have been investigated for their psychological effect. This included colour, texture, transparency, reflectivity, and perceived mass. This shows that the use of colour has a major influence on perception and is associated with specific feelings. The colours that evoke the most positive feelings are green, yellow, and blue-green and with the most negative feelings grey, black and green-yellow. Cultural differences could be present.

The texture, in particular the roughness, also influences perception. A low roughness is associated with feelings like cold, humid, sticky and glistening. A high roughness evokes warm, dry, non-sticky and non-shiny feelings. In addition, the way the light reflects on the material is also determined by the texture. A high roughness gives visual quality and a calming feeling. A low roughness makes material properties less perceptible. However, a variation between different textures is recommended. This creates an interesting and memorable object.

Transparency also influences perception. Transparent materials are experienced as fragile and sexy, and in combination with refraction, they can have a special effect. However, the occurrence of disturbing reflections must be considered. By contrast, a reflective surface can also have value. On the one hand, by creating a memorable experience. For example, because the environment flows into it, through the dynamic image or the distortion of the reflection. On the other hand, by the symbolic meaning behind it.

The material properties of colour, temperature and density influence the perceived mass and thus the perception. Bright colours are seen as lighter, while dark colours are considered heavier. Cold or warm objects are also felt to be heavier in comparison to objects with a neutral temperature. In addition, experience has taught us that materials with a high density are perceived as heavier and materials with a low density as lighter. Embodied metaphors play a role in the assessment of experienced mass. For example, materials with a high perceived mass are seen as important and evoke heavy feelings. While lighter ones are viewed as less important and evoke lighter emotions.

The emotion theory was applied to five tangible materials in three public historical and trauma-related case studies. The analyses were carried out in a similar manner and under comparable conditions: weather conditions, time of day and distance to the material. The analyses show the expected emotional response to the materials and how they could have better matched the ideology of the designed memorial to achieve the desired emotional effect.

4.2 Strengths and limitations

In this study, many various sources were used by authors with different expertise. This makes the result valid. However, the theory examined the perception of a single colour and did not look at a combination of colours. In the analyses, a general colour was determined, which may result in a

slight difference in the perceived colour tone and brightness. The roughness depends on the exact location and can therefore differ.

4.3 Application

The study is an addition to the existing literature. In previous research, only a single aspect of a material property was investigated, while this research combined the various aspects. This allows the perception of materials to be analysed. The knowledge about the effect of materials on perception helps designers in the choice of materials. To achieve a certain perception on the part of the spectator. However, this research only focuses on the perception of colour, texture, transparency, reflectivity, and perceived mass of materials. If other material properties are included, a more complete picture of the perception of a material emerges, and possibly also a different result.

4.4 Future research

The advice for further research is to do similar research on the perception of other material properties, such as odour and hardness. This will give a more complete picture of what influences the perception of materials.

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- Figure 15: Simons, R. S. (2021, February 26). Material analysis of The Auschwitz Monument [Sketch]. Own image.
- Figure 16: Simons, R. S. (2021, February 26). Impressions of The Jewish Memorial Forest [Sketch]. Own image.
- Figure 17: Simons, R. S. (2021, February 26). The layout of The Jewish Memorial Forest [Illustration]. Own Image.
- Figure 18: Simons, R. S. (2021, February 26). Material analysis of The Jewish Memorial Forest [Sketch]. Own image.