

MUSEUMS: Include us all! Built environment requisites in inclusive museums.

Dipl.-Ing. Tina Merk
Accessibility Consultant

Abstract

Museums are no longer facilities that are made just to present views on subjects from various eras or to showcase conserved artifacts in vitrines or on walls, but also to encourage each and every one of us to come together and explore exhibits with different sensory interactions, to learn, research and engage at our own pace and preference.

This presentation will focus on museums' built environment and how universal design affects the level of autonomy in physical access to allocated space and the content/exhibits therein, and helps in setting a universal ground for individuals to come together, interact, explore and learn.

"I hear and I forget. I see and I remember. I do and I understand." (Confucius)

Design solutions, their advantages and disadvantages as well as suitable alternatives will be discussed in detail. This presentation demonstrates how sometimes small and low cost adjustments can have a positive impact on maximizing inclusivity in a world of global education, research and discourse.

Keywords: museum, universal design, built environment

Introduction

Visiting a museum individually, as a family or taking part in a study group daytrip can be a great source of joy and entertainment. More importantly, this can widen the intellectual horizon of each and every one of us and deepen our knowledge. Unfortunately, not everyone can access museums and the information encompassed within its walls as easy as it should be. People with any kind of impairment, whether temporary or permanent, often face barriers that may be caused by attitudes from poorly trained staff, the way exhibits are showcased, or how information is being passed through the museum's website, app, leaflets, or other various mediums. Similar reasons cause exclusion of such people; not only from leisure facilities that come as a source of education and cultural exchange but also from society as a whole. Whereas attitudinal and technological barriers can be crossed easily often without much effort involved, the built environment requires planning, expertise, time and budget.

Many museums are located in historic buildings and, therefore, face lots of restrictions for attempting modifications. Some building owners bring up lack of budget to justify inaccessibility of their facilities even though there are readily available, simple and inexpensive solutions in construction and technology markets. Furthermore, not all physical barriers are seen as such by concerned parties or addressed similarly in services such as events or workshops.

Arrival at the museum

All visitors must have equal access to all main facilities and services through a fully accessible and continuous route which connects parking spaces, entrance, reception, cloakroom, accessible toilets and the exhibition. This does not exclude restaurants and shops provided. Any discrepancies can cause lack of physical access and affect independent evacuation in case of an emergency.

The journey of each individual visiting the museum and its exhibits does not start at the doorstep of the facility, it begins with arrival. Usually, visitors use the public transportation system, taxis or drive their own cars. Therefore, all nearby buses, metro and tram stations must welcome visitors in the most universally designed way possible. Taxis should be allowed to drop-off visitors at an accessible drop-off zone close to the museum's entry points. Visitors using their own vehicle need to have access to accessible parking spaces and drop-off zones. Guests who have to pay for the parking should be able to use the parking meter independently.

Every station, accessible parking and drop-off zone needs to have direct access to an accessible path. Clear signage with detailed information about distances from any point of arrival to the entrance of the museum is essential, especially if the plot is considerable in size. Golf carts or pick-up services have to be considered if there is a long walking distance between parking spaces and the entrance of the museum.

The path leading directly from the arrival to the accessible entrance of the museum is ideally the main path every visitor uses. If an alternative route has to be provided due to the lack of access for wheelchair users or temporary maintenance work, this has to be clearly indicated and universally designed. Uneven or unstable paths need to be covered with planks, wheelchair access mats made out of a non-slip surface, or finely-crushed and well compacted stones and bricks. Regardless what material is being used to create an accessible path to the museum,

maintenance throughout the year is important. This includes refilling gaps in the path, compacting the floor surface, removing leaves and snow, and cutting trees to make signage along the route visible and prevent any obstruction caused by branches and twigs along the way.

The walkway has to guide the visitor safely to the entrance. A main factor to do so is a proper lighting concept and signage system. Tactile maps, especially if the plot is significant in size, is one way to support with orientation. A proper guidance system provided by a visually and haptically contrasting floor surfaces helps a person with low vision as another form of assistance for on-site navigation. Alternatively, well defined edges such as kerbs and hedges along the path serve the same purpose.



Figure 1. Tactile model of a preserved area



Figure 2. Guidance provided by haptically contrasting floor surface, light and kerbs

Street furniture are potential hazards if not placed outside the main path of travel and identified haptically or visually. Nevertheless, the existence of different styles of benches or seats, with or without back and armrest, along the way is important especially for people with low stamina.

Some visitors require a service or a guide dog to visit the museum. Guests who have a long distance to travel either by public transport or car need to have the possibility to let their dog's relieve themselves in dedicated areas. A well sign-posted, enclosed and regularly cleaned

area close to the parking space or the main entrance helps visitors who depend on dog assistance when visiting a museum [1].

Entrance to the museum

A universally designed main entrance to a museum should be seen from a fair distance. Steps are either entirely avoided where wheelchair accessible ramps and lifts serve as an alternative or placed side by side. This nonetheless is often not the case because most museums are in existing and often preserved buildings with large steps as part of its architectural design. If modification to the main entrance is impossible or limited due to local restrictions, a second fully accessible entrance should be provided in close proximity and in an area where that does less effect to the historic façade and overall appearance of the building. A directional sign indicating the location of the universally designed entrance should be placed at the inaccessible building entrance.

Steps

The following recommendations are suitable on the assumption that modifications can be made to steps or other stairs that are of less importance to the building appearance. Steps are more accessible if they are well-lit, have visually contrasting handrails (on both sides preferably), and can be used by adults and children. Thus, the provision of a lower and upper handrail is an ideal solution. Supplementary handrails can be installed next to existing preserved handrails or on external walls depending on local restrictions. All handrails should be stable and easy to grasp and should not cause any discomfort while touching them during hot or cold seasons. Coatings (e.g. PVC coating or translucent insulation and corrosion prevention coating), special handrail coverings or tapes such as grip tape with a PET base can be added to make

existing handrails safe to touch. Handrails need to extend horizontally beyond the first and last step considering that hands are positioned slightly in front of the body when using the handrail. Additional tactile information about directions and location on the handrail supports people with vision impairment.

Any change in level requires visually contrasting, slip resistant tactile information to be placed on the floor surface on top and at the bottom of each flight of stairs. If standardized tactile ground surface indicators (TGSI) are not available, slip resistant paint or thermoplastic paint as well as rubber ribbed strips and tapes can serve as an alternative. Everyone benefits from highlighted steps which prevent visitors from tripping or falling. Visually contrasting edges (painted, provided through integrated design or readymade profiles) on each step or at least on the top and bottom steps are consequently required to make stairs more accessible.



Figure 3. Steps in a preserved area



Figure 4. Alternative to standardized tactile warning Surface in a preserved area

Steps certainly cannot be used by all guests, thus ramps or lifts are essential to provide equal access to every member of society.

Ramps

Pavements with a slopes greater than 5% in angle require additional support in form of handrails and protection along the edges [2]. Ramps are made to be used independently and often serve as part of an accessible route in case of an emergency. New ramps should be well-lit and have a smooth incline with a maximum slope of 6% in angle to guarantee that every guest arrives less fatigued. After all, ramps can be built steeper over a short distance especially when there is not sufficient space provided in front of the building entrance. Ramp slopes greater than 10% in angle can increase the risk of flipping and should thus be avoided or combined with a call-for-assistance button [3]. Portable ramps can be provided if no other option is available, for the reason that it is often not as safe as a permanent ramp and requires training museum staff. It usually lacks protection on the edges and handrails on both sides.



Figure 5. Ramp as an alternative to the existing stairs **Figure 6.** Ramp with call-for-assistance button

Ramps have to be wide enough to accommodate at least one wheelchair user and ideally allow another person to pass. Existing ramps can be made more accessible by lengthening the ramp to construct a smoother incline or by the provision of a call-for-assistance button, installation of protection along the edges as well as handrails that are safe and easy to grasp by everyone throughout the year.

If a ramp lacks sufficient landing space on top and at the bottom of each ramp run, it can cause a serious safety issue for wheelchair users. Any change in level requires visually contrasting, slip resistant tactile information placed on the floor surface, on top and at the bottom of each ramp run.

Platform lifts can alternatively be used to overcome higher differences in level or if space is limited on the plot. Not only are such lifting devices more expensive and require constant maintenance, but they also often do not serve wheelchair users and parents with a pram in case of an emergency. Requirements for lifts and platform lifts will be discussed at a later stage.

Entrance door

The entrance area should be well-lit especially at night and the main accessible entrance door should clearly be identified as such. All glass panels and doors require a visually contrasting strip at the eye and knee height to prevent people from walking into them. Revolving doors are inaccessible and should therefore be avoided. Alternatively, a second universally designed entrance next to the revolving door can be installed to welcome all visitors.

Heavy entrance doors that require a force of more than 22.2N to be opened or closed may not be deemed accessible for some visitors [4]. Low friction hinges or adjusting door closers can minimise the opening force. Automatic doors are an additional solution to provide access to all. It is important to ensure that motion operated doors are equipped with a sensor that detects an approaching person to avoid collisions and can be activated by wheelchair users or children. If the door is button operated, it needs to be clearly visible and placed outside the arc of the door swing and in reach range of a wheelchair user and children. The opening time of an automatic door shall allow visitors with mobility aids to pass through securely. If neither local restrictions

nor budget allow the installation of an automatic door, an intercom system that supports people with a vision and hearing impairment or a doorbell can be taken in consideration.

Door knobs and other kinds of door hardware that requires twisting are not suitable for people who lack the ability to turn a knob. Thus, the installation of lever door handles in reach range for a wheelchair user or child has to be given priority and are simple fixes. The material of the door hardware should not get hot when exposed to the sun or cold in the winter months.

Visitors with walking aids and parents with a pram require sufficient space on the latch side, in front and after the door to be able to manoeuvre, especially if the entrance door is manually operated. The clear width of the door has to accommodate all kinds of walking aids and prams, otherwise the entrance door needs to be widened. The installation of offset hinges is recommended to gain a few centimetres in doorway width.

Thresholds are often installed to prevent rainwater from entering the building. Unfortunately, this water barrier presents an access obstacle for many guests. There are several solutions to tackle this. The first option is the removal of thresholds as a whole and sloping the surrounding external area away from the building. Alternatively, magnetic door seals with a flush threshold drain provide access for all and keeps rainwater outside the museum. The third option is to lower the existing threshold, bevel the edges, or to add threshold plates or ramps.



Figure 7. Ramps overcome the level difference in a preserved area



Figure 8. Threshold plate

Reception area

The reception area is part of an intuitive building layout that leads visitors from the main accessible entrance door to the reception desk, cloakroom, toilets, stairs, lifts and eventually to the heart of every museum – the exhibition. A great orientation is supported by a well-designed wayfinding system, sufficient lighting and comfortable acoustics. Furniture and potential obstacles should contrast against walls and floor surfaces. The lobby has to provide sufficient space for the expected rush of visitors while sustaining required manoeuvring area and path width for people with a mobility aid and for parents with a pram. All notifications on displays need to be clearly visible at all times.

Reception counter

The reception counter should be placed close to the main accessible building entrance in a calmer area of the lobby and clearly identified as such. Adding visually contrasting stripes to the edges of the counter and installing additional light sources, or changing the existing light bulbs for a more even and brighter illumination are reasonable modifications to make the counter more accessible for people with vision impairment.

The acoustics around the reception desk and the provision of a hearing enhancement system tremendously improve communication between a person who is hard of hearing and museum staff. A sign informing guests about the existence of a permanent or portable hearing enhancement system needs to be out within sight. Pen and paper serve as alternatives to the assistive listening system.

The reception counter shall be designed to allow a wheelchair user to approach the desk from the front. Thus, a lowered part with sufficient knee clearance underneath the counter top allows a wheelchair user to fill out forms and sign papers comfortably without twisting his or her

upper body. If the reception counter allows a parallel approach only, the museum staff have to provide an additional writing surface to visitors with limited upper body movements. Both options of approaching the desk require sufficient manoeuvring space in front of the counter.

Cloakroom and toilets

Cloakroom and toilets have to be clearly signposted and located along the accessible path of travel. Generally, colour contrast within rooms is essential for better orientation. The older people get the more likely their vision succumbs to change. Hence, sanitary ware and accessories, aside from furniture and coat hooks, must contrast visually against walls and floors. Moreover, installing coat hooks and lockers at various heights collectively enhances everyone's usage, despite having different body measurements and abilities.

At least one accessible bathroom should be large enough to facilitate multiple transfers to the toilet bowl and provide enough space to manoeuvre comfortably. Space, especially in existing buildings, is often limited, which renders sufficient transfer on both sides of the accessible toilet unattainable. An exception in case, is the provision of accessible toilets, one with a right and another with a left transfer, in different areas or floors. Some museums are small or have historic value that restrict implementation of wet rooms. In which case, museum staff should be aware of the closest accessible toilet. All accessible toilets need to be labelled with the International Symbol of Accessibility and communicated effectively with people of vision impairment through embossed characters and Braille in reach range on the latch side of the door.

In case a visitor falls on the ground, for instance while transferring to the toilet, museum staff can assist if the door opens to the outside whilst the cubicle or room is also equipped with an emergency call system. A push button or red pull rope, which is part of an audio and visual alarm system and in reach range from both the toilet bowl and the floor, alarms the staff through

a display in the reception area, security room or control room, together with a flashing light above the toilet door.

Conventional thumbturns often cannot be operated by the side of someone's palm and thus should be replaced by a universally designed door lock. All toilet accessories like coat hooks, soap and paper towel dispensers and taps are easy to use by everyone if they are installed in reach range from a wheelchair user and can be operated without twisting, pinching or applying much force. Special attention has to be given to hot air dryers inside all toilets. The noise coming from them can cause discomfort to many people, so visitors should be warned about this through a sign outside the toilets, which overall makes the case for giving priority to using less audible products.

The toilet bowl and grab bars in accessible toilets shall accommodate all kinds of visitors and their preferred ways of transfer while using them. This requires the provision of grab bars on either side and preferably behind the toilet bowl. All grab bars shall be in reach range while using the toilet and installed at a comfortable height. The cleaning team must ensure that bins do not block the transfer space on either side of the toilet. Close attention has to be paid when choosing the type of bins not only for the toilet but also throughout the museum. Pedal type bins are not suitable, especially for wheelchair users.

Approach to the washbasin has to be from the front, so sufficient knee clearance underneath the washbasin should be present. Proper insulation of the pipes, an installation of a cover panel or the provision of a concealed trap prevent burns. The latter option enhances knee clearance underneath the washbasin. Mirrors have to be installed directly above the accessible washbasin to be usable in a sitting position. Otherwise a second full-length mirror can be provided at any location inside accessible bathrooms.

Height-adjustable changing tables are a practical solution for adults, not only parents with babies but also to anyone who might depend on this feature. Changing locations of toilet accessories and repainting walls are simple fixes that can benefit lots of people.

Circulation through the museum

Movement within the museum requires sufficient space so that people can communicate in sign language comfortably and parents with a pram can stroll around without feeling constricted while other visitors walk past them, for instance next to exhibits where a larger group of visitors is expected to gather. Throughout the path of travel, furniture has to contrast against its surroundings and be detectable by a white cane. Detailed options will be discussed under “Exhibition space”. A change in the floor surface, the provision of clear head room along the route of travel and the location where obstacles are placed can help in making the route safe for everyone. Evenly distributed daylight or artificial light assist all visitors with their navigation, but lighting strips close to the floor surface per-se enhances visibility in case lighting levels have to be lower. A well-designed lighting concept can be part of the overall wayfinding system. Contrasting doors, floor and wall surfaces, handrails and railings are elements that significantly improve independent mobility throughout the museum, nevertheless, a proper signage system must complement the building layout and architectural features.

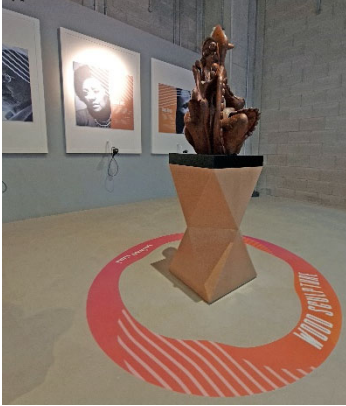


Figure 9. Highlighted floor surface around an object for enhanced visibility



Figure 10. Lighting strips close to the floor surface for enhanced wayfinding

Regardless of the material being used for the floor surface, the circulation route has to be safe not to cause people to trip, slip or twist an ankle or get affected either by reflection of light or transmission of impact noise. Visitors using walking aids or parents with a pram often face difficulties if high-pile carpets are used as flooring material and thus should be avoided.

Changes in level can make a visit to the museum so difficult if not entirely inaccessible for many guests, in particular when no alternatives such as (platform) lifts or ramps are installed. At least the entrance floor should contain all major universally designed facilities, including a multipurpose room that showcases duplicates of exhibits in form of photographs, video or through perception of a Virtual Reality simulation of the building or the exhibits therein; all made in the utmost universally designed manner so that everyone is able to enjoy their experience in what the subject institution has to offer.

Steps and ramps

The requirements for universally designed steps and ramps are equivalent to the external accessible steps and inclines that were discussed earlier. Maintenance plays a significant role especially if well-lit steps are part of the evacuation route. Alterations to existing main stairs are often difficult and may be impossible if the structure is preserved by local authorities for reasons of historical significance. Hence, it is advisable to modify an alternate staircase of less importance inside the museum and connect it to the facility's main accessible path [5]. Implementation of single steps should be avoided or replaced by a ramp with smooth incline, accompanied with handrails and edge protection on both sides. Ramps are usually not installed to overcome significant difference in level inside a building unless they are part of the design as in the Mercedes Benz Museum in Stuttgart. Therefore, alternatives have to be provided to evacuate all visitors efficiently from all floors. Protected areas inside enclosed staircases or neighbouring rooms serve as waiting areas as long as people do not block the route or the required width of any landing while waiting for assistance. An uninterrupted communication with people at the reception or control room has to be guaranteed for everyone, which includes people with walking aids, loss of vision or hearing.

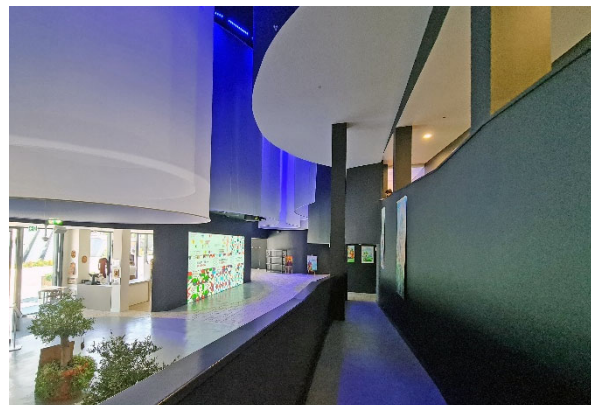


Figure 11 and 12. Internal ramp is the main circulation route

(Platform)Lifts

Where museums span to more than one floor, lifts provide all visitors with equal access to all public areas on each story as long as they are universally designed. This includes the cabin size, door width, opening time and the lift's ability to transport a wheelchair user in addition to one person or parents with a pram. The layout and location of external and internal control panels as well as buttons should be operatable by children, people of short stature and people with vision loss (e.g. via provision of Braille and embossed characters).

Audible and visual information of an arriving lift, direction of travel and announcement of the floor level are particularly important for people who have hearing difficulties or lack of vision. Lifts need to be equipped with safety measures such as door sensors that stop and reopen the doors in case a person or an object blocks the entrance, in addition to a two-way communication system in case of an emergency. The emergency communication system has to be designed to assist all guests regardless of their needs. Control buttons have to be within reach range and supports people with visual or hearing impairments. This includes but is not limited to the provision of Braille, embossed characters, backlit buttons for answered emergency calls and an indication for when help is on the way, induction loop system, and a text or video based communication system.

Small modification work, like adding haptical stickers to control buttons, door jambs or providing a full length mirror to assist wheelchair users inside a small cabin to reverse, all add value to existing lifts and make them more accessible. If a historical museum or any unpreserved facility with insufficient space requires a lift to be more inclusive and welcoming to all parts of society, this can be installed in one of the less prominent areas inside or outside the building. Depending on the height and number of floors that need to be covered, platform lifts are another

point in case. Based on the travel distance either the platform lift has to be partially enclosed or fully enclosed to provide visitors with the best safety precautions.

Doors

Major design considerations for providing universally designed doors and thresholds in museums and alternatives to improve accessibility have been pointed out under “Entrance to the museum” and “Entrance door”. Internal doors often create an internal barrier and should either be kept to a minimum, be left open or be replaced by an automatic door system (especially where space for manoeuvring is not sufficient or doors are too heavy). Small adjustments to the door and its hardware can be achieved easily and are inexpensive. Colouring the wall around the door in a contrasting colour eases detection. If sufficient clear door width cannot be achieved, services behind the door have to be relocated to another area. Less favourably, a narrower wheelchair can be supplied by the museum management to guests in need.

Wayfinding

The wayfinding system in a museum needs to be unified and continuously appealing to all senses from the point of arrival and throughout all public areas. At least two complementing senses have to be targeted to navigate through the facility independently.

Every visitor benefits from a clear signage system that contains large contrasting fonts that are easy to read. Using symbols as a way to communicate relevant information makes it easier for the public, in particular if the used language is not someone’s native tongue. The implementation of a proper signage system is something that can be fixed easily and is in everyone’s interest. A lighting system and applying colour coding to the interior can support wayfinding.

Information has to be communicated through hearing and touch, in particular to guests with vision impairments that rely on these senses. The path of travel, the exhibition space and the location of tactile maps, touchable artifacts or replicas in lieu thereof can be highlighted through a change in flooring that differs haptically and visually from their surroundings. The change in texture needs to be perceived by a person with a white cane. While doing so, the usability of the circulation route should not affect people using walking aids. Braille and embossed characters on handrails can serve as additional mediums for orientation. Public areas such as bathrooms, areas of refuge and emergency exits require signs in embossed letters and Braille to be within reach and should be placed on the latch side of the door. All of this information should conform in tactile maps if provided.

Simplified haptical versions of the floor plan should be part of the museum entrance, either fixed or portable, and ideally in every room to identify exhibits and closest emergency exits. Using audio guides in combination with tactile maps can replace tactile guidance on the floor whenever a reversible system is required. Assistive navigation through audio guides and special apps on mobile phones can simultaneously complement self-guided tours throughout the exhibition.

Exhibition space

Every exhibition has to be inclusively designed in collaboration with groups of various interests and potential visitors. The choice of exhibits, layout and the design of space are some areas of interest in this regard. The route through the exhibition has to be safe at all times and should have the ability to accommodate crowd rushes. People with walking aids and parents with a pram should have sufficient space in front of exhibited items for wide and closer looks, and can comfortably walk around artifacts that are intended to be viewed from different angles.

The exhibition space must be well-lit for better content visibility and clarity when reading attached labels without experiencing glare, reflections or shadows. Ambient light can enhance conventional direct light or even replace it, depending on the concept. Conservation guidelines often require lower light levels in museums [6]. Lighter floor and wall colours can counteract this to make exhibits more visible. A well-established light concept allows people to lip-read and communicate through sign language either closely around the displayed item or in dedicated areas close by. Brochures or copies of the exhibited element in a brighter area assist people with vision loss if the illumination level cannot be raised. Experimenting with colours and contrasts within the exhibition space does not only contribute to the artifacts level of visibility but also exposes potential hazards. Nevertheless, special attention has to be applied during the design stage to avoid overstimulation.



Figure 13. Evenly distributed light and contrasting elements in an exhibition space

Acoustics in the exhibition area plays another important role to prevent visitors from having sensory overload during their stay. Selecting the right building material during the design process can reduce reverberation time in the rooms. Soft surfaces can replace hard surfaces wherever possible or are usually added to improve the acoustics in existing facilities.

Ceiling and wall-mounted objects conflicting with the accessible path of travel must be made detectable by a white cane through a low railing or floor mounted object such as a solid opaque base or plexiglass to prevent collisions.

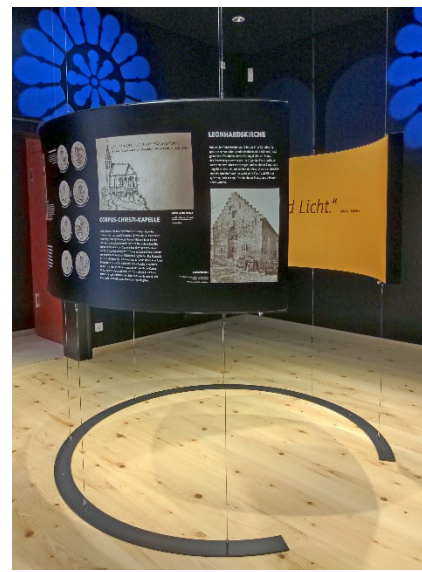


Figure 14 - 17. Protruding exhibits with various types of detectable elements

Large exhibitions can be especially tiring, that is when seating options along the accessible path are required. Various styles of seating, with or without armrests and backrests, have to contrast visually and can be placed in corridors or even within the exhibition space where they do not interfere with the required width of the accessible path.

Artifacts and exhibited objects are usually wall-hung, placed in showcases or on podiums. Whenever railings are installed for security reasons, they must be mounted at a height that does not collide with the line of sight of children or wheelchair users. Media stations and interacting tables are nowadays essential elements in most museums to boost engagement with the audience which in turn enriches the learning outcome for each individual.



Figure 18 and 19. Lowered barrier in front of exhibits

Not all exhibits are naturally accessible to the all members of the audience, especially rare objects or items of historical value. However, the museum management has to ensure that exhibition contents can be accessed and experienced in various ways by all visitors. Alternative

approaches to the content has to be developed which utilises at least two complementing senses such as hearing and touching/smelling/tasting or seeing and touching/smelling/tasting.

Nowadays various technologies are out on the market that can enhance visitor experience such as 3D prints of paintings, photographs, and sculptures, Augmented Reality, audio guides, hearing enhancement systems, implementation of QR Codes, inclusively designed museum apps and closed captions in films and short videos. Additionally, brochures providing background information in clear, simplified language and Braille, magnifying glasses as well as specialised tours during quieter hours that allow touching objects or provide sign language interpreters, all make a museum and its content more accessible to the society.

SMELL



Figure 20 and 21. Scent station

TOUCH



Figure 22. Touch replica of a sculpture



Figure 23. Touch stations

HEAR



Figure 24. Listening station

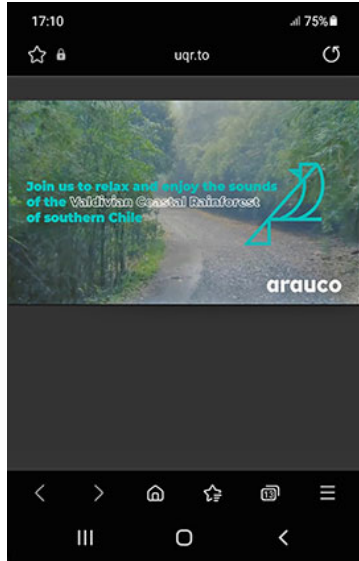


Figure 25 and 26. QR code to listen to the sound of the forest

SEE

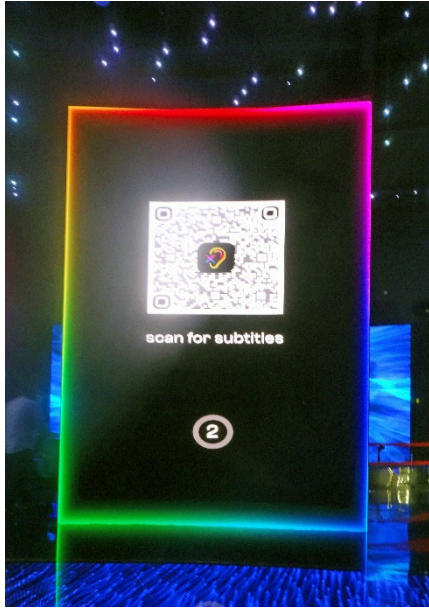


Figure 27. QR code for closed captions



Figure 28. Camera to zoom in areas that are barely visible

Showcases

Every visitor shall have the possibility to come close to showcases in order to see the artwork and ideally approach it from different angles. The line of sight of children and wheelchair users, however, differs from other visitors and this must be considered when installing showcases. Instead of lowering vitrines, the bottom part of the display can be tilted to provide clear and full view of the object. Sufficient space underneath the showcase facilitates forward approach to people using wheelchairs but might cause a hazard for people with vision impairment if the showcase cannot be detected by a white cane.

Sufficient contrast in vitrines can improve visibility of the object within, especially when conservation requires lower light levels [7]. Unlike ceiling or wall mounted lights that often cause reflections on the glass panel of the vitrine, light sources inside the showcase provide even illumination when placed properly [8].



Figure 29. Light sources inside the showcase and object are showcased in different line of sight

Media stations and interactive tables

Media stations and interactive tables find their way more and more into our museums. They stand as an excellent resource for communication with the audience and provide the opportunity to engage with all visitors if they are universally designed. This includes sufficient knee clearance underneath the stations, detectability for people using white canes, seating options, reachability and accessibility of all operable parts, provision of glare-free displays as well as integrated visual and audible enhancement systems. Location and design of media stations and interactive tables have to be well-chosen, especially during the design process and that is to reduce the sound level they will likely produce and its overspill to other areas.



Figure 30. Interactive table

Labels

Labels have to be installed close to the object they are referring to and placed at the same position relevant to each object throughout the exhibition [9]. Information has to be precise and contain clear and simple language that can be easily read from a distance and contain embossed characters and Braille. Special consideration has to be taken with installation height, because the line of sight of wheelchair users and children differ from average.

Complementing services

Needless to say, any additional service areas within the museum are favourable when designed to conform with a diverse targeted society, bearing in mind the requirements discussed earlier. Thus, restaurants or cafes should additionally provide clearly identifiable seating and

table options throughout the facility. Wherever and whenever self-service policy is practiced, goods, plates, cutlery and condiments have to be within everyone's reach and displayed in the range of various eye levels. Additionally, trained staff members have to assist if the built environment demands additional human support. Vertical stacking system of products in museum shops and a variety of accessible and visually highlighted furniture attract diverse groups of potential buyers. The availability of different seating options, assistive technology and accessible lecterns during an event give each individual enough physical space to participate. A quiet space for relaxation helps distraught people or people with sensory overload to feel better or regain composure.

Emergency evacuation

The museum management and staff have to ensure that visitors can not only arrive and make their way through the facility independently but also be able to leave in case of an emergency. If the building and the facility within are universal designed from the start, guests are more likely capable to make their way out without assistance.

A large number of accessible fire exits, installation of evacuation lifts and a proper wayfinding system besides provisioning audible and visual alarms are essential in assisting self-evacuation. Evacuation plans and exit signs have to consider visitors with low vision and their need to navigate through the building via touch and sound exclusively. Evenly distributed tactile maps inside the building or portable 3D print of the floor plan can be rented out to visitors at the reception for more reliability during emergencies compared to specialised apps or guiding via mobile phone. People with hearing impairment rely on visual alarms and hence these are required at all available toilets of various types and exhibition areas in general. A fire warden has

to be appointed by the museum management to make sure that all areas are cleared in case of an emergency if flashing lights are not in place.

Every museum needs to have its own policies and procedures set in the event of an emergency. Staff have to be trained and aware of how to approach and assist a person with a disability, especially when own evacuation is not possible due to difficulties influenced by the building structure or preservation status. Not every facility in a multi-storey building has evacuation lifts. As such, there have to be specific waiting areas either inside staircases or in an area close to an emergency exit. These so called "Areas of refuge/rescue" should be labelled properly and protected by fire-resistant walls and floors. People in rescue areas ought to communicate through a universally designed communication system (positioned in reach range, includes information in Braille, embossed letters, induction loop system) with the management control point to request assistance or converse.

Conclusion

Barriers in the built environment do not only exist for people with visible signs of motion disability such as using a wheelchair but also for individuals with vision or hearing impairment, neurodiverse conditions, parents with a pram, the elderly as well as foreign visitors who do not speak the official language of the country.

The modification of the built environment is a constant process that first and foremost bears in mind people with disability in all stages of alteration. Secondly, it identifies all kinds of barriers from the point of arrival to all kinds of services in place through an accessibility audit. Whenever museums make changes to their exhibition, an interior or exterior audit becomes vital. Thirdly, a detailed plan highlighting required work, budget, responsibilities as well as a

timeframe has to be set to identify every single (potential) obstacle and present workable solutions or suitable alternatives.

Without a doubt, maintenance of equipment especially alarm and communication systems, and all public areas within the facility plays a significant role. If a supposed accessible path is not serviced regularly or an inaccessible alternative route is provided during any kind of repair, the museum and its exhibits can collectively turn to a place that cannot be visited by all. Each and every one of us benefits from an inclusive environment that welcomes all individuals.

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