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Original Article

Assessment of barrier-free environment in government institutions and schools in Kaohsiung, Taiwan

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Purpose: This study critically assesses the accessibility infrastructure in Kaohsiung's government institutions and schools, emphasizing the urgency of aligning with contemporary accessibility standards. By highlighting the specific compliance levels with existing regulations, this research underlines the significance of accessibility in promoting an inclusive society.
Methods: Employing a systematic evaluation, the study conducted on-site audits at eight key institutions—four government entities and four educational institutions. Each location was assessed using a detailed audit form based on "Regulations for the Design of Accessible Facilities in Buildings" in Taiwan, providing a comprehensive view of the current state of accessibility.
Results: The results demonstrate a varied level of compliance across the institutions, with the Nanzi District Household Registration Office and Shu-Te University showing the highest levels of accessibility among government and educational institutions, respectively. Significant discrepancies were noted in stair dimensions, parking facilities, and restroom accessibility across most sites.
Conclusion: The findings from this study contribute to the broader discourse on accessibility and inclusivity, offering actionable insights for policymakers, architects, and educational leaders. Improving these facilities not only addresses the immediate needs of people with disabilities but also serves the broader community by fostering an environment of equality and access. The study advocates for ongoing revisions to accessibility standards and a commitment to user-centered design to ensure that public spaces are truly inclusive.

Keywords: Accessibility, compliance, inclusivity, government institutions, schools.

1. Introduction

Globally, there are approximately 650 million people with disabilities (PWD), including around 5.7 million in Taiwan. The aging population, accidents, and diseases are expected to further increase the number of PWD. Projections suggest that within a decade, nearly 20% of the world's population will be over 65 years old, emphasizing the global shift toward an aging society(1). Taiwan, in particular, is experiencing a rapid increase in its elderly population, underscoring the direct link between demographic changes and disabilities(2). It is crucial to note that everyone, not just PWD, can face mobility challenges at some point in life, whether due to the need for

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a wheelchair, childcare, pregnancy, old age or temporary limitations(3).

The perception of disability has undergone a profound evolution over time, shifting from a personal medical problem to a multifaceted sociopolitical issue with far-reaching implications at the local, national, and international levels. This transformation is due in large part to the efforts of disability rights activists during the 1960s(4). Today, it is widely recognized that individuals with various impairments, including physical, sensory, and cognitive challenges, face a spectrum of environmental and social barriers that hinder their full participation in the economic, political, and cultural life of their communities. In particular, this exclusion is conspicuously evident in the design and construction of both physical and cultural infrastructure(5).

Use-centered design aims to address these barriers by prioritizing the needs and perspectives of individuals with disabilities, ensuring that products, services, and environments are inclusive and accessible to all(6). This design approach emphasizes integrating user needs, capabilities, and feedback into the design process to ensure that facilities meet the diverse needs of users. In accessible infrastructure, this means that designs should consider individuals with different abilities and requirements, including people with disabilities, older adults, and others with specific needs(7). For example, designing an accessible building should consider the needs of wheelchair users, including the width of wheelchair pathways and the location of accessible elevators(8). By adopting a user-centered design approach, accessible infrastructure can better meet the diverse needs of society, enhancing social inclusivity and accessibility(9).

To promote equal opportunity and social inclusion, Taiwan has embraced a barrier-free environment, enshrining this commitment in its Constitution in 1997. Although not a UN member, Taiwan ratified the International Covenant on Economic, Social and Cultural Rights, fully endorsed barrier-free human rights. In 2013, the Legislative expanded the scope of public buildings to implement 'comprehensive facility barrier-free' concepts, making Taiwan a pioneer in this regard. This represents a significant step towards environmental sustainability and poses a challenge for 21st century architects and investors(10, 11).

The integration of barrier-free concepts in public buildings is a pivotal step towards fostering environmental sustainability and social inclusivity(12). It necessitates the collective effort of diverse stakeholders, including government entities, non-profits, businesses, and individuals with disabilities(13). Such collaboration can lead to the development of comprehensive strategies that enhance accessibility through audits, design standards, and educational initiatives. The research highlights barriers such as political, policy-related, and governance issues that hinder collaborative urban planning for resilient environments(14). Additionally, it underscores the need for practical assessments and stakeholder education to bridge the gap between top-down expectations and bottom-up practices in age-friendly city initiatives(15). Furthermore, Taiwan's successful collaborative environmental governance relies on the ongoing commitment of local citizens, challenges posed by political competition, and unequal national societal partnerships(16). Addressing these barriers through effective stakeholder engagement and transparent governance mechanisms is crucial for achieving a barrier-free environment in Taiwan(17).

Although the importance of accessibility in public spaces is increasingly acknowledged, recent academic research indicates that the satisfaction levels and conditions, including those in Taipei City, Changhua City, Tainan City, and Yilan County, still require improvements(18). Previous research is often confined to specific regions or facility types. However, beyond the lack of similar studies in Kaohsiung City, this research aims to fill the knowledge gap by simultaneously evaluating government institutions and school campuses, and combining barrier-free design codes/regulations with on-site assessments. By doing so, it contributes to refining the practical pathways for advancing research on accessible environments. Furthermore, as a major urban center in southern Taiwan, Kaohsiung offers a representative setting to explore the challenges and strategies for realizing accessible development in high-density urban environments, it provides valuable insights applicable to other cities facing similar challenges.

Accessibility environments, designed to ensure

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inclusivity and equal opportunities for individuals of all abilities, are vital components of modern societies. This study assesses accessibility in Kaohsiung's government and school buildings, identifying areas for improvement based on existing standards.

2. Methods

This study investigates government institutions in Kaohsiung City, including Kaohsiung Cultural Center, Nanzi Train Station, Metropolitan Park MRT Station, and Nanzi District Household Registration Office, as well as schools such as Nanzi Senior High School, Kaohsiung Municipal Special Education School, Renwu Special Education School, and Shu-Te University.

The development of accessible environments in Taiwan spans over 20 years. Initially, the Disabled Welfare Act was enacted in 1980, mandating the consideration of barrier-free designs in public buildings, but limited to educational, vocational training, and medical facilities. In 1988, the Ministry of the Interior first incorporated regulations stipulating that public buildings must have 11 types of accessible facilities in the Building Technical Regulations. In 1990, amendments to the law required new public facilities to have accessible equipment installed, and existing facilities were to be renovated within five years. In 1997, the law was renamed the Protection of the Rights of the Handicapped Act, removing the five-year renovation period and instead requiring the submission of alternative improvement plans. In 2005, revisions were made to the Building Technical Regulations, adjusting the scope of public buildings and the types of required facilities. In 2008, recognizing that the design standards and illustrations were not sufficiently detailed, causing difficulties in the installation and improvement of accessible facilities, the Construction and Planning Agency of the Ministry of the Interior formulated the "Regulations for the Design of Accessible Facilities in Buildings". These regulations detailed the design standards and illustrations for accessible routes, stairs, elevating equipment, toilets and washrooms, bathrooms, wheelchair seating areas, parking spaces, and accessible signage. The formulation of these regulations marked a new chapter in the promotion of accessible facilities, rendering Taiwan's regulations for accessibility more comprehensive(11). For the audit form design, the present study employs the "Regulations for the Design of Accessible Facilities in Buildings" formulated by the Ministry of the Interior in 2008 to create the accessibility facility standard audit form(19).

Once the audit form was developed, two researchers who were undergraduate students in an occupational therapy program conducted on-site audits of the accessibility facilities in government institutions and school campuses in Kaohsiung City based on the audit form items and assessment criteria. The on-site audits took place within the period of 2019 and 2023. At each site, the audits typically required 4-5 hours to complete, depending on the size of the facility. The two auditors had received prior training on properly utilizing the audit form and assessment criteria from experienced occupational therapists to ensure standardization. During the on-site audits, the auditors followed a systematic process of evaluating each area and recording scores based on the criteria, with periodic quality checks by the supervisors to maintain consistency in scoring across sites. The key accessibility guidelines for government institutions are listed in Table 1, and those for schools are listed in Table 2. The audit form design content for

Table 1. Key Accessibility Guidelines for Government Institutions(19)

Facilities		Key Guidelines
Indoor Entry & Exit Passages	Slope	Gradient of slope shall not exceed a ratio of 1:15. This study specifies that on accessible passages, if there is a height difference of more than 3 centimeters between the upper and lower platforms or if the slope exceeds 1:15 over a continuous 5-meter ramp, it is not compliant.
	Net Width of Path	Must exceed 130 cm.

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	Ramp Width	The net width of the ramp must not be less than 90 centimeters; if the ramp replaces stairs, the net width must not be less than 150 centimeters.
	End Platform	For both the starting and ending points of the ramp, a platform with a length and width of at least 150 centimeters must be provided, and the slope of this platform must not exceed 1/50.
	Intermediate Platforms	For every 75-centimeter height difference on the ramp, a platform with a length of at least 150 centimeters must be provided, and the slope of this platform must not exceed 1/50.
	Turning Platforms	At locations where the direction of the ramp changes, a platform must be provided with dimensions of at least 150 centimeters in length and width, and the slope of this platform must not exceed 1/50.
Indoor Facilities	Accessible Turnstile	Accessible ticket gates with a height greater than 80 cm and a ground slope not exceeding 1/50 are required.
	Service Desk	The service counter should have a distance of 70-80 cm between the counter surface and the floor, with a net space from the floor up to 65 cm within a range of 45 cm below the counter surface.
	Accessible Public Telephone	Accessible public phones should have a height of 120 cm or less.
	Ticket Booth and Ticket Vending Machine	Ticket booths and vending machines should also have a height of 120 cm or less.
Indoor Passages & Doors	Indoor Cage Corridor Width	The width of the indoor corridor should not be less than 120 cm.
	Turning Space	Turning spaces, within corridors with a width less than 150cm, should have a turning space of at least 150×150cm every 10 meters, at the end of corridors, or at converging points within 3.5 meters.
	Door Panels	Door leaves, if made of transparent glass, should have informative markings positioned between 120 and 150 cm above the floor.
	Opening Method	The door opening mechanism should not include revolving doors. If automatic doors are used, they must be horizontally sliding, equipped with a system to automatically stop and restart when obstructed by objects or people. This system should be activated by sensing obstacles at distances of 15-25cm and 50-75cm above the floor.
	Door Handle	The door handles should be placed 75-85 cm above the floor and no lever locks should be used.
Stairs	Step Depth	The tread depth should be 16 cm or less.
	Step Height	The height of the riser should not be less than 26 cm.
	Terminal Warning	Terminal warning: 30 cm from the end of the stair tread, a warning facility with a depth not less than 30 cm and a different color and texture should be installed.
	Rest Platform	Rest platforms should not have stairs or level differences.
	Step Nose	The curved radius along the groove of the staircase tread should not exceed 1.3 cm, and any protrusion beyond the tread should have a sloping surface below with a slope not greater than 2 cm.

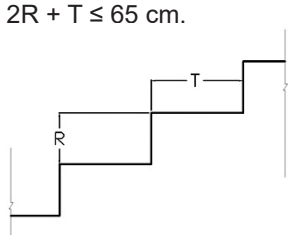
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	Edge Guard	Where the tread of the stairs is not adjacent to a wall, edge protection with a height greater than 5 cm above the tread of the stairs should be installed.
Elevators	Call Button Height	The height of the call button should be 110 cm from the floor.
	Call Button Size	The minimum dimensions should be above 2 cm in length and width each, or a diameter of 2 cm or more.
	Braille Call Button	30 cm in front of the button, there should be a 30 × 60 cm area with a different texture on the floor to indicate the location.
	Wheelchair Turning Space	The floor at the entrance and exit of the elevator should have no level differences, and the slope should not exceed 1/50. A net space with a diameter not less than 1.5 meters should be provided.
	Elevator Door	The elevator door should open horizontally and be of the automatic switch type. If the door is obstructed by an object or person, the elevator door should have a device that automatically stops and reopens it. This device should be activated by sensing obstacles on the floor at distances of 15-25 cm and 50-75 cm.
	Door Closing Time	The time from the elevator reaching the open position to closing should not be less than 5 seconds. If the door is opened from inside the elevator, it should remain in the fully open position for at least 5 seconds.
	Cabin Size	Cabin dimensions: The net width of the elevator door should not be less than 90 cm, and the depth of the cabin should not be less than 135 cm.
Handrails	Cabin Handrail	Handrails should be installed on at least both side walls inside the elevator cabin.
	Ramp Handrail Height	For ramps with dual handrails, the suggested heights are 85 cm and 65 cm. For ramps with a single handrail, the height from the floor to the upper edge of the handrail should be 75 cm.
	Urinal	The distance from the upper edge of the vertical surface handrail to the floor should be 128 cm. The distance between two vertical surface handrails should be 60 cm. The distance between two vertical surface handrails and the wall should be 25 cm.
	Toilet	L-shaped handrails should be installed on the side wall next to the toilet.
Toilets & Bathrooms	Toilet net space	The diameter should not be less than 150 cm.
	Toilet Entrance	Should not be less than 80 cm.
	Urinal Net Space	Net space on both sides of the centerline of the urinal (total of 100 cm).
	Washbasin	Height should not exceed 85 cm.
	Space Below Washbasin	In the area 20 cm below the edge of the basin, measured from the floor, there should be a net space starting at 65 cm high and extending horizontally 30 cm.
	Door Handle Height	75-85 cm.
Parking Lots	Single Car Parking Space	Length should not be less than 600 cm, and width should not be less than 350 cm, including a 150 cm wide area underneath the car.
	Parking Space Sign	Vertical sign for parking spaces: A luminous accessible parking space sign should be placed next to the parking space, with a size of at least 40 × 40 cm and a bottom edge height of 190-200 cm.
	Entrance Guidance	Clear directional signs should be placed at the entrance of the driveway and at turns along the driveway to guide the direction and location of accessible parking.

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government institutions includes indoor entry and exit Passages, indoor facilities, indoor Passages & doors, stairs, elevators, handrails, toilets & bathrooms, and parking lots, totaling 8 major categories and 41 sub-items. For schools, it includes classroom entry and exit path, classroom desks, chairs & podiums, stairs, building corridors, elevators or handrails, toilets & bathrooms, access to playgrounds, cafeterias, auditoriums & playgrounds, and parking lots, totaling 8 major categories and 38 sub-items. The data collected were compared against existing regulations. Facilities were categorized as "Compliant (C)" if they met accessibility standards, "Non-compliant (NC)" if they did not, and "Data Insufficient (DI)" if measurements were not available.

Table 2. Key Accessibility Guidelines for Schools(19)

Facilities		Key Guidelines
Classroom Entry and Exit Path	Indoor Entrance and Exit	Doorways must be free of thresholds and have a clear width of at least 90 cm. Folding doors must be pushed open, and the clear width of the opening must be at least 80 cm.
Classroom Desk and Chair & Podium	Dimensions	The minimum net space required for a wheelchair to fit is 75 cm x 120 cm.
Stairs	Stair Type	No spiral stairs or open stairs without vertical plates between steps are allowed.
	Step Depth and Height	The height (R) of all steps and the depth (T) should be uniform. R should be below 16 cm, T should not be less than 26 cm, and 55 cm ≤ 2R + T ≤ 65 cm. 
	Anti-Slip Strips	The horizontal tread part of the step edge should be treated to prevent slipping and be level with the tread surface.
	Handrail	Handrails with a height of 75-85 cm should be installed on both sides of the stairs or double-sided handrails (65 cm and 85 cm high).
	Horizontal Extension of Handrails	Both ends of the stairs should extend horizontally for at least 30 cm and have end collision prevention treatment.
	Terminal Warning	Warning facilities with a depth not less than 30 cm and different color and texture should be installed 30 cm from the end of the stairs. Platforms in the middle of the stairs do not require warning facilities.
Building Corridors	Width	Corridor width should not be less than 120 cm, and if there are doors, the width should not be less than 120 cm after subtracting the width of the open door.
	Accessible Pathway	Ramp and handrail width: Ramp net width should not be less than 90 cm. If there is a single handrail, the height from the ground to the upper edge of the handrail is 75 cm. Handrail ends should be collision-resistant.

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Elevators or Handrails	Elevator Guidance	The floor in front of the elevator call button with Braille should have a different material treatment of 30 cm x 60 cm.
	Main Entrance Floor Signs	Parallel wall-mounted accessible signs should have a bottom edge 90-150 cm from the floor, with a size not less than 5 cm.
	Wheelchair Turning Space	The elevator entrance floor should have no height difference, and the slope should not exceed 1/50, with a clear space not less than 1.5 meters in diameter.
	Elevator Call Buttons	The centerline height of the call buttons in the hall and door hall should be 110 cm from the floor, and Braille should be placed to the left of the call button.
	Cabin Size	The net width of the elevator door should not be less than 90 cm, and the depth of the cabin should not be less than 135 cm (excluding the space occupied by the handrail).
	Wheelchair User Control Panel	For a set of control panels, the centerline distance from the top button with floor indication to the cabin floor should not be more than 120 cm (can be relaxed to 130 cm if the space is insufficient), and the centerline distance from the bottom button to the cabin floor should not be less than 85 cm.
	Distance Between Control Panel and Elevator Entrance Wall	The distance from the control panel to the cabin entrance wall should not be less than 30 cm, and the distance to the opposite wall should not be less than 20 cm.
	Buttons	The minimum size of the buttons should be at least 2 cm, and the distance between the buttons should not be less than 1 cm. The numbers on the buttons should be clearly different from the base color, and touch-sensitive buttons should not be used.
	Braille Signs	Braille signs should be placed on the left side of the general control panel (vertical control panel). For buildings with 30 floors or more, if the installation position is insufficient, it can be placed in a suitable position.
	Distance and Height Between Handrails and Wall	If the handrail is close to the wall, there should be a gap of 3-5 cm between the handrail and the wall. The upper edge of a single handrail should be 75 cm from the floor, and for double handrails, the upper edges should be at heights of 65 cm and 85 cm. If used in elementary schools, the heights are reduced by 10 cm each.
	Closing Time	The time from the elevator reaching the door opening to closing should not be less than 5 seconds.
Toilets & Bathrooms	Door	The net width of the toilet lavatory space should not be less than 80 cm.
	Toilet Net Space	A turning space with a diameter not less than 150 cm should be provided inside the toilet lavatory space.
	Height of Washbasin from Floor	The height of the sink rim should not exceed 85 cm, and the space below the sink edge within 20 cm should be clear from the floor, meeting the A102.6 knee and toe clear space requirements.
	Faucet	The faucet should have a lever or automatic sensing control device.
	Washbasin Depth	The distance between the sink edge and the water faucet control lever or the outlet of the automatic sensing faucet should not be more than 45 cm, and the space below the sink, external pipelines, and the surface of fixtures should not have sharp or easily eroded devices.

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	Toilet and Bathroom Handrails	Handrails should be installed on both sides and in front of the washbasin, with the height of the handrail being 1-3 cm higher than the edge of the washbasin.
	Emergency Bell	Emergency call buttons should be installed inside the toilet lavatory space, with buttons placed in two locations: one 15 cm backward from the front edge of the toilet and 60 cm above the toilet seat, and the other 35 cm forward from the front edge of the toilet and 35 cm high, clearly marked.
	Toilet Net Space	The clear space on at least one side of the toilet should not be less than 75 cm.
	Toilet Height	Unless there are special requirements for medical or nursing institutions, ordinary toilet bowls should be used. The seat height should be 40-45 cm, the toilet should not have a lid, and a backrest should be provided with a distance of 42-48 cm from the front edge of the toilet seat (considering its flatness and pressure resistance for the water tank as a backrest). The net distance between the backrest and the toilet seat should be 20 cm.
	Flush Control	Flush control can be manual or automatic. Manual flush controls should be installed on the side wall with L-shaped handrails, 10 cm forward from the front edge of the toilet and approximately 40 cm above the toilet seat.
	Side L-Shaped Handrail	L-shaped handrails should be installed on the side wall of the toilet, with both horizontal and vertical lengths not less than 70 cm. The distance between the outer edge of the vertical handrail and the front edge of the toilet should be 27 cm, and the distance between the upper edge of the horizontal handrail and the toilet seat should be 27 cm.
	Retractable Handrail	At least one side of the toilet should have a movable handrail (can be lifting or horizontally movable). When in use, the distance between the outer edge of the handrail and the centerline of the toilet should be 35 cm, the height of the handrail should be equal to the height on the opposite side, and the length of the handrail should not be less than the front end of the toilet, and the protruding part should not be more than 15 cm.
Access to Playgrounds, Cafeterias, Auditoriums, and Playgrounds	Outdoor Path Net Width	The net width of the path should not be less than 130 cm.
	Indoor Exit	When the door is open, the ground should be smooth without thresholds, and the distance between door frames should not be less than 90 cm. For folding doors, after folding, the distance should not be less than 80 cm.
Parking Lots	Car Parking Space Length	Car parking space length should not be less than 600 cm, and width should not be less than 350 cm, including a 150 cm drop-off area.
	Parking Space Ground Markings	On the ground of parking spaces, there should be an accessible parking space sign, and the color of parking spaces should be blue, and the drop-off area should have white diagonal lines for distinction.
	Motorcycle Parking Space Length	Motorcycle parking space length should not be less than 220 cm, and width should not be less than 225 cm.

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3. Results

3.1. Accessibility Facilities in Government Institutions

The evaluation of barrier-free environments in government institutions encompassed various facilities, focusing on key aspects such as indoor entry and exit passages, indoor facilities, stairs, elevators, handrails, toilets and bathrooms, and parking lots. The following summary highlights the results for each institution (Table 3).

I. Kaohsiung Cultural Center

Kaohsiung Cultural Center exhibits mixed accessibility compliance. Indoor entry & exit passages have compliant net width of path and ramp width but a non-compliant slope. Indoor facilities lack data, except for the compliant accessible public telephone. Indoor cages & doors show compliant door panels, opening method, and door handle. Stairs have a compliant step height but a non-compliant step depth. Elevators lack compliance in call button height, and wheelchair turning space data is insufficient. Handrails are compliant in cabin handrail and door handle height but not in ramp handrail height. Toilets & bathrooms have varied compliance, with toilet net space and toilet entrance meeting standards. Parking lots show a non-compliant single car parking space, with insufficient data for parking space sign and entrance guidance.

II. Nanzi Train Station

Nanzi Train Station faces considerable challenges in terms of accessibility compliance. Indoor entry & exit passages show non-compliance in slope, net width of path, end platform, and turning platforms. Indoor facilities exhibit mixed results, with accessible turnstile and service desk meeting standards, but accessible public telephone and ticket booth/vending machine falling short. Indoor cages & doors present compliant indoor cage corridor width, turning space, door panels, opening method, and door handle. Stairs have compliant step depth and step height, but non-compliance in terminal warning. Elevators lack compliance in various aspects, including call button height and wheelchair turning space. Handrails show compliance in cabin handrail and ramp handrail height. Toilets & bathrooms present varied compliance, with toilet net space and toilet entrance meeting standards, but urinal net space and space below washbasin falling short. Parking lots exhibit non-compliance in single car parking space, parking space sign, and urinal net space, with entrance guidance meeting standards.

III. Metropolitan Park MRT Station

Metropolitan Park MRT Station demonstrates a mixed level of accessibility across various facilities. Indoor entry & exit passages have compliant slope and ramp width but face non-compliance in net width of path and turning platforms. Indoor facilities exhibit compliance in accessible turnstile, accessible public telephone, and ticket booth/vending machine, while service desk falls short. Indoor cages & doors meet standards in terms of indoor cage corridor width, turning space, and door handle, but door panels and opening method exhibit non-compliance. Stairs show compliance in step depth, step height, and rest platform but face non-compliance in terminal warning, step nose, and edge guard. Elevators exhibit varied compliance, with call button height, call button size, braille call button, wheelchair turning space, elevator door, door closing time, and cabin size meeting standards. Handrails demonstrate compliance in cabin handrail, ramp handrail height, urinal, toilet, and door handle height. However, toilets & bathrooms present non-compliance in toilet net space, washbasin, and space below washbasin. Parking lots exhibit compliance in single car parking space and entrance guidance but face non-compliance in parking space sign.

IV. Nanzi District Household Registration Office

Nanzi District Household Registration Office demonstrates a noteworthy level of accessibility compliance across various facilities. Indoor entry & exit passages meet standards with compliant slope, net width of path, ramp width, end platform, intermediate platforms, and turning platforms. Indoor facilities show compliance in service desk, while accessible turnstile, accessible public telephone, and ticket booth/vending machine exhibit some non-compliance. Indoor cages & doors present compliance in indoor cage corridor width, turning space, door handle, but

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Table 3. Assessment of Barrier-Free Environments in Government Institutions

Facilities \ Government Institutions		Kaohsiung Cultural Center	Nanzi Train Station	Metropolitan Park MRT Station	Nanzi District Household Registration Office
Indoor Entry & Exit Passages	Slope	NC	NC	C	C
	Net Width of Path	C	NC	DI	C
	Ramp Width	C	C	C	C
	End Platform	DI	NC	C	C
	Intermediate Platforms	C	C	DI	C
	Turning Platforms	C	NC	DI	C
Indoor Facilities	Accessible Turnstile	DI	DI	C	DI
	Service Desk	DI	DI	DI	C
	Accessible Public Telephone	C	NC	C	DI
	Ticket Booth and Ticket Vending Machine	DI	NC	C	DI
Indoor Passages & Doors	Indoor Cage Corridor Width	DI	DI	C	C
	Turning Space	DI	DI	C	C
	Door Panels	DI	DI	DI	NC
	Opening Method	DI	DI	DI	NC
	Door Handle	C	DI	DI	C
Stairs	Step Depth	NC	C	DI	NC
	Step Height	C	C	DI	NC
	Terminal Warning	DI	NC	DI	C
	Rest Platform	C	DI	DI	C
	Step Nose	DI	DI	DI	NC
	Edge Guard	DI	DI	DI	NC
Elevators	Call Button Height	NC	DI	C	C
	Call Button Size	C	DI	DI	C
	Braille Call Button	C	DI	C	C
	Wheelchair Turning Space	DI	DI	C	C
	Elevator Door	DI	DI	DI	C
	Door Closing Time	DI	DI	DI	C
	Cabin Size	C	DI	C	NC
Handrails	Cabin Handrail	C	DI	C	NC
	Ramp Handrail Height	NC	DI	DI	NC
	Urinal	NC	NC	DI	NC
	Toilet	NC	NC	C	C

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Toilets & Bathrooms	Toilet Net Space	C	DI	NC	NC
	Toilet Entrance	C	DI	C	C
	Urinal Net Space	NC	NC	DI	NC
	Washbasin	NC	C	NC	C
	Space Below Washbasin	NC	NC	DI	NC
	Door Handle Height	C	DI	C	DI
Parking Lots	Single Car Parking Space	NC	NC	C	NC
	Parking Space Sign	DI	NC	DI	NC
	Entrance Guidance	DI	DI	DI	C

Note: "Compliant (C)" if they met accessibility standards, "Non-compliant (NC)" if they did not, and "Data Insufficient (DI)" if measurements were not available.

non-compliance in door panels and opening method. Stairs face non-compliance in step depth, step height, terminal warning, step nose, and edge guard. Elevators exhibit compliance in call button height, call button size, braille call button, wheelchair turning space, elevator door, door closing time, and partial compliance in cabin size. Handrails showcase non-compliance in cabin handrail, ramp handrail height, urinal, toilet, toilet net space, urinal net space, space below washbasin, and door handle height. Parking lots exhibit non-compliance in single car parking space, parking space sign, and partial compliance in entrance guidance.

Among the assessed government institutions, Nanzi District Household Registration Office demonstrated the highest level of accessibility compliance, with 22 features meeting accessibility standards, followed by Metropolitan Park MRT Station (17 compliant features) and Kaohsiung Cultural Center (15 compliant features) with similar performance. Nanzi Train Station exhibited the lowest compliance, with only 5 features meeting accessibility standards.

While Nanzi District Household Registration Office showcased the most compliant features, gaps remain in areas like handrail assessment for cabin, ramp and urinal, as well as data availability for certain stair and bathroom features. Nanzi Train Station warrants particular attention due to its lowest compliance rate, with non-compliance identified in Indoor entry & exit passages, parking lots, and several other accessibility aspects.

3.2. Accessibility Facilities in Schools

The assessment of barrier-free environments in schools covered a range of facilities, with a particular emphasis on critical elements like classroom entry & exit path, classroom desk and chair, and podium, stairs, building corridor, elevators or handrails, toilets & bathrooms, access to playgrounds, cafeterias, auditoriums, and playgrounds, parking lots. The subsequent summary provides an overview of the outcomes for each school (Table 4).

I. Nanzih Senior High School

Nanzih Senior High School exhibits mixed accessibility compliance across various facilities. The classroom entry and exit path demonstrates compliance in indoor entrance and exit but non-compliance in dimensions of classroom desk, chair, and podium. Staircase compliance is observed in stair type, anti-slip strips, handrail, terminal warning, but non-compliance in step depth and height, and horizontal extension of handrails. The building corridor showcases compliance in width and accessible pathway. Elevator or handrail compliance includes elevator guidance, main entrance floor signs, wheelchair turning space, elevator call buttons, braille signs, and buttons, but non-compliance in cabin size, distance between control panel and elevator entrance wall, and distance and height between handrails and wall. Toilet and bathroom exhibit compliance in door, toilet net space, washbasin depth, side l-shaped handrail, and toilet height, but non-compliance in height of washbasin from floor, faucet, toilet and

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Table 4. Assessment of Barrier-Free Environments in Schools

		Nanzih Senior High School	Kaohsiung Municipal Special Education School	Renwu Special Education School	Shu-Te University
Classroom Entry & Exit Path	Indoor Entrance and Exit	C	C	DI	C
Classroom Desk and Chair, And Podium	Dimensions	NC	NC	DI	C
Stairs	Stair Type	C	C	C	C
	Step Depth and Height	C	C	NC	NC
	Anti-Slip Strips	C	C	C	C
	Handrail	C	C	C	C
	Horizontal Extension of Handrails	NC	C	C	NC
	Terminal Warning	C	NC	C	C
Building Corridor	Width	C	C	DI	C
	Accessible Pathway	C	DI	DI	DI
Elevator or Handrail	Elevator Guidance	C	C	C	DI
	Main Entrance Floor Signs	C	NC	NC	C
	Wheelchair Turning Space	C	DI	DI	C
	Elevator Call Buttons	C	NC	C	NC
	Cabin Size	NC	C	C	C
	Wheelchair User Control Panel	NC	C	C	C
	Distance Between Control Panel and Elevator Entrance Wall	C	C	C	C
	Buttons	C	C	C	C
	Braille Signs	C	C	C	C
	Distance and Height Between Handrails and Wall	NC	DI	C	C
	Closing Time	DI	DI	C	C
Toilets & Bathrooms	Door	C	C	C	C
	Toilet Net Space	C	DI	DI	C
	Height of Washbasin from Floor	NC	NC	C	C
	Faucet	C	C	C	C
	Washbasin Depth	C	DI	DI	C

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	Toilet and Bathroom Handrails	NC	DI	C	C
	Emergency Bell	NC	DI	DI	DI
	Toilet Net Space	C	NC	DI	DI
	Toilet Height	NC	NC	C	NC
	Flush Control	NC	DI	C	NC
	Side L-Shaped Handrail	C	DI	NC	C
	Retractable Handrail	NC	C	DI	DI
Access to Playgrounds, Cafeterias, Auditoriums & Playgrounds	Outdoor Path Net Width	C	DI	C	C
	Indoor Entrance and Exit	C	DI	DI	C
Parking Lots	Car Parking Space Length	NC	DI	NC	NC
	Parking Space Ground Markings	C	DI	C	C
	Motorcycle Parking Space Length	DI	DI	DI	C

Note: "Compliant (C)" if they met accessibility standards, "Non-compliant (NC)" if they did not, and "Data Insufficient (DI)" if measurements were not available.

bathroom handrails, emergency bell, flush control, and retractable handrail. Access to playground, cafeteria, auditorium, and playground demonstrates compliance in outdoor path net width and indoor entrance and exit. Parking lot compliance includes parking space ground markings but non-compliance in car parking space length and motorcycle parking space length.

II. Kaohsiung Municipal Special Education School

Kaohsiung Municipal Special Education School was comprehensively assessed for its barrier-free environments, covering various aspects within its facilities. The indoor entry and exit paths demonstrated compliance, ensuring accessibility for individuals with diverse mobility needs. However, challenges were identified in the dimensions of classroom desks, chairs, and podiums, highlighting the need for adjustments to meet accessibility standards. In terms of the staircase, the school adheres to compliance standards regarding stair type, step depth and height, anti-slip strips, handrails, and their horizontal extension. Nevertheless, a notable gap exists in providing terminal warnings on the staircase, which needs attention to enhance safety. The building corridor showcased compliance in terms of width, but data insufficiency was noted in assessing the accessible pathway. Elevators and related features exhibited a mix of compliance and non-compliance, emphasizing the importance of addressing issues related to floor signs, elevator call buttons, and wheelchair turning spaces. Toilet and bathroom facilities revealed a mixed picture, with compliance observed in certain aspects such as doors, faucets, and retractable handrails. However, data insufficiency hindered a comprehensive evaluation of dimensions, handrails, emergency bells, and other critical elements.

III. Renwu Special Education School

Renwu Special Education School demonstrates a commendable level of compliance in several crucial aspects of accessibility. The indoor entry and exit paths, along with the building corridors and elevator features, adhere to established standards. However, there are notable areas of concern that require attention and improvement. In terms of staircases, there is non-compliance in the dimensions,

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particularly in step depth and height. Addressing these issues is essential to ensure the safety and accessibility of staircases within the school premises. Additionally, specific outdoor areas, such as pathways and parking lots, need further consideration. While the school has made strides in certain aspects of outdoor access, there are still opportunities for improvement, particularly in achieving compliance with car parking space length and motorcycle parking space markings.

IV. Shu-Te University

Shu-Te University exhibits a generally satisfactory level of accessibility in various aspects, contributing to a welcoming environment for all individuals. The indoor entry and exit paths, classroom dimensions, and staircase type meet established standards. However, there are specific areas that warrant attention for enhancement. Notably, stair dimensions, including step depth and height, require adjustments to align with accessibility standards. Additionally, ensuring horizontal extension and anti-slip measures on handrails can further improve safety for individuals navigating staircases.

In terms of elevator facilities, there is a need to address the non-compliance in certain aspects, such as the main entrance floor signs, elevator call buttons, and wheelchair user control panel. The university excels in outdoor and indoor pathways but requires attention to car parking space length for enhanced accessibility in the parking lot.

Overall, Shu-Te University displayed the highest degree of accessibility compliance, boasting 27 features aligning with accessibility standards. Following closely were Nanzih Senior High School and Renwu Special Education School, both securing 24 and 22 compliant features, respectively. Kaohsiung Municipal Special Education School demonstrated moderate performance with 16 compliant features.

Notably, non-compliance was more prominent in Kaohsiung Municipal Special Education School, especially in comparison to Shu-Te University, which exhibited the lowest number of non-compliant features.

Table 3 outlines the evaluation of four government institutions - Kaohsiung Cultural Center, Nanzi Train Station, Metropolitan Park MRT Station, and Nanzi District Household Registration Office. It scrutinizes various facilities, including indoor entry and exit passages, indoor facilities, stairs, elevators, handrails, toilets, and parking lots. The Nanzi District Household Registration Office exhibits the highest compliance rate (68%), followed by the Metropolitan Park MRT Station (53%) and Kaohsiung Cultural Center (47%), while Nanzi Train Station demonstrates the lowest compliance at merely 16% of its facilities meeting regulatory standards.

Table 4 evaluates four schools - Nanzih Senior High School, Kaohsiung Municipal Special Education School, Renwu Special Education School, and Shu-Te University. Shu-Te University demonstrates the highest compliance rate (73%), followed by Nanzih Senior High School (66%) and Renwu Special Education School (61%), while Kaohsiung Municipal Special Education School exhibits the lowest compliance, with only 44% of its facilities adhering to regulations.

Collectively, the most prevalent non-compliance instances across both government institutions and schools involve stair dimensions, parking lots, and restroom facilities, indicating substantial room for improvement in these areas.

4. Discussion

This study evaluated the accessibility of government institutions and schools in Kaohsiung City, Taiwan, focusing on compliance with existing regulations and identifying areas for improvement.

The assessment of accessibility facilities in government institutions revealed varying levels of compliance. Kaohsiung Cultural Center demonstrated mixed compliance, while Nanzi Train Station faced significant challenges. Metropolitan Park MRT Station showcased a mixed level of accessibility, and Nanzi District Household Registration Office stood out with the highest compliance. The findings emphasize the need for targeted improvements, especially in areas where non-compliance was identified.

In schools, Nanzih Senior High School exhibited mixed compliance, particularly in classroom dimensions and parking lots. Kaohsiung Municipal Special Education School showed challenges in several aspects, underscoring the need for

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adjustments. Renwu Special Education School demonstrated commendable compliance, yet specific areas, such as stair dimensions, require attention. Shu-Te University presented a generally satisfactory level of accessibility, emphasizing the importance of addressing non-compliance in certain aspects.

Several common areas for improvement were identified across institutions. Stair dimensions, including step depth and height, emerged as a consistent challenge, emphasizing the critical need for adjustments to ensure safety and accessibility. In government institutions, Kaohsiung Cultural Center and Nanzi Train Station faced challenges in indoor and outdoor environments, indicating a need for comprehensive improvements. Schools, particularly Kaohsiung Municipal Special Education School, displayed gaps in specific facilities like classrooms and parking lots. Addressing these areas for improvement is essential to enhance overall accessibility.

Furthermore, the distinctive characteristics of each institution are delved into, exploring how their design objectives, construction periods, and geographical contexts influence their compliance with accessibility standards. **The Kaohsiung Cultural Center**, constructed in 1981, reflects architectural practices and norms of the 1980s, a period when modern accessibility standards were not fully integrated into building designs. Designed primarily as a cultural hub, it initially focused on providing multifunctional spaces, which may have led to insufficient attention to accessibility features during its construction. Situated in the city center on flat terrain, the location should have facilitated the implementation of accessible design features. However, the need for modernization is evident, with enhancements such as accessible ramps and extensive signage systems being crucial steps to improve accessibility. These upgrades are essential to align the facility with contemporary standards and ensure that it serves all visitors effectively, particularly in public areas such as entrances, seating sections, and restrooms. **Nanzi Train Station**, originally constructed in 1967, serves as a medium-sized urban transit hub featuring a mix of island and side platforms. As a transportation hub, it should have prioritized accessible design; however, its older infrastructure likely does not meet current standards. The design from the late 1960s may not have initially incorporated modern accessibility standards. Situated in a busy traffic area, the station may face spatial constraints that affect the perfection of accessible facilities. As a significant transit hub, the architectural style and function of the station necessitate ongoing adaptations to improve accessibility. Key focus areas for improvement include updating facilities to comply with modern accessibility standards, such as enhancing staircases, ramps, and elevator designs, as well as improving platform access, implementing effective signage, and integrating tactile pathways to enable more independent navigation for the visually impaired. **Metropolitan Park MRT Station**, built in 2008, was designed during a time when accessibility considerations were more integral to architectural planning. As a newly constructed subway station, it was intended to meet modern accessibility standards from the outset. Located near a park, the station has ample space to implement extensive accessibility features. As a relatively new structure, it likely incorporates current accessibility standards, ensuring that all entrances and platforms are easily accessible. However, maintaining these features and making minor improvements, such as adding sensory devices and visual aids, are important to continue meeting the needs of all users, especially those with disabilities. These ongoing updates help ensure that the station remains a fully accessible transit hub in an urban environment, with sufficient directional signage to aid navigation throughout the facility. **Nanzi District Household Registration Office**, established in 1988 within the administrative center of Nanzi District, operates on the first floor, shared with the social affairs unit. As a facility designed to provide governmental services, it is equipped with basic accessibility features necessary to serve a broad demographic, including individuals with disabilities. Given its age and the shared nature of its space, the office faces inherent challenges in optimizing accessibility features, particularly as it is likely housed in an older building that requires additional structural adjustments to enhance accessibility. Enhancing entryways, signage, and the overall layout is critical to better serve all visitors, especially those with mobility and visual impairments. Therefore,

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key improvements are focused on making the service counters and waiting areas more accessible and updating restroom facilities to meet high accessibility standards. The expansive, elongated geographical layout of its jurisdiction facilitate the necessary upgrades to accessibility infrastructures, ensuring continued service to all community members.

As for schools, **Nanzi Senior High School** saw its first construction phase completed in August 2003, with subsequent additions like administrative offices and a library completed by March 2006. Constructed in the early 2000s, the buildings likely included contemporary accessibility standards. Situated on a large campus, the school has ample space to implement and enhance accessible designs. However, to ensure that all sections of the campus meet current norms, a comprehensive renovation is crucial. This renovation should focus on enhancing accessibility in classrooms, the library, and sports facilities, ensuring that all areas of the campus are fully accessible. Continuous evaluation and upgrades are essential to meet evolving educational needs and to maintain compliance with current accessibility standards. Founded in 1982, the **Kaohsiung Municipal Special Education School** caters to students with moderate to severe intellectual disabilities. For a special education institution, surpassing standard accessibility requirements is crucial to effectively accommodate a diverse range of student needs. The focus is on specialized adaptations in classrooms, recreational areas, and therapeutic facilities to ensure they are fully accessible, fostering an inclusive educational environment. **Renwu Special Education School** relocated to its new campus in 2001, which was specifically designed to enhance its educational offerings and accessibility features. The campus's design incorporates advanced accessibility features tailored to the needs of students with severe disabilities, emphasizing the creation of safe, accessible, and engaging learning environments that support the educational advancement and well-being of all students. To further strengthen this environment, improvements focus on enhancing accessibility channels and classroom facilities, particularly entrances and restrooms. **Shu-Te University**, established in 1997 and renamed in 2000, is a relatively new addition to Taiwan's higher education landscape. Given its recent establishment, the university was likely designed with modern accessibility standards in mind. Ensuring that all facilities, including academic buildings, dormitories, and recreational areas, maintain high accessibility standards is essential to accommodate a diverse student body. This commitment helps in creating an inclusive atmosphere that supports the academic and social integration of all students.

Studies from China, India, and Southeast Asia report similar non-compliance issues with accessibility regulations, including non-compliant stair dimensions, parking lots, and restrooms. This finding underlines the need for stricter enforcement mechanisms and consistent design standards across regions(14, 20-24). Research by Rogulj and Jajac(22) and Scott and Bruno(21) emphasize the crucial role of user-centered design, involving individuals with diverse abilities, to create truly accessible environments. This aligns with the current study's call for involving users in accessibility assessments and design decisions. Yaroshenko et al.(25) and Gong and Takahashi(23) highlight the need for a comprehensive approach to accessibility, going beyond physical infrastructure to encompass systematized planning, information design, and inclusive services. This resonates with the current study's recommendation for collaboration between diverse stakeholders, including educational institutions, local authorities, and architectural professionals.

Stakeholder collaboration plays a vital role in enhancing Taiwan's barrier-free environment by promoting effective communication and cooperation among various parties(13, 26). This collaboration helps in addressing common constraints and mitigating risks associated with digital innovation and climate change adaptation(27, 28). In Taiwan, projects like the Climate Change Projection Information and Adaptation Knowledge Platform emphasize stakeholder engagement to improve local climate change data and hazard maps, demonstrating the importance of involving stakeholders in decision-making processes(15). Additionally, studies highlight the significance of stakeholder roles, such as government, businesses, and workers, in improving occupational health and safety efforts, underscoring the need for collaboration among stakeholders to

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enhance overall performance. Therefore, fostering stakeholder collaboration is essential for creating a barrier-free environment in Taiwan.

This study may be affected by several limitations, including the possibility of measurement errors, a restricted number of visited schools and institutions, incomplete data due to some unattained measurements, and time constraints during on-site visits. These constraints may impact the accuracy, generalizability, and comprehensiveness of the findings. Acknowledging these limitations is crucial for a nuanced understanding of the study's outcomes and highlights the need for improvements in future research efforts.

The study emphasizes the ongoing necessity for enhancing accessibility within government institutions and schools, with the Nanzi District Household Registration Office serving as a positive exemplar, showcasing the efficacy of comprehensive policies. Targeted interventions, particularly addressing areas like stair dimensions and parking lots, should be a focal point for policymakers. Collaborative efforts involving educational institutions, local authorities, and architectural professionals are paramount for the successful implementation of effective policies and practices. Strengthening the enforcement of accessibility regulations is imperative, as evident gaps underscore the need for stricter oversight by relevant authorities. Additionally, promoting awareness and providing training for architects, builders, and facility managers is crucial to ensure consistent compliance with accessibility standards. Adequate financial investment and prioritization from both government and private stakeholders are necessary for retrofitting existing facilities and integrating accessibility considerations into new construction projects. Emphasizing user-centered design practices, involving individuals with diverse abilities, remains pivotal in creating genuinely inclusive and accessible environments. While schools demonstrate relatively higher rates of accessibility infrastructure, driven by increased demand and utilization, both institutions and schools must prioritize meeting regulatory standards comprehensively. Our findings highlight several areas where the application of user-centered design could enhance the effectiveness of accessibility features. For instance, while many facilities met technical compliance standards, they fell short in addressing the practical needs of users, such as easy navigation or comfort. This gap underscores the importance of incorporating user-centered design principles in the planning and retrofitting of public spaces to ensure they meet the nuanced needs of all users, particularly those with disabilities. The findings of this research have implications for policy formulation and practical actions aimed at fostering inclusivity and equal opportunities for all individuals in society.

5. Conclusion

In summary, despite the **Nanzi District Household Registration Office** having been constructed in 1988 and thus being relatively aged, its location on the first floor, coupled with the elongated and expansive geographical layout of its jurisdictional area, provides favorable conditions for the necessary upgrades to its accessibility facilities. **Kaohsiung Cultural Center and Nanzi Train Station** among other older buildings, exhibit deficiencies in accessibility design and require improvement projects to meet modern accessibility standards. Examples include the addition of accessible ramps, updating signage systems, and optimizing service counters and waiting areas. Newly constructed buildings such as the **Metropolitan Park MRT Station** and **Nanzi Senior High School** have incorporated accessibility considerations during the design phase. However, continuous evaluation and upgrades are necessary to ensure that all areas are accessible and meet the needs of different users. Schools like **Kaohsiung Municipal Special Education School** and **Renwu Special Education School** cater specifically to students with disabilities, necessitating standards beyond general accessibility. Specialized renovations in classrooms, recreational areas, and therapeutic facilities are required to create safe, accessible, and educationally meaningful environments. **Shu-Te University**, established in recent years as a higher education institution, should have been designed with modern accessibility standards in mind. Moving forward, it is imperative to ensure that all areas of the campus, including academic buildings, dormitories, and recreational areas, maintain high-quality accessibility

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facilities to create an inclusive learning environment for students from diverse backgrounds.

While existing research often focuses on general public spaces, this study specifically looks at accessibility in critical institutions like schools and government offices, shedding light on specific challenges and priorities in these settings. The study employs robust methods of data collection and analysis to pinpoint areas in need of improvement, providing tangible evidence for policymakers and stakeholders to prioritize necessary interventions. Moving beyond mere problem identification, the study outlines actionable recommendations encompassing improved enforcement, awareness training, accessibility upgrades, and practices centered around user-centric design.

The current study on Kaohsiung's accessibility landscape contributes significantly to the global conversation on creating inclusive environments. By drawing parallels with existing research and offering data-driven insights, it lays the groundwork for targeted interventions and collaborative efforts towards a more accessible and equitable future for Kaohsiung and beyond. The emphasis on user-centered design, comprehensive strategies, and collaboration remains key to overcoming the challenges and realizing the full potential of inclusive communities.

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