A Study of Ergonomic Design of the Environment for the Disabled with Wheelchair

wheelchair를 사용하는 장애인에 대한 인간공학적인 환경 설계에 관한 연구

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ABSTRACT

국제연합은 1975년에 "장애인 권리선언"을 결의하였고, 1981년을 "세계 장애인의 해"로 결정하였다. 우리 나라에서도 1981년 6월 5일, 법률 제 3452호 "심신장애자 복지법"을 제정, 공포하였고 1989년 12월 30일 "장애인 복지법"으로 개정하였다. 한편, 미국에서는 1990년 7월 26일 George Bush 전 대통령이 "The American with Disabilities Act of 1990(ADA)"에 서명하였다. 이 법은 인종, 성별, 출신지, 그리고 종교에 관계없이 장애자에게도 같은 시민 권리 보호를 제공한다는 것이다. 그럼에도 불구하고 장애인을 위해 설계된 건물이나 시설물들이 그렇게 많지 않다는데 그 문제점이 있다. 따라서 본 연구의 목적은 신체 장애인에게 "동등한 생활의 질"을 제공하자는 데 있다. 그에 따른 목표로써 신체장애에 대한 구분이 이루어 졌고, 이동 수단으로서의 wheelchair에 대해 조사되었고, ADA accessibility guidelines가 분석되었다. 또한 인간공학과 감성공학으로 재활공학에 접근하였으며 가상현실이 이용되는 현 추세도 연구되었다. 결론적으로, 제시된 guidelines를 이용하여 가상현실의 세계에서 충분히 simulation을 마친 후에 장애인을 위한 좀더 과학적이고 합리적인 건물 또는 시설물 그리고 wheelchair를 제작할 수 있으면 한다.

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1. Introduction

1.1 Statement of purpose

The United Nations has resolved "The Right Declaration for Disabled Person" in 1975 and decided year of 1981 as "Year of World Disabled Person". We has established and promulgated "The welfare laws for mentally and physically handicapped person"(laws of 3452" on June 5, 1981, and revised as "The welfare laws for the handicapped person" on Dec. 30, 1989. On the other hand, the former President George Bush has signed "The Americans with Disabilities Act of 1990(ADA)" in the United States on July 26, 1990. This laws were to offer equal citizen right protection to the handicapped person without discrimination of race, sex, nationality and religion. Nevertheless, the handicapped person did not get equal treatment with mentally and physically normal person in our society. The slogan of "Equal Opportunity" was not set yet due to prejudice of handicapped and lack of special facilities for them.

1.2 Description of problem

There are few places, facilities, and wheelchairs to be designed for disabled person.

1.3 Scope of the study

The purpose of this study was to offer "Equal Quality of life" under the slogan to the mentally and physically handicapped person. The objectives of this study was to classify the mentally and physically handicapped person, to analyze factors of design, and propose suggestion under approach of rehabilitation engineering and human sensibility ergonomics. The limitation of this study was to fix to wheelchair users.

2. Classification of the mentally and physically handicapped person

The numbers of disabled person in our country are 1,053,000 (The Ministry of Health and Welfare, 1995) and the numbers are increasing in every years. The causes are due to occurrence of old disabled person, traffic accidents, and industrial injuries.

Disability and impairment are two terms that are being used interchangeably and mistakenly. A impaired individual may not necessarily be disabled. Disability is a limitation in performance. It is determined based on ability/inability to perform

partial or total. Disability can be described in terms of residual functional capacity activities of daily living (occupational and/or non-occupational). Disability could be in relation to task demands and can be determined through the use of a variety of assessment instruments (medical, vocational, physical, psychological, and others).

Impairment describes anatomic or functional abnormality or loss: natural or induced reduction in one or more of a organ's function. At the present time, the American Association Guidelines remain one of the most useful instruments to rate impairment for medico-legal purposes. Other Impairment rating systems have been adopted by some states. An impaired individual does not necessarily have to be disabled. The former applies to human body characteristics, while the latter relates to performance of a job function or demands of daily living.

ADA-90 defines disability has a physical or mental impairment that substantially limits one or more of the person's major "life activities," such as ambulation, communication, education, employment, housing, self-care, socialization, transportation, and vocational training. Also, the disability has a record of such impairment, or is received as having such an impairment. The terms "physical or mental impairment" would included, but not be limited to, theses conditions: diseases and infections, orthopedic, visual, speech, and hearing impairments, cerebral palsy, epilepsy, muscular dystrophy, multiple sclerosis, HIV, cancer, heart diseases, diabetes, mental retardation, emotional illness, drug addiction and alcoholism.

The United Nations classifies the disabled person as four terms.

(1) The disabled person has anatomical, bodily structural, intellectual, psychological abnormality or loss.
(2) The functional disability does not exhibit necessary function completely by oneself in daily living due to chronic illness.
(3) Those who have disability have some reaction for oneself disability.
(4) WHO classifies disability as three terms.
   ① Impairment : In case of loss of partial psychological, physical or anatomical structure and function.
   ② disability : Due to the result of impairment.
   ③ handicap : In case of having limitation or difficulty on performance of one's role due to the result of impairment or disability.

3. Wheelchair

3.1 Power wheelchair

Most power wheelchair have maneuverability by joystick control. Some power wheelchair have programmable joystick controller. The power wheelchairs are compact for indoor and outdoor use, but they have dual motors for power. The padded armrests are equipped and the armrest length is adjustable. Also seat height, backrest angle, footrest and headrests are adjustable. Speed ranges are also variable. Low center gravity design provides a very smooth and stable ride.

3.2 Manual wheelchair

Most manual wheelchair have light weight for ease to hold. Other functions are same with power wheelchair, one specific merit is to adjust seat width.

3.3 Scooter

To determine right scooter, followings should be considered first. If the primary use of scooter is indoor, the width of the doors, especially bathroom doors, should be considered. In case of using it outside, a rear wheel drive scooter is recommended for added power. The width of the seat and length of the scooter should be determined. On transporting the scooter, physical ability to lift 40 to 50 lbs. should have. If yes, some scooters can be easily dissembled and will fit in vehicle trunk. If no, different styles of scooters should be used to fit car.

3.4 Pediatric wheelchair

The pediatric wheelchair was designed for disabled children. It is designed as a wheelchair but with few options can look more like a stroller. A wide variety of seating and positioning options are easily adaptable.

3.5 Recreation

The disabled person have the right to enjoy outdoor recreation. For the outdoor activities like cycling, golfing, bowling, fishing tanning, and etc., various wheelchairs and aid equipment has been developing.

4. Dimensions

It is important to know the basic dimensional tolerances for compliance with the ADA. The ADA Accessibility Guidelines Standards for Accessible Design give complete information for applying these basics, as well as scoping requirements for new construction.

4.1 Wheelchair space allowances and reach ranges

The minimum dimensions for new construction are shown [Table 1].

4.2 ADA Accessibility guidelines for specific elements

(1) Sidewalks(path of travel)

The sidewalks require 36″ minimum clear width, with passing space of 60″ × 60″ provided every 200′. The clear head room is 80″ minimum. There is no changes in level greater than 1/4 without beveling.

(2) Protruding objects

[Table 1] Minimum Dimensions

item	dimension
clear width	36″
turning diameter	60″
clear floor space	30″×48″
mounting height	15″ to 48″
clear head room	80″ high
clear knee space	27″
table and counter tops	28″ to 34″
clear openings	32″ wide
access aisle(8′ + 8′ for van)	8′ wide parking with 5′ wide
centerline of signage	60″
for handrails	34″ - 38″
mount all grab bars and handrails	33″ - 36″
all controls, door handles, etc.	closed fist
accessible parking minimum slope	1:50
path of travel maximum slope	1:20
ramps, curb cuts maximum slope	1:12
beveling at thresholds, level changes maximum slope	1:2

The protruding objects are 4″ maximum for objects projecting from walls with their leading edge between 27″ and 80″.

(3) Head room

The head room requires 80″ minimum for walks and other circulation spaces.

(4) Carpet

The carpet should have 1/2″ maximum pile thickness.

(5) Gratings

The gratings should have 1/2″ maximum wide spaces in one direction.

(6) Parking spaces

The parking spaces are required 96″ minimum wide with 60″ minimum wide access aisle for accessible spaces. Surfaces slope should not exceed 1:50. The spaces require 96″ wide space with 96″ wide access aisle for vans(minimum of one required). It also should have 114″ vertical clearance. It should be complied signage mounted so as not to be obscured by a vehicle parked in the space(no dimension stated, it is suggested no less than 72″ high).

(7) Curb ramps

The curb ramps should have 1:12 maximum slope. The maximum slope for adjacent surfaces is 1:20. The maximum slope for flared sides is 1:10. The curb ramps should have 36″ minimum width.

(8) Ramps

The ramps should have 1:12 maximum slope. It is required 30″ maximum rise for any run and 36″ minimum clear width. The level landing at top and bottom should be wide at least as the ramp and 60″ clear length. (60″ × 60″ if ramp changes direction) The maximum slope for cross slopes should be 1:50.

(9) Handrails

The ramps with a rise greater 6″ or a horizontal projection greater than 72″ must have handrails on both sides. It should have 12″ extension parallel to ground top and bottom. It also should have 1-1/4″ - 1-1/2″ diameter of gripping surface. The clear space between rail and wall should be 1-1/2″. Top of gripping surfaces mounted is recommended 34″ - 38″ above ramp surface. Ends of rails is required to be rounded or returned smoothly to floor, wall, or post.

(10) Stairs

The stairs should have 11″ minimum wide treads, uniform riser heights and tread widths. It should have 1-1/2″ maximum nosing projection, undersides to be sloped with a minimum angle of 60^0 from the horizontal. The stairs should be complied handrails both sides. It should have 12″ horizontal projection of handrail

at top; handrail to continue to slope width of one tread plus have 12″ horizontal extension at bottom.

(11) Elevators

The elevator should have hall call buttons - 42″ to centerline and hall lantern fixtures - 72″ minimum to centerline. The elevator is required door reopening devices - 5″ and 29″. Car control floor buttons should be 54″ maximum (side approach) and 48″ maximum (front approach). Car emergency controls should be 3 35″ minimum to centerline. Emergency communication system is required 48″ maximum to highest operable part. Hoistway entrances are floor designations both jambs, 60″ to centerline of 2″ high characters. Car size is 54″ deep by 80″ wide minimum (68″ wide alternate). Illumination levels should be no less than 5 footcandles.

(12) Door

The door should have 32″ minimum clear width. It must have 48″ plus width of door swing into space clear width for two doors in a series. It is required 1/2″ maximum threshold height. It is required 48″ maximum height for door handles, pulls, latches, locks, and other operating devices - operable with closed fist. It is required 3 seconds minimum sweep(closing) period. The maximum opening force is required 5lbs for interior hinged, sliding, or folding doors. Fire doors to have minimum opening force allowed by appropriate authority. Automatic and power-assisted doors are complied with ANSI/BHMA A156.10-1985.

(13) Drinking fountains

The maximum to the spout outlet is 36″. The flow of water should be 4″ minimum high. The clear knee space is required 27″ minimum between the bottom of the apron and the floor, 30″ minimum wide, 17″ to 19″ deep. The clear floor space is 30″ wide×48″ deep for forward approach. It should controlled at front and operated with closed fist.

(14) Water closets(toilets)

The clear floor space is varied but 17″ - 19″ high to top of toilet seat is recommended. The grab bars required 36″ rear grab bar and 42″ side grab bar. The flush controls should be maximum 44″ and mounted on the wide side of toilet areas.

(15) Toilet stalls

Standard stall is 60″ wide and 56″ - 92″ deep. Toilet stall doors is complied with door requirements, with handles both inside and outside, mounted 48″ maximum.

(16) Urinals

The urinals are recommended 17″ maximum to rim. It should be 30″ wide×48″ deep clear floor space for forward approach. Flush controls is recommended 44″ maximum.

(17) Lavatories(sinks)

The sink should be 34″ maximum to rim or counter surface. It should have 29″ minimum clear knee space to bottom of apron. It is required 27″ minimum clear to bottom of sink bowl. The clear space should be 30″ wide by 19″ deep underneath sinks. It should have 6-1/2″ maximum sink bowl depth. The clear floor space should be 30″ wide by 48″ deep for forward approach. The faucets should be operated with closed fist.

(18) Mirrors

The bottom edge of reflecting surface should be 40″ maximum.

(19) Restroom dispensers

The maximum height of restroom dispensers should have 48″ maximum height.

(20) Fixed storage(cabinets, shelves, closets, drawers, etc.)

The clear floor space should be 30″ × 48″ for forward or parallel approach. The reach ranges should be applied to accessible storage spaces. The clothes rods or shelves should be 54″ maximum for side approach, 48″ maximum for forward approach.

(21) Controls and operating mechanisms

The clear floor space should be 30″×48″ for wheel chair approach. It is required 48″ - 54″ maximum height to highest operable part for forward or parallel approach (48″ maximum is recommended). It is also required 15″ minimum for electrical and communications system receptacles on walls. All controls and mechanisms to be operable with one hand and not require tight grasping, pinching, or twisting of the wrist, with maximum force of 5 lbs for activation. (The "closed fist" test for handles and controls: If you can operate the mechanism with one hand, held in a fist, so can a person with limited use of the hands.)

(22) Alarms

Visual signal devices are required in restrooms and general usage areas such as meeting rooms, hallways, lobbies, and any other area for common use. It is required 80″ above the highest floor level within the space or 6″ below the ceiling, whichever is lower. The place should not be in any room or space more than 50′ from visual signal.

(23) Signage

The signage should be width-to-height between 3:5 and 1:1; stroke-width-to-height ratio between 1:5 and 1:10. The character height should be 3″ minimum for signage mounted overhead. The letters and numerals should be raised 1/32″, upper case, and 5/8″ to 2″ in height. Pictogram field should be at least 6″ high. The characters and symbols should be contrasted with background(70% typical). The sign should be installed on wall adjacent to the latch side of door at 60″ to the centerline of the sign (exit signs can be mounted directly on out-swinging doors). The accessible elements should be identified with the international symbols of accessibility.

(24) Telephones

The telephones should have 30″×48″ clear floor space for wheelchair approach. The highest operable part should be within reach ranges (48″ is safe). It is required 29″ minimum cord length. The telephone books should be also within reach range.

(25) Fixed or built-in seating and tables

The knee space should be 27″ high, 30″ wide, and 19″ deep for wheelchairs. Tops of accessible tables and counters should be 28″ to 34″.

(26) Automated teller machines

It is required to be provided for parallel approach and both forward and side reach. Instructions and all information for use should be accessible and independently usable by persons with vision impairments.

(27) Dressing and fitting rooms

It should have 60″ diameter clear floor space and 32″ wide clear opening. It should have 24″×48″ bench fixed to the wall along the longer dimension, mounted 17″ to 19″. Full length mirrors, 18″ wide by 54″ high, should mounted to afford a view from the bench.

(28) Restaurants and cafeterias

The fixed table, 5% but not less than one, should be accessible. Counters and bars should have an accessible area, 60″ long. The clear aisle should be 36″ wide to be provided to accessible seating. The food service lines should be 36″ minimum wide, 42″ preferred; tray slides should be mounted maximum 34″. The tableware and condiment area should be within reach ranges. The vending machines and other equipment should have operable parts within reach ranges.

5. Rehabilitation Engineering and Human Sensibility

Ergonomics

Recently, living level has been improving with economic development, information society has come, and our society has been becoming welfare society. Our nations require to develop medical welfare equipment technology using high-tech as the concept of health is changing to qualitatively and quantitatively. The electronic engineering has been developing rapidly and it made medical electronics and bio-engineering to be active. It influences on improvement of medical equipment function, reliability, and medical technology spreading. It made rehabilitation engineering to be developed practical technology for electronic equipment for aids of disabled person. The ergonomics engineering has been performing for walking, which is fundamental field of the rehabilitation engineering. The rehabilitation engineering has been devoting to robot development, sports, equipment, electricity and electronic fields.

The three principles of welfare equipment design are followings:

(1) Fool proof
(2) Fail safe
(3) Long life

The classification of the welfare equipment is followings:

(1) For convenience for disabled person.
(2) For curing and training for disabled person.
(3) For substituting losing functions.
(4) For developing ability for disabled person.

The rehabilitation engineering is adopting human sensibility ergonomics. The human sensibility ergonomics is engineering technology which realizes human's sensibility as design factors. The human sensibility ergonomics is technology which connects sensibility and engineering, analyzes human sensibility, and uses product design for customer satisfaction. Because the hypermedia, which computers and various media are combined, has been appeared in the medical field, the virtual reality is needed. The virtual reality is used in various fields.

The virtual reality can be used for construction for the disabled person. On discussing point of contraction of design of construction and technology of the virtual reality, the possibilities of the virtual reality technology application are followings:

(1) To use the virtual reality for the design of desirable construction space.
(2) To use the virtual reality for rationality of construction manufacturing systems,

improvement of productivity, and safety of operation.

As designer of construction, the possibilities of the virtual reality application are followings:

(1) To make virtual construction space in the virtual realty, to study interaction of man-environment and human action in the virtual reality, and to feed forward knowledge which acquires in the virtual realty into creation of real construction space.

(2) To unity real construction space and virtual reality space, to make comfort living space, and to improve environment which human can not adapt.

Referring to design with virtual reality, the construction is useful in cost cutting. The scientists in the North Carolina State University evaluated new churches, computer science buildings and new campus with the virtual reality, and developed mover with handles. The operator with HMD feels moving without forwarding. The operator will experience walking in the 3-D space.

The power wheelchair is being investigated by KAIST. The research is to design and make rehabilitation engineering system, and to make possibility for disabled person of moving with robot arms. The robot arms perform through image disposition. The algorithm, which recognize objects with intelligent method is being developed. The intelligent method is to be input color image which various color mark is on specific object. Also, the virtual environment has been setup to realize simulation system which operates and trains system in the virtual reality, and system modelling is being performed.

6. Conclusion and Future Study

The numbers of disabled person in our country are 1,053,000(The Ministry of Health and Welfare, 1995) and the numbers are increasing in every year. The causes are due to occurrence of old disabled person, traffic accidents, and industrial injuries. There are not many places, facilities, and wheelchairs to be designed for the disabled person. WHO classifies disability as three terms: impairment, disability, and handicap. The maneuvering aids are power wheelchair, manual wheelchair, and scooter. The ADA suggests various accessibility guidelines for specific elements. Those are useful for wheelchair users, however, the guidelines are for American disabled person, not for us. The anthropometric dimensions for our disabled person and our guidelines should be developed.

The principles of welfare equipment design are fool proof, fail safe, and long life.

The classifications of welfare equipment are for convenience, curing and training, substituting, and developing ability for the disabled person.

The human factors engineering, human sensibility ergonomics, medical engineering are used to rehabilitation engineering. The virtual reality is useful for simulation and design new construction for the disabled person. The construction of the virtual reality is needed for the future study in considering of new building, facilities and wheelchair for the disabled person.

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