Master's thesis

NTNU
Norwegian University of Science and Technology
Faculty of Engineering
Department of Civil and Environmental Engineering

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Accessibility barriers and sustainable solutions: Case Elgeseter street

Master's thesis in Project Management
Supervisor: Alenka Temeljotov-Salaj
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Abstract

Purpose: This thesis aims to identify the accessibility barriers and provide a sustainable solution in the built environment for all users while keeping the heritage value of the buildings. The study focuses on the accessibility barriers of Trondheim's Elgeseter street, which was built in the early twentieth century. The area's accessibility, including the main street and the old buildings beside the street, is unpleasant for all users, especially those with mobility limitations. The thesis covers the main Elgeseter street, including pedestrian lanes, bike lanes, intersections, and the internal and external environment of one residential building. Also, the parking spaces in the neighborhood are included.

Design/methodology/approach: The thesis was conducted using qualitative and quantitative methods to achieve the study objectives, including site observation, semi-structured interviews, an online survey, and document analysis (archival records). The methods used to identify the accessibility barriers in Elgeseter street and develop user-friendly solutions by engaging all users while keeping the heritage value of the buildings. In addition, a literature study was carried out to achieve the aim of the study in the autumn of 2021 for the specialization project, the preparation course for the master's thesis. The scientific papers were chosen using Google Scholar, Science Direct, Web of Science, and Emerald, published only in English.

Findings: The results shows that the current accessibility of Elgeseter street is riddled with barriers that make it difficult for everyone to use. The main reason is the less attention on the area and different viewpoints of the decision-makers on the development of the street, including the old buildings. Regarding sustainability, the future development of the main street and the old buildings should consider everyone. The thesis includes sustainable solutions for the current accessibility barriers while keeping the heritage value of the old buildings.

Limitations: Future development should involve all stakeholders to make the street pleasant for everyone. However, in this thesis, only the public is included.

Practical implications: This thesis demonstrates the accessibility barriers for all users in the built environment, and they are sustainable solutions while keeping the building's heritage value.

Key words: Accessibility, Sustainability, Built environment, Universal design, Elgeseter area.

Acknowledgements

Writing this thesis has been very challenging, but also it was amazing because I received countless support from people. I would first like to thank my supervisor Alenka Temeljotov-Salaj (Prof.), for her exceptional support in writing this thesis by offering practical feedback and guidance on my work. I would also like to thank the Trøndelag fylkeskommune representatives and the Trondheim municipality archive workers for their help during my study. Finally, my parents deserve special thanks for their continued support and inspiration throughout my life. Thank you!

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1 Introduction

Accessibility is one key element in achieving the United Nations sustainable development goal 11 (Sustainable Cities and Communities), attributed to the environmental pillar. Firstly, "access to safe, affordable, accessible, and sustainable transport systems" should be provided. Furthermore, the public transport organization should respect the needs of those in vulnerable situations, including people with disabilities. Secondly, it is necessary to provide "universal access to safe, inclusive, and accessible green and public spaces, particularly for women and children, older people, and people with disabilities [UN (2015b)]." Around the world, many people are disabled due to wars, natural disasters, poverty, epidemics, traffic accidents, and prenatal and postnatal disabilities [Yılmaz (2018)]. According to a 2011 estimation by WHO, more than one billion people live with different types of disabilities worldwide [WHO (2011)]. According, to the Norwegian Disability Administration Directorate, In Norway, people with disabilities account for 15 – 20% of the total population.

According to the United Nations estimation, by 2050, two-thirds of the world's population will expect to live in cities. The United Nations sustainable development goal 11 states that up to 2020, substantially the number of cities and human settlements will increase [UN (2015b)]. Both estimations show that urbanism is growing dynamically. The development of human mobility in the built environment needs modification of the existing environment because most of the built environment areas are not suitable for everyone [Frattari et al. (2013)]. Nowadays, accessibility has gained popularity because citizens believe they should have unrestricted access to all public and private infrastructures [Soltani et al. (2012)].

Worldwide old public and private infrastructures account for a large portion of the world's infrastructure [Kristl et al. (2019)]. Inbuilt environment development's key elements are the existing environment's economic, social, and environmental values [Franzoni et al. (2018)]. Protecting the architectural significance of buildings and infrastructures should be done sustainably. The accessibility of the built environment, including the streets, crossings, and internal and external environments of buildings, is difficult to access by all users due to the limitations of different design standards. Everyone has the right to access and use urban spaces independently and equally. To participate in social life, everyone must first access and use urban spaces. Inaccessibility to the built environment is one of the major obstacles to full participation in society for people with disabilities [Vonica and Brumaru (2012)]. Therefore, the issue of easy access to public infrastructure and buildings has become an essential aspect of our daily lives.

1.1 Elgeseter area

Elgeseter area is part of Trondheim, located just south of the city center (Midtbyen), and stretches from Elgeseter bridge to Lerkendal stadium between Nidarø and Gløshaugen. The street was named in 1886 after the Elgeseter farm. Elgeseter gate is one of the four main streets in Trondheim; the others are Innherredsveien, Olav Tryggvason's gate, and Kongens gate [miljopakken (2021)]. The road is part of the main access road to Trondheim from the south, via the E6. The Elgeseter area has mainly residential buildings. According to the information from the municipal archive, most of the buildings in the street are residential buildings; there are also a few cafes, restaurants, offices, and school buildings. There are also buildings that are out of function and registered to be demolished for the future development of the street [Archive (2022)].

Elgeseter gate was built in the 20th century; for the last 25 years, and the area was under different discussions and decisions for development. One of the discussion areas is the mobility and accessibility of the area, especially for pedestrians and cyclists. The area is with old buildings, and the main Elgeseter street does not meet modern standards. Currently, the accessibility of the area is challenging for both pedestrians and cyclists, especially for disabled users. Figure[1], shows the map of the Elgeseter area. Specifically, the red line on the map shows the main Elgeseter street, which covers from the lerkendal bridge to Elgeseter bridge, which is the focus of this study.

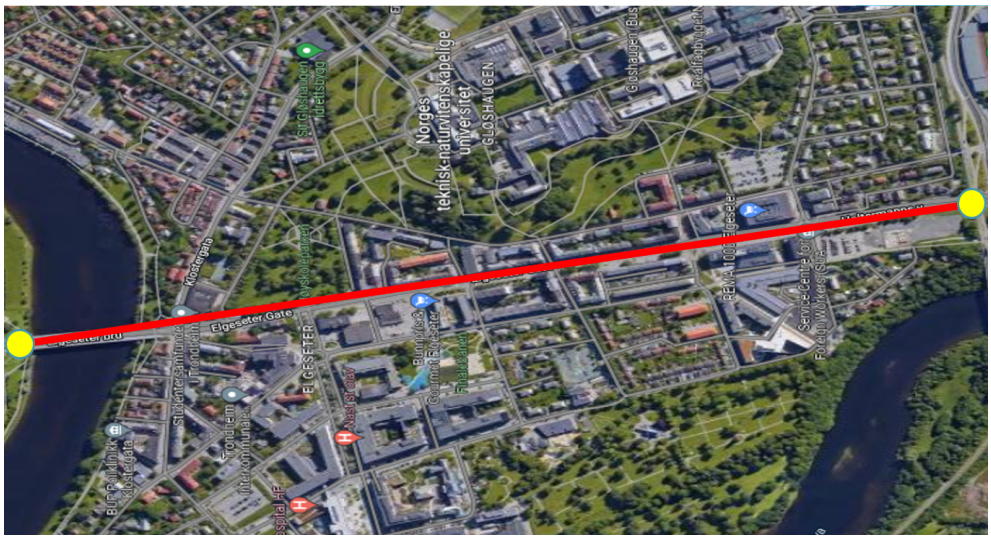

Figure 1: Elgeseter street [Source: Google map]

1.2 Research objective

The concept of accessibility is becoming very dominant in today's world because people need to participate equally in daily life. Also, accessibility is one of the United Nations goals expected to be achieved by 2030. However, the existing built environment does not fulfill the modern standards and is challenging to satisfy all users. To achieve this goal needs the modification and development of the built environment by considering all users.

This thesis aims to provide a sustainable solution for accessibility barriers in the built environment for all users while keeping the heritage value of the buildings. The study focuses on the accessibility barriers of Trondheim's Elgeseter street from the early twentieth century. The streets current accessibility is unpleasant for all users. The study covers the internal and external environment of one residential building located on the main street. It also includes the pedestrian lanes, intersections, bike lanes, parking spaces, and the route from the parking space to the buildings.

To find the accessibility barriers of the Elgeseter street and to suggest future solutions in consideration of all users while keeping the heritage value of the buildings, this thesis will answer the following questions:

Main research question:

How to transform the accessibility of Elgeseter street in a sustainable way for all users while keeping the heritage value of the buildings?

The following sub-research questions will cover in detail to answer the main research question:

Sub-Research questions:

- What are the accessibility barriers in the Elgeseter street?
- How is the closeness of the buildings affect the accessibility?
- What are the solutions to the accessibility barriers for all users?

1.3 Scope and limitation of the study

1.3.1 Scope of the study

This thesis covers the accessibility barriers in Elgeseter street, which stretches from Lerkendal bridge to Elgeseter bridge. The thesis includes the intersections (studentsamfundet and Hestaghen), pedestrian lanes, and bike lanes of the main street. Also, the buildings' internal and external environment consists of the entrances, entrance hallways, and interior stairs. In addition, the parking spaces, and the route from the parking spaces to the buildings are evaluated.

The following limitations apply to this thesis: The articles reviewed are only in English and were chosen from well-known and easily accessible scientific journals. The literature review and the thesis survey were conducted in Autumn 2021 for the specialization project, which is the preparation of the master's thesis. Moreover, the time duration for the publication of the articles was limited to the period 2000–2021. Furthermore, in the spring semester of 2022, document analysis and structured interviews were conducted.

1.3.2 Limitation of the study

According to the meeting with the transport director of Trøndelag fylkeskommune, one of the reasons for the delay in the area's development is the different interests of the decision-makers or politicians. The politicians have different viewpoints on the old buildings and other elements in the street. In this study,the view of the politicians is not included, due to the time limitation. The duration time for the master thesis was only four months, and it was not enough to meet the political parties and know their perceptions of the area. The accessibility barriers are evaluated in details, and their solutions also suggested for future development while keeping the heritage value of the buildings. For example, in order to increase the size of the street, creating a hallway through the buildings is suggested as one solution in this thesis. But the politicians or decision-makers are not included in the solution suggestion; only residents of the Trondheim participate in the study for the solution. In addition to the political parties' perception, the economic analysis of the suggested solutions is not assessed. The solutions for different accessibility barriers suggested in this thesis are from the social and environmental perspectives.

In Norway, some people are not involved in choosing solutions and making decisions on public projects. Also, they are called silent voice people, for example, disabled users, children under 18 age, people who have difficulties speaking the Norwegian language, or migrants. The results of the study are all from the case study area. Currently, the area is not attractive for disabled users due to several accessibility obstacles. Due to this reason, meeting people with different impairments was challenging in the study area. Also, the age of all the survey respondents was above 20, which is not inclusive for people under 20.

Structure of the thesis

The thesis is structured into five sections as follows to answer the question and achieve the study's goal: The first is a comprehensive introduction to the study and a description of the case. The theoretical background of the study follows this. Then, I will present details of the methodological choices I made in this study. Next, in the result section, I will present all the study findings. In the last section, I present the discussion of the findings and conclusion of the thesis. Also, in the last section, the thesis includes further future works that are not covered in this thesis.

2 Theoretical background

This section will outline the collection of theories from the literature study. The literature review is from autumn 2021 for the specialization project, the preparation course for the master's thesis. First, the definition of disability according to different worldwide organizations and types of disabilities is explained. Secondly, the concept of accessibility and principles of universal design are discussed in detail. Thirdly the built environment and the barriers in the built environment will be described, including the internal and external environments of the built environment. Finally, sustainability will explain briefly based on the United Nations Sustainable Development Goals by considering the three elements (environment, the economy, and society).

2.1 Disability

Definition of disability

According to the United Nations Convention on the Rights of Persons with Disabilities, the definition of disability is "a difficulty in functioning at the body, person, or societal levels, in one or more life domains, as experienced by an individual with a health condition in interaction with contextual factors" [Leonardi et al. (2006)]. According to the United Nations Declaration on the Rights of the Disabled, which was adopted on December 9, 1975, by the United Nations (UN) General Assembly, in essence, the Declaration on the Rights of Persons with Disabilities states that all people with disabilities have the same rights as everyone else. The term "disabled person" refers to anyone unable to meet "the needs of a normal individual and social life due to a deficiency... in physical or mental capabilities" [UN (2015b)]. In 2011, the World Health Organization (WHO) estimated that more than one billion people worldwide suffered from disabilities [Kristl et al. (2019)]. [Gürsoy et al. (2017)] defines, disability causes as "wars, natural disasters, poverty, epidemics, traffic accidents, and prenatal and postnatal."

According to [Sendi and Kerbler-Kefo (2009)], the focus on disability has become an important political issue, specifically guaranteeing universal human rights. In Europe, 15 to 25% of the active population is estimated to as functionally impaired at various levels of impairment. Worldwide, the document, adopted by the general assembly in 2006, is the first officially binding document of the United Nations on disability. The main aim is to ensure the fulfillment of human rights and the principle of equal opportunities for all people. This law also helps to prevent discrimination against disabled people.

Furthermore, the importance of accessibility to the physical, social, and economic environment in conjunction with the rights of the disabled and fundamental freedoms as recognized in the convention. The Amsterdam Treaty is the most important document regarding the disabled at the European Union level. In this document, article (13), the European Commission approved the human rights-centered method as the basic principle for stopping and solving the challenges of people with disabilities [Sendi and Kerbler-Kefo (2009)].

Types of Disabilities

According to [Hussien and E. Jones (2016)], the World Health Organization (WHO) defines disability as "the long-term or permanent functional limitations produced by physical impairments. There are various types of disabilities; while one person may have multiple disabilities, another may have a single disability with fluctuating symptoms." According to [Darcy (2000)], the World Health Organization classified people with disabilities into eleven categories:

- People in wheelchairs.
- People who experience difficulties with independent mobility without the need of additional devices, such a walker or crutches.
- Elderly people.
- Infants and children under 5 years old.

- The visually impaired.
- People with hearing disabilities.
- People suffering from heart disease, arthritis, asthma.
- Peoples suffering from panic attacks and various phobias.
- Pregnant women.
- Peoples with mobility difficulties resulting from a previous disease or accident.
- People who are mentally retarded.

2.2 Accessibility

Definition of accessibility

The United Nations Convention on the Rights of Persons with Disabilities formulates 'accessibility' as a general principle and overarching obligation, referring to the inclusive practice of removing barriers to ensure equal access for persons with disabilities to, among other things, built environments, goods and services, and facilities [Guide (2010)].

[Soltani et al. (2012)] defines, accessibility as "giving equal access to everyone, and without being able to access the facilities and services, people with disabilities will never be fully included."

2.2.1 Importance of accessibility

The most crucial aspect for disabled people is the ability to move around is, known as accessibility [Yılmaz (2018)]. Accessibility is significant in everyday life, particularly when dealing with external and internal environments. The Declaration on the Rights of the Disabled was adopted on December 9, 1975, by the United Nations [UN (2015a)] General Assembly. The Declaration on the Rights of Persons with Disabilities states that all people with disabilities have the same rights. The term "disabled person" refers to anyone unable to meet "the needs of a normal individual and social life due to a deficiency in... physical or mental capabilities."

In United Nations Sustainable Development Goals (11 Sustainable Cities and Communities), accessibility is one of the targets to be achieved by 2030 and fulfill all users' needs [UN (2015b)]. However, the current accessibility of the existing built environment is not equal and participatory for all users. Most buildings and infrastructures were built in the 20th century and didn't fulfill modern standards. Globally, a decade following the adoption of the United Nations Convention on the Rights of Persons with Disabilities, the existing built-environment infrastructure is challenging for disabled users. Public buildings, business buildings, and private houses are still not inclusive to meet the accessibility requirements of people with disabilities [Jackson (2018)].

The internal and external environment accessibility is significant in the daily life of human beings. [Soltani et al. (2012)], studied the accessibility in public transport areas, including streets and terminals. He mentions that the lack of accessibility in public transport infrastructures is headed to incommoded and prohibits many disabled people from moving around freely. Inaccessibility to the built environment is one of the critical obstacles to fully involving persons with disabilities in society. [Soltani et al. (2012)], identifies the internal and external factors that affect the accessibility of disabled users in public transport infrastructures, including the entrances, pedestrian lanes, ramps, curbs, and door types. He also suggests that the increase of easy access for everyone requires the involvement of all users during designing and planning.

Accessibility in public transportation and public spaces needs more attention to achieve equal participation by all users. [Zając (2016)] studied the universal design principle to increase public transportation accessibility. The design of public areas and transportation infrastructure features, such as roadways, stops, stations, and transportation hubs, is linked to the accessibility of public

transportation. He argues that involving stakeholders, including persons with disabilities, in infrastructure design and planning can increase accessibility. Furthermore, he suggests that all public infrastructures be based on universal design principles.

The main issue in urban planning and design is wheelchair accessibility in the built environment. [Evcil (2009)], assesses the accessibility of wheelchairs in the built environment, which includes buildings, public areas, and transportation infrastructure. [Evcil (2009)], discusses the importance of accessibility in public spaces and urban areas and the factors that affect the accessibility of disabled users in public spaces. According to his study, for urban areas to be positive, public spaces should be accessible. He argues that persons with disabilities are largely excluded from work, recreation, consumption, and circulation spaces based on his findings. The main reason for the exclusion is the preliminary design of cities. In this scenario, the factors influencing accessibility in the built environment are poorly designed regions and legal problems. In his case, the factors that affect the accessibility in the built environment are inadequately designed areas and legal situations. Designers and public authorities mainly limit accessibility; disabled users have difficulty accessing spaces due to architectural barriers. Another factor affecting disabled people's access to the built environment is the legal situation; depending on the context of legalizing standards and regulations in different countries, disabled people experience difficulties in their daily life.

2.3 Universal Design

2.3.1 What is universal design?

Universal design is "a process that enables and empowers a diverse population by improving human performance, health and wellness, and social participation" [Steinfeld and Maisel (2012)]. In the mid-1980s, a United States architect named Ronald L. Mace coined the term "universal design" to describe the concept of designing to meet the needs of everyone rather than the needs of many users [Sholanke et al. (2019)]. Universal design provides options or numerous ways of accessing and utilizing a product to ensure that the designed environment is responsive to the simplicity of use by many people [Imrie (2012)].

[Björk (2014)] defines, universal design as "a strategy aimed at making the design and composition of various environments, products, communication, information technology, and services accessible, usable, and understandable to as many people as possible independently and naturally, preferably without the need for adaptation or specialized solutions." According to Norwegian building regulations, "universal design" refers to "the design or facilitation of the main solution in the physical conditions so that as many people can use the general function of the business as possible" [TEK17 (2017)].

The term "universal design" originated in the United States of America, while "design for all" is usually applied in Europe, and "inclusive design" is common in Great Britain [Kadir, Jamaludin and Rahim (2012)]. These terms are built on the same concept of "designing for the whole of the population bell curve by creating the maximum utility for the maximum number of people regardless of age, culture, and education or ability level" [Kadir, Jamaludin and Rahim (2012)]. Countries like Germany, the Netherlands, and Norway, have developed the universal design in their national action plan to ensure "equal and democratic rights in society for all individuals, regardless of their age, abilities, or cultural background"[Imrie (2012)]. The seven universal design principles are illustrated in table [1] as per [Kadir and Jamaludin (2013)].

Table 1: The key principles of Universal Design

PRINCIPLE	DESCRIPTION
Equitable Use	The design is useful and marketable to people with diverse abilities.
Flexibility in Use	The design accommodates a wide range of individual preferences and abilities.
Simple and Intuitive Use	Use of the design is easy to understand, regardless of the user's experience, knowledge, language skills, or current concentration level.
Perceptible Information	The design communicates necessary information effectively to the user, regardless of ambient conditions or the user's sensory abilities.
Tolerance for Error	The design minimizes hazards and the adverse consequences of accident or unintended actions.
Low Physical Effort	The design can be used efficiently and comfortably and with a minimum of fatigue.
Size and Space for Approach and Use	Appropriate size and space is provided for approach, reach, manipulation, and use regardless of user's body size, posture, or mobility.

The growing development of human living standards demands equal opportunities for all users, especially those with disabilities. [Gossett et al. (2009)], conducted a case study on the relationship between accessibility, sustainability, and universal design. In his case study, he shows how to apply the principles of universal design, accessibility, and sustainability to achieve full participation and access in the built environment. His findings show that universal design emerged from the environmental accessibility movement, which is coordinated with the mobility of disabled users and their barriers in the built environment. Where accessibility is defined as "removing barriers" and "providing special features,", especially for people with disabilities, Sustainable design is focused on the design of buildings and infrastructures in compliance with economic and ecological sustainability principles. [Kadir and Jamaludin (2013)], emphasizes the concept of universal design in achieving a sustainable way of life and social development. A universally built environment provides comfort, adaptability, and flexibility, which helps in reducing the difficulties associated with community engagement, including social and economic aspects.

2.4 Built environment

The concept of a built environment is comparatively the latest, and social scientists originally invented it. The built environment comprises man-made buildings and infrastructure stocks that constitute the physical, natural, economic, and cultural capital.

2.4.1 Importance of Built environment

Heritage buildings symbolize the past period and must be protected [Dyson et al. (2016)]. According to [Kristl et al. (2019)], the built environment has different uses in transferring the value of the cultural identity and historical memory of the environment to future generations and having created or modified the built environment that allows for the development of different human activities. According to [Frattari et al. (2013)], the built environment includes (administration, health, commerce, culture, transport, tourism, religion, education, sports), residential buildings, historic buildings, archeological sites, streets, alleys, squares, parks, green areas, parking, playing ground areas, beaches, nature reserves, transportation. To access the mentioned places, the following are some of the accessibility elements: doors, windows, corridors, elevators, lifts, handrails, lighting, ramps, stairs, sidewalks, alleys, pedestrian crossings, and public spaces, and public transportation facilities. According to [Kristl et al. (2019)], accessibility of the built environment is a complicated issue because many tasks, such as cultural, physical, environmental, human, and societal aspects of the built environment, would be considered in the design of accessibility. Everyone must be able to use the built environment independently and equitably [Yılmaz (2018)].

[Yiing et al. (2013)], conducts study on achieving sustainable development in green building accessibility, mentioning that the fundamental goal of "Universal Design" and "Green Building Design" is to achieve sustainability in the built environment. To improve society's "healthiness" and "comfortability," the balance in green building, sustainability, and accessibility must be parallel. In their study, they present the importance of sustainable development in human well-being, which is associated with social equity, economic viability, and environmental conservation and protection. Furthermore, they address the built environment's need to be well-designed to provide full access to persons with disabilities. Finally, they argue that social equity, economic viability, and environmental sustainability play a key role in achieving sustainable development.

2.4.2 Built environment barriers

"The built environment can support multiple activities and exercises if the outdoor area allows for individuals equally [Yen et al. (2009)]. Disabled users are isolated from society due to different built environment barriers, which cause social inclusion. Worldwide, many disabled people face different types of discrimination. Discrimination in the built environment relates to accessibility barriers. [Sendi and Kerbler-Kefo (2009)], identifies the barriers in the built environment and communication barriers in the case of Slovenia. He did his studies in the built environment, including the buildings and transport facilities, considering disabled users. He focuses on the identification of accessibility barriers for disabled users. [Sendi and Kerbler-Kefo (2009)], mentions the barriers in the built environment are architectural and technical barriers, which include steeps, curbs, entrances, signs, pavements, door sizes, etc. Finally, he concludes that the built environment barriers are related to the planning and construction of private buildings and the planning and development of public and private spaces [Gebremeskel (2021)]."

Differences in the built environment are caused by the different physical features of geographic areas, especially related to disabled people [Botticello et al. (2014)]. The built environment is the main obstacle to accessing spaces by all users, especially people with disabilities. The built environment includes indoor and outdoor areas. Buildings, transportation facilities, and other public places are examples of built-environment obstacles. According to [Rosenberg et al. (2013)], in buildings, the main obstacles are entrances and exits, including door size, entrance finishing material, elevators, ramps, and signs. Furthermore, building lighting is one of the barriers for disabled users. The transportation infrastructure includes sidewalk pavement, street crossings, puddles, parking, curbs, narrow walkways, signs, and information boards. Public spaces are also among the barriers for disabled users in the built environment, including unpaved paths, lack of facilities, and inadequate signs and information.

2.5 Elements of the built environment

2.5.1 Intersections

In the built environment, intersections are the joints that play a significant role in connecting places for pedestrians and vehicles [Obeng-Atuah et al. (2017)]. Therefore, pedestrian infrastructures play a vital role in increasing the safety and well-being of pedestrians. In modern cities, the need for intersections has become very high because of the unbalanced proportion of vehicles and pedestrians. The improper balance of pedestrians and traffics leads to collisions. Worldwide different cities take different actions to prevent the collision. To guarantee the safety of pedestrians in the urban environment providing a safe crossing infrastructure is the solution.

Pedestrian crossing demand

Buildings are the cause of the places of traffic creation and attraction that spread along the sides of streets [Li et al. (2013)]. For example, a shopping mall attracts more people than a small barbershop, which means more pedestrian crossing needs. Additionally, public buildings, restaurants, cultural buildings, and health buildings appeal more [Anciaes and P. Jones (2018)]. Therefore, the need for a pedestrian crossing is the most critical thing in placing a pedestrian

crossing facility.

Pedestrian crossing types

Pedestrian crossings are designed to follow the traffic and pedestrians of the intersections [Li et al. (2013)]. The main purpose of the different crossings is to keep the safety of the pedestrians. But due to various reasons, pedestrians use cross streets away from the designated crossing. At low vehicle speeds, pedestrians face different experiences due to vehicle-pedestrian interactions. For this reason, different types of crossing facilities are built in different countries. According to [Demiroz et al. (2015)], There are four types of crossing types: straight crossing, staggered crossing, foot (overpass bridge), and tunnel (underpass) bridge.

Straight signalized crossings are direct street crossings that do not require stopping. The problem with these crossings is that people in different situations can't reach the other side on time. For example, on highways with heavy traffic, elderly and disabled people can't cross the street at the green passing light for pedestrians. The staggered signalized crossing is safer than Street signalized crossings because people with different problems can cross the street in two rounds by stooping on the island between the two ways of the Street. But they have problems with detours and delays due to the additional waiting time. People do not like this type of crossing because of the waiting time.

Grade-separated crossing facilities, including foot (overpass) bridges and tunnel (underpass) bridges, are safe in vehicle-pedestrian collisions. Still, they are universally disliked due to the time and effort needed to use them and issues related to safety. Several studies show that people prefer to cross on a normal surface than grade-separated crossing. The main reason is that the time to reach the crossing facility is much longer than crossing the street directly, with a high vehicle-pedestrian collision rate. One case study in the UK, shows that people are not comfortable using grade separate crossing facilities [Anciaes and P. Jones (2018)]. The reason is the detour and time delay caused by using the grade-separated crossings. Also, some people have safety and security issues with using the facilities. Especially women, children, and older people. The case study shares the same experiences as previous studies from different countries.

2.5.2 Bike lane

Integrating cycling into everyday life in an urban environment is the best way to boost the physical activity of society [Parker et al. (2013)]. Biking play a great role in allowing easy access to crowded cities and streets [Dondi et al. (2011)]. Additionally, using bikes decreases the urban air pollution from the transport sector. Urban air pollution is the main human health problem with significant emissions from the transport sector. Urban transportation users (car drivers, cyclists, pedestrians, etc.) are subjected to a high-ranking level of air pollution. Globally, in 2015, air pollution was estimated to contribute to around 4.2 million deaths.

Different studies show that the benefits of active travel offset the negative health impacts of air pollution exposure. For various reasons, European cities are starting to change towards more sustainable modes of transport. Several cities worldwide are acting to achieve the United Nations sustainable development goals by reducing air pollution. To achieve the reduction of air pollution cities in our world are taking different actions. For example, some cities focus on reducing emissions of greenhouse gases and reducing the health impacts of air pollution. At the same time, others focus on creating safe and attractive modes of transport for their citizens. One of the safest and most attractive modes of transport for reducing emissions is cycling [Schmitz et al. (2021)].

2.5.3 Pedestrian lane

The design of pedestrian lanes must be in consideration of a diverse group of people with respect to gender, travel behavior, age, and socioeconomic status [Stoker et al. (2015)]. Providing a walkable neighborhood with the nature of the built environment, with facilities close to each other, increases walkability [Zegeer (2002)]. For example, being near a school, parks, shopping malls, public areas,

and mixed-use buildings. In addition, walking paths should be safe and accessible to all pedestrians. People walk for various activities, including running, visiting places, going shopping, and taking children to neighborhood parks and playgrounds.

If people are not walking, they are not allowed to perform; this may happen for different reasons. In the built environment, the curbs in the pedestrian lane are one of the barriers, especially for older people and wheelchair users [Rimmer et al. (2004)]. Among the few reasons are insufficient infrastructure, such as the poor continuity of the walkways, or if there are physical barriers such as drainage ways and walls. Also, sidewalk pavement, puddles, and narrow sidewalks are among the obstacles for visual and mobility-impaired people [Kirchner et al. (2008)].

The walking percentage in various neighborhoods in the same city is directly proportional to the system's quality. Many people walk in neighborhoods with good quality pedestrian environments. In contrast, people will walk less if the system fails, such as missing sidewalks or altered walking barriers.

During winter, due to heavy snow, the streets become icy surfaces which cause difficulties for users. Especially for people with mobility difficulties, slippery surfaces are challenging. Several studies show that worldwide to prevent the safety of users and to maintain accessible transportation, different measurements are taken. According to [Malakooti et al. (2020)], Hydronic and electric sub-surface heating systems have been suggested to solve snow and ice formation. The prevention of snow accumulation and ice formation on roads, especially in critical places, bridges, and ramp slopes, is a high priority to improve. The application of deicing technologies using the heated system is restricted due to economic reasons, environmental contamination, and costs associated with construction technology [Won et al. (2014)]. [Joey (2019)], studied the installation and operation costs of different deicing technologies for street intersections and crosswalks. The result shows the annual energy cost of an electrical resistance-heating method, and the carbon fiber tape deicing is the same. But the electrical resistance-heating deicing system minimizes the safety of pedestrians.

2.5.4 Internal environment of buildings

The internal environment of the building includes the internal stair, hallways, corridors, toilets, elevators, washing sinks, etc. Nowadays, the new buildings' internal environment elements are different from the old buildings due to the latest standards and the universal design principles. According to the Norwegian building regulations [TEK17 (2017)] and other studies, the following standards for the internal building environment are stated for the different elements.

Stairs and lifts

Stairs and lifts are the main components of a building, and they are the key elements to access the building. But, in the built environments, the common architectural barrier is the steps at the entrances [Evcil (2009)]. Moreover, stairs are the primary source of challenges for people with mobility difficulties. Therefore, it is recommendable to make lifts equal access in buildings for all users. According to the Norwegian building regulations [TEK17 (2017)], the stairs and lift should include the following to be accessible by all users:

- Treads must be marked in such a way that a minimum luminance contrast of 0.8 is achieved in relation to the color of the steps. The trademark should not be more than 0.04m deep.
- The finishing material of the stairs should not be slippery.
- The design of the lift should be in consideration for people with disabilities. The door size of the elevator should be a minimum of 0.9m.
- The distance between the door and the start or end of the stair flight must be a minimum of 0.5 m. Internally in housing units, the distance must be at least 0.3 m.

Entrance hallway and Corridors

In most old buildings, the entrance halls are not accessible enough. The main reason is the insufficient size of the hallway and steps in the hallways. The hallways should be wide enough to let the parallel passage of two wheelchairs [Vonica and Brumaru (2012)]. All building entrances and corridors should be designed with the consideration of all users. For disabled users, especially wheelchair users, the space next to the entrance must be enough for moving around. According to the Norwegian building regulation [TEK17 (2017)] (section 12-4), the following are stated to make buildings accessible for everyone and fulfill universal design standards.

- The doorbells, door lock, and the opening and closing of the door should consider wheelchair users.
- Entrance halls should be step-free.
- For the sufficient mobility of wheelchair users, the minimum horizontal field at the entrance should be at least 1.5m x 1.5m.
- To make doors' opening operation easier and avoid collisions for wheelchair users, doors should be automatic.
- The size of the corridors should be designed in consideration of wheelchair users.
- The lighting strength is adapted to the material and color use so that the entrance hall and the main entrance door are visible in relation to surrounding surfaces with a luminance contrast minimum of 0.4

2.5.5 External environment of buildings

The external environment of a building includes the parking spaces, routes to reach from the parking space to the building, entrances, stairs, ramps, door types, etc. According to the Norwegian building regulations [TEK17 (2017)], the following standards for the external building environment are stated for the different elements.

Ramp

A ramp is the means of access usually used by disabled people, especially wheelchair users and visually impaired people. The absence of ramps in the built environment makes challenging the accessibility of spaces for those who have mobility difficulties, especially wheelchair users [Welage and Liu (2011)]. According to the Norwegian Building Regulations [TEK17 (2017)], to make buildings accessible for everyone, the following requirements are stated:

- The width must be appropriate in relation to the functioning of the building and the expected traffic. A ramp should have a minimum width of 0.9m.
- The ramp must have an even and non-slip cover and ascent maximum of 1:15. For stretches below 3.0 m, the rise can be a maximum of 1:12. For every 1.0 m height difference, there should be a horizontal resting plane with a length minimum of 1.5 m., which provides suitable conditions for most people. Moreover, the slope is helpful for people with strollers and manual wheelchairs.
- The Ramp must have handrails on both sides at one height of more than 0.8 m above the deck or two heights with a height of 0.9 m and 0.7 m above the deck, respectively. The handrail should contrast with the wall and railing. The handrail should be designed to provide a good grip.

Exterior Stairs

Stairs are the main component of a building, and they are vital in accessing buildings. Stairs must be simple and secure to use. The width and height of the stairs must be designed to accommodate the expected traffic and transportation. In addition, during the time of escape in the event of a fire. According to Norwegian building regulations [TEK17 (2017)], treads must be marked in such a way that a minimum luminance contrast of 0.8 is achieved in relation to the color of the steps. The tread markings must span the entire step width and be no more than 0.04 m deep. When considering disabled users, the minimum width of the stair step should be 28 cm, and the maximum height of the steps should be 16 cm.

Doors

Doors are the key elements in accessing buildings. But in many old buildings, the door width remains an obstacle for all users. It is extraordinary that even in countries where accessibility and universal design principles are in operation, heavy and narrow doors become obstacles, especially for those with mobility difficulties [Evcil (2009)]. Entrance doors should be wide enough to allow anyone to pass through them [Vonica and Brumaru (2012)]. The door types play a significant role in accessing buildings, especially obstacles for people who have difficulty pushing and wheelchair users. In order to achieve easy access in the built environment, the main entrances of buildings must be designed equally for all users. According to Norwegian building regulations [TEK17 (2017)] (section 12-13), the minimum requirement for doors is as follows:

- The maximum opening power needed to open doors to and from access and escape routes manually shall be 30 N.
- Automatic door opener buttons should be installed outside the door's swing radius. Buttons must be visible and positioned at 0.8 m to 1.2 m above the floor.
- The door opener buttons should be positioned at a sufficient distance on the inside corners.
- Doorsills must be step-free.
- Sliding and side-hinged doors must have enough side clearance to allow wheelchair users to open and close the door. This requirement does not apply to automatic door openers.

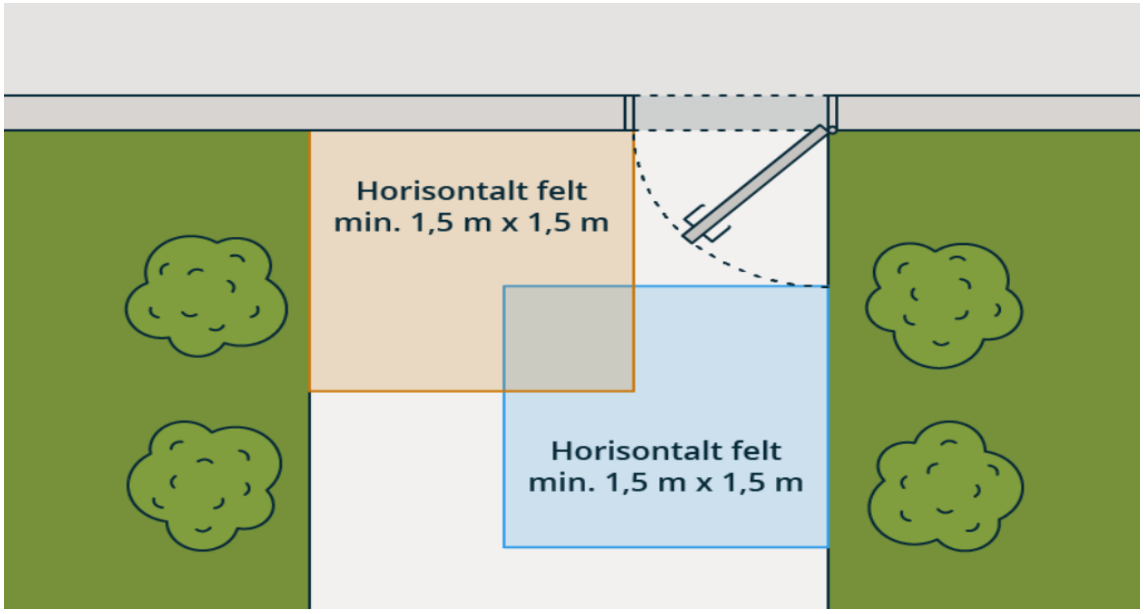

Figure 2: Horizontal field of main entrance doors [Source: TEK 17, Section 14,4]

According to the Norwegian building regulation [TEK17 (2017)], Figure[2] shows the standard for a horizontal field in entrances. The horizontal field is enough space for opening the doors and ensuring adequate space for people with mobility difficulties, especially wheelchair users.

2.5.6 Parking Space and route to main entrance of buildings

Nowadays, providing accessible parking spaces for disabled people has become a standard. This is because parking spaces are one of the critical elements of the built environment. In cities, the availability of parking spaces increases the attractiveness of places; for this purpose, most public and private buildings have their parking places. But, nowadays, the access for wheelchair users remains challenging because of the availability of special marked parking [Evcil (2009)] .

Disabled people should have a special privilege to access buildings. Another element connected to the parking spaces is the route from the parking spaces to the main entrance of the buildings. The route from parking to the main entrance of buildings must consider people with mobility difficulties, especially wheelchair users. Also, the sizes of the disabled cars parking side by side must be a minimum of 250cm x 250cm [Yılmaz (2018)] .

The Norwegian Building Regulations [TEK17 (2017)] (section 8-8), suggests the following rules for parking:

- The parking space should include reserved and marked spaces with proper signs for disabled users.
- There should always be at least one parking space for disabled people should be built-in parking spaces.
- Parking spaces must be placed on safe and short pedestrian connections to the buildings. The distance between the main entrance and the parking lot must be as short as possible.
- The parking lot should be close to the main entrance.
- The distance between the main entrance and the parking lot must be as short as possible.

2.6 Accessibility and built environment

Buildings built in the past are less accessible than newer buildings [Kadir, Jamaludin and Rahim (2012)] due to different reasons. In the past, the consideration of people with disabilities was very low. The regulations and standards of accessibility in relation to the built environment and people with different mobility limitations were introduced decades ago [Mustaquim (2015)]. One of the regulations is the universal design principles which focus on providing equal access for everyone. However, for different reasons, the standards are not implemented seriously, which causes differences in the users of the built environment. Different studies come up with various reasons; the misunderstanding of the regulations and weak implementation is one of the reasons. Indifferent countries vary the implementation of the universal design principles due to the commitment of the architects, engineers, and decision-makers. The heritage value of the built environment is another reason for implementing the principles. All users do not consider buildings built before the universal design principles; This causes difficulties in improving the accessibility of the built environment. The aim of equal access to the built environment is vital in the adjustments to every environment in consideration of architectural heritages from different perspectives [Roulstone and Prideaux (2009)].

2.7 Sustainability

Sustainability is the key agenda of the 21st century, which is built on three key elements: the environment, the economy, and society. Social sustainability focuses on how the environment influences the human quality of life. In a 1987 United Nations report, Gro Harlem Brundtland defined sustainable development as "meeting the needs of the present without compromising future generations' ability to meet their own needs" [Pionke (2016)]. Sustainability in the built environment considers all the aspects and values of the environment. A socially sustainable built environment must be designed through careful planning and design. Universal design is one of the approaches to accomplish the goals of socially sustainable strategies.

According to the United Nations General Assembly of 2015 [UN (2015b)], "Sustainable cities and communities" is one of the 17 Sustainable Development Goals focused on "making cities inclusive, safe, resilient, and sustainable." This sustainable development goal 11 targets 11.7 "Provide universal access to safe, inclusive and accessible, green and public spaces," which aims to involve all users in the built environment. Sustainability includes different principles, including protecting the environment, using renewable resources, economic divergence, equality in the community, and fulfilling basic human needs [Dyson et al. (2016)].

2.7.1 Elements of sustainability

The concept of Sustainability is built on the environment, economy, and society; these three elements play a significant role in achieving the Sustainable Development Goals, especially in goal 11, "Sustainable cities and communities." Figure [3], shows how the three elements contribute to sustainability and have equal value.

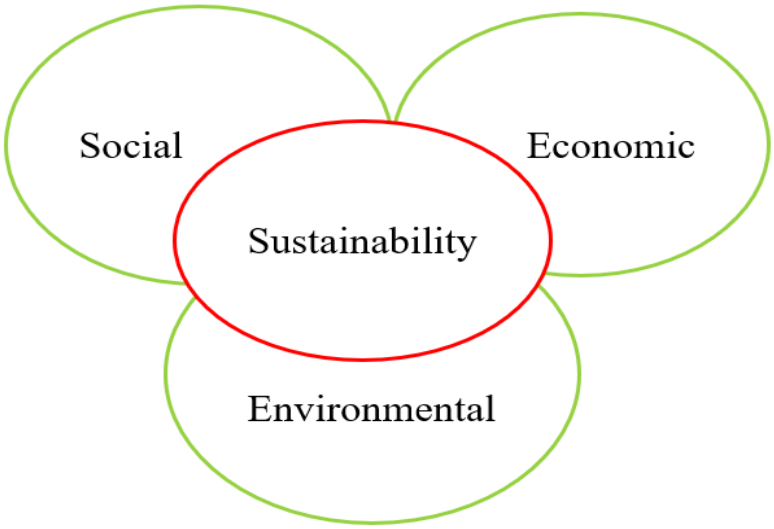

Figure 3: Sustainability elements [Source: Made by author]

Environmental advantages

Demolition and reconstruction are seen as extravagant and thus are considered unsustainable [Bullen and Love (2009)]. To stop the practice of demolition and reconstruction, adopting the adaptive reuse approach will make society more sustainable by recycling and reusing resources. This approach reduces landfills, keeps heritage value, produces less waste, reduces the transportation of materials, reuses existing infrastructure, and lowers the use of new raw materials [Conejos et al. (2016)].

Economic advantages

The economic aspect is one of the key elements in sustainable development. For example, adaptive reuse is more cost-effective in the built environment than constructing new buildings because the demolition and reconstruction costs are high [Dyson et al. (2016)]. To be cost-effective in designing and building infrastructures, the capital, operational, maintenance costs, potential market, and financial sources must be considered [Yung and Chan (2012)].

Social advantages

Social value is another element of sustainability that focuses on the advantages of the built environment to society. The historic environment needs architectural protection for societal benefit [Wilkinson (2014)]. In the urban environment, having unused or abandoned buildings has a negative impact on the community, which supports an environment for crime and other anti-social behaviors [Dyson et al. (2016)]. In sustainable development, one focus is improving "social inclusiveness" and "social cohesion." According to [Yung and Chan (2012)], the development of social sustainability requires developing citizenship, expanding access, recognizing multiculturalism, and improving partnerships and community engagement.

2.8 Built Environment and sustainability

Several studies on accessibility in the built environment have been conducted, but sustainability has been neglected. The relation between the built environment and sustainability is the key in the 21st century because cities focus on improving the living standards, social equality, cultural diversity, and social inclusiveness of citizens. To maintain social sustainability and increase people's well-being, creating a sustainable and prosperous environment is the key [Kadir, Jamaludin and Rahim (2012)]. One of the United Nations Sustainable Development Goals is making "Sustainable cities and communities," focused on making cities sustainable. In making the built environment sustainable, all users and the heritage value of the environment should be considered.

Relationship between accessibility; built environment and sustainability

In the 21st century, accessibility, built environment, and sustainability cannot be seen separately because these subjects are dependent on each other. To achieve sustainability in society, accessibility of the built environment plays a significant role. Currently, accessibility of the built environment is challenging for everyone due to the age of the buildings and infrastructures. Decades ago, in the USA, principles of Universal Design were developed by Ronald L. Mace to solve the problem of accessibility and create equal access for everyone. But the implementation of the principles was very challenging, and it is poor in different countries. One of the reasons is to implement the universal design in the built environment needs modification of the existing structure; this may require special technology and high investment. Another reason is the heritage value of the infrastructures; in the built environment, the main concern is the architectural value of the infrastructures and needs protection to keep the values. The heritage value of the existing environment represents the past building history to the future generation. Therefore, increasing social sustainability and achieving easy access for everyone in the built environment will remain challenging.

"[Kristl et al. (2019)] uses the literature review approach to identify the sustainability and universal design components in heritage building refurbishment. Their study discusses the relevance of historical and cultural buildings in terms of social, economic, and environmental reasons. The study aims to fill a gap in sustainability factors influencing the adaptive reuse of heritage buildings, focusing on people with disabilities. The "protection" of architectural aspects is a critical component in refurbishing old buildings. They defined the importance of universal design, heritage, and sustainability in their study. They also evaluate the coverage of the relationship between heritage buildings, universal design, and sustainability. According to their literature analysis, most studies cover accessibility, sustainability, and heritage buildings separately. They evaluate a wide range of literature, but the combined topics of sustainability, heritage buildings, and universal design are not well covered. They conclude that the relationship between the topics is inadequately covered [Gebremeskel (2021)]."

3 Method

3.1 Introduction

This section aims to present the methodological choices that I made for this study. I will first discuss the study's research design, which includes the methods I used to achieve the study's aim. This will be followed by a description of the methods and the selection of specific study areas.

3.2 Research design

Accessibility is the main subject of this study and plays a central role in this research question. The thesis aims to answer "how to transform the accessibility of Elgeseter street in a sustainable way for all users while keeping the heritage value of the buildings?" Qualitative and quantitative methods were used to achieve the study objectives, including site observation, semi-structured interviews, an online survey, and document analysis (archival records). As shown in figure [4], the different methods are used to answer the sub-research questions, and the sub-research questions answer the main research question. Finally, suggestions for future work will be followed after achieving the aim of the study.

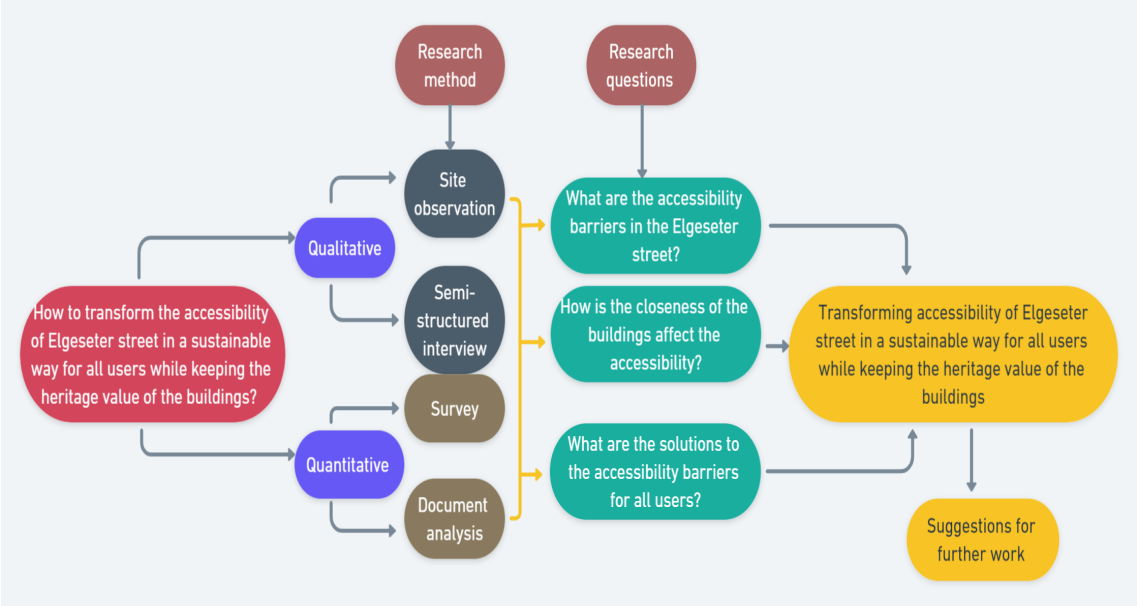

Figure 4: Research design [Source: Made by author]

3.3 Document analysis

Document analysis refers to the systematic reviewing and evaluating of documents in order to gain an understanding of cases. Archival records are in data files, governmental legal acts and regulations, and documents in many case studies. According to [Yin (2018)], archival records include, "public use files" and other statistical data made available by regional and municipal governments; maps and charts of the geographical characteristics of a place; and survey data produced by others.

In this study, I collected government policies, maps, and archival records. The archival records are from the Trondheim municipality archive [Archive (2022)], and the maps are from the Norwegian map authority [Archivemap (2022)]. The archival data was useful to get information about the buildings, including the building owners and their functions. The maps are also helpful to know the exact number of buildings in the street.

The first step in this study was collecting information about the buildings and the area. To get the data, I use the Trondheim Municipality archive. The buildings are classified based on their function and ownership depending on the archive data. The classification of the buildings helps to know their functions and their influence on the main street. Based on data from the municipality archive, most of the buildings are owned by private individuals, and they are residential buildings. But there are also a few cafes, restaurants, offices, and school buildings. Some buildings are out of function and registered for demolition for the future development of the street.

The second step was to use the archival records for choosing the cases for this study; based on the data from the municipality archive, the buildings are classified by two criteria;

- Ownership of the buildings
- The Function of the buildings

According to the data from the municipality archive, there are 45 buildings with different functions [Archivemap (2022)]. To know the detailed functions and quantity of the buildings, I classified them into three groups: residential buildings, mixed-use buildings, and buildings without functions. Mixed-used buildings include cafes, restaurants, grocery shops, barbershops, and commercial offices. Buildings without function are the buildings that have been out of operation for the last ten years. For example, Elgeseter 4, 6, 30B.

Figure [5], shows the position of the buildings along the main Elgeseter street. In the representation of the buildings on the map, all the buildings are not represented in numbers because some of the buildings are connected buildings with different building numbers. Due to this reason, I put one number for many buildings. For example, Elgeseter 4 and 6 are classified under buildings without function; this building is represented on the map by one number because they are two buildings together. Also, the same for the mix-used and residential buildings. Not all buildings are represented on the map. The representation only shows how the buildings are positioned on the main street. I used the building's representation on the map to show the building's influence on the main street.

Table 2: Building's classification based on their function

No.	Building function	Quantity
1	Buildings without function	4
2	Residential Buildings	30
3	Mix-used buildings	11

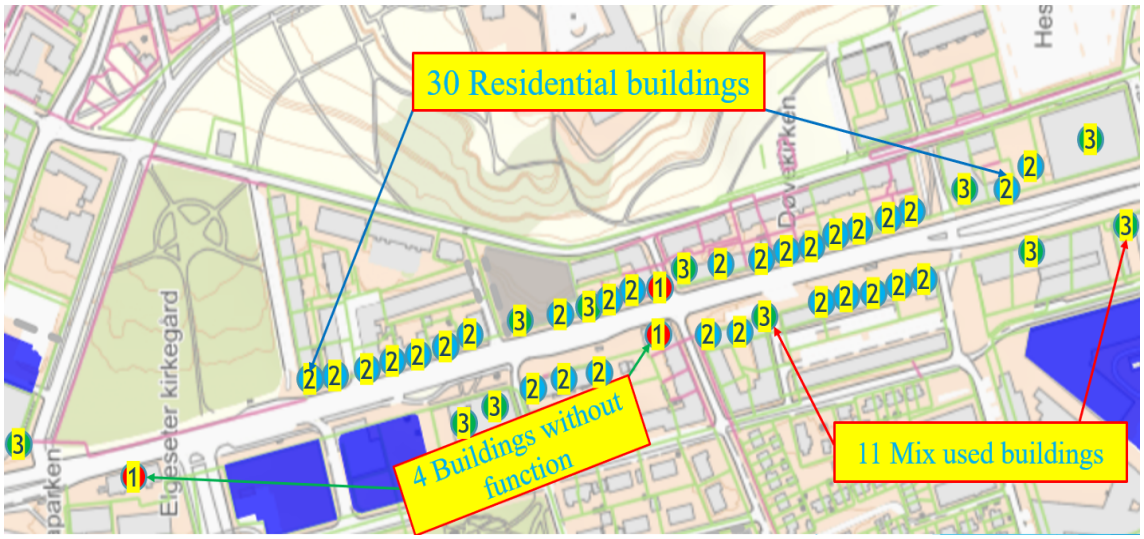

Figure 5: Building's classification based on their function [Source: Google map and archive data]

In terms of the ownership of the buildings, their classified into three categories: private, public (buildings owned by the Trøndelag fylkeskommune and statsbygg), and buildings without any information in the archive. According to the information from the municipality archive experts, people don't register the status of their property because of different privacy issues. As a result, obtaining the owners' data of some buildings becomes difficult. Trøndelag fylkeskommune, and statsbygg own the public buildings.

Table 3: Building's classification based on their ownership

No.	Building owners	Quantity
1	Public buildings	6
2	Buildings not registered	13
3	Private buildings	26

The same as mentioned on the previous page [3.3], also in figure [6], the representation of the buildings on the map is not for all buildings. Some of the buildings have the same ownership, and if they are connected buildings with different building numbers, I represented them by using one number. For example, Elgeseter 4 and 6 are classified under public buildings because they are owned by Trøndelag fylkeskommune, and still, they are 'represented on the map by one number because the two buildings are together. Also, the same for the Private buildings and Buildings not registered. Therefore, not all buildings are represented on the map by numbers.

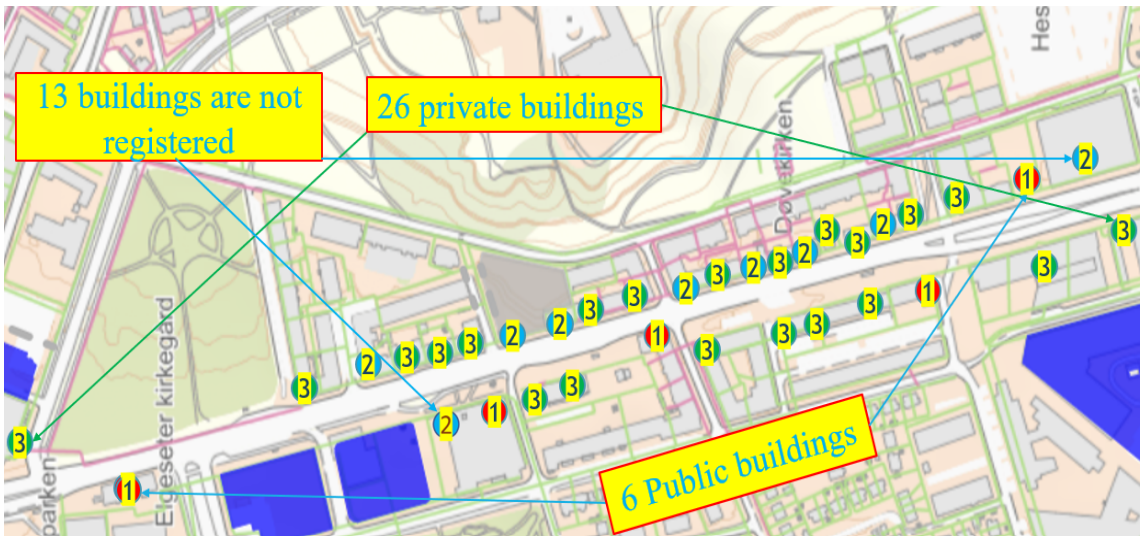

Figure 6: Building's classification based on their ownership [Source: Google map and archive data]

3.4 Selection of study areas

This subsection will present how the different study areas are selected for this thesis. The thesis aims to identify the accessibility challenges and provide sustainable solutions for all users in future development while keeping the heritage value of the buildings. After I classified the buildings based on the data from the municipality archive, the next step was to select the cases for this study. Therefore, the thesis will focus on four areas from different perspectives and considerations of all users in the built environment.

To this end, the thesis focuses on Hestaghen and Student samfundet intersections, the closeness to the street of the buildings of Elgeseter Gate 4, 6, and 30B, the Hestaghen parking plot, and one residential building. The selection of the areas for this study was from the significance for the area's future development. The reason for the selection of the four areas will explain below.

3.4.1 Student samfundet and Hesthagen intersections

Sudent samfundet and Hesthagen intersections are the chosen intersections for this study. Because of several reasons, the main reason is the number of users of the intersection, including vehicles and pedestrians. Student samfundet intersection is the intersection that connects the road towards Gloshugen to the main campus of NTNU-moholt student village-Dragvoll campus, and it connects to the main E6 Highway. The E6 Highway is the primary source of traffic heading towards the city center. The current number of pedestrians in this intersection is high, and it rates as one of the city's busy intersections, especially during rush hours.

Hesthagen intersection is the second intersection focus of this study. It is the intersection located on Elgeseter street that connects the city center to the E6 Highway from the city center. The current traffic at the intersection is the same as at Student Samfundet, but the number of pedestrians is much lower due to the less attractive places in this area. The main reason for including the Hesthagen intersection in this study is that the area is now under construction of new commercial buildings. Because of this reason, in the future, the area will become busy with pedestrians. Therefore, for the reasons mentioned above, these two intersections were chosen for this study and better future solutions based on the needs of people/users.

3.4.2 Elgeseter gate 4, 6, and 30B buildings

Another focus is the three buildings on the street (Elgeseter Gate 4, 6, and 30B). These old buildings are from the 20th century. By the decision of the Trøndelag fylkeskommune, these buildings have been out of function for the last ten years. Choosing these buildings for this case study is from different perspectives. The first reason is because of the location of the building on the main street. These three buildings are very close to the road; there is no bike lane, and the pedestrian lane is small because of the closeness. Due to this reason, the street is unpleasant to all users. The second reason that inspires me to choose these buildings for this study is the decision made by the Trøndelag fylkeskommune. Based on the data from the municipality archive, these buildings are on the decision to be demolished for the future development of the area [miljopakken (2021)]. Initially, when I see it from the heritage value perspective, these buildings are among the few buildings in Trondheim city that show the design of buildings and architectural history of the 20th century to future generations. Moreover, these buildings have been out of function for the last ten years without any maintenance. In this study, I will suggest ways to make these buildings functional without changing the current architectural value for the better future of the street while keeping all users.

3.4.3 Hestaghen parking plot

In the Elgeseter area, the number of parking spaces is significantly less. The area Elgeseter is from the 20th century and did not meet the modern standard of facilities expected in neighborhoods. However, there is one proper parking space in the area under the Norwegian University of Science and Technology, and it gives service only to its workers and students. This parking plot is enormous, but the problem is that the service is limited only to the university staffs. Additionally, a few shops and residential buildings have their own parkings. But the route from the parking spaces is not under the consideration of all users. For this reason, the attractiveness of the area is less because people with different mobility limitations face several challenges. Therefore, in the future development of the area, the parking issue should be considered one of the critical elements that increase the area's attractiveness. Therefore, the parking space was chosen for this study for the above reasons.

3.4.4 Internal and external environment of one residential building

The residential buildings on both sides of the street are another focus of this study. According to the municipality archive data in Elgeseter Gate, there are 30 residential buildings, more than 60% of the buildings in Elgeseter Gate. However, from the accessibility point of view, most residential buildings are not accessible to everyone. The main reason is that due to the age of the buildings, this area is from the 20th century and does not meet modern standards.

This thesis will evaluate the internal and external environment of one residential building. I chose only one building for this study because most of the old buildings in the area are from the same age. Also, within the period of this study, it was difficult to cover the accessibility of all residential buildings. Therefore, for this thesis, Elgeseter 13 building is chosen. Figure [7], shows the selected cases for the study based on the above reasons. Finally, Hestaghen and Student samfundet intersections, the closeness to the street of the buildings of Elgeseter Gate 4, 6, and 30B, the Hestaghen parking plot, internal and external environment of Elgeseter 13.

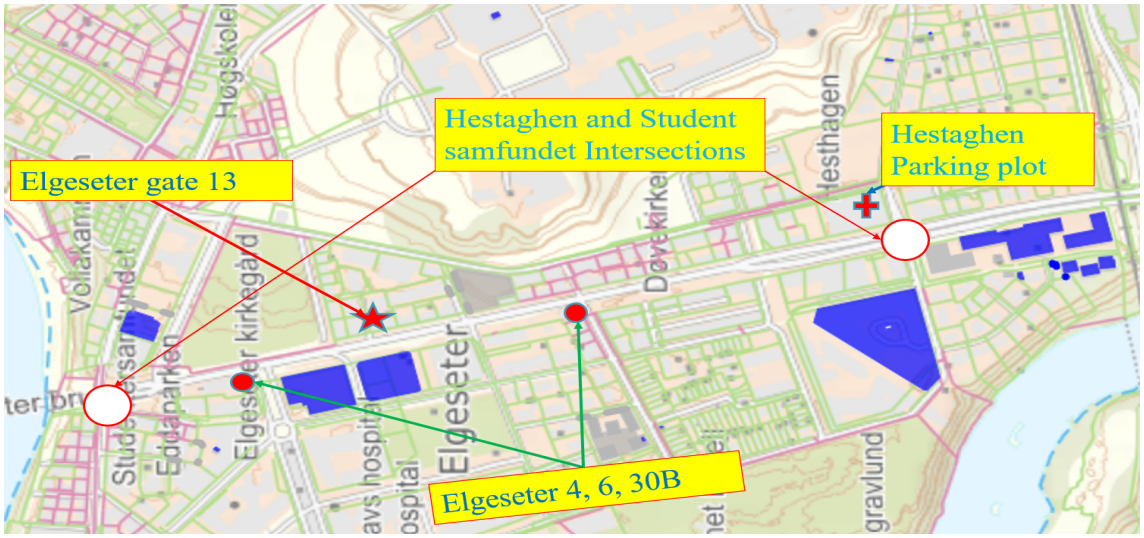

Figure 7: Chosen cases for the study [Source: Google map and archive data]

3.5 Interview

According to [Yin (2018)], interviews are an essential source of case studies because the majority of case studies are based on human issues. The aim of this study is to perceive the accessibility in the built environment Elgeseter area. Accordingly, it is crucial to know how people and individuals experience accessibility within the area. Therefore, semi-structured interviews and an online survey have evaluated the subjective, personal issue of how people encounter accessibility in the area.

3.5.1 Semi-structured interviews

Semi-structured interviews, in most cases, are open and take the form of informal detail conversations with study participants. Short and straightforward interviews have been used to obtain more profound perceptions of the accessibility of the built environment and its challenges for all users in the Elgeseter area. Interview participants include ten members, and some of the interviewees have mobility limitations (see table)[4]. In addition, the interviewees are with different ages and mobility types.

The interviews took place in the area, including restaurants, shops, cafes, and people who use the street for walking. All interviews were conducted by walking throughout the streets and sitting in cafes and restaurants. Also, by visiting the shops and meeting the people who use them, having

interviews with the interviewees in the area and different places provides additional perception as the interviewer can see the obstructions and how the interviewee is affected.

Interview questions are developed in a way people can understand easily. As the interview took place in the case area, it was easy for the participants to answer the questions by visualizing the area. Also, most of the questions for the interview were in detail in the selected areas. For example, the question in the intersections is related to the everyday accessibility challenges in crossing the main street. Having the interview in the case area helped me to see the different challenges for all users.

The interviews were in English because most of the participants speak the language and my limitations in speaking the Norwegian language were. But with, some of the participants have difficulties communicating with the English language. So, to give them the chance to speak, I asked in English, and they answered in Norwegian.

3.5.2 Survey

In data collection, a survey is one of the ways to gather authentic information from individuals. The data collection is conducted using an online survey. The online survey was distributed to participants for the specialization project and preparation course for the master's thesis in October 2021. The survey participants are Trondheim residents who, hopefully, are familiar with Elgeseter Gate. The respondents were asked about the accessibility barriers and suggestions for the area's future development. The survey is distributed using QR codes with a short description of the study and the case area. The case area is the main distribution place, but also on the main campus of the Norwegian university of science and technology is disturbed.

The survey questions mainly focus on the four selected areas of this study. The questions are organized based on the current accessibility challenges in the area. I observed some accessibility barriers in the case area before preparing the survey questions, which helped me to construct the questions. In addition, in the survey, I asked the participants their perceptions on some alternative solutions for the accessibility barriers in each area of the study for future development. The alternative solutions are based on different theories and case studies from different countries. Solutions are included in the survey questions by considering the current accessibility for all users and the value of the built environment.

The purpose of the survey is to get people's opinions and give them a chance to suggest their solutions for improving the area. The survey helps how well they know the street and what they think of it, considering accessibility in parts of the area for all users, including the old buildings, parking, and the main street. Also, it suggests different alternative solutions for the different parts of the area, giving the people who answer the survey a chance to vote for their preferences. In total, the survey was filled out by 56 respondents.

3.6 Site observation

Observation-based studies attempt to put up a sense of the actions and intentions of the people one studies. One of the methods I used to collect data was observing the case area. The direct Observation allows me to see the real accessibility challenges in the selected areas of the study. The observations were carried out several times in the Elgeseter area between September 2021 and May 2022.

The site observation includes the external and internal environment of one building, including (the exterior ramp, main entrance, door type, stair, and entrance hall). Also, the pedestrian lane, parking space, the route from the parking space to the buildings, crossings, bike lanes, and the closeness of the buildings to the main street are observed. In addition, during the site observation, the parking spaces of buildings with different functions and the routes to their entrances are well observed.

Furthermore, during the site visit, the chance was high for me to see how people use the street and whether they face difficulties, especially for people with different mobility impairments. During the site observation, the time duration of the green light for pedestrians and cyclists in the intersections is measured. In addition, Video recordings and photos are taken for further qualitative evaluation of the existing facilities.

In this study, I used an unstructured observation, which implies that I had largely defined issues that I was interested in. My aim in using observation was to understand the accessibility challenges by visiting the area, including the main street, at different times. The times are all the seasons of a year. Because the users of the main street vary in the different seasons. For example, people use electric scooters in the main street pedestrian lane during spring and summer, which is challenging for pedestrians. Also, during winter, the pedestrian lane becomes challenging because it becomes very slippery when the snow stays in the pedestrian lane for a while.

4 Results

This section covers all the results from the interviews, observations, document analysis (archival records), and online surveys. The intersections, the closeness of the buildings to the main street, bike and pedestrian lanes, and the parking plots focused on the results—additionally, the internal and external environments of the buildings. The results from the different methods will answer each sub-research question.

4.1 Data Overview

The semi-structured interview has conducted in the case area (Elgeseter), which includes people with different mobilities and ages. The interview has a total of ten interviewees. Table [4] shows the overview of the interviewees.

Table 4: Overview of the interviewees

Interviewee	Gender	Mobility aid	Interview place
1	Female	None	Grocery shop
2	Male	None	On the street
3	Female	Crutches	On the park
4	Female	None	Cafe
5	Male	None	Residential apartment
6	Female	Limited mobility	cafe
7	Male	None	Residential apartment
8	Female	None	Restaurant
9	Male	Limited mobility	On the street
10	Female	None	Student samfundet

In total, there were 56 respondents to the online survey. 52% of the survey respondents were female, while 41% were male [see appendix]. However, 7% of the respondents did not fill their gender. The age of the respondents ranged from 20 to 70 years of age; however, one respondent was above 70 [8]. Consequently, 49% of the survey respondents were in the age range of 20 to 29. The result is because the participants are from the case area, and most of them are students and young residents.

Furthermore, the case area is close to the university's main campus, and old residential buildings stretch along the street. Additionally, it is because of the student samfundet, the student club for students. Further, 96% of the respondents were residents of Trondheim, with the remaining 4% being from other parts of Norway.

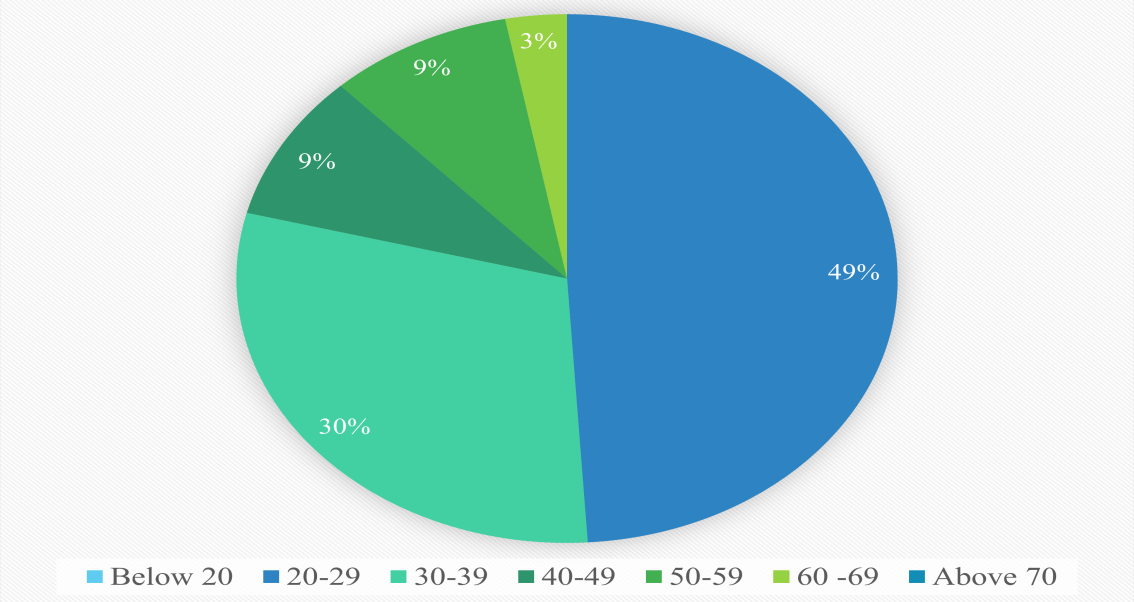

Figure 8: Age percentage of the survey respondents [Source: From the online survey of the study]

First, when identifying the accessibility barriers in the area, it is good to know how often the participant uses the street for walking. Therefore, I asked the participant how often they step on the road monthly to see the frequency. The result shows that around 74% of the respondents walk on the street a few times a month. This result indicates that the road is not friendly for walking.

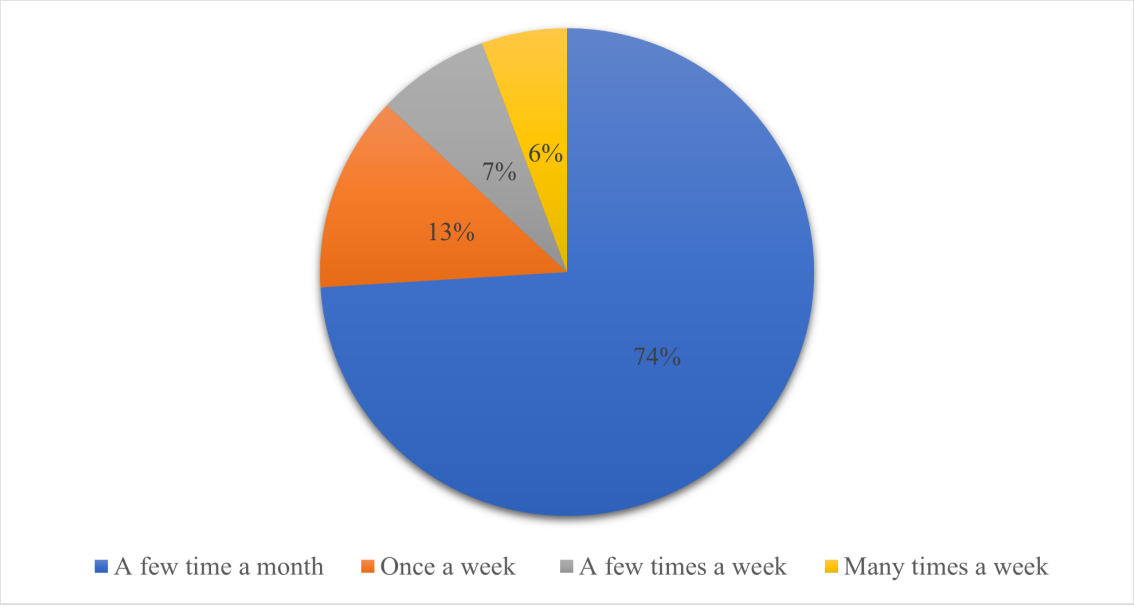

Figure 9: Walking frequency of the respondents on Elgeseter street [Source: From the online survey of the study]

After knowing the frequency of walking on the main street and the age of the survey respondents, the first step was to identify the accessibility barriers on Elgeseter Street.

Sub-Research question: What are the accessibility barriers in the Elgeseter street?

4.2 Intersections

The intersections are the one area of the study. The focus was on the time duration of the green traffic light for pedestrians and cyclists at the intersection. Also, the curbs and slopes are included.

The time duration of the traffic light for pedestrians and cyclists

In the case of Elgeseter Street, the main street pedestrian and bike crossings are challenging for all users. One of the main problems is the time duration of the green traffic light in all intersections. But for the several reasons mentioned in the methodology section [3.4], this study focuses only on student samfundet and Hestaghen intersections. During the site observation, I had a chance to see how people face different challenges while crossing the street. The time duration for crossing the street is less than the standard time for all users. A median separates the road around the intersection. The median function is to help people take a break before completing the second opposite side of the street. The median size is small and causes a fear of collision with traffic, which makes it difficult to wait for the second round of green lights to pass. The median size is especially challenging for those who have mobility limitations. One of the comments from the survey mentions how frightening it is to cross the main street in the student samfundet to the saint Olav hospital.

"Since there is a lot of traffic during rush hour, maybe it's a little scary to walk the street, especially the area crossing to the hospital [student samfundet intersection]."

[Comment from the survey]

During the site observation, I managed to measure the time duration of the green traffic light for pedestrians and cyclists. The result was only 15 seconds. However, the time duration causes differences in the users, especially those with difficulties with mobility and older people. This time duration is the same in all intersections, but for different reasons in student samfundet and Hestaghen intersections, the effect of time duration on the users is high. For example, crossing the street from Teknobyen Innovation Center to the Hestaghen bus stop is extremely difficult due to the timing of the traffic light. Also, due to the green light time duration, those who want to use the bus cannot reach the bus on time. During the interview, one interviewee shared her experience of how the older people try to cross the main street in the student samfundet.

"Yes, I have seen when old people rush to cross the traffic light in student samfundent the same as other people. You know, old people need special care...."

[Younger female shop worker, Age. 28]

The survey result presented in figure [10], is about how enough is the traffic light time duration to cross the main street for pedestrians and cyclists. Based on the outcome, 50 % (28 people) of the respondents responded that the period of the traffic light is medium.

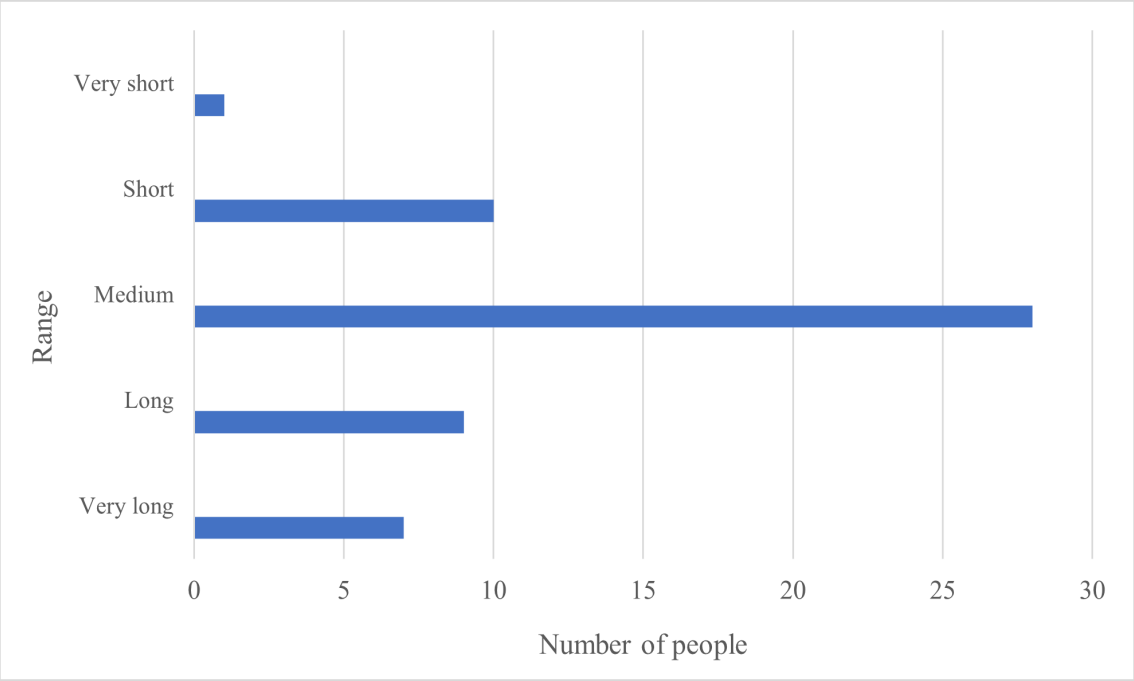

Figure 10: Crossing traffic light time duration for pedestrians and cyclists [Source: From the online survey of the study]

In Elgeseter street, all the crossings for pedestrians and cyclists are on normal surfaces. However, for the future development of the road, some optional crossings were proposed in the survey for the participants. According to the survey, more than 57% choose to keep the signalized crossing over the overpass bridges and underpass tunnels. Figure [11], illustrates the participant results for crossing types for future intersection development in the main street.

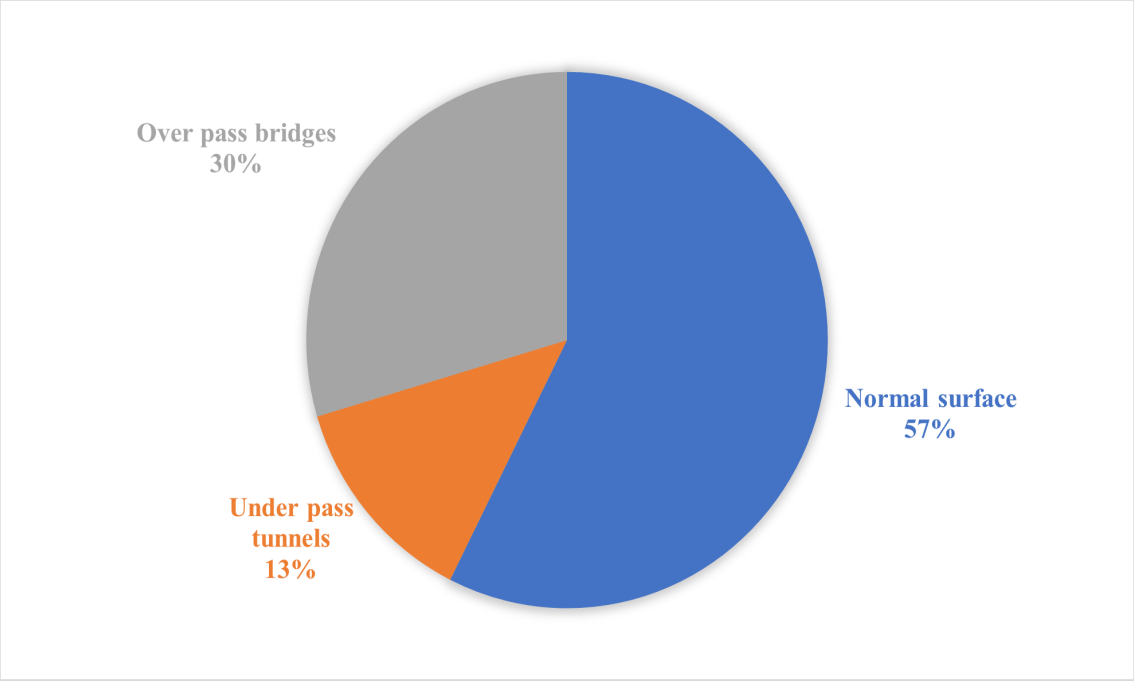

Figure 11: Crossing types for future development of the main street [Source: From the online survey of the study]

Curbs and slopes in the intersections

The damaged curbs at the intersections are one of the challenges in crossing the main street. During the site observation, I observed the effect of the damaged curbs on accessibility. The damaged curbs are especially challenging for wheelchair users and people with vision impairments. One of the interviewees shared his experience of how people with different impairments face difficulties because of the damaged curbs.

"One day, a visually disabled man was struggling to walk around the student samfundet because of the damaged curves[curbs]. The curves [curbs] should be smooth and comfortable for everyone."

[Young man–Resident in the area, Age. 26]

The slopes of the pedestrian's lane from the crossings are unsuitable for all users, especially those who have mobility limitations. I observe how the slope around the Studentsamfundet bus stop is rugged for all users during the site observation. The slope of the pedestrian lane towards the klostergata is very high. In winter, this area is very slippery, which causes difficulties for all users, especially wheelchair users and people with mobility limitations. Figure [12], shows the slippery surface of the slope in front of student samfundet.

Figure 12: The slippery surface of the slope in the student samfundet [Photo: by author]

4.3 Pedestrian lane

Elgeseter street is one of the four gates into the city center. The road is busy with traffic, but not with pedestrians. The street is not comfortable for pedestrians, including disabled users, for different reasons. First, the size of the pedestrian lane is too narrow, which is very poor for carrying the capacity of pedestrians and cyclists. Due to the closeness of the pedestrian lane to the carriageway, many people feel unsafe walking in the pedestrian lane. Figure [13], shows the damaged pedestrian lane pavement near Elgeseter Gate 30B. According to the comments from the survey, the respondents mention several reasons why the pedestrian lane is uncomfortable for pedestrians.

"Narrow pavement cluttered with light- and sign-poles, electric scooters, pavement-elevations at crossings, noise and water-splashing from passing motor vehicles."

[Comment from the survey]

"During summer and autumn, people always park their scooters in the pedestrian lane, creating an obstacle for pedestrians."

[Comment from the survey]

Figure 13: Damaged pedestrian pavement [Photo: by author]

I observed that the pedestrian lane slope is higher towards the edge of the buildings and very low towards the carriageway side during the site observation. Because of this, it causes accidents, and it becomes challenging to use the pedestrian lane during the winter when it is very slippery due to snow. In addition, the size of the pedestrian lane is very narrow in some places and very wide in others. For example, in front of Elgesetergate 30, 6, and 4 buildings the size of the pedestrian lane is less than 1.5m. Figure [18], shows one of the buildings located on the main street. Because of this building, the pedestrian lane is very narrow. During the interview, people shared the following experiences in the pedestrian lane:

"The street is not good for disabled and elderly people because the size of the walking path is too small for users. For example, during spring and summer, cyclists and electric scooters use the walking path a lot, making it very difficult to use the path for walking."

[Older female café user, Age. 48]

"Oh, this street is not good for walking and cycling because the road [Pedestrian Lane] is damaged and has small holes. Because of this, it is not common to see people in the road [pedestrian lane]."

[Younger female Restaurant worker, Age. 35]

4.4 Bike lane

A bike lane is one of the parts of modern street standards. In the case of Elgeseter, the street is without a proper bike lane. Moreover, according to the municipality regulations, using bikes and electric scooters on the main road is not allowed. The map below is the bike path in the Elgeseter area. The red line on the map shows the Klæbuveien bike lane.

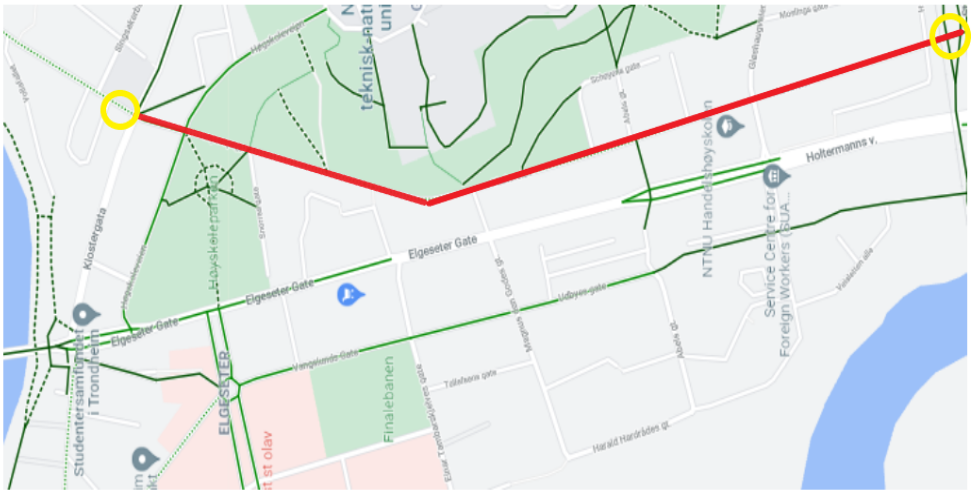

Figure 14: Current bike path in Elgeseter area [Source: Google map]

During the site observation, I observed when people were riding their bikes and scooters in the pedestrian lane of the main street. According to the survey results, 75% of respondents believe riding a bike in the pedestrian lane is difficult. The most severe problems with bike and scooter riders is speed. The speed is extremely high, making the pedestrian lane uncomfortable for all users. One of the comments on the survey illustrates how people are facing challenges because of the missing bike lane.

"Because of the bike and scooter users, the elderly and disabled people are particularly annoyed in this street."

[Comment from the survey]

Figure [15], shows the need for a separate bike lane on the main street. Around 60% of the respondents would like it if the municipality provided a bike lane. The comment on the survey states how the bike lane should be in the future in the Elgeseter street.

"There is Klæbuveien which is parallel to the Elgesetergate for a period. I would like them to build a bike lane from 30b building to Samfundet, where the bike lane will connect to the one over Elgeseter bru [bridge]".

[Comment from the survey]

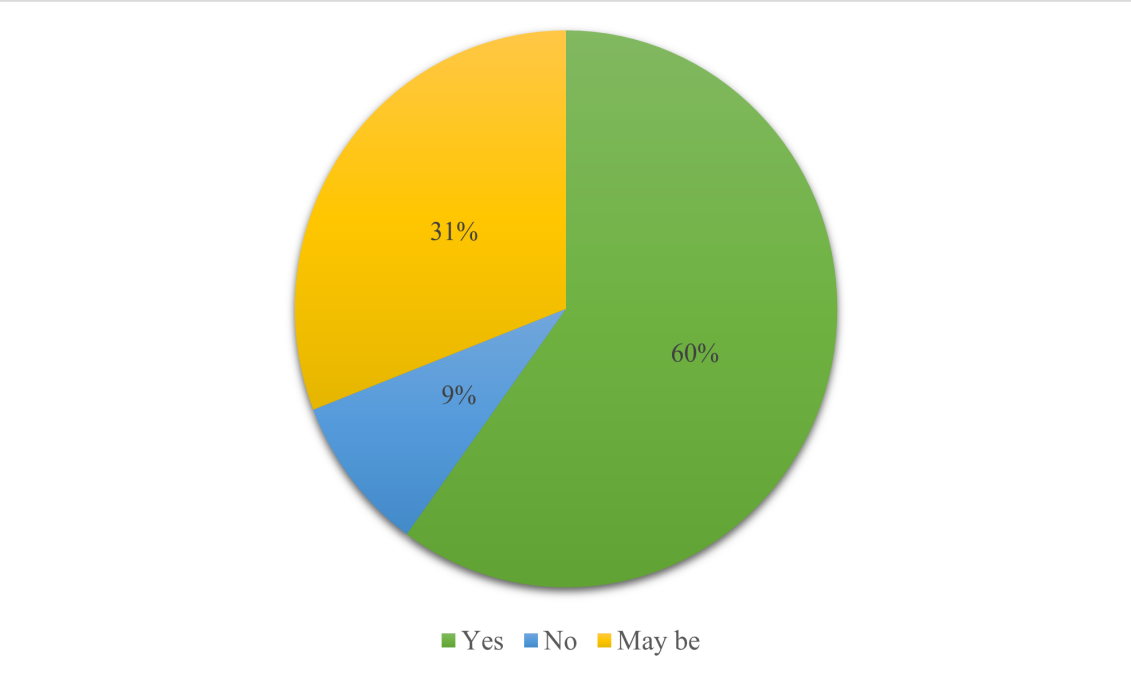

Figure 15: Providing a bike lane on the main street [Source: From the online survey of the study]

4.5 Internal and external environment of the building

According to the municipality archive data, most buildings are residential buildings, while few are commercial and mixed-use. In evaluating the accessibility of the buildings, we took Elgesetergate 13 building. The building is located on the main Elgeseter street. The evaluation includes the internal and external environment of the building. The entrance hallway, corridors, and stairs are elements in assessing the internal environment of the building. Also, The building entrances, including the stair, and door types, are assessed from the external environment. In addition, the external environment of the cafes, shops, and restaurants on the main street is assessed.

4.5.1 External environment of the building

The accessibility of the residential building is challenging for all users, especially those who have mobility limitations. I observed that the entrance were inaccessible because it is only stair. The observation covered building entrance, including the door type and stair.

As per the result of the site observation, the door of sample building Elgesetergate 13 is old and not automatic, which is very difficult to open, especially for disabled people. The doors are from the 20th century and don't meet today's entrance standards. Another challenge in the entrance is the horizontal field in the main entrance. There is no flat field that can help wheelchair users turn around and rich the door bell.

During the site observation, also, I observe the stair of the main entrance. Unfortunately, the entrance of Elgesetergate 13 is only a stair, which shows that the entrance of the building is very poor from an accessibility perspective. Figure [16], shows the main entrance, including the stair and door of Elgesetergate 13.

Figure 16: Main entrance of Elgesetergate 13 [Photo: by author]

4.5.2 Internal environment of the building

During the site observation, the internal environment was assessed for further evaluation of the accessibility of the building. The results of the site observation show that the internal environment of the buildings, including the entrance hallway, stairs, and corridors, is unpleasant for all users, especially those who have mobility difficulties. For example, during the site observation, I observed that the entrance hallway has steps that cause difficulties accessing the building. Figure [17], shows the steps in the entrance hallway of the Elgesetergate 13 building.

Figure 17: Entrance hallway of Elgesetergate 13 [Photo: by author]

The building has three floors, and it is without an elevator. The stair of the building is a winding type of stair, which is very difficult for older people and people with mobility difficulties. Also, the stair material is very slippery wooden without edge sign markings. During the site observation, we observed that the current situation of the stair does not fulfill modern standards. In figure [17], shows the stair type of the Elgesetergate 13 building.

In addition to the residential building (Elgesetergate 13), accessibility of the cafes, shops, and restaurants is assessed in the site observation and interview. During the site observation, I observed the shops and café in front of the studentsamfundet, which are not accessible for those who have mobility difficulties. One of the barriers to accessing this building is the entrance stair. There is only one restaurant on the street, which is the entrance of the building is accessible to everyone. The interview participants shared they are experience in the area, especially in the shops and cafes. The experience of the two participants is stated below:

"We like to visit this area and use the cafes and shops, but the problem is that the cafes and shops are not good for old people. For example, my wife doesn't like to come to the café here because of the entrance stairs and the toilet. It is also not comfortable."

[Older female and man café users- Tourist from Stavanger, Age 66 and 71]

"We don't have many disabled users, but we have visually impaired people who come with their families and friends. We don't have any wheelchair users."

[Younger female café worker, Age.29]

4.6 Parking space and the route to the buildings

One of the focuses of the study is the parking spaces and the route from the parking spaces to the buildings in the main streets. Unfortunately, parking spaces in the Elgesetergate area are very small. According to the results of the site observation, there is only one proper parking lot in the area. The parking is property of the Norwegian university of science and technology. Currently, the parking lot is giving service only to the students and staff of the university.

In addition to the NTNU parking, few shops and the residential buildings have their own parking's. The problem with the parking is the route from parking spaces to the main entrance of the buildings is not accessible for all users. During the site observation, I observe that people use the path to the buildings for parking their cars. Because of these reasons, the route is damaged and uncomfortable for people with mobility limitations. In addition, some of the cafes and restaurants on the main street don't have parking spaces. The absence of parking shows the area does not meet modern neighborhood standards. The participants in the interview mentioned the following experiences:

"We have parking space, and often disabled people come to our shop without any difficulties, but it is not common to see disabled people in our shop. But we have few."

[Younger female shop worker, Age.37]

"We don't have parking space, but we have customers who use a wheelchair. You can see our entrance is suitable for people. People with sight difficulties come to our restaurant with their helpers."

[Younger female Restaurant worker, Age.35]

Sub-Research question: How is the closeness of the buildings affect the accessibility?

According to the municipality archive data, Elgesetergate 30B, 6, and 4 has been closed since 2013 by the Trøndelag fylkeskommune. Currently, these buildings are out of function due to safety matters. These three buildings are from the 20th century. This study covers the detailed effects of the closeness of the buildings to the main street.

During the site observation, I observe how these three buildings' closeness affects the carriageway. Due to the location of these three buildings on the main street, the pedestrian lane is not comfortable for pedestrians. The actual distance of the buildings from the edge of the main road is less than 2 m. Figure [18], shows how the buildings are close to the main street.

Figure 18: Narrow pedestrian lane infront of Elgeseter gate 30B [Photo: by author]

According to the information from the Trøndelag fylkeskommune, director of transportation for the last 25 years, this area was under consideration for development. But due to different reasons still, the area is not developed. One of the reasons is the existence of these three buildings leads to disagreement between the decision-makers. The main issue in these buildings is either to keep them in the future development of the area as historical buildings or to demolish and expand the size of the main street.

Participants of the interview and survey were able to comment on these three buildings in the future development of the street. Strong views were expressed, especially by older participants, not to demolish the buildings.

"*No...no, you know this is our history. These buildings are among the few buildings from the 20th century in Trondheim city. Also, there are now new buildings in this area, and it is nice to keep them for future generations to show the history of the area. Therefore, we should protect them.*"

[Older man – Resident in the area, Age.60]

"Keep the subtle uniqueness (don't demolish or improve everything) but improve the offer of socializing arenas."

[Comment from the survey]

On the other side, the participants support the demolishing of the three buildings to expand the size of the main street and accommodate all the necessary lanes, including the bike lane and proper pedestrian lane.

"Yes, I agree. If the demolishing of these three buildings contributes to increasing the size of the street, why not? I fully agree. I will be happy if the municipality works to increase the size of the street and make the area inhabitable."

[Younger man - Hestaghen area, Age.30]

"Trondheim city is developing and expanding fast. The number of residents is increasing, and due to this, the traffic demands on the street are high. I can see there are old buildings on the street, restricting the width and quality of the street. Therefore, in my opinion, it is better to demolish these old buildings than reserve them for historical purposes and renovate the street to the desired quality."

[Comment from the survey]

One of the questions to the participants in the survey was if they agreed or not with providing a hallway through the Elgeseter gate 30B building. The aim of providing the hallway is for a pedestrian lane that helps to increase the size of the street. As per the result shown in figure [19], 74% of the respondents agree with providing the hallway through the building.

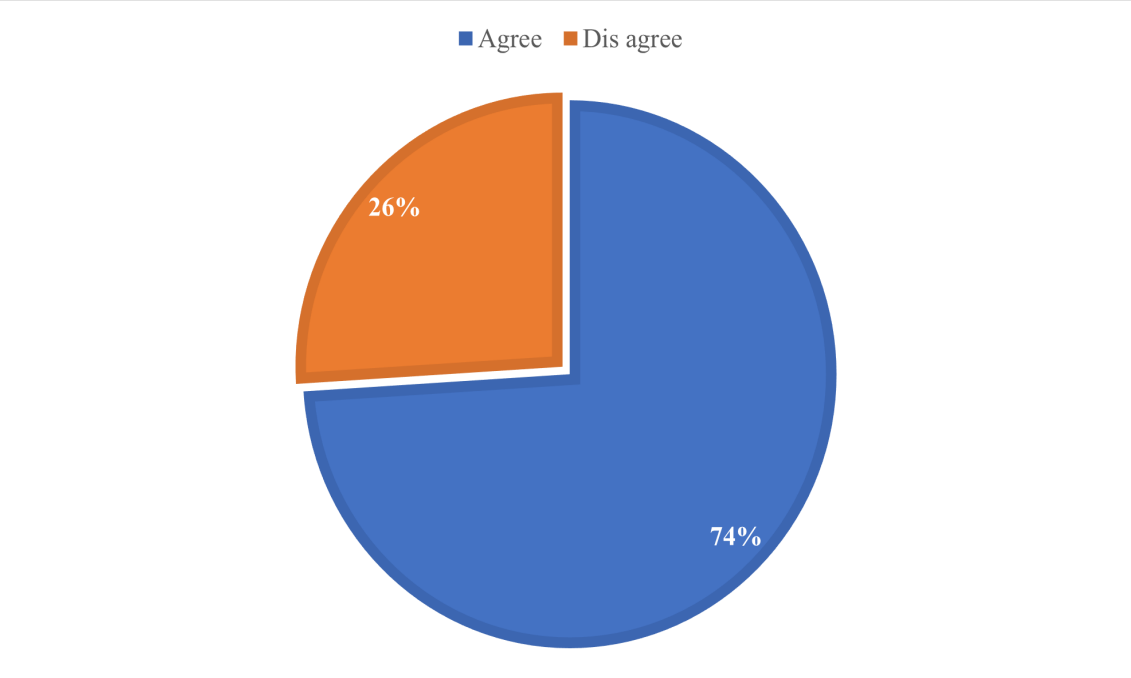

Figure 19: Providing a hallway through the Elgeseter gate 30B building [Source: From the online survey of the study]

5 Discussion

The discussion presents the theoretical and practical results to reach the goal of the research questions. Also, it includes the study's conclusion with logical suggestions to Trøndelag fylkeskommune. The discussion is divided into three based on the sub-research questions to answer the main question.

Sub-Research question: What are the accessibility barriers in Elgeseter street?

The current accessibility of the Elgeseter is challenging for everyone. One of the main reasons is the area is from the 20th century and does not fulfill the universal design standards. The survey and interview results show that people have different thoughts about the area's future development. While also keeping the architectural and heritage values of the old buildings. This study aims to evaluate the accessibility of the external and internal environment of the buildings. Additionally, the parking spaces and the main street (pedestrian lane, bike lane, and crossings) are the areas of the study.

Intersections

The intersections of the main street, including studentsamfundet and Hestaghen, are the focus of the study. The intersections have different challenges for pedestrians and bike users, especially those with mobility difficulties. The Time duration of the traffic light is one of the challenges for pedestrians and cyclists. The green light duration for pedestrians and cyclists to cross the road is only 15 seconds, which causes difficulties in crossing the carriageway on time, especially for those with mobility difficulties and older people. Furthermore, as mentioned in the result section [4.2], I observe when people, especially people with mobility limitations, rush to cross the studentsamfundet intersection. The time causes differences in the users of the street. In cities like Brussels and Paris, the average period for the crossing light for pedestrians is 25 – 30 seconds.

As stated in the theory section, one of the main reasons for the need for crossings in the urban environment is the attractiveness of places. According to [Li et al. (2013)], places that require different crossings in urban streets are those places with high attractions, for example, shopping malls, health centers, bus stations, and schools. In the case of Elgeseter street, the student samfundent intersection is the place with many bus stops, which causes a high number of pedestrians. Also, the Hestaghen intersection, one of the intersections, required different crossings. Currently, new buildings are under construction, which will cause more pedestrians in the future. This shows that in future requires a different way of crossing than the current signal-controlled crossing.

According to [Demiroz et al. (2015)], several cities confront the same problem as Elgeseter at intersections for pedestrians and cyclists. To solve this problem of crossings, they provide different measures. According to [Demiroz et al. (2015)], providing a staggered signalized crossing is one of the solutions by using the space of the median of the street. The space between the two opposites direction roads helps to take a break before crossing the second opposite direction of the Carriageway. The staggered signalized crossing is the most common solution in different cities. Also, the safety of collision between traffic and pedestrians is lesser than Normal signalized crossing. The result from the survey also shows that people prefer to have crossings on a normal surface. Using this type of crossing in the case of Elgeseter street can be the one solution for the future development of the street. But due to the size of the main Elgeseter street, it can be challenging to implement.

The second solution is to provide a different way of crossing than the signal-controlled. According to [Demiroz et al. (2015)], underpass tunnels and overpass bridges are the best solutions for pedestrian safety. But the result from the survey shows that people prefer to cross the street on a normal surface. People do not like crossing streets through underpass tunnels because of security and safety issues. Also, using overpass bridges is unacceptable to people because it requires time and additional effort. As mentioned in chapter two of the thesis [2.5.1], the issue of security and safety is the one challenge in implementing underpass tunnel crossings. According to [Anciaes and P. Jones (2018)], case study in the UK, people don't like using grade-separated crossings. The case study was conducted in London and Birmingham cities using experience from different countries worldwide. The result of the study was the same as the result of other countries, which is people

like using normal surface crossings. This case study result corresponds with the result of this thesis, Elgeseter street.

The slippery surface in front of the studentsamfundet is another accessibility challenge in the intersection. The place is located around the studentsamfundet bus stop, the connection place for pedestrians and bus users. The pedestrian path heading towards klostergata is high in grade and slippery during winter. Due to the icy surface during winter, people face difficulties crossing the studentsamfundet intersection going up to klostergata and taking a bus from the station. Exceptionally this place is difficult for those who have mobility difficulties and wheelchair users. In Trondheim, there are pedestrian paths made from heated pavements in different streets. This mechanism helps to melt the ice immediately before making icy and slippery surfaces. In the coming development of the street, applying heated pavement will be the best solution.

In the future development of the street, the traffic volume and the pedestrians influence the crossing type. Currently, there is ongoing new construction of buildings in the area. In the future, this will increase the number of pedestrians in the street. Also, if the Municipality works on improving the area, the attractiveness will become high. All these reasons push to have grade-separated crossings. In addition, the space limitation in the street does not allow for providing staggered signalized crossing. Therefore, to improve pedestrian safety in the street, providing grade-separated crossings with less effort and time is reasonable while keeping the area's heritage value.

Bike lane

Nowadays, a bike lane is one of the parts of a street that helps to accommodate bike and wheelchair users. [Parker et al. (2013)], stated that integrating bike lanes into daily life in the urban environment helps in initiating people to use bikes. Using bikes helps decrease urban air pollution and increases people's health and activities. In the case of Elgeseter, the street is inconvenient for all users due to various problems with the street. The lack of a bike lane is the one challenge in the street. The main street has only a carriageway and a pedestrian lane. According to the Municipality regulation riding a bike in the main street is not allowed. One bike lane is adjacent to the main street in klæbuveien to access the Elgeseter area. But this bike path is not connected with the one that reaches the center of Trondheim starts from Elgeseter bridge. Based on the results from the site observation, people ride their bikes in the pedestrian lane of the main street, which is extremely dangerous for pedestrians. People ride bikes on the main street because most do not want to use the klæbuveien bike path. Using the pedestrian lane of the main street is more direct to reach the center of the city than the klæbuveien bike path.

According to [Schmitz et al. (2021)], a study in Germany shows that cycling has become one of the safest modes of transport. In addition, several European cities are integrating bike lanes to achieve the United Nations Sustainable development goals by reducing the emissions from vehicle transport [Dondi et al. (2011)]. Also, to enhance a safe and accessible urban environment. Riding bikes in the pedestrian lane causes a collision with pedestrians, leading to the death of the users. Many countries take various measures to prevent the death and collision of street users. One of the actions is implementing separate bike and pedestrian lanes like in Oslo and Copenhagen cities. Oslo city is an example of cities with zero pedestrian deaths in the Nordic zone. Also, in Trondheim, some of the main streets have separate bike lanes. The result shows that most survey respondents required a separate bike lane in the main street [15]. By taking the experience from cities like Oslo, Trøndelag fylkeskommune should work on providing bike lanes in the future development of the street to accommodate all the street users.

Pedestrian lane

In the urban environment, pedestrian lanes must consider people with different types of mobility [Stoker et al. (2015)]. Pedestrian lanes are key elements in cities, but in the Elgeseter area, the pedestrian lane is not pleasant for users. The area location is in the central part of Trondheim, which is expected to be an attractive and friendly place for users. According to the results, most of the buildings in the area are residential and have few commercial buildings. The survey results show that around 74% of the respondents say they walk on the street a few times a month. Due to different reasons, the street is not comfortable; when we see it from an accessibility point of view, the pedestrian lane is uncomfortable.

A study conducted by [Rimmer et al. (2004)], states that if people are not walking in neighborhoods, they are not allowed to act. This may be due to different reasons. One of the main reasons in Elgeseter is that many neighborhood access roads are connected to the main street. Because of these roads, there are many curbs at corners. Most curbs are damaged and unpleasant for people with mobility issues, especially wheelchair users and the visually impaired. Also, the pedestrian lane pavement has holes and cracks, as shown in figure [13], which makes the street challenging for all users. In addition, the pedestrian lane lacks tactile edge guiding markings, which makes the street difficult to access for visually impaired users. Instead of walking, people prefer to use the street only to drive into the city center. Because the place's attractiveness is less, people don't have any reason to stay in the area. According to [Zegeer (2002)], Walkable pedestrian lanes are the key reason for increasing neighborhoods' attractiveness. In future development, to improve the area's attractiveness, pedestrian lanes must be one of the critical elements.

Furthermore, the area is not inclusive for all users, especially those with mobility limitations. In general, the area does not fulfill the requirements for modern neighborhoods. In the United Nations sustainable development goals, goal 11 focuses on Sustainable cities and communities [UN (2015a)]. One aim of the goal is "universal access to safe, inclusive, and accessible green and public spaces, in particular for women and children, older people, and people with disabilities." To ensure the participation of people with mobility limitations in all social life, the accessibility of the environment plays a crucial role. One of the means of accessing is a pedestrian lane. To achieve the accessibility of the area, users need enough size and a safe pedestrian lane.

Internal and external environment of the buildings

The internal and external environment of the buildings on both sides of the main Elgeseter street is another focus of the study. Most of the buildings are from the 20th century, and they are not accessible to everyone. The study covers the internal and external environment of one residential building and the external environment of the cafes, shops, and restaurants. I assessed the entrance hallway and stairs from the internal environment of the residential building. In addition, the exterior stair and door types are evaluated from the external environment of the building. Results show that the accessibility of the residential building is challenging, especially for disabled people.

Due to the old building standards, the building is not accessible for everyone, especially for disabled users. According to [TEK17 (2017)], building regulation building with three floors and above the elevator requirement is a must. The sample building, Elgeseter 13, is without an elevator, and the stair is a winding type of stair as shown in figure [17]. Winding type of stairs is not recommendable in buildings. TEK 17 building regulation (section 12 – 14) suggests that having a straight Running stair is easier to walk than a winding one. The building stair is a wooden stairs without a step edge color, and it is slippery. According to [TEK17 (2017)], the stairs edge should be visible to users with a maximum 0.04 m depth, and the surface finish material of the stairs should not be slippery. [Evcil (2009)], conducts a study on the built environment, and he concludes that stairs are the main obstacle in accessing buildings, especially for wheelchair users. As shown in figure [17], the hallway of the building is with stairs, which is challenging for people who have mobility limitations, especially wheelchair users. According to [TEK17 (2017)], (Section 12-4), the entrance hallway of buildings must be free of steps. In general, the accessibility of the internal environment of the building is challenging, and it does not meet today's standards.

From the external environment, the main entrance of the building is evaluated. The evaluation covers the accessibility of the entrance stairs and door type. As shown in the figure [16], The entrance of the building is only stairs, which is difficult for people with disability and impossible for wheelchair users to access the building. TEK 17 (section 12-16) suggests that buildings must have at least one accessible route to access, especially for wheelchair users. [Welage and Liu (2011)], states that the absence of a ramp in the built environment makes it challenging to access buildings. The absence of the ramp in the Elgeseter 13 is one of the main accessibility barriers in order to access the building, especially for wheelchair users. Also, the main entrance of the building is an old wooden door, which is difficult to open for people with different disabilities. As suggested in the [TEK17 (2017)] (section 12-13), the requirement for opening power of all doors should be easy and does not require help from others to open doors. The suggested maximum requirement for opening power is 30N. Making accessible openings ensures access to people with power difficulties,

like children, older people, wheelchair users, and people walking with aid.

In addition to the residential building, the external environment of the cafes, shops, and restaurants, was also assessed. There are a few cafes, restaurants, and shops on the main street. However, the accessibility of these places is challenging for all users; this shows the facilities in the main street are not inclusive for everyone. For example, the cafes and shops in front of the studentsamfundet are among the few places in the street. Furthermore, the main entrance of these buildings is only stairs, which is challenging for people with mobility difficulties. [TEK17 (2017)] (section 12-14), suggests that the main entrance of the buildings must be step-free, and at least one accessible route must provide to access the building entrance. Currently, the places in the main street don't fulfill the minimum requirement for entrances. Due to this reason, the area's attractiveness is less.

Parking space

Parking spaces are one of the critical elements in the built environment. Parking spaces play a vital role in increasing the attractiveness of places. For safe access to buildings, the placement of parking spaces should consider all users. In the case of the Elgeseter area, one of the problems is the availability of parking spaces. The area does not have proper public parking spaces which can accommodate all types of users. But few shops have they are own parking spaces. According to the results, most of the buildings in the area are residential buildings, which are expected to have people with different mobility characteristics. In addition, the rest of the buildings are commercial buildings. One of the main reasons for decreasing the area's attractiveness is the absence of parking spaces. Another problem is the route from the private residential buildings to the main entrances. The distance of the route from the parking spaces to the main entrance is long, which is not suitable for people with mobility difficulties.

The absence of parking spaces in the area is challenging for users, especially those with mobility limitations. According to [Evcil (2009)] studies in the built environment, the main problem for people with disabilities is the absence of accessible parking. The thesis results also show that Elgeseter has the same problem for people with disabilities. Elgeseter area is not the area for all, which causes social differences. [TEK17 (2017)] building regulation, suggests a neighborhood must have accessible public parking spaces for all users. Also, as mentioned in the theory chapter [2.5.5]„ the distance between the main entrance and the parking plots must be as short as possible. One of the themes of United Nations sustainable development goals, goal 11, is providing accessible and safe places for everyone. To achieve the aim of this goal and to make the area inclusive for everyone in the future development of the area, providing a proper parking space is necessary. Also, the route to the main entrances should be short as possible and comfortable for all.

Sub-Research question: How is the closeness of the buildings affect the accessibility?

The current size of the main Elgeseter street is inadequate to provide all necessary street elements, including a bike lane and pedestrian lane. The main reason is the location of Elgeseter 30B, 6, 4 buildings. The buildings are positioned very close to the main street. These three buildings have been closed since 2013 for different reasons; one of the reasons that I heard from the municipality is the safety of the buildings. The buildings are from the early 20th century, which requires refurbishment and protection. The buildings are the obstacles to provide bike and pedestrian lanes with current space for future street development. According to the results, these three buildings are considered to be demolished in the street future development.

To avoid the improper use of bikes in the pedestrian lane of the main street in the future project development providing a separate bike lane is the solution. I strongly oppose the decision made by the municipality to close and demolish the buildings for the development of the area. These buildings are among the few buildings which can show the architectural history of Trondheim city to the future generation. The survey and interview results also shows that most participants oppose the demolishing of the buildings. Also, from the heritage conservation regulations demolishing these buildings will raise questions from the people. According to the transport director of Trøndelag fylkeskommune, this area has been under different development decisions for the last 25 years. The buildings are among the part of the decisions. But, due to the different interests of the political parties, the final decision has not been made.

The only solution to get enough space on the main street to provide a bike lane is to create a hallway through the three buildings. Creating hallways will keep the buildings from demolishing and give enough space to provide all the elements of the street. The hallway can use for pedestrians' passage, and the current pedestrian lane can be a bike lane for the future. This hallway will make the buildings more active in the area's future rather than demolishing or keeping them closed as they are now. The buildings are three-four floors, the first floor can be the hallway, and the rest of the floors can be for cafes or shops.

What are the solutions to the accessibility barriers for all users?

Elgeseter area will never be fully accessible for everyone, but it can improve from the current level of accessibility. The old buildings are the main obstacles in order to improve the accessibility of the area. These old buildings are valuable in the environment. In addition, people want to preserve the old buildings in the street. But the requirement for accessibility will become a challenge in the area's future development. In the future development, accessibility of the area should be considered for all users while preserving the heritage value of the buildings. The accessibility improvement of Elgeseter street will increase the attractiveness of the area.

Furthermore, the development of the area should protect the heritage value of the buildings because these buildings represent the past. The inclusiveness of everyone plays a significant role in enhancing the social sustainability of the area. Therefore, Trøndelag fylkeskommune should involve all stakeholders from the designing and planning stage up to the decision making, including people with disabilities and non-disabled. Engaging different users will help in developing solutions and helps during decision-making. Most of the time, architects, engineers, and politicians decide the needs of the people in the built environment, but this is not proper. Considering all users will help improve the social sustainability of the area and the safety of different users. Therefore, I suggest the following solutions in order to make the area accessible as much as possible while keeping the heritage.

Intersections

The intersections in the main street are the other challenges in future street development. Based on the current situation, the time duration of the light for pedestrians and cyclists is not suitable for all users. In the future development of the street, the intersections require a different way of crossing than the current signal-controlled crossing. Because the existing crossing is not in consideration of everyone, in the future, as the main street ahead of the city center, the traffic may become high. Also, due to the development of the area, the attractiveness of the area will increase, and this will increase the number of pedestrians in the street. The recommendable solutions provide staggered signal-controlled crossings because people like to cross on normal surfaces rather than grade-separated. As an option, if providing staggered signal-controlled crossings becomes challenging to implement, the other choice is grade-separated crossings, but people dislike them.

The slippery surface toward klostergata in front of the studentsamfundet building is challenging [12]. This area is where people take buses, and during winter, it is very slippery due to ice. Especially for people who use a wheelchair, the surface is very risky. As mentioned in the theory chapter [2.5.2], different cities implement the heated pavement way of removing ice from the pavement to increase the safety of pedestrians. Removing ice using heated pavement from pedestrian lanes is also implemented in other streets in Trondheim city. In Trondheim, pedestrian paths are made from heated pavements in different streets. This mechanism helps melt the ice immediately before making icy and slippery surfaces. In the future development of the street, applying heated pavement will be the best solution.

Bike and pedestrian lane

First, the major challenge with the size of the street is the lack of bike lanes. The main street cannot develop in the future without a bike lane. To increase the area's attractiveness and create a livable place bike lane should be provided in the main street rather than the adjacent klæbuveien path. People don't like using the klæbuveien path because the path does not connect to the bike Lane that goes to the city center, which starts from Elgeseter bridge. Providing bike lanes will enhance the safety of pedestrians and cyclists in the development of the project.

The second challenge in the area is the suitability of the pedestrian lane. The size of the pedestrian lane varies within the street due to the position of the buildings. In most parts of the street, the size of the pedestrian lane is more than enough. But in front of Elgeseter 30B, 6, and 4 buildings, the size of the pedestrian lane is small. To increase the size of the pedestrian lane, as mentioned chapter [5] creating a hallway through the buildings is the better solution. Creating a hallway will make the buildings multi-functional, keeping them from demolishing and providing enough space for a pedestrian lane.

Internal and external environment of the building

In addition to the one-sample building of the study (Elgeseter gate 13), most of the buildings are not accessible to everyone. In the future, this building cannot be fully accessible due to the current space and flexibility of the buildings. Also, to keep the buildings' architectural value, providing access to all floors of the buildings will be challenging. Therefore, the better solution is to improve the entrances of the first floors of all buildings so people can access and use the first floor of the buildings. This solution is also for the cafes, shops, and restaurants on the main street. For example, the existing entrance of the Lille Thailand restaurant is accessible for everyone because the building entrance is in the consideration for wheelchair users.

Parking spaces

Currently, the Elgeseter area is challenging for everyone due to the absence of parking spaces. Therefore, parking spaces should be considered one key element of the neighborhood in the future development to increase the area's attractiveness. Also, the route from the parking spaces to the main entrance of the buildings must consider all users. In addition, the parking spaces must-have reserved places for disabled users.

5.1 Conclusion

So, how can Elgeseter be accessible for everyone? How will improve the current accessibility of Elgeseter street in a sustainable way for all users while keeping the heritage value of the buildings? Elgeseter is one of the old-built environments in Trondheim city. However, the accessibility of the area is not inclusive due to several reasons: The crossings, including studentsamfundet and Hestaghen, are the challenges in accessing the area. Especially in studentsamfundet, the number of pedestrians is high, and the time of crossing for pedestrians is not proportional to the users with different mobilities. Therefore, providing a different way of crossing than the current signal-controlled will be the recommendable solution to increase the safety of pedestrians and cyclists. But, as I argued in the discussion section, this solution might be challenging to implement due to various reasons. One of the main reasons is these different ways of crossing are universally disliked. Also, the results of this thesis show that people in Trondheim like using signal-controlled crossings. Another reason is the space for providing the different ways of crossings. The size of the main street will be challenging, especially in providing a staggered signal-controlled crossing. Therefore, the interest of different users with different mobility types should be considered in designing and planning future crossings in the area.

Elgeseter Gate 30B, 6, and 4 are one of the reasons for the size of the main street. As I argued in the discussion section, the buildings are positioned very close to the main street. Due to the location of the buildings, the street did not have a bike lane and the pedestrian lane is not adequate. The result shows that many people argue not to demolish these three buildings, while others agree on demolishing and increasing the size of the main street. Therefore, the existence of these buildings becomes questionable for the project's decision for future development. To fulfill the concern of the various groups keeping the buildings and increasing the size of the main street will be the best solution. Building a hallway for pedestrians through the first floor of the buildings is the recommendable solution for increasing the street size. Also, this helps to get enough space for providing a bike lane. Providing a hallway will protect the buildings from demolishing to increase the size of the street.

The buildings' current internal and external environment is challenging for everyone, especially those who have mobility limitations. Making this old building accessible for everyone needs high-level modification to the structural elements. In addition, improving the buildings may cause changing their architectural value. Moreover, the cost of improving the internal environment of the buildings will not be economical. Therefore, the accessibility to the buildings cannot be fully accessible to everyone in the future. But it can be possible to provide access at least to the first floor of all old buildings. In addition to the buildings, the current parking spaces in the area do not consider all users. In order to increase the attractiveness of the area and fulfill the neighborhood's modern standards, providing accessible parking is recommendable. Also, the route from the parking spaces to the entrance should consider all users.

5.2 Future work

This thesis covers identifying the accessibility barriers in the Elgeseter area and their sustainable solutions for everyone while keeping the heritage value of the buildings. The following recommendations are suggested for further studies.

- This thesis distinguishes the accessibility barriers for everyone, including disabled users. It is recommendable to involve people from all kinds of groups in future studies, for example, people who don't have the chance to choose solutions and make decisions in public projects.
- Different studies show that the involvement of political parties makes it challenging for the decision-making of projects. This reason may also affect the decision-making of the future development of the Elgeseter area. Therefore, it is reasonable to understand the political parties' perceptions and interests in this project's future development.
- In this thesis, several solutions are suggested based on several studies on the accessibility of the built environment. It is recommendable in future studies to analyze in detail the economic advantages of the different solutions.

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Appendix

A Appendix

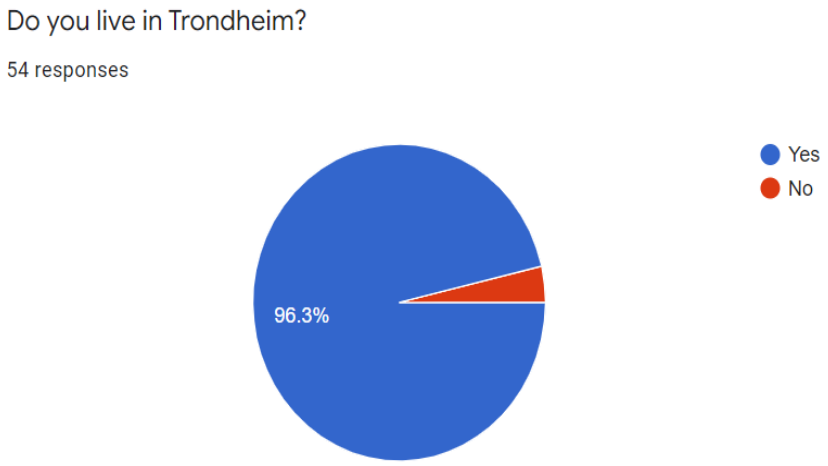
Online survey questions

1	What is your age group? [Age]
2	What is your gender? [Male, Female, Other]
3	Do you live in Trondheim? [Yes, No]
4	How well do you know Elgeseter gate? [Range]
5	How often do you walk down (parts of) the street? [A few times a month, Once a week, A few times a week, Many times a week]
6	How do you evaluate your walking experience on Elgesetergate? [Range]
7	Is it difficult to use a bicycle in the pedestrian lane? If not, why? [Yes, No]
8	Do you like it if the municipality provides a bike lane beside the pedestrian lane? [Yes, No]
9	How do you think about the crossing traffic light time duration for pedestrians? [Range]
10	Do you feel safe crossing the street? If not, why? [Yes, No]
11	If you have a possibility to change the type of crossings on Elgesetergate, which one do you prefer? [Over pass bridges, Underpass tunnels, On normal surface]
12	How good do you think is the accessibility of the Elgesetergate area for disabled users? [Range]
13	Have you seen any difficulties for disabled users on this street? if you have seen it? What kind of difficulties? [Yes, No]
14	Do you agree if the municipality provides a hallway for pedestrians through the Elgeseter gate 30B building? [Agree, Not agree]
15	How good do you think is the availability of Pedestrian signage on the street? [Range]
16	What is your opinion about the feasibility of accessing the old buildings' entrances for all users (for example disabled persons, the elderly, and young families with small children)?
17	Do you have any comments if the municipality wants to upgrade the road?

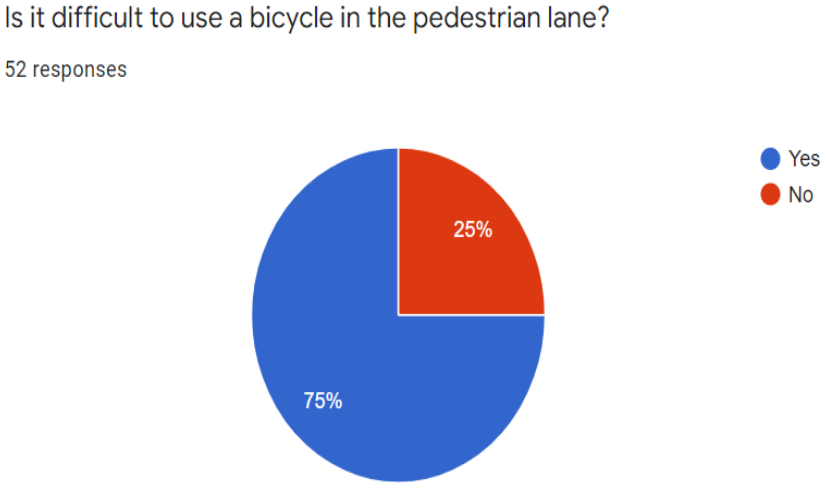
B Appendix

Result from the online survey

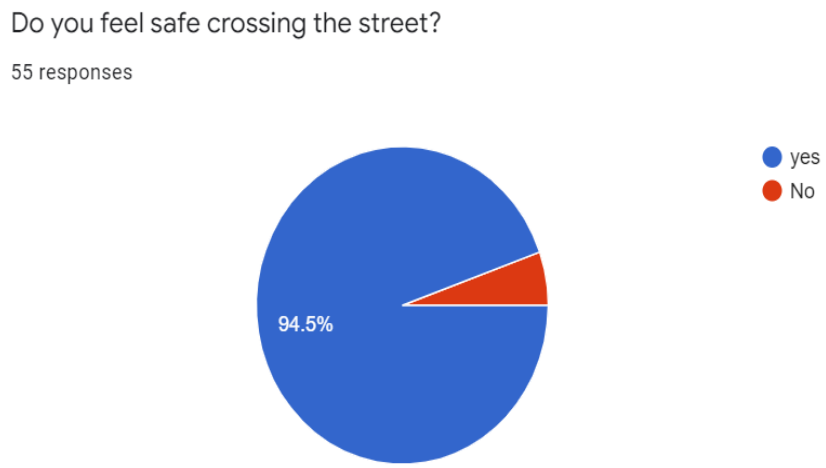
1,



2,


Is it difficult to use a bicycle in the pedestrian lane?
52 responses
25%
75%
Yes
No

3,

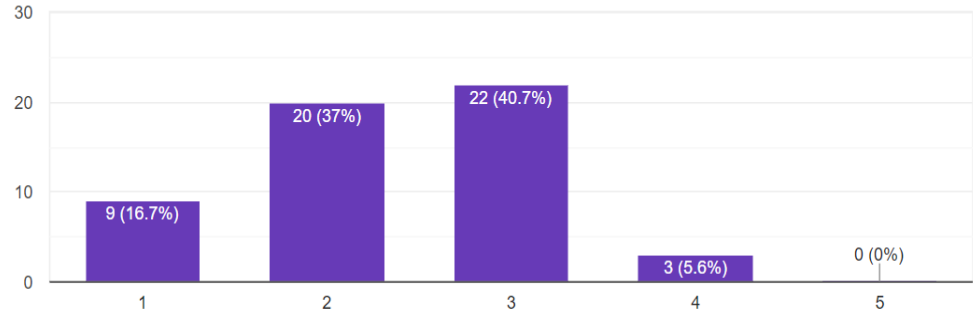

Do you feel safe crossing the street?
55 responses
94.5%
yes
No

4,

How good do you think is the accessibility of the Elgesetergate area for disabled users?

Copy

54 responses

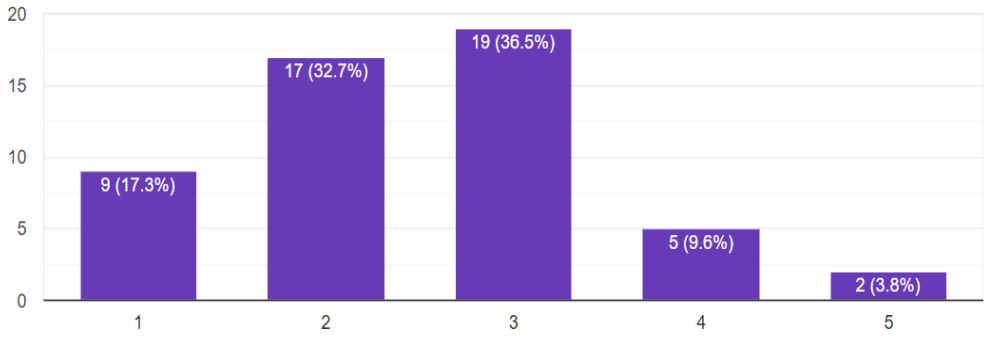


5,

What is your opinion about the feasibility of accessing the old buildings' entrances for all users (for example disable persons, elderly, young families with small children)?

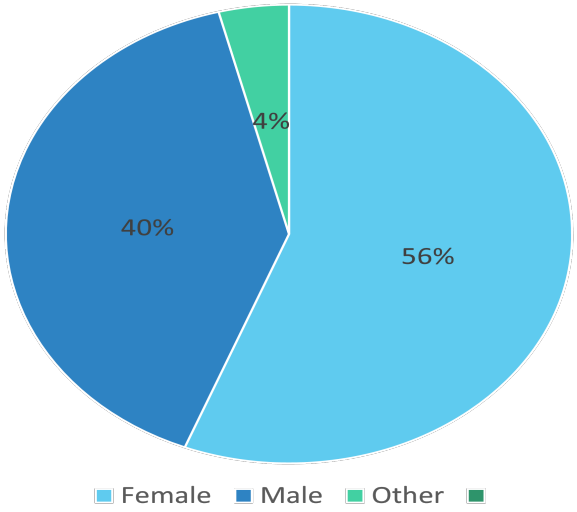
Copy

52 responses



6,

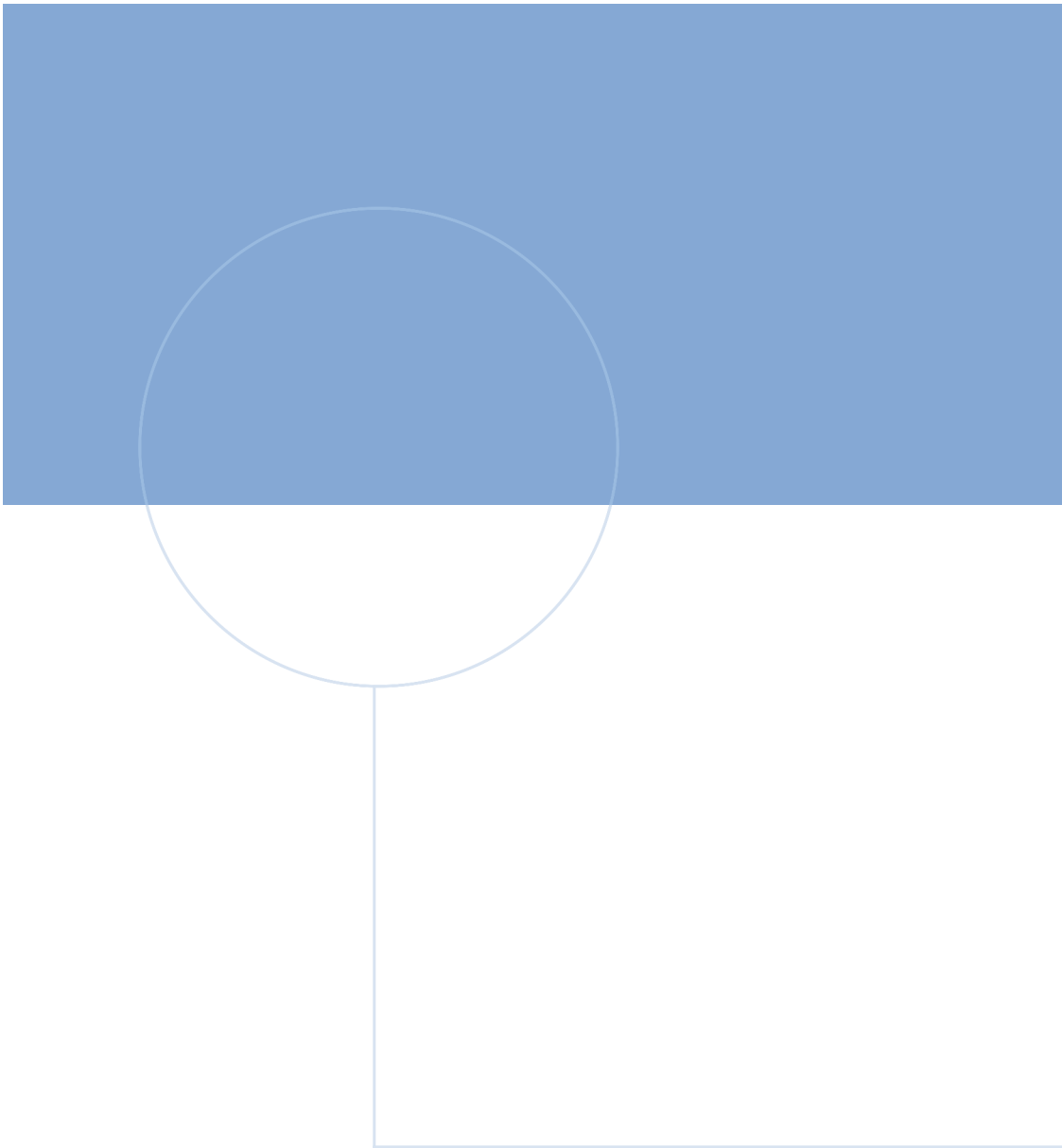
What is your gender?



C Appendix

Semi- structured interview questions

1	Have you seen any difficulties for disabled users on this street? If you see, what kind of difficulties?
2	Do you have any disabled neighborhoods? If so, how good do you think the external environment is for them, including the entrances, parking spaces, and routes to the buildings?
3	How good do you think is the accessibility of the Elgesetergate area for disabled users?
4	If you have a possibility to change the type of crossings on Elgesetergate, which on do you prefer? [Overpass bridges, Underpass tunnels, On normal surface] Reason?
5	Do you agree if Trøndelag fylkeskommune wants to demolish Elgesetergate 4, 6, and 30B for increasing the size of the main street? Or do you have any ideas?
6	Do you have parking spaces for everyone including disabled users?
7	If you have any comments?
Thank you so much for taking part	



NTNU

Norwegian University of
Science and Technology