# Searching for ways of improving usability, accessibility and safety for sight impaired people in complex transport environments

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**Abstract.** Within the ideals of universal design, built environments should be designed in ways allowing sight impaired people to orient themselves and find their ways in the transport system without excessive use of specialized tactile paving. In the Norwegian debate, two issues regarding the design of streets and pavements and of public transport stops and terminals are of particular concern for the responsible authorities: Tactile paving seems to be implemented in situations where more thoughtful design could have better ensured usability, accessibility and safety for sight impaired persons, and; lack of consistency where tactile paving is laid out. The aim of this paper is to discuss how and why some planning- and design processes produce such results, and to suggest ways of improving the situation.

**Keywords.** Wayfinding, sight impaired, usability, standards, planning.

## 1 Introduction

Making transport systems accessible, usable and safe for visually impaired people is an important part of creating an inclusive society. In their efforts towards such a society, many governments have introduced the concept of Universal Design (UD) in their transportation planning systems during the last decade or so [1].

The concept of UD has no one definition and is subject to different interpretations across countries, sectors and disciplines. The United Nations' Convention on the Rights of Persons with Disabilities [2] offers the following definition (Article 2): *"Universal design" means the design of products, environments, programmes and services to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design.* A term closely related to UD and which is sometimes used interchangeably with it is *accessibility for all.*

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## *1.1 Facilitating usable transport environments for visually impaired people*

Wayfinding is a key element in the everyday journeys, of various lengths and complexity, which form a natural and important part of most people's lives. Wayfinding is defined by Farr et al [3] as *"the process of finding your way to a destination in a familiar or unfamiliar setting by using cues given by the environment*". This process is so commonplace that it often is perceived as simple. In reality, Farr et al. claim, wayfinding is a deeply complex process, involving our cognitive abilities and use of all senses, as well as interaction between human and environmental factors.

Lynch [4] discusses five elements of mental mapping: Paths (familiar streets, walkways, bus lines), edges (physical barriers of walls, fences, rivers, or shoreline), districts (places with a distinct identity), nodes (major intersection or meeting places) and landmarks (tall, visible structures that allow you to orient over long distances). Use of sight is generally acknowledged to be the most effective way to gather information about the environment. However, this presents difficulties for those with a visual impairment. For those with some sight loss, greater reliance on information through sounds, smells and changes in surfaces is necessitated, whilst totally blind people will rely entirely on these non-visual sources.

Visually impaired people often learn about a new area or route together with a sighted companion. When learning a route, usable reference points and tactile street elements are identified which can be useful in orientation and wayfinding. The person learns to follow a chain of such elements, which can be termed *lead line*. A lead line is often defined as a chain of natural and built leading elements that is easy to follow for visually impaired people, where elements provide visual and tactile information that is easy to recognise and understand [5,6]. This can be well defined kerbs, tactile differences between surfaces, a fountain or a crossing.

In order to increase awareness and knowledge of UD throughout the professions, treaties and legislations have translated into handbooks and manuals for UD provision in the transport and building sectors, among others. The current Norwegian planning framework demands that all new infrastructure investments and buildings must be universally designed [7].

A universally designed travel chain is usable also for visually impaired people. This includes that they find their way, feel safe, and are not exposed to dangerous situations. Norwegian standards, handbooks and guidelines (hereafter collectively termed *standards*) emphasise that this among others includes continuous lead lines to follow. The standards distinguish between *natural* and *artificial* lead lines. Natural lead lines are elements naturally belonging in the environment, such as facades or kerbs. Artificial lead lines are those which solely serve the purpose of guiding visually impaired people, and which have a standardised design, often termed tactile walking surface indicators or tactile paving in the English language literature

Within the ideals of universal design, the built environment should be designed such that all people including the visually impaired can orient themselves and find their way without specialized tactile paving. It is, however, acknowledged that particular circumstances require special fittings and tactile paving to warn, guide or inform sight impaired people. Where tactile paving is used, homogeneity and consistency are imperative to ensure that the message they convey is clear.

### *1.2 Research questions*

In the Norwegian debate, two concerns regarding the design of street environments, as well as public transport stops and terminals, are of special concern to the responsible authorities: Tactile paving seems to be chosen as the solution in situations where more thoughtful design could have better ensured usability, accessibility and safety for visually impaired persons, and; Lack of homogeneity and consistency where tactile paving is laid out - tactile paving systems are often neither logical nor homogenous.

The main research questions that this paper aims at answering are therefore: 1) How and why are some planning- and design-processes producing such non-optimal results? and; 2) How can the situation be improved? In our readings, we found no studies covering this issue.

## 2 Theoretical framework

If streets, terminals, bus stops, etc. are to be accessible and usable also for visually impaired people, certain qualities are required [5,6,8,9,10]: Simple and logical organization of the physical environment; Short distances; Obstacle-free walkways; Warning if danger; Smooth, even paving; Crosswalks perpendicular to the kerb; Proper lighting; Strong tonal contrasts; A coherent system of natural lead lines complemented with tactile paving where necessary.

The usability, accessibility and safety of streetscapes depend not only on how they are built, but also on how they are operated and maintained. This, in turn, depends on how they are planned and designed. In order for those designing, planning, projecting, and constructing various parts of the pedestrian environment to consciously and coherently be able to shape physical environments in ways making them usable and accessible for visually impaired people, they need to possess the necessary knowledge and expertise. To help provide this, standards are developed, intended to contribute to ensuring streetscapes are coherently designed, and that usability for visually impaired people is given priority in competition with other considerations. In order for standards to contribute to usable, accessible and safe environments, they need to be based on sound practical and scientific knowledge on how visually impaired people orient themselves, find their way and use different elements in the environment for this. Further, they need to translate this knowledge into relevant and usable requirements and recommendations.

As many have experienced, built environments don’t always meet the requirements for being usable, accessible and safe for visually impaired people. This could be due to one or more of the above pre-conditions not being met.

## 3 Research design and methods

### *3.1 Research design*

In order to answer the research questions, a research design was chosen which scrutinize how qualities of the scientific knowledge base, of standards, handbooks and guidelines, as well as of practice affect qualities of the built environment. This consists of three distinct parts.

Examination of the scientific knowledge with respect to whether it offers sound and accessible knowledge regarding: i) How visually impaired people orient themselves and find their way with the help of cues given by the environment, and ii) How characteristics of the built environment affect the usability, accessibility and safety for visually impaired people

Norwegian standards, handbooks and guidelines were analysed with respect to whether they i) recommend use of natural rather than artificial lead lines in street designs, ii) present recommendations that actually point in the direction ensuring usable, accessible and safe environments for visually impaired people, ii) are consistent with each other and other foreign or international standards, and the scientific literature, iii) and include the type of situations often faced by practitioners and are thus usable, clear and understandable to those who use them.

Concerning practice, the research was directed towards disclosing: i) which knowledge and understandings that form the basis for practice; ii) whether there are disagreements over knowledge or lack of knowledge among practitioners, iii) if and how practitioners use standards, iv) how stakeholders involved, as well as procedures of planning- and design-processes, affect the results, and v) if other considerations are given higher priority than usability for visually impaired persons

The findings were used in analyses aiming at disclosing how and why these factors can explain deviations between ideals of universal design and the actual built environment. Based on this, recommendations for how the situation can be improved were developed.

### *3.2 Methods*

Several complementary approaches are applied in order to gather relevant data: Literature studies, Documents studies; Interviews with relevant actors; stakeholder seminars; and a Case study.

The literature review compiles a large body of research literature concerning facilitation for the visually impaired. In the documents studies, standards, handbooks and guidelines produced by Norwegian national and municipal authorities and by user organisations were reviewed, as well as similar documents from Sweden, Denmark, UK, and international bodies. In total, 36 such documents were reviewed.

Semi-structured in-depth interviews were made with authorities responsible for developing standards, organisations representing visually impaired people, and practitioners involved in planning, designing, building and maintaining built environments. All together, 20 persons were interviewed. Two seminars with relevant stakeholders involved in or working with facilitation for visually impaired people were conducted. In the first seminar (with 26 participants) we asked for input and contributions to preliminary findings, while the second seminar (21 participants) served as a quality control of findings and conclusions.

Finally, a case study was conducted, where the aim was to examine whether and how the mechanisms disclosed through the previous work act out in a concrete bus terminal project in the city of Bergen. More details about the methods are to be found in the project report [11].

## 4 Findings

### *4.1 Scientific knowledge*

The literature review revealed that research mainly focuses on tactile paving, and how visually impaired people use these [e.g. 10,12,13,14]. Little empirical research relates to how the built environment should be organised and designed in order for people with sight loss to navigate and find their way. One important exception is Atkin [8], presenting results of empirical studies regarding how people with different grades of sight loss and different assistive devices make use of artificial and natural lead lines in the built environment. Atkin [8] stresses that visually impaired people will have the best premise for safe orientation if the built environment is predictable, with even surfaces and unobstructed paths. Ståhl and Almén [10] found that natural guiding elements are superior to the artificial when it comes to orientation and wayfinding. It is, however, crucial that these natural elements are designed so that gaps are avoided, as this will break the continuous line visually impaired people need in order to orient.

### *4.2 Standards, handbooks and guidelines*

Studies of standards, handbooks and guidelines from Norway, Sweden, Denmark, UK and international bodies revealed that the ideals of universal design are more or less similar in these countries [5,6,9,15,16,17,18,19]. They all recommend or take for granted that natural lead lines are the first choice and best solution, and they stress that standardised tactile paving should be used only if it is hard to achieve adequate lead lines with the help of natural elements alone and where warning is required.

Still, standards are not very detailed and specific in their recommendations on how built environments should be designed so that usability, accessibility and safety are achieved with natural lead lines. There is a general lack of descriptions, examples and illustrations of facilitation addressing these issues. The NPRA’s handbook [6] mentions the use of natural guiding elements specifically in one page, while the use of artificial lead lines has its own subchapter consisting of six pages. Tactile paving system elements are mentioned throughout the handbook in various settings, while natural lead lines are not. The ISO-standard [16] has one sentence regarding natural lead lines, while the remainder of the standard is dedicated to tactile paving. Further, it is sometimes difficult to interpret what the different standards define as natural and artificial lead lines, and how the different elements should be used and combined.

Guidance with respect to tactile paving solutions is described in much more detail and with many examples in the standards. Recommendations on when tactile paving *should* and *should not* be implemented are often diffuse, or missing. A reader could understand the standards to recommend use of tactile paving in numerous situations where interviewees stressed that natural leading should be the first choice. Even though tactile paving is described in much detail, these descriptions represent mainly simple and ideal situations - the standards don’t address the many complex situations that are present in real life. This was emphasized as a problem during interviews with practitioners.

The Norwegian and Nordic standards are relatively coherent when it comes to the physical design of the tactile paving, and what the different patterns shall indicate [5,6,9,15,17,18], i.e. guiding path surfaces, warning surfaces and information surfaces, even though there are some minor differences in the details. This differs from the UK, where no less than seven different tactile patterns, indicating different hazardous situations, guidance and information, are in use [20]. This could add to the potential for confusion and mis-interpretation of the standards. It was found some Norwegian standards, reported to be used by practitioners are outdated, while others recommend solutions that are in certain respects deviating from the national standards or current knowledge.

Further, recommended solutions are rarely sufficiently justified and explained. For instance, concerning pedestrian crossings, it is especially critical that the standards are clear, and that the practitioners understand the security risks of deviating from the norm. It was found that standards are not clear on the fact that crossings should be placed perpendicular to the kerb. Neither do they explain why: Blind people often orient themselves in crossings by place both feet on the kerb to identify the direction over the crossing. If the crossing is placed at a curve, they may end up walking obliquely over the crossing and end up in the middle of the intersection not knowing where the sidewalk is. Needless to say, this is dangerous. This is hardly mentioned in guidelines. Practitioners also emphasise their troubles with designing pedestrian crossings, since there are so many considerations that need to be kept in mind. They claim that the standards do not present ways of solving the complex situations they often face in their practice.

Based on these observations, it was concluded that current standards, handbooks and guidelines are not sufficient to encourage practitioners to emphasise natural lead lines as the preferred solution and ensure consistency in tactile paving systems.

### *4.3 Practice*

Even though standards have their shortcomings, the performance of those planning, designing, building, operating and maintaining the built environment also play a big part in the level of usability achieved for visually impaired people.

In general, the practitioners interviewed for the study demonstrated good knowledge of the basic principles in universal design, and they regard it as a part of their professional knowledge base. However, they claim that most people working in this field do not have the same level of knowledge with respect to universal design and facilitating for visually impaired persons.

All practitioners agreed that tactile paving is used too frequently and that tactile and visual information mainly should be used to warn danger. This is in line with the ideals of universal design. Practitioners explain that they would rather try to facilitate the environment without use of tactile paving. Still, they admit to often using tactile paving as the solution when upgrading or building new environments. The explanation for this is often related to the complexity of the situation, and problems of finding good solutions by using natural leading elements. They report that they mainly use standards for double-checking specific requirements, such as minimum and maximum heights of dropped kerbs.

Practitioners explain that they frequently encounter difficult and complex situations where implementing optimal facilitation might be hard, or even impossible. They complain that standards and the like often are not very helpful in these situations, since they mainly present examples and recommendations fitted for ideal and simple situations. Hence, they often need to develop solutions fitted for the specific context, and without guidance from standards.

Another problem, causing sub-optimal solutions, is that considerations regarding universal design in general are considered too late in the planning and design processes. Many decisions are made in zoning plan processes, where the necessary level of detail is not considered. When landscape architects and architects later in the design process aim at universal design, they find that decisions made earlier in the process strongly hamper the possibilities for designing streetscapes, public transport stops and crossings in ways that are usable for all. Further, the practitioners stress that there are always many considerations to take into account in a project, meaning that there is a constant struggle regarding prioritisation between various groups, values and objectives such as aesthetics, technical solutions, economics, facilitation for wheelchair-users, and more.

Practitioners find that user consultations are necessary, often useful, and in many ways a good thing altogether. Still, many also found that such processes may be frustrating, in various ways. Some designers treat local users as experts in universal design, and lean on them for advice when dealing with complex design problems. Users are, however, normally not experts in this field, and may give advice that leads to solutions that designers are later criticized for. Several of the practitioners claimed that users involved pushed for tactile paving in situations when the practitioners found this to be un-necessary or not the best solution. Others had experiences that local users complained to the press or to politicians when they did not get their will through, for instance regarding tactile paving. The practitioners saw this as un-professional behaviour. In the stakeholder seminars, it was concluded that these experiences demonstrate the need to clarify the role of users and user consultations in such processes. It was emphasised that designers should not expect users to be experts or to behave as professionals, since this is not in accordance with their role.

Finally, the case study of a developer with high ambitions regarding universal design revealed that focus on universal design from the start, involvement of competent and confident professionals during design and construction, as well as knowledgeable supervision throughout the project, increases the chances of arriving at built environments that are usable for visually impaired persons.

Still, the case study illustrated perfectly how even projects with the best possible basis for universal design also may include solutions that are far from optimal. This could be illustrated by two examples. One is the use of tactile paving leading towards a revolving door, which can be a difficult object to pass for visually impaired people. The designers saw, in retrospect, that this is not an optimal solution (that is why alternative doors are required), but explained that standards did not address this issue and that they hadn't considered whether this was a good solution. Another example regards a pedestrian crossing with different tactile paving design on each side. The explanation for this was that one side of the crossing was completed years prior as part of another project, and the design was based on older recommendations. This underlines the fact that cities are continuously built and developed, according to varying requirements. The edges of a project always meet the edges of other (previous) projects. Solutions chosen in other project areas might affect the usability altogether. Sometimes it might not be difficult to merge the natural reference points or tactile paving. In other situations, the solutions chosen in other project areas can greatly disturb the usability for the visually impaired.

## 5 Discussion: What are the main explanations when the built environment is not usable?

The aim of this research was to arrive at explanations how and why tactile paving is often used in situations where natural lead lines would be a better solution, and why there is a lack of consistency in tactile paving systems. Based on the empirical findings of this study, some explanations can be suggested.

*5.1 How and why is tactile paving used where natural lead lines would be a better solution?*

Seen from the point of view of practitioners, they often face complex situations where several considerations need to be taken into account, and they seek to solve the situations in the best way they can. They may face situations where they introduce changes of elements in already existing streetscapes, and where main structures are already in place, or they may be presented a zoning plan where sub-optimal schemes (with respect to universal design) has already been decided upon. The practitioners might anyhow aim at using natural elements to form lead lines that are usable and safe, helping visually impaired people to orient and find their way. They rely on their education, previous experiences, and discussions with knowledgeable colleagues, and they consult standards, guidelines and handbooks. When turning to such documents, they find thorough descriptions of artificial lead lines or tactile paving, but only brief and vague descriptions for how to solve the situation with the help of natural lead lines. This is one reason for choosing artificial lead lines.

Practitioners do also encounter local users participating in the design processes pushing for tactile paving. When designers turn to the standards, they are vague and not a good tool for convincing the users that natural lead lines are a better solution in the specific case. If conscientious practitioners turn to scientific literature for help, they will not find compelling evidence there either. Knowing that users may complain to press or to politicians, and lacking documented evidence or clear recommendations for using natural lead lines, practitioners may choose tactile paving even though they don’t find this to be the better solution.

These mechanisms seem, from our studies, to be important parts of the explanations of how and why tactile paving is used more frequently than most of those interviewed find optimal. Another relevant explanation is that many practitioners are not very knowledgeable with respect to these issues, and believe that tactile paving is the better solution. If they turn to available standards, guidelines and handbooks, such believes might seem to be affirmed.

*5.2 Why do inconsistencies in systems of tactile paving occur?*

Turning to the problem of lack of consistency with respect to tactile paving, many of the same elements play a part. Practitioners face complex situations where many considerations need to be made. When turning to standards and the like, they find recommendations and examples from simple and ideal situations, which are not helpful. Hence, they need to figure out how to solve the situation on their own. If they are of a conscientious kind, they may read the standards carefully, or they may turn to research literature in order to figure out how visually impaired people orient themselves and what needs to be emphasised when doing the local adjustments. As found in our studies, this will not be helpful. Hence, the practitioners need to develop on the spot solutions based on their personal understanding of how people with sight loss orient and find their way, and how the built environment should be designed in order to be usable for them. Needless to say, the results are deviating designs and hence inconsistent systems of tactile paving. Further, as demonstrated by the case study, streetscapes are continuously built, and standards as well as ideas of what are good solutions vary over time. This is also an important part of the explanation. Yet another explanation is that some practitioners use old and outdated standards, which may recommend tactile paving designs deviating from current standards.

All standards and all interviewees agreed that tactile paving should be used to warn against stairs and pedestrians crossing. The studies revealed quite a severe problem - that the practice of using warning surfaces to demarcate dropped kerbs at crossings anyhow varies strongly. There are variations in designs, and in many cases warning surfaces are missing. In one example, a stretch of an urban street was re-built with warning surfaces demarcating some crossings but not in others. In another example, warning surfaces were missing in connection with a traffic light-regulated pedestrian crossing being part of the main pedestrian street in Oslo, rebuilt only five years ago. One explanation for this, we were told in interviews, was that the responsible authorities in Oslo didn't believe that visually impaired people are able to detect these warning surfaces, or that "they don't use them". Another suggestion was "sloppy work and project management". Unfortunately, the responsible authorities were not available to be interviewed.

## 6 Main recommendations

An important finding in this work is a lack of systematic and research-based knowledge on how people with sight loss orient and find their way in complex transport environments, how they use elements of the physical environment in these processes, and hence how the built environment ought to be designed in order to be usable for people with sight losses. The strongest recommendation is hence that more systematic research on these issues should be conducted, and to make this knowledge available to those developing standards, guidelines and handbooks, as well as to practitioners. Institutions engaged in mobility training for the blind and visually impaired may be useful partners in such work.

Regarding standards, guidelines and handbooks, they should present more comprehensive and specific descriptions on how to design usable built environments, allowing easy and safe wayfinding for the visually impaired, and how the use of natural lead lines could be used to reinforce this. The standards should contain more, better and concrete discussions, examples, and illustrations of good facilitation.

The balance between the focus on tactile paving and natural lead lines should be shifted towards natural lead lines. Further, standards need to explain and justify recommended solutions. Otherwise, planners and designers may ignore details that are important for the visually impaired, or misunderstand the intentions of recommendations. Once again, pedestrian crossings are a particularly good example, where deviations from the norm can have potentially dangerous and even deadly outcomes. There is thus a need for clarification and explanations regarding recommendations for pedestrian crossings.

Most practitioners requested better guidance for complex situations. The standards should also contain guidance on how visually impaired people orient and find their way, and how the built environment can be design to help and support them on their everyday journeys, with and without the use of tactile paving. Knowing how visually impaired persons orient, it may be easier for practitioners to familiarize themselves with their situation and hence facilitate a better and more usable environment.

Further, the efforts to harmonize different standards, handbooks and guidelines should be continued. This is especially important when it regards warning of hazards. Further, the central government bodies have a challenge in harmonizing standards, and to identify and withdraw standards and other guidance documents that are outdated or deviating from current standards.

Regarding practice, another recommendation regards improving the knowledge of relevant practitioners. This could be done through training programs mandatory for those involved in facilitation, and with recurring refresher courses on a frequent basis. Further, there is a need for highly qualified experts in this field. Another approach could be to put in place a system for certifying mobility consultants which have received special training, as is already done in the UK.

Recommendations concerning processes include that universal design is considered already when producing zoning plans, in order to prevent sub-optimal frames with respect to usable solutions for people with sight loss and other impairments. Another lesson learnt is that the role of users participating in planning- and design processes needs to be clarified. Finally, deeper and more thorough research than that presented here is needed regarding how planning- and design-processes proceed, to clarify the mechanisms contributing to the built environment being designed in ways that are usable and safe for visually impaired persons.

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