

## Conference Paper

# Cycling Mobility in Slopping Cities: Trondheim and Other Lessons

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### Abstract

Soft mobility is on the top of city's agenda. Several plans are emerging to improve its performance, regarding sustainable, climate-friendly or easy ways of mobility, without using the car. The political decision-makers, urban designers and academics are working upon new approaches of developing these skills. In sloping cities, specially with ancient roots of narrow and winding streets, the bicycle is still a tricky way of transportation, because it can represent a deep changing of previous urban fabric. This paper presents a set of good practices of bicycles use as soft mobility solution in mountain cities. The example is the sloping city of Trondheim in Norway. The interest for this topic lies in the ongoing Doctorate program in Civil Engineering at the University of Beira Interior, having as case study the city of Covilhã. The system is called CycloCable and it's the first cycle lift for collective transport designed to help cyclists moving easily to overcome urban slopes. The literature review is the main methodological approach, identifying the good practices of CycloCable, which can be used in other cities with similar morphological conditions. The conclusion has revealed that this system increases the number of cyclists, with environmental, economic and social benefits.

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## 1. Introduction

The topic of soft mobility is on the top of the agenda of the urban studies. Everywhere there are strategies emerging in order to improve the performance of the cities regarding sustainable, climate-friendly and easy on the environment ways of mobility, without using the car. The decision-makers regarding the city policies, the urban designers and the academics are working on new approaches of developing these skills, considering the urban space features. In many cases the focus is being put on the bicycles as pivotal solutions. However, in the particular case of sloping cities, with ancient roots of narrow and winding streets, the bicycle is still seen as a tricky way of transportation, given that its use can represent a deep transformation of the urban fabric.

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In this sense, this paper presents a set of good practices coming from the experience of the use of the bicycle as a soft mobility way in mountain cities. The example comes from one sloping city in Norway, Trondheim, which is considered a pioneer case of success in terms of bicycle solutions. The interest and knowledge about this topic are related to the research work of the Doctorate program in Civil Engineering at the University of Beira Interior. The use of mechanical means in soft transports has been studied [1] as a suitable example for other mountain cities on the subject of e-City Research Methodologies, where the lessons from Trondheim were studied. The system is called Cyclocable and it's the first cycle lift for collective transportation, which was designed and created in order to help cyclists, to moving easily, to overcome the steepest urban streets. The literature review was the main methodological approach, allowing the identification of the good practices coming from this Norwegian example, which can be used in other cases, having similar morphological conditions, such as the case of Covilhã.

## 2. Bicycle as a Sustainable Alternative

Promoting smooth mobility in urban areas is an effective strategy to improve urban sustainability, especially in small and medium-sized cities. In fact, in these cities a large percentage of journeys have distances compatible with pedestrian or bicycle mobility.

The creation of pedestrian networks and bike paths is sometimes combined with bike-sharing, which is one of the most common solution among the transport policies to encourage mobility. However, for cities settled on the mountains, where there are sharp slopes, other solutions must be considered.

With the exception of users of electric bicycles (e-bikes), the potential users of soft mobility (inhabitants or tourists) are discouraged by the steep slopes.

This issue is particularly important for mountain cities that generally have their historic centres located in sloping areas. In such cases, connection systems, vertical or oblique, that can be equipped with mechanical means, including escalators or funiculars, should be used. The choice of appropriate technology should be guided by an analysis of the technical, economic and financial feasibility.

In the Norwegian city of Trondheim, since 1993 that an innovative solution was design to encourage the use of the bicycle. The system comprises a bicycle lift or cyclo-elevator, and it was invented by an inhabitant of the city, whose main goal was to reduce the effort in the ascent of one of the urban slopes, on his way to work.

### 3. Factors Influencing Bicycle Use

In order to understanding the factors that influence bicycle choice at urban scale is necessary for implementing efficient pro-bike-transport policies [2].

The use of the bicycle as a means of urban transport is conditioned by several factors, namely the physical capacity of the user, the distance to be travelled, the space structure of cities and existing bicycle infrastructure, road safety, climate and the relief, fundamentally, the slope and the extension of the sloping zones.

The last condition, characteristic of cities with steep slopes, exceeding 5% limits and restricts the use of the bicycle additional effort that the user has to spend to overcome these territories [3]. The ideal slope for bicycle use will preferably be less than 3%.

There are slope values from which the use of bicycle is no longer possible (or recommended), which are closely linked to the extent of terrain that has to be overcome in ascending: the smaller the extent of the climb, the greater the acceptable slope, since the additional physical effort will be carried out for less time [4].

For example, ASSHTO considers that the maximum recommend length to go on 5% slopes will be 240 meters and for slopes of 11% will be 15 meters [4].

In other words, these maximum limits indicate that it is possible to cycle in areas with greater slope provided they do not have a great extension.

### 4. Bicycle Trails in Steeper Slope Cities

Generally, the idea of the population is that there is only possible to ride bicycles in cities with gentle slopes. However, is perfectly possible to overcome steeper slopes, every time that the distance to go is not very extensive. In general, the ideal slope for bicycle use will be as small as possible, preferably less than 3%. The latter value can change for electric bicycles, also known as e-bikes or pedelec.

In general terms, e-bikes are similar to conventional bikes, considering their appearance and components, but they are additionally equipped with an electric motor, that can watch the user pedalling. Should be noted that these e-bicycles do not replace the rider's effort but only complement or relieve it.

The cities with steeper slopes present lower levels of bikes utilization, since they depend on the cyclist's physical performance and his level of experience, which may even prefer courses with greater slope, for the pleasure of accomplishment and/or additional exercise [5].

Thus, although the slope constitutes a condition for the use of the bicycle, it cannot be seen as an obstacle for its use. In the cases of cities with a more rugged relief the urban planning strategies, monitoring of bicycle use, as well as the concrete actions in the urban morphology gain a greater protagonist [6].

Inevitably on bumpy streets the rider will dismount from the bike if his physical fitness is not adequate. Thus, in order to allow these bike trips all over the city, should always exist a pedestrian path side by side with the cycling lane, making necessary to provide a set of infrastructures that allow pedestrians to go to these ways safely, comfortably and quickly [7].

The auxiliary mechanical means for transporting bicycles over short distances with a steep slope, can significantly contribute to increased bicycle use. Additionally, they allow cyclists to overcome steep slopes with mechanical assistance and to circulate without undue strain on sloped areas less marked [6].

Several solutions were implemented in cities to overcome differences in significant topographic quotas, as follow.

#### 4.1. Mechanical Systems

South Korea and Japan have Mechanical Elevation Systems (SME) for bicycles under the form of thin treadmills, designated Bike Escalator, and placed next to stairs conventional which allows cyclists to push the bike up assisted (Fig. 1). There are other systems of bicycles lifts such as in Trondheim, Norway (Fig. 2).

These SME's have the following advantages [8]:

- Reduce physical stress to cyclists by encouraging inter-modality;
- It can be installed in a small space and next to convectional stairs or ramps.

They present, however, the following disadvantages:

- Substantial investment and maintenance;
- Specific for bicycles (not helping pedestrians, wheelchairs, pushchairs, among others);
- Subject to vandalism.



**Figure 1:** Bike Escalator in public spaces at the city of Tokyo, Japan [9].



**Figure 2:** CycloCable® in Trondheim, Norway [10].

## 4.2. Other Systems

There are other mechanical systems that are not specific for bicycles and can be used for this purpose, as is the case of public spaces rolling carpets, escalators exteriors, funicular, such as in several Spanish cities (Fig. 3).

These systems have all several advantages. However, they are not protecting from having some disadvantages (Table 1).

In Portugal, the mountain city of Covilhã has several mechanical means that were built following a study of mobility by the architect Nuno Teotónio Pereira.

These soft mobility elements, comprise two inclined lifts (the Santo André Lift and the Goldra Park lift), two vertical lifts (Public Garden Elevators) and the Funicular of São João.

The proposal of the mechanical means in Covilhã was planned to mitigate the effects of the characteristic steep slopes of this mountainous city, on the pedestrian mobility. Although these infrastructures have not been designed for the purpose of getting bicycles. Even though they can be easily being adapted for these means (Fig. 4).

TABLE 1: Advantage and disadvantage of other mechanical means of lifting bicycles, adapted from [11].

Mechanical means	
Advantages	Disadvantages
Rolling carpets in public place	
Help pedestrians and bicycles	Considerable investment and maintenance Important visual impact Slopes than the escalators
Escalator Outdoor	
Possibility of transporting bicycles and pedestrians Well tested solution technologically	Considerable investment and maintenance Less comfortable for bicycles
Funicular	
Help pedestrians and bicycles (from which take into account the cabin)	Considerable investment and maintenance Important visual impact



Figure 3: Exterior escalators at urban public space - Spain (Vitoria – Gasteiz) [12].



Figure 4: Santo André lift and the funicular of the city of Covilhã, Portugal [13].

The prediction of existing stairways, which could be made of concrete or U-shapes sheet-metal (Fig. 5), can overcome unevenness in places where there are no shorter

alternative routes. This solution makes easier to transport the bicycle by hand, proposing a mechanism with reduced costs (about 30 euros per each linear meter) [14].

The metal section should be at least 0,10 meters wide and 0,05 meters deep, being applied at about 0,20 meters from the wall [14]. This system allows an urban continuity in the cycling networks of cities of steep slopes. Therefore, it contributes to minimizing the effort of the users of the bicycles at reduced costs.

This solution will be adopted within the framework of the construction work of the cycling network of the city of Covilhã, which is currently in execution. An action planned in both the Covilhã Strategic Urban Development Plan (PEDU) and the Sustainable Urban Mobility Action Plan (PAMUS) of Beiras and Serra da Estrela Inter-municipal Community (CIMBSE), of which the Municipality of Covilhã forms an integral part.



**Figure 5:** Localization of stairways, where the metal rails will be applied (green circle) in Covilhã, Portugal [14].



**Figure 6:** Example of metal gutter in the city of Almada, Portugal [14].

The planned cycling network of Covilhã will interconnect the generating poles and equipment with greater emphasis in the urban context. It will put a special focus on the connection between educational facilities such as schools, residential areas, commercial and services areas, seeking to respond to the main daily dynamics of the population and urban commuters. This aspect addresses and confirm a clear intention to promote

the use of bicycles in an integrated way, despite the rugged orography of the historical urban fabric.

The gutters will be installed on the stairways next to the existing mechanical means. The Portuguese city of Almada, in the metropolitan region of Lisbon, has already a system like this (Fig. 6).

## 5. Lessons from Trondheim

### 5.1. CycloCable: the bicycles lift

Trondheim is a sloping city in Norway (Fig. 7) where in 1993 was invented a cycling elevator by JarleWanvik, “who was simply tired of climbing every morning up a hill to go to work” [15].

The system was called CycloCable and it was the first cycle lift for collective transport, which was designed to help pedestrians and cyclists moving easily to overcome steeper slopes of the city. This system can be used in other cities with similar morphological conditions as Covilhã.



**Figure 7:** Trondheim upon the Nidelva River [16].

This system is a pioneer mechanism for bicycles mobility and it was inspired on ski lifts. It helps the cyclists to climb up the slope making less effort, and staying on the bicycle. Such as Covilhã, Trondheim is a university city, where students riding their bicycles everyday, besides of its topography. The highest point of the urban fabric is above the 500 meters high, which is similar another similar aspect with Covilhã. Over the years this system has been used by more than 220 thousand cyclists and every year this number is increasing, not only among the inhabitants but also by the tourists. Until, this moment there is no report of accidents and therefore it is considered a successful mechanism of soft mobility.



## 5.2. The specifications of the mechanical lift

The CycloCable® is a mechanical lift that was developed by POMA [17] allowing a collective transport of cyclists, “who wish to move more easily to overcome the steepest slopes in urban areas, even in mountainous cities, and constitute a true revolution in urban mobility” [15].

The mechanical lift takes up little space and can easily be installed on narrow and winding streets, below the pavement surface with no conflicts with traffic (Fig. 8).

The system is installed underground at 30 cm from the street surface. It works by a keycard, with the cost of about 10 euros per year [19].

In mechanical terms the CycloCable is a with a rope of “11 footrests, attached to a handle cable” [15]. It is operated by an electric engine with a minimum power of 5.5 kW, installed on the top of the hill, inside the structure of the exit station.

In both ends of the cable, there are wheels with at least 600 mm diameter, pushing the handlebar, where the foot platform, similar to a pedal, is housed, to enable it to circulating continuously.

There is an accelerator which is a piston put at the starting point, “to make it easier to start the climb” [15]. The foot support for cyclist or pedestrians (for example managing baby push-chair) is “coupled to the accelerator and after the initial impulse, it detaches of this one and follows with the cyclist by the rail” [15].

The user should approach the station at the starting point and put the foot on the tiny platform, after this he passes the keycard in the machine and press the button “start”. Consequently, a buzzer starts to sound telling that the climb action will start.

The user must put his weight over the foot platform for a comfortable journey.

For security reasons, the bicycle brakes should never be used during the way up [20]. The foot platform is individual, designed to carry out only one person and it automatically retracts when the user pulls off its foot.

The speed of the system increases gradually, from zero at the entrance station point until 1.5 m / s.

Finally, the mechanism includes in each stations an emergency button which stops the system for 5 minutes, after this time, the system starts again [21].



**Figure 8:** CycloCable lift for pedestrians and bicycles in Trondheim, Norway [18].

## 6. Conclusions

The conclusions have revealed that soft mobility systems are increasing the number of cyclists and pedestrians as users among commuters. This work is part of an ongoing research, so the indicators related to sustainable mobility systems, the importance of mechanical means in slopping cities and the final conclusions about the environmental, economic and social benefits of these systems will be reached during this process.

However, the lesson from Trondheim shows CycloCable as a simple mechanism comprising the following five elements:

- The entrance station, spotted at the beginning of the slope, where the keycards reader machine is installed;
- The exit station, spotted at the end of the slope, where the electric engine is installed;
- The rail where the handlebar operates;
- The handlebar cable, where the feet platforms are installed;

- The electronic system controlled by the user's card.

It has several advantages as a collective mean of transport for cyclists and pedestrians. Its users can easily move in the city, overcoming the steepest slopes of urban streets. Its use is not expensive and the bicycle doesn't need to have anything extra to allow the cyclers to use it.

The previous analysis has shown that the soft mobility systems such as the Cyclo-Cable are becoming more popular among the city's inhabitants. They are a funny way of mobility promoting the user's enjoyment. For example, the funiculars, the exterior escalators and the lifts are not only systems of transport but also elements of leisure, from where users can view the city landscape and enjoy their journeys along to the urban fabric.

CycloCable is a case of success and popularity among citizens, being easy to use by a wide range of people, even with mobility restrictions. As the analysis has presented, there are people of different physical conditions using it, pushing baby chairs, carrying others on their bicycles or people of different age, from elderly citizens to children.

Covilhã, at the Serra da Estrela Mountain, is giving its first steps at the domain of soft mobility, offering already a relevant set of funiculars, lifts or pedestrian bridges. The use of mechanical means in sustainable mobility policies should therefore be assessed as a means of reaching continuous corridor comprising cycling paths, pedestrian sidewalks, funiculars, pedestrian bridges and lifts over public spaces, where pedestrians and bikes can share the ways. Its goal is to achieve an extensive cycling network that can be used as an alternative mode of urban transport, including the narrow winding streets of the historic centre of cities with steep slopes such as Covilhã, either by conventional or electric bicycles.

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