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Bike lane design: the context sensitive approach

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Abstract

In these days of increasing congestion on roads, bicycles continue to provide a valuable contribution to mobility in Europe. Their relatively small size and low cost enable them to blend efficiently into the traffic flow while needing less space compared to other vehicles. However, cyclists form one of the most vulnerable groups of road users. So the design of safe infrastructures for all travellers categories, included the cyclists, becomes a primary requirement. To obtain these results, a Context Sensitive Design approach is a very useful tool. In this way, in fact, it is possible to examine a project or existing road, reporting its crash potential and safety performances and detecting its deficiencies, taking into consideration communities and lands which it passes through. In this paper the authors, starting from results collected on a bike lane placed in Rimini, provide useful results for designers, construction and maintenance contractors, in order to obtain safe bike lanes.

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1. Introduction

Bicycles in the increasing congestion of European roads offer an efficient form of transport allowing easy access to crowded cities and streets. However cyclists form one of the most vulnerable groups of road users and accidents involving injuries to them are a major social concern. Since, moreover, the majority of these accidents involve young people, it becomes essential that all parties work together to improve the safety of this vulnerable category.

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To obtain these results, is very important to take into consideration that cyclists are more vulnerable than car drivers. This exposure is particularly due to the lack of a body-work, a lesser perceptibility of the cyclist by other road users and to the fact that cycle is a vehicle with unsteady balance.

Numerous studies show that human failure is the primary cause of cyclists' accidents; nevertheless a large number of them are produced by infrastructure shortcomings. So the evaluation of what elements of the road may present a safety concern and what opportunities exist to eliminate or moderate them becomes very important. In this way Context Sensitive Design (CSD) criteria are very useful tools.

After an overview on the CSD state of practice, starting from numerous data detected on an existing bike lane placed in Rimini, the aim of this paper consists in providing useful results for designers, construction and maintenance contractors, in order to obtain safe bikeway networks.

2. The Context Sensitive Design approach

Context Sensitive Design (CSD) or Context Sensitive Solution (CSS) refer to a process of merging the function of a transportation project with its setting.

The Federal Highway Administration defines CSD as “a collaborative, interdisciplinary approach that involves all stakeholders to develop a transportation facility that fits its physical setting and preserves scenic, aesthetic, historic and environmental resources, while maintaining safety and mobility. CSD is an approach that considers the total context within which a transportation improvement project will exist” [1, 2].

Road conventional design methods consider the three primary criteria of minimizing costs, maximizing throughputs and maximizing safety and choose the project alternative that optimally balances these conditions. The design process is frequently driven by traffic demand and level of service objectives and this mobility-focused procedure influences the rest of the design process.

The CSD approach, instead, is an effort to develop better and improved ways of designing roads, highways and other transportation facilities that are integrated with their environment and are more consistent with the needs of the communities they serve. Functional classification, travel forecasts and levels of service are factors to consider in CSD but through an interdisciplinary approach that seeks to identify the core issues/problems including a full range of stakeholders, developing a spectrum of alternatives and reaching consensus on the best solution [1].

The key elements of CSD for any project are [3]:

- purpose and transportation need;
- environment;
- public participation;
- transportation design element;
- safety and mobility.

The process of applying CSD approach is based on these phases [4]:

- identifying an interdisciplinary team for the CSD analysis, consisting of such expertise as traffic engineers, urban designers, ecologists, historians, transportation and urban planners, biologists, social scientists, landscape architects, geologists, etc...;
- evaluation and analysis of the context (place audit): this procedure systematically reviews many potential elements of the cultural, historic, economic, social, and environmental context that may be affected by the project, analyzes potential impacts, and develops information that can then be used to generate context-sensitive design options;
- synthesizing information and articulation of a statement of context (determination of needs): once the place audit is completed, the task becomes to determine its implications for project design;

- developing design alternatives: having determined potential project impacts, project staff can develop design alternatives to mitigate or avoid these impacts. The process should be carried out in consultation with stakeholders, as they may have the most detailed knowledge of the project context and local needs;
- displaying and communicating proposals and ideas (visualization strategies);
- evaluating design strategies, including funding, regulatory, environmental considerations and community feedback;
- evaluation of CSD process and outcomes, as the project is built and starting to be in use.

3. The experimental investigation

3.1. Introduction

This study involved a bike lane placed in Rimini, a city in the Emilia-Romagna region of Italy and capital town of the Province of Rimini, centerpiece of Adriatic Riviera. It is an open, hospitable and people-friendly city, where many Italians and foreigners head for this place for their holidays.

The examined bike lane connects the beach zone to the old town centre, underpassing the railway area, with a length of 1500 m (figure 1). It is designed for cyclists and pedestrians and it is completely separated from traffic by locating inside an urban wildlife park, the Ausa park (figure 2). It has a variable cross section with a lane width varies from 3.70 m to 4.00 m, it cross level terrains and is characterized by low longitudinal grades.

The experimental study has been composed of two phases:

- analysis of the general context in which the bike lane is inserted, in order to obtain an initial view of the area object of study;
- investigation and identification of its possible safety defects, which can cause unexpected dangerous situations for users.

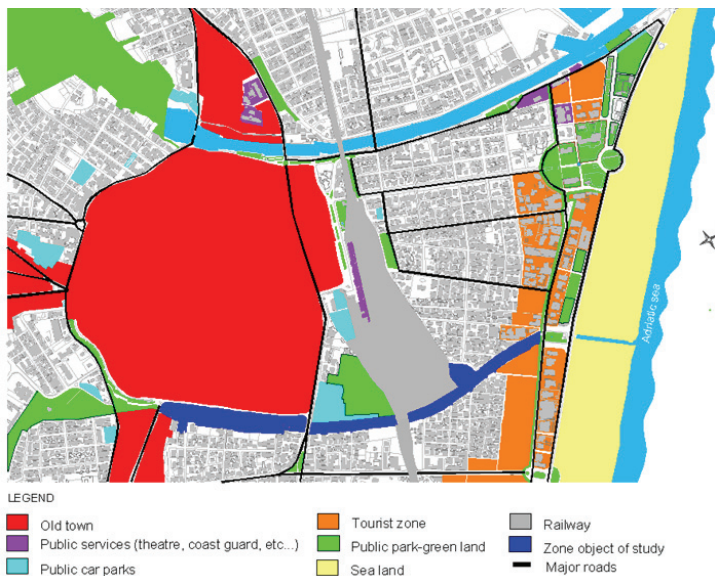


Fig. 1. Rimini map (in dark blue the zone object of study)



Fig. 2. the bike lane object of study

3.2. Context analysis

The context analysis reviews many elements that, for clarity, have been grouped in the following categories:

- general contextual conditions, in order to understand the broad sense of visual character, spatial distribution and roadway experience;
- environmental context, to capture the ecological and natural resources of the area in which the bike lane is inserted;
- roadway and traffic considerations, to obtain information about the way in which the bike lane is used and to understand the experience of movement along it.

General contextual conditions

Figure-ground map shows a high density environment with a little amount of open land (figure 1). The bike lane characters are the same along its development, with small open areas connected with the town context. The map is full of small buildings in a traditional urban street pattern and the lands along the bike lane are primarily residential and commercial with some hotel uses near the coast. A great part of the Rimini center is occupied by the old town, characterized by ancient narrow streets and cosmopolitan squares in contrast to the tourist zones and beach areas. Many of the buildings in this area have historic and cultural importance, dating back to Roman and medieval era (figure 3). Near the old town, moreover, there is a big railway area in which runs up and down many train lines from Rimini to Ravenna and Ancona districts.

Environmental context

Rimini is located on the Adriatic Sea, between the rivers Ausa and Marecchia (figure 3). The surface drainage system is characterized by numerous ditches that are largely harmonized with the platted landscape. The town is characterized by many urban wildlife parks, integrated in a long greenbelt included between the coast area and the national road n. 16 “Adriatica”. It is an invisible line that goes around the examined area, stopping people building on there, so that some of the wild land can be saved. The stated objectives of greenbelt are protect natural or semi natural environments, improve air quality within urban area and defend the unique character of rural community which might otherwise be absorbed by expanding suburbs. In this way the area inside the greenbelt becomes the habitat for wild plants, animals with a better land use of areas within the bordering city. Along and around the examined bike

lane there are different categories of vegetation as maples, birches, ash trees, beech trees, pines and poplars. They have a significant visual impact along the corridor and provide shade, reduce glare and help to lower air temperatures along the bike lane.

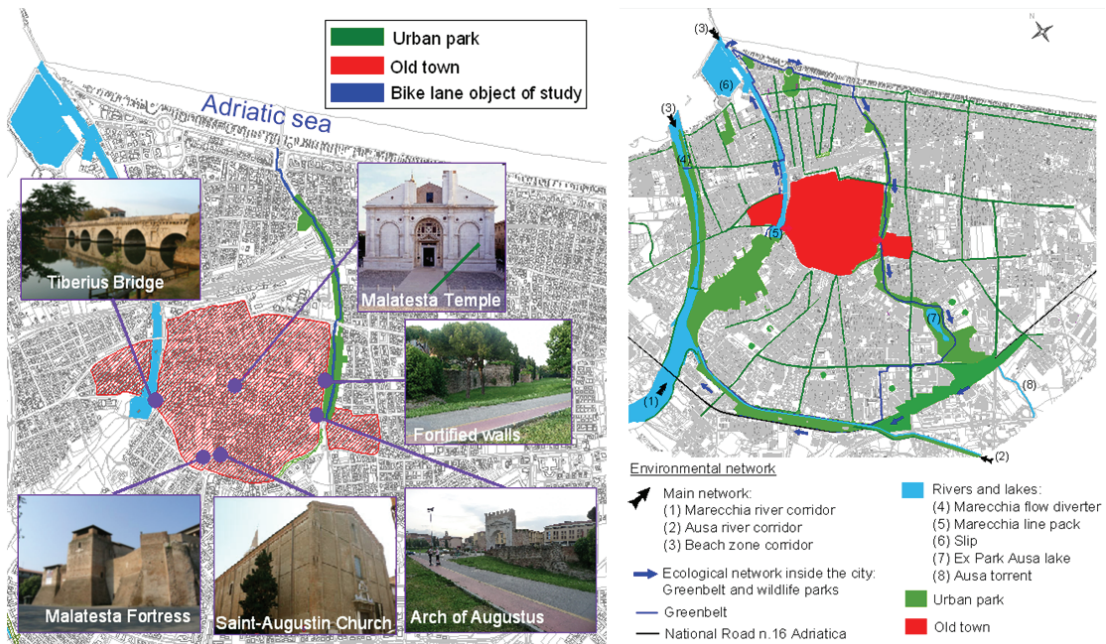


Fig. 3. historical and hydrology maps of the bike lane object of study

Roadway and traffic considerations

The examined path serves a local function and the vehicle types using it are bicycles (90%) and pedestrians (10%). Traffic flows have been monitored in five sections, during the peak hour (12 to 13 pm), both in a weekday and in a festival day, during both summer and autumn season (table 1). They appear to be stable along the corridor and during summer are bigger than in autumn. This bike lane, in fact, is characterized by high bicycle traffic flows especially in the summertime when many Italians and foreigners head for Rimini for their holidays. During the fall the major flows go to the old town, while in summer go to the sea. For each case the level of service has been evaluated using the IDOT (Illinois Department of Transportation) and CBF (Chicagoland Bicycle Federation) methods [5]. In fall it is equal to D, with steady traffic at high density; in summer, instead, the situation degenerates to traffic saturation (level E) and to congestion (level F).

Parking occurs along the shoulders on each side of the bike lane and is related directly to businesses or other land use along the road. So it is possible to conclude that there is not a need for additional casual parking. There are different intersections along the bike path with formalized pedestrian crossings and there are many turnings and accesses.

In order to obtain more information about users' behaviour on the examined bike lane, an experimental questionnaire has been distributed to a sample of 150 cyclists of both genders, ranging in age from 5 to over 65 years old. The first series of questions considers the trip frequency and purpose on the examined bike lane and it shows that only the 16% of interviewers uses it frequently, against the most which utilizes car daily and this bike lane only for fun. The second series of questions refers to the accident rate on the

analyzed way. 52 interviewers got an accident, of which 16 and 9 against respectively a pedestrian and a cyclist. The accident causes are imprudence (16%), low attention (24%) and high traffic flow with poor visibility conditions (10%).

Table 1. Traffic flows along the bike lane

| | Festival day | | Weekday | |
|------------------|--------------|--------|---------|--------|
| | Summer | Autumn | Summer | Autumn |
| Pedestrians | 39 | 24 | 35 | 23 |
| Bicycles | 345 | 209 | 313 | 218 |
| Totals | 384 | 233 | 348 | 241 |
| Level of service | F | D | E | D |

3.3. Results

The results obtained on the examined bike lane shows many common safety issues, grouped for clarity in the following classes:

- road alignment (horizontal, vertical, geometry, sight distance, cross section, ...);
- pavement (texture, friction, ...);
- signs and lights (road markings, vertical signals,...);
- intersections (sight, perception, maneuvers,...);
- amenities (benches, shade structures, bicycle parking, trash cans, water fountains, playgrounds, ...).

Road alignment

The accurate analysis of the bike lane geometry points out that its lane width is narrow to contain traffic flow moving on it, especially during summer. This problem is confirmed by the level of service values resulted from CSD analysis, equal to E and F, and by the fact that users tend to follow personalized itineraries, going out the bike lane and moving inside the park toward desired destinations, in order to reduce the distance between the old town and the car parking located in the neighborhood (figure 4). In this way rises a vertical gap between the bike path and the adjacent lawn, very dangerous for cyclists in transit, from which dirt and debris are thrown on the road surface with a dramatic decrease of skid resistance. These are important contributing factors in crossroad accidents for cyclists, because they can cause them to lose control. In these conditions specific protective measures should be taken in order to qualify the bike lane building and paving these new itineraries, selecting correct materials that must be level with the adjoining pavement and the frictional conditions must be very similar.



Fig. 4. pedestrian itineraries out of bike lane inside park

Numerous black spots, moreover, are placed in correspondence of curves, which are frequently characterized by small radii and poor sight distances. These circumstances are very dangerous for cyclists because of the necessity of leaning the bicycle, with a high risk to skid (figure 5). Here is necessary to work in order to improve lane safety:

- upgrading the visibility, which allows for detection of hazards in time and planning the riding accordingly. It can be increased by the elimination of lateral elements such as trees and vegetation, that impair driver's field of vision;
- using indication signs: when adequate signals are being used, cyclists can anticipate curves more easily. It should be noted that signs must be installed in safe locations;
- avoiding obstacles that may aggravate the severity of injuries to a cyclist in case of overturning or driving off the road, such as sign posts. When such installations cannot be avoided, they should be placed as far as possible away from the edge of the road.



Fig. 5. curves characterized by small radii and poor sight distances

Much attention, moreover, should be address to the subway of the railway area, because its exit lane is characterized by a high longitudinal grade (8%), difficult to overcome for cyclists and, in particular, for disabled peoples (figure 6).



Fig. 6. entry and exit lanes of subway of the railway area

Pavement

The examined bike lane is characterized by different pavement types; its most part is composed of a traditional flexible pavement, while the rest is described by a block one.

Much attention should be addressed to the connection zones, because most of them are in a lack of maintenance with a great degradation of surface evenness and skid resistance, and to the poor maintenance conditions of the block pavement, which is characterized of potholes and resurfaced patches, with high risk that a detached concrete element comes on the roadway becoming very dangerous for cyclists (figure 7). The same safety problem, in particular, is present in correspondence to the sunk manholes located on the whole road alignment and in proximity of the bike lane shoulders (figure 7).



Fig. 7. poor maintenance conditions of the block pavement and near bike lane shoulders

Since pavement damages can greatly influence road safety and in particular the cyclist's handling, potholes and patches must be repaired quickly using correct method. The patching material must be level with the adjoining pavement and the frictional conditions must be very similar.

Cyclists, in fact, have a much greater need for consistent and high coefficient of friction between tires and road surface than other vehicles. To obtain these results different safety measures can be taken:

- use of asphalt mixtures with good frictional properties;
- keeping of roadway cleaning trough an efficient maintenance program, avoiding leaves on the lanes;
- placing manholes and cattle guards outside the travelled way, especially in curves, because they tend to be more slippery than the rest of the road surface, especially when wet.

Signs and lights

In the whole bike lane alignment are lacking both road markings and destination vertical signs.

Road lighting, moreover, is very poor with important problems of road and public safety. In these conditions specific protective measures should be taken in order to increase the number of the streetlamps in and around the bike lane. Is very important, moreover, place these element away from the edge of the road because their posts can represent an injury when hit by a cyclist.

Intersections and road accesses

The intersections reviewed are in general characterized by a good visibility, without obstacles that reducing visual distance, with opportunity for the crossing traffic to see the bicycles in the entire sight zone. Road markings and pedestrian crossings, however, often need of maintenance: in many cases, in fact, they are poor discernible (figure 8). Because of the damaged state of pavement, they guarantee moreover a poor skid resistance. So is very important to follow an efficient maintenance program, able to guarantee a perfect condition and visibility of them.

Many of the numerous bike lane accesses, moreover, are characterized by a poor visibility caused by obstacles located in sight zones, such trees or vegetation (figure 8). Since this is an important contributing factor in bicycle crossroads accidents, it is necessary to eliminate these lateral elements, which impair driver's field of vision.



Fig.8. road markings in poor maintenance conditions and poor visibility in bike lane accesses

Amenities

The examined bike lane is characterized by numerous amenities which build a sense of place and enhance the environment for pedestrians as well as cyclists. They include features such as benches, shade structures, bicycle parking, place to rest, route map signage, trash cans, water fountains and numerous playgrounds for children. In the playground areas it is advisable to install safety flooring systems consist of rubber flooring that cushions effectively the impact with the ground in case of falls (figure 9). According to the EN 1177 European certification tiles are made of recycled rubber granules bonded by special binders and they are available in different sizes, colors and thicknesses. They are self-laying and self-fixing through the use of joint pins. Panels can be laid directly on a sub-base of draining material, such as sand or fine gravel, provided it is well leveled and compacted.



Fig. 9. safety flooring systems

Near the railway area, alongside of the bike lane, there is a dog park, named “Fidopark”, where dogs can exercise and play off-leash in a controlled environment under the supervision of their owners.

Along the “inside” zone, from XX settembre street to Roma one, moreover, the pavement of the examined bike lane is characterized by a tactile paving edge, with a yellow textured surface to assist blind and vision impaired pedestrians (figure 10). Tactile warnings provide a distinctive surface pattern of "truncated domes" or cones, detectable by long cane or underfoot, which are used to alert people with vision impairments. It is being hoped that this is be installed in the whole bike lane.



Fig. 10. tactile paving for blind and vision impaired pedestrians

Along the examined bike lane, moreover, is available a bicycle sharing system, named “RimininBici Bikesharing”. It is an increasingly popular system whereby bicycles are made available on a large scale in a city allowing people to have ready access to these public bikes rather than rely on their own bikes. The central concept is free or affordable access to bicycles for city transport in order to reduce the use of cars for short trips inside the city thereby diminishing traffic congestion, noise and air-pollution. In this type of program the bicycles are simply released into given areas and a small cash deposit releases the bike from a locked terminal, which can only be retrieved by returning it to another.

4. Conclusions

In this paper it has been analyzed the results came from a Context Sensitive Design analysis of a bike lane placed in Rimini, a city in the Emilia-Romagna region of Italy. These results have been obtained not

only by place audit analysis, but also by the answers of an experimental questionnaire distributed to a sample of 150 cyclists. In this way it has been possible to examine the bike lane taking into consideration their point of view, difficult to evaluate from a simple technical approach.

The obtained results shown that the safety measures carried out on it are not always effective for cyclists. The analyzed bike way, in fact, is characterized by the presence of sign posts, lighting poles, trees, sunk manholes, which can turn a cyclist fall into a fatal accident. Since cyclists provide a growing contribution to Italian mobility, filling this safety gap becomes very important.

To obtain these results, the potentialities of the Context Sensitive Design approach are examined and confirmed. In fact it proves itself to be a rapid and effective tool, able to detecting the safety deficiencies of an existing bike lane, without waiting for accidents accumulation and respecting communities and lands which it passes through.

The CSD approach, moreover, allows a new traffic design concept, called "shared space", involving the removal of the traditional signs, signals and lines in combination with the shared use of the same area by different vulnerable lane users. In this way each user is forced to choose his speed taking to account the behavior of other users.

The CSD approach, moreover, allows to consider the coherent and integrated regional bike planning as a strategic component of the territorial planning. For example in our region there is a new multimodal public transport policy in a unique fare, called "Mi nuovo in bici".

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