PEDESTRIAN MOBILITY IN THE PROXIMITY OF CONSTRUCTION SITES: AN APPROACH TO ANALYSE AND IMPROVE THE PEDESTRIAN EXPERIENCE

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ABSTRACT

Pedestrian mobility is the only mobility that is included in all types of itineraries, while pedestrians are one of the most vulnerable users of the road. In the Hauts de France region, which has been transforming from an industrial into an IT and service-oriented region, it is possible to denote a massive presence of construction sites that cause numerous issues to the local community in their proximity. Literature analysis shows that researchers often underestimate the importance of pedestrians, hence, one of the problems which is analysed in this study is the mobility in construction site proximity. The purpose was to analyse the comfort of the sidewalks and the pedestrian behaviour. The analysis of pedestrian mobility is conducted in the regional capital Lille including (1) an analysis of the history of Lille's Catholic University and the territory using GIS; (2) a CAWI survey to study the attitude of pedestrians and their opinions about construction sites; and (3) an observation of three sidewalks located in proximity of construction sites. Observations and questionnaires show that residents are willing to accept construction sites and adapt to the changes, showing particular interest in the construction projects and their progress. In their interest lies an opportunity for a better integration of construction sites within the neighbourhood. The study concludes that better communication between stakeholders using real-time plans of temporary dynamics, would bring specific improvements to different types of sidewalks and streets.

Keywords: construction sites, pedestrian mobility, road safety.

1 INTRODUCTION

New constructions and renovation processes of existing buildings, in general are bearers regional development, transformation, and economic growth [1]. However, the negative effect of construction is inevitable and includes noise, environmental pollution, dust, traffic issues, etc. Noise issues and their impact on the neighbourhood are widely described in many research papers: Ng has been conducting experiments on residents of student dorms [2], while Hong et al. created a rating system to define the impact of noise pollution on residents [3]. The problems of the environment and pollution are commonly analysed using traditional measurement methods and cost analysis [4], [5] and they are regulated by local and European laws [6]. During the initial observations in Lille, important issues regarding traffic had been noticed, especially for pedestrians and cyclists, and particularly for persons with reduced mobility (PRM) who must pass by the construction site. An attempt to analyse this issue has been made in an occupational safety journal where the problem has been analysed in relation to construction site employees [7]. Also, pedestrian traffic is often analysed by scientific papers and technical booklets to determine pedestrian comfort [8]. Finally, issues related to PRM mobilities and the effects of temporary architecture on pedestrian mobility were subjects of separate studies [9], [10]. Therefore, literature review has shown only a very limited analysis of the impact of construction sites on a pedestrian flow. This study bridges that gap discussing issues of pedestrian mobility within the sustainable transportation framework, and with the 11.2 goal of the United Nations sustainable development in mind [11].

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Pedestrian mobility composes our everyday lives. Almost every trip includes at least one part of mobility which needs to be done on foot. Examples of this phenomenon can be driving, the necessity to walk to and from the parking lot or taking public transport, the need of reaching the public transport stop, etc. The current approach of the European Union (EU) classifies pedestrians as vulnerable road users (VRU) and identifies them as one of the seven main focuses of the EU Road Safety Policy Orientations 2011–2020 [12]. Pedestrian mobility has also been strongly encouraged in the last years as a mitigation to the current climate change crisis [13].

In parallel, newly constructed buildings as well as renovated historical buildings are developed to provide comfortable spaces with high efficiency that meet sustainability goals. However, a large-scale construction sites and renovation projects that are common in historical cities (such as Lille), in multiple cases cause a long-term impact on daily life of local communities through the sound, vibrations, dust, and traffic pollution. The construction companies often overlook the impact on the community, especially on pedestrians in the proximity of their construction sites. Therefore, this research is an effort to address that issue and to face modern challenges of pedestrian mobility [14].

2 THE CITY OF LILLE AND THE CAMPUS OF THE CATHOLIC UNIVERSITY

This study explores Lille, a city located in the north of France, in the Hauts-de-France region, counting 236,400 inhabitants and an area of 446.7 km^2 divided into 12 quarters. The city is inscribed in the Metropole Europeenne de Lille (MEL) accounting 1,174,273 inhabitants and 672 km^2 [15]. It is a historical city, with industrial past, where large scale construction sites regenerate existing city tissue. The city has developed together with The Catholic University of Lille, located in its heart, which brings 15,000 of students [16] to the Vauban-Esquermes neighbourhood and its 19,335 inhabitants [17].

2.1 The city of Lille

The history of the city begins in the year 620 and the word “L’Isle” appears for the first time in a document dated 1066. The town begins to develop next to the port, located in the current “Vieux-Lille” neighbourhood. Lille develops strongly throughout the centuries, especially thanks to its strategic position between the Netherlands, Flanders, and the flow of business connections [18].

The development of the Vauban-Esquermes area can be dated approximately to the 17th century when Lille becomes a French city. Soon after the overtaking of the Lille by the French, king Louis XIV ordered the renovation of the fortifications and the construction of a Citadelle, which remains the city core until today. The name of the neighbourhood derives from the engineer Vauban, who designed fortifications in the Citadelle [19].

The position of the city of Lille since its foundation makes it an important transportation hub in central Europe and provides an important base for urban development: connectivity remains one of the city’s main characteristics. The metropolitan area of Lille is the fourth biggest agglomeration in France causing it to constantly develop and extend its city borders. New roads and buildings are currently being designed to be friendly for pedestrian, cyclists, and public transport [20].

Considering its size, population, and the number of daily commutes within the city, Lille and Vauban-Esquermes become a suitable context for further improvement of and experimentation with the pedestrian mobility. This is even more relevant considering the present development goals of local government [21], which develops existing infrastructure as well new infrastructure to accommodate soft mobility.

2.2 The Catholic University and Junia Camplus

Vauban-Esquermes neighbourhood is also a neighbourhood where the story of Catholic University of Lille begins in the end of the 17th century. First transformation of the area and expansion of university took place in 1873, when due to the lack of space, University decided to reach for new terrains in the newly established quarter Vauban-Esquermes (Fig. 1). An important amount of terrain was bought in the area and first construction projects were developed [22]. The Catholic University of Lille today is composed of 11 institutes and 10 graduate schools, which brings the dynamics to the whole neighbourhood. In this paper, Junia graduate school, which is a part of the Catholic University of Lille, and its construction sites are further analysed [23]. Junia is a higher education institute, joining three graduate schools of engineering HEI, ISA, and ISEN. In September 2019 the YNCREA community (previous name of the Junia institution) presented a real-estate project to be completed by September 2024. The Camplus project must increase the surface available from 29,200 m^2 to 40,300 m^2 with over 22,000 m^2 of new buildings. The main construction works are on the three main campus "Isles": (1) the Maison Legrand, where a new student service area is being created; (2) the Palais Rameau where the revitalisation of an important monument of the city of Lille takes place to expose horticulture to the public; and (3) the Colson buildings which with two new buildings must provide new space for education. The Camplus project has continued despite the pandemic and its completion is expected in December 2025. All this makes Junia an interesting observation site, where the link between the pedestrian mobility and redevelopment allows understanding of interaction between the temporary and permanent residents and the construction project.

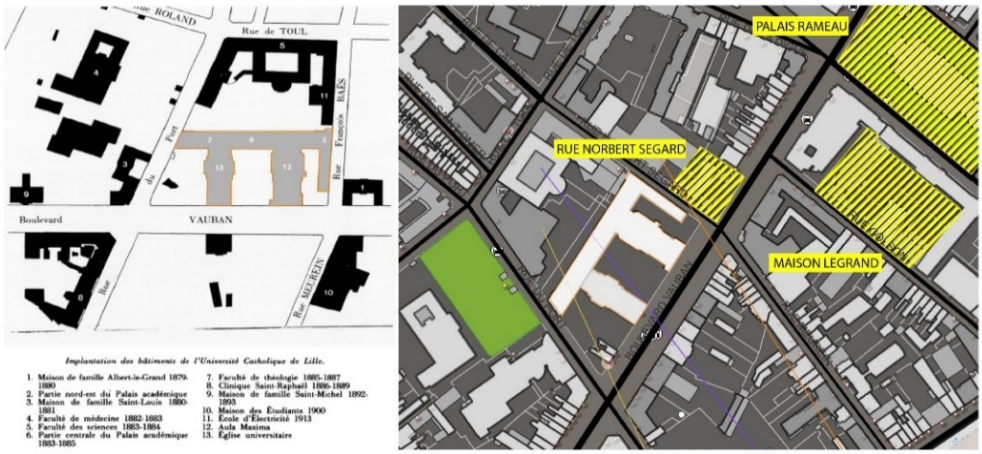

Figure 1: The evolution of the catholic university in time and location of case studies [24]–[26].

3 METHODOLOGY

To understand behaviours of local population in the selected context, proposed methodology is based on three main steps:

- an analysis of the history of Lille's Catholic University and Vauban-Esquermes district using GIS,

- a computer aided web interview (CAWI) survey to study the attitude of pedestrians and the impact of construction sites on their daily routines, and
- observation of three sidewalks in the proximity of Junia construction sites.

The main goal of the research is to analyse the comfort of the sidewalks and pedestrian behaviour, and to propose possible improvements of pedestrian mobility in proximity of construction sites.

3.1 Analysis of the history of Lille's Catholic University and the territory using GIS

The first part of this research was to understand the impact Junia construction site has on pedestrian mobility. The three sites identified are construction sites of the Junia Camplus: two of them are in the Vauban-Esquermes and one is in the Lille Centre neighbourhood. Spatial data is collected from the open data base, including the mapping provided by the metropole of Lille (MEL Open Data). The legal status of how construction sites occupy space is analysed considering "Permisse de stationament", which is a document that must be obtained and exposed to the public before the construction starts [27]. Site visits and photographs of the current situation and real conditions on the site were then collected and added to GIS to allow spatial analysis.

3.2 CAWI survey to study the attitude of pedestrians and their opinion about construction sites

The main purpose of CAWI was to understand the approach of pedestrians, to understand the main problems of their mobility in a construction site districts, and to search for solutions to improve their comfort. The online form consists of 40 conditional responses, which means that interviewees would answer only questions relevant to their case. The first out of four sections of the interview are focused on movement habits, where the respondent provides their living area, working area, the transport method used to reach works, possessed transport vehicles and general rating of the area and why they like or dislike to walk in it. The second section includes questions about the impact on decision making with a series of statements on walking. The third section is specific to construction sites asking the respondent if they pass next to one or more studied locations and the effect of the construction sites on their walking habits. The section concludes with statements on construction sites. The CAWI also allows the possibility of language choice and in this way also international students were included in the study. The survey provided 204 responses. The survey is finally analysed using Python with the use of numerous data processing libraries including Pandas. The analysis includes basic statistical analysis of all numerical variables plotting graphs of all the columns and producing a correlation matrix.

3.3 Observation of three sidewalks located in the proximity of construction sites

One of the main references in this study used for the evaluation of comfort in pedestrian zones is the Pedestrian Comfort Level Guidance for London [8]. This reference is used as it provides a quality method to calculate the comfort of pedestrians on determined sidewalks and give them a grading system from A to E. In this grading system, "A+" stands for a sidewalk in which a pedestrian has a choice to move at whatever speed and in direction they want, while "E" stands for a very limited personal space where movement is very restricted. The assessment suggests measuring flows with the static gate method, "whereby all pedestrians who cross an imaginary line perpendicular to the footway are counted" [17], in

specific hours depending on the typology of the road, and 10-minute observation intervals twice an hour to provide the result. To assess the comfort level, video recordings of the pedestrian movement are made during the observation process. The goal of the recording is to observe and photograph common pedestrian behaviours throughout the observation period. The recordings made during the observations are 79 recordings with a total size of over 170 GB. The observation was then analysed, and the counts of the pedestrian flows were counted on a spreadsheet.

4 CASE STUDIES

First, in order to select the case studies an analysis of the types of sidewalks in the Vauban-Esquermes and Lille-Centre districts is made using MEL Open Data, Google Maps Street view, and on-site observations (Fig. 2). A sidewalk typology is then created, and four main types have been identified as follows:

- Local alley: Small alleys including a narrow one-way street, with one pedestrian sidewalk. This type of road is not common in the area (there are only two roads of this type) therefore it is not further observed in this research.
- Local street: A local street confined by buildings with one or more traffic lanes and two pedestrian sidewalks on both sides. There are 16 local streets within the area and an example of such road is the Rue Norbert Segard.
- City boulevard: Large roads confined by buildings consisting of a driveway canalised into more than two lanes. There are four such roads on the site. A case selected for further observations is the Boulevard Vauban in front of the Maison Legrand.
- Green boulevard: Large roads, with large sidewalks on both sides, confined by buildings on the one hand and greeneries on the other hand. A case studied in this research is Boulevard Vauban in front of Palais Rameau.

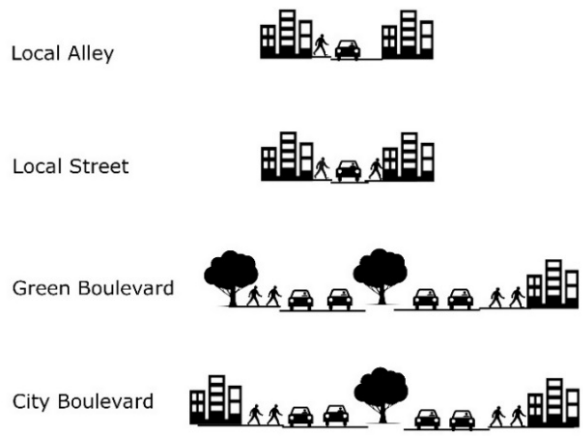

Figure 2: Models of streets design.

For each type of the sidewalk a case study is chosen to be observed and the comfort was assessed according to the Pedestrian Comfort Level Guidance of the city of London [8]. The observations were made in the period between the 22 June and 2 July. Each location was observed for a full weekday. The boulevard sidewalks, were also observed on weekend,

following the recommendations of the London Guidance [8]. Video recordings were 10 minutes long and they were taken twice per hour on weekdays and once per hour on weekends. Specific behaviours were photographed along with taking notes to record the flows and pedestrian behaviour and create photograms of the recording. As a result, sheets with typical and atypical behaviours are created and presented assessing the comfort on each location (Fig. 3).

Figure 3: Photographs of behaviours.

4.1 Rue Norbert Segard a case study of a local street

The first case studied is Rue Norbert Segard, a local street often used by students and office workers who every day reach their offices located within the Catholic University of Lille. The road connects the bus stop located on Boulevard Vauban and the metro station "Gambetta" to the entrance of ISA building and the side entrance to the main courtyard of the Lille Catholic University (Fig. 1).

The purpose of the observation in this street is to understand the parking attitudes, the pedestrian behaviour, and to understand what route they choose to reach buildings on the sidewalk next to the construction site. Particular attention is given to pedestrians that are forced to walk on the roadway and directly exposed to vehicles.

The observations of this construction site included counting the flows of people in different directions during a weekday as also observing the people who decide to walk on the road on the side of the construction site to reach the ISA building entrance. The observations

were made on a Friday between 7 am and 7 pm with warm weather and light rain in the morning.

The road has been affected by the renovation works of the building named "Maison Legrand" located at the intersection of Boulevard Vauban and Rue Norbert Segard, which causes a total closure of the sidewalk in front of it (Fig. 1). The sidewalk not occupied by the construction works according to the "permisse de stationament" is regularly used as a parking for vehicles and machinery involved in this construction site reducing this way the useful passage from 257 cm to 140 cm, while other machinery and equipment placed next to the cars cause a reduction of the available space to 80 cm.

4.2 Boulevard Vauban in front of Maison Legrand a case study of a city Boulevard

The second case study is on Boulevard Vauban in front of Maison Legrand. It is a city boulevard, which has two large sidewalks separated by trees from the road. Purpose of the observation in this street is to see the modifications of the temporary sidewalks and the pedestrian reaction to obstacles. The observations of this construction site included counting of flows in both directions, observing the attitude of pedestrians who use the temporary sidewalk, and observing the construction workers and the changes in the sidewalk throughout the day. The observations were made on a weekday from 7 am to 7 pm and on a Saturday between 9 am and 5 pm both days of observation were characterised by sunny weather.

The current construction occupies fully the sidewalk in front of it and a temporary sidewalk protected by fences allows pedestrian movement. The sidewalk has irregular sizes as the movement of machinery and parking cause the workers to modify the passage during the day, therefore not allowing a fixed measure.

4.3 Boulevard Vauban in front of Palais Rameau a case study of a green boulevard

The last case study is in Boulevard Vauban in front of the Palais Rameau. The Boulevard is in direct proximity to the park surrounding the Palais Rameau and a college located on Rue Solferino (Fig. 1). The main goal of the observation was to understand the flows of pedestrians and observe their curiosity about the construction site. The observations were made on a weekday from 7 am to 7 pm and on a Saturday between 9 am and 5 pm both days of observation were characterised by sunny weather. The sidewalk has a total width of 380 cm, and one side is separated from the construction site with a fence and panels describing the current constructions and the history of the area. The current construction works do not affect the sidewalk as the plan of the construction uses the area of the park. The mobility of pedestrians, therefore, is not interrupted nor modified with the exception of the park which is currently unavailable.

5 DISCUSSION

5.1 Flows of pedestrian and assessment of comfort level

The observation sessions denoted peak hours on weekdays while flows during weekends were distributed more homogenously on all sites (Fig. 4). The main observations of pedestrian flows and comfort level were as follows:

1. Rue Norbert Segard: the peak of pedestrian flow is between 8 am and 9 am compatible with the office hours and entrance of university students. Second peak hour between 12:00 and 13:30 is compatible with lunchbreak hours, and finally the third peak is at

5 pm, after work. The average flow per hour is of 186 people in both directions, while the peak was of 444 pedestrians per hour. The comfort level assessed is F, assessing very low pedestrian Comfort due to limited width caused by parking of vehicles.

2. Boulevard Vauban/Maison Legrand: the peak flow of pedestrian in front of Maison Legrand was observed at 12 am and an increase in flow was observed after 4:30 pm. The average flow of pedestrians was of 57 pedestrians and the peak flow of 360 pedestrian per hour. The comfort level assessed is F, as the size of the protected pathway does not allow comfortable movement.
3. Boulevard Vauban/Palais Rameau: the peak flow of pedestrian in front of Palais Rameau is more homogenous and observes important peaks after 5 pm. Moreover a few minutes before the beginning of the lessons in the institute located in Rue Solferino and a few minutes after the end of the lessons an important flow of children on bicycles may be noticed. The flow of bicycles is not counted in this study. The comfort level thanks to its large sidewalk has been assessed to be A+. The average flow of pedestrians is of 110 pedestrians per hour and the peak flow is of 240 pedestrians per hour.

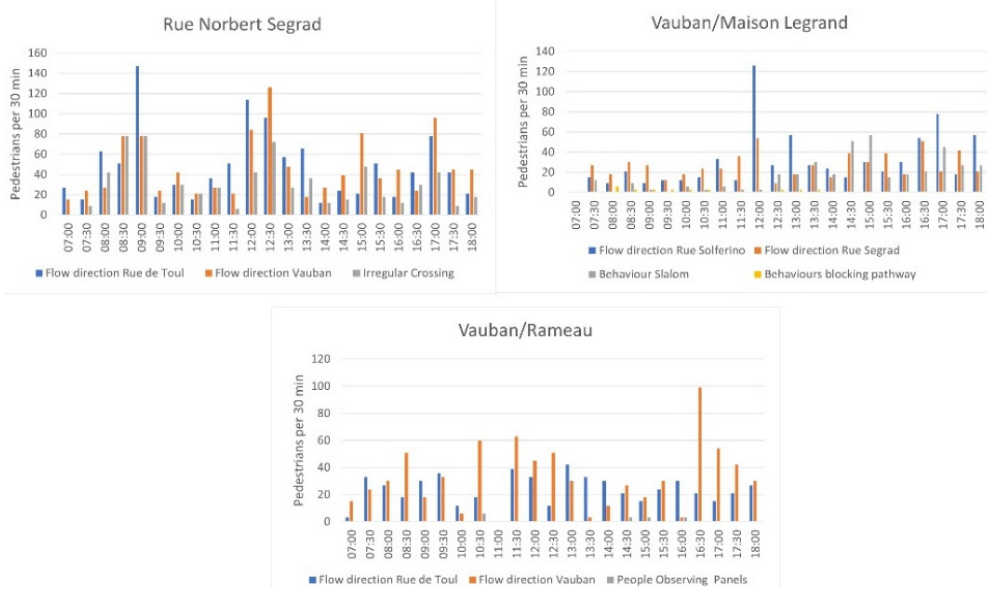

Figure 4: Flow counts during weekday.

5.2 Behaviour observations

The main behaviour observed, especially in the case of the Rue Norbert Segard, was walking on the road and irregular crossing: walking on the road or crossing without an official pedestrian sidewalk accounted 228 occurrences and increases significantly during rush hours (Fig. 3). The second most common type of behaviour, especially in the case of Boulevard Vauban, was a respond to, or a reaction to, physical elements/obstacles (such as cars, machines, and material deposits). The constantly replaced temporary sidewalk (accounting six occurrences), caused confusion of pedestrians who could not find their way. Therefore, an important amount of people (130) decided to take alternative pathways using the road or slaloming between the obstacles deposited on the sidewalk. During the weekend observation

the problem was partially solved with a temporary pathway. The third most common behaviour is irregular car parking, with 12 photographed and registered cases. Actors were mainly construction site deliveries and other couriers who dropped their car and left after a few minutes. Another important behaviour is the curiosity towards the construction sites and to its history reflected actions such as peeking through the panels, reading information, looking through the fence, etc. The observation allowed understanding the frequency of reaction to panels in both the Maison Legrand construction and the Palais Rameau, showing more interest during weekends. The panels located in front of Palais Rameau were partially covered with graffiti, which did not discourage pedestrians to look at the panels, with seven people reading panels contents on weekday and over 10 on weekend. Another important behaviour includes construction workers who redirect traffic and use the road without personal protective equipment (PPE) required and recommended for road operations. At last, a dangerous behaviour often repeated by all road users was jaywalking of main roads observed within eight photograms of people deciding to neglect the designed crossing on road intersections.

5.3 Survey results

The CAWI was conducted through Microsoft forms software and was distributed through a QR code through posters and leaflets distributed in the proximity of the Catholic University of Lille. The survey was also distributed electronically with the usage of the university mailing lists. The total amount of answers was 203 of which 194 of people living or working in the MEL. The period of distribution started on the first of June 2022 and was terminated on 11 July 2022. 33% of participants affirmed that their main transport method is walking, followed by 29% by car and 24% by public transport. Main reasons for the decision of their dominant transport method are simplicity, over 60% of respondents, and time, over 50% of respondents. The respondents were asked to rate the walkability of the area answering with an average rating of 3.66, with more than 85% of respondents generally satisfied of the area rating it level three or higher. When it comes to the statements about walkability and construction sites, almost 32% of respondents had a strongly negative opinion on the parking of cars compatible with the observations previously made, and over 41% of them did not feel recognised by construction companies. Most pedestrians accept issues related to construction if they provide improvements to the area, and surprisingly they are comfortable walking in their proximity (under scaffolding, for example). Respondents feel safe on sidewalks and find pleasure in walking, especially when in proximity of green spaces. Correlation of data, with the use of correlation provided by Pandas function Pearson correlation function, allowed finding an important correlation between travel time and transport method (Fig. 5). The noticeable fact is that users who choose walking as their main transport method generally have the lowest commute time, while the highest times is for those using public transport.

6 CONCLUSION

The current study shows that pedestrian mobility in proximity of construction sites triggers different, often unpredictable, and unsafe behaviours. However, it is obvious from the survey and observations, that respondents are curious about and feeling comfortable in a proximity of construction site. Therefore, walkable spaces in proximity of construction site may be produced with the use of construction elements and machinery, which would allow an extension of sidewalks inside construction sites providing a safe passage for pedestrians. The boundary between construction sites and pedestrian zones would blur, and communication between users on both sides would improve.

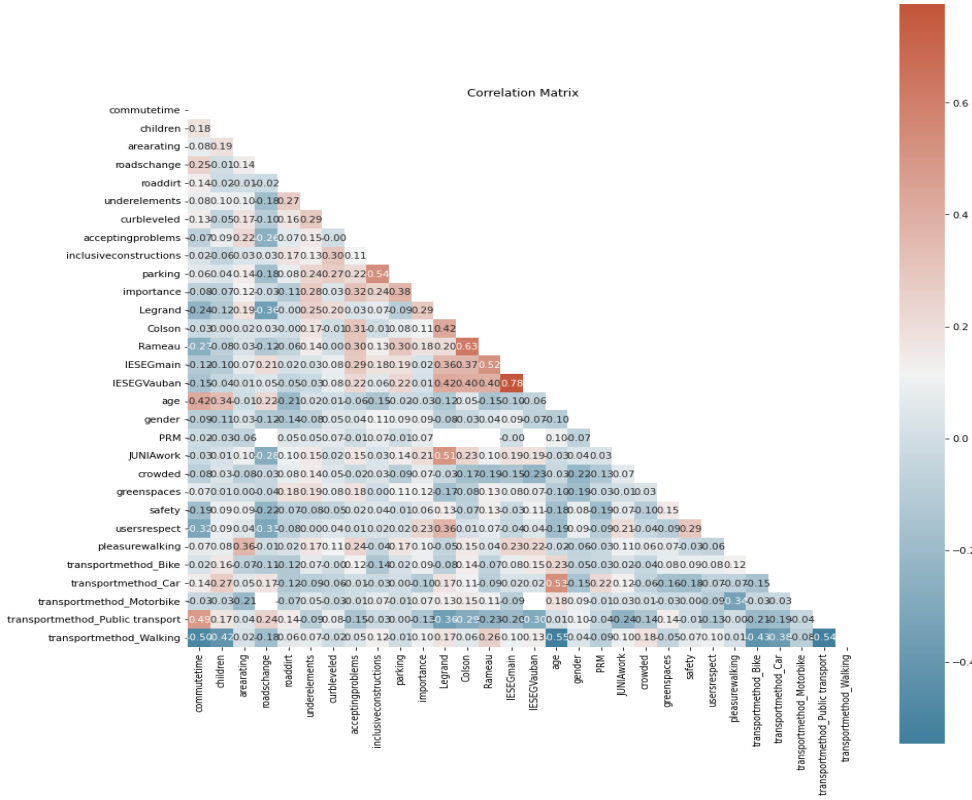

Figure 5: Correlation matrix of answers to CAWI interview.

As one solution, for the city boulevard sidewalks a more detailed and real-time plan of protected pathways could be established for both pedestrians and workers, who would then more easily apply to these solutions avoiding unsafe behaviours. The plan of pedestrian mobility addressed by the “permisse de stationament” and “permisse a voire” could consider a wider area affected by the activities on the site, especially considering daily traffic. This could be achieved with a parking plan that includes both permanent and temporary vehicles and machines used on the site. The legislative process for obtaining such a permission could include a plan of pedestrian mobility to compensate the issues caused by the occupation of sidewalks. Moreover, by avoiding narrow and uncomfortable sidewalks, a comfortable mobility through the city which encourages pedestrian mobility would be achieved.

This is especially relevant in compact and dense urban areas like Lille, where the proximity of services and its existing infrastructure allow comfortable movement to its permanent and temporary residents. In that sense, it is possible to address Road safety Policies through small urban actions and to address current climate crisis at local scale.

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