PROPOSAL AND VALIDATION OF A QUESTIONNAIRE TO INVESTIGATE RISK BEHAVIOR OF DRIVERS FROM BRAZIL AND PORTUGAL

Cintia Isabel de Campos
Cira Souza Pitombo
University of São Paulo
Patricia Delhomme
French Institute of Science and Technology for Transport, Development and Networks
Sara Ferreira
University of Porto
Elisabete Fraga de Freitas
University of Minho

ABSTRACT

Traffic accidents are among the leading causes of death around the world. The causes of its occurrence largely correspond to the human factor. With this, many studies are carried out to examine the main determinants underlying human behavior in traffic and more specifically, risk behaviors. The use of questionnaires to relate personality traits and other characteristics are widely used to investigate this type of behavior. This paper aims to present the steps performed during the development of a questionnaire to investigate risk behaviors, including qualitative and quantitative analyzes. Through pilot tests, it was possible to evaluate the comprehension of the questions as well as the reliability of the scale with the Cronbach's alpha test. At the end of all steps, the questionnaire reached satisfactory results that made it suitable for application to the final sample.

RESUMO

Os acidentes de trânsito estão entre as principais causas de morte em todo o mundo. As causas de sua ocorrência correspondem na sua maior parte ao fator humano. Com isso, muitos estudos são realizados a título de compreender o comportamento humano no trânsito e mais especificamente, comportamentos de risco. Questionários relacionando traços de personalidade e outras características são amplamente utilizados a fim de investigar esse tipo de comportamento. Esse trabalho tem por objetivo apresentar as etapas realizadas durante o desenvolvimento de um questionário para investigação de comportamentos de risco, contemplando análises qualitativas e quantitativas. Através de testes pilotos, foi possível avaliar a compreensão das perguntas, bem como a confiabilidade da escala com o teste do alfa de Cronbach. Ao final de todas as etapas, o questionário atingiu resultados satisfatórios indicando que está adequado para aplicação à amostra final.

1. INTRODUCTION

Traffic Accidents (TA) are the eighth leading cause of death in the world. More than 1.2 million people lose their lives daily, and thousands more are seriously injured. In Brazil, there are more than 43,000 annual deaths corresponding to the index 23.4 deaths per 100,000 inhabitants, above the world average of 17.4, and more than twice the average of high-income countries, that is 9.2 (DATASUS, 2016; World Health Organization, 2015).

The road environment is the result of different interactions, and driving corresponds to the constant process of adaptation to them, which may be external (laws, infrastructure) or internal (reasons that lead to user actions). When the adaptation does not occur, the TA can occur, whose causes are divided into three categories, corresponding to the human factors, road and vehicle factors (Norman, 1962; Downing *et al.*, 1991; Delhomme *et al.*, 2009).

There are many studies undertaken to investigate and understand these categories. In terms of infrastructure, in general, many studies are developed to diagnose factors that may be associated

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to a higher incidence of accidents. With respect to human factors, which are present as the main cause in most accidents, there are efforts to understand the driver behavior, and how to measure it, in different approaches, such as using questionnaires, driving simulators and naturalistic driver studies.

Risk-taking is considered as one of the main factors behind the high risk of collision (Jonah, 1986, Iversen and Rundmo, 2002). Some studies applied questionnaires to reveal that there is a tendency of risk behavior that varies depending on the dimensions of the driver's personality (Delhomme *et al.*, 2012; Cristea and Delhomme, 2016; Gheorghiu *et al.*, 2015; Iversen, 2004; Iversen and Rundmo, 2002; Letirand and Delhomme, 2005; Oltedal and Rundmo, 2006; Ulleberg and Rundmo, 2003).

Studies carried out in the areas of psychology and ergonomics seek to understand aspects related to risk behavior. The personality traits sensation seeking (Yagil, 2001) and driver anger (Deffenbacher *et al.*, 1994) are examples of traits positively correlated to risk behavior and present validated versions of questionnaires with specific scales for the context of road safety. The Driver Behavior Questionnaire (DBQ), developed by Reason *et al.* (1990), is widely used to analyze the frequency of driver risk behavior. Lajunen *et al.* (2004) suggest that some items must be elaborated to use together with DBQ items, taking into account the reality of the study region, and to compare the results due the difference of culture.

The main objective of this paper is to present the steps for the proposal of a questionnaire to investigate the risk behavior of drivers considering personality traits of anger and sensation seeking as well as driver perception of the road environment. Based on the information obtained throughout the questionnaire discrete models will be developed to analyze the variables of personality traits and road environment and their influence on risk behavior.

This paper consists of four sections, besides this introduction. Section 2 describes all procedure to create the questionnaire, and section 3 show the development of the questions. Section 4 include the results of the pilot test and discussion. Finally, final considerations are presented in section 5.

2. PROCEDURE

The development of the questionnaire began with the literature review on driver risk behavior. The next step was to create questions related to the points observed in the literature. Besides, interviews were carried out with drivers who take risks in traffic.

Based on the content of the interviewees' answers, the conditions to be investigated with the questionnaire were defined. Questions were elaborated to outline the socioeconomic profile and experience of driving, perception of road environment in which the person usually drives as well as questions to investigate behavior and attitude in traffic. To assist in the investigation of behaviors, attitudes and personality traits, scales already validated in English, were used: Sensation Seeking, Driver Anger Scale (DAS) and Driver Behavior Questionnaire (DBQ). These questionnaires were applied successfully as seen at Yang *et al.* (2013), Schwebel *et al.* (2006), Ulleber and Rundmo (2003), Delhomme et al. (2012), Dourado *et al.* (2017) and Özkan *et a*l. (2006).

In the questions about the environment characterization, we used images to represent the urban and highway context, pavement conditions and design of the road. In the case of the urban context, the images represent streets more or less dense, and in the highways context, the images represent a scale of bad to very good conditions of pavement, and the presence or not of curves.

Throughout the process of creating the questionnaire, discussions and reviews were carried out together in the research group, in order to evaluate the questions considering the parameters to be investigated. Some measures that indicate the sensitivity, reliability and validity of the questions were evaluated with the application of two pilot tests.

2.1 Validated Questionnaires

As mentioned before, some instruments already validated previously are part of the final version of the questionnaire. A brief description of them is presented as follows.

2.1.1 Sensation Seeking

The scale that investigates the personality trait Sensation Seeking was developed by Taubman *et al.* (1996, apud Yagil, 2001), and is directly related to sensation seeking in traffic. This instrument consists of seven items that investigate driving preferences on a seven-point Likert scale (1 = "Not true at all" to 7 = "Absolutely true").

2.1.2 Driver Anger Scale (DAS)

The Driver Anger Scale instrument, developed by Deffenbacher *et al.* (1994), was designed to evaluate the propensity of drivers to become irritated or aggressive in traffic. There are two versions, a long one, with 33 items, and a short one, with 14 items, describing traffic situations that the driver must classify the degree of anger that would feel for each circumstance, in a scale of 5 points (1 = Nothing" for 5 =" very much "). For this study the short version, translated into Portuguese by Cantini *et al.* (2015), was used.

2.1.3 Driver Behavior Questionnaire (DBQ)

The Driver Behavior Questionnaire (DBQ), originally developed by Reason *et al.* (1990), has 50 items that investigate the behavior of the driver through three elements: errors, lapses and violations. The short version of Özkan *et al.* (2006), with 19 items divided into errors, common violations and aggressive violations, was used in this study. Some research has indicated that lapses have not shown safety relevance (Parker *et al*., 2000 apud Özkan *et al*., 2006). A component related to alcohol consumption deleted by Özkan *et al.* (2006) was maintained in our version, totaling 20 items. The Portuguese version was based on the version by Bianchi and Summala (2002) and some adaptations were made to improve understanding.

2.2 Translation and adaptations of original versions

The scales already validated went through a process of translation and adaptation of the language. The versions already translated from English to Portuguese have been adapted to the Portuguese version of Portugal. The questionnaires that only had the English version were

translated into Portuguese. The version of the questionnaire for Portugal had all its contents reviewed by native speakers of both psychology and engineering.

The sensation-seeking questionnaire, has its original version in Hebrew and did not have a Portuguese version. The translation has been made considering the English (Yagil, 2001) and French versions (Delhomme *et al*., 2009).

The Likert scales of the original version of the Driver Behavior Questionnaire and Sensation Seeking were adapted to five points, as the standard adopted for this questionnaire. The adequacy of the translations, scales and other adaptations were tested in the questions' validation stage.

2.4 Validation of the questions: sensitivity and reliability analysis

In this stage two pilot studies, with 12 participants each one, were carried out to test the comprehension of the questions by the respondents and the reliability of the scales. The participants were chosen for convenience and the only criteria was drive frequently. They were invited to respond the questionnaire in a printed version and make notes about questions regarding comprehension, errors or suggestions about the issues. In addition to the comments, the data collected with the pilot sample were also analyzed with descriptive statistics and Cronbach's alpha.

Sensitivity analysis was performed using descriptive measures (mean, mode, standard deviation and variance), which were generated to observe the distribution of the answers and, consequently, if there were questions in which the answers focused on a single option (Alferes, 1997). Low variability in response may indicate that the question was not being well interpreted in the way it was presented or that the scale was not adequate, for example.

The reliability of the scale can be evaluated in different ways. Among the simpler forms, techniques such as: applying the questionnaire twice to the same people, in a time interval where the results of score should be the same in times 1 and 2; or, divide the sample into two parts, among many participants, in which the score of those parts must be positively correlated. However, in this later method, the result can vary according to the division of the set.

In this study, the reliability of the scale was evaluated with Cronbach's alpha. This test is a measure equivalent to the division in two parts. However, makes it possible to calculate all possible divisions for the set by computing the correlation coefficients of each part, according to Equation 1 (Field, 2013).

$$\alpha = \frac{N^2 \overline{Cov}}{\sum s_{item}^2 + \sum Cov_{item}} \qquad (1)$$

Where, *N* is the number of items, s^2 is the variance and *Cov* is the covariance.

To apply the alpha coefficient, it is necessary that all items are in the same order of scale, and when there are inverse items, it is necessary to reverse the scale of these items before applying the alpha coefficient.

According to Field (2013), a value considered acceptable for the alpha is between 0.70 and 0.80. For psychological constructs, values below 0.70 can be found because of the diversity of the constructs (Kline, 1999 *apud* Field, 2013).

When analyzing the results of the first pilot test, some problems were identified and subsequently corrected, as presented in section 4. A new version was applied to other drivers, with the same criteria of the first one, consisting of the second pilot test. The questionnaire was respond in a printed version and with the same guidelines considered in the first test. The same statistical tests were performed to compare and evaluate the corrections.

3   QUESTIONNAIRE DEVELOPMENT

3.1 Interviews

Considering the main points treated in the literature, the open questions were answered in the form of interviews to assist the elaboration of the questions of the questionnaire. The questions aim was to investigate the behavior and opinion of the driver regarding the following items: speeding, evaluation of the road environment, alcohol and drugs, violation of traffic laws, sensation when committing infractions, attitudes in traffic and traffic accidents.

Participants were chosen for convenience and not randomly, and had in common the characteristic of take risk in traffic. The sample consisted of three drivers, two men and one woman, between 30 and 34 years old, with 10 years of driving experience, on average, and who frequently drive on highways. The questions and their objectives are presented in Table 1.

Table 1: Questions and aim

Questions	Aim
What do you think about speeding by the other drivers? What speed do you drive on the straight road when traffic is light? Do you think this is a risk? Why? Why do you think the drivers speeding?	Investigate the opinion and perception of risk related to speeding and your own behavior
Do you feel safe in the roads that you drive? Why? Do you know drivers who take risks? What they do? Why?	Identify how the driver analyzes the road environment and how perceives drivers' behavior in their environment
Have you ever drank and drove? Do you think that drive after drink is a risk? Have you ever driven under the influence of drugs? Do you think that is it a risk? Why? Do the people around you do this? What is your opinion about their conduct?	Investigate the perception of risk associated with driving under the influence of alcohol or drugs, in contrast to the behavior itself
Have you ever been fined? What reason? Have you ever committed any traffic violations? If so, which one? Do you frequently disregard any traffic law? What? Do you disagree with any traffic law? What? Do you know the punishments for those who commit infractions like the ones we discussed? Do you respect road signs? Do you think that not respecting traffic signs is a risk? Why?	Identify recurring practices of violation
What is your feeling when you disrespect some traffic law, such as: - Speeding; - Drink and drive; - Driving under the influence of drugs; - Disrespect some law	Check for emotion-related reasons associated with violation

Do you think your behavior changes in traffic? If so, what kinds of changes do you observe? What are the reasons for you to change?	Identify external factors that influence driver behavior
Have you ever suffered any kind of traffic accident? If so, was it serious? Were you at fault in the accident? Do you feel that you have changed your behavior after the accident?	Get information about accident history and influence in their life

3.2 Elaboration of questions

For the development of the questions, we considered the respondents' answers, the content discussed in the literature and the objectives and hypotheses of the final study, which consists in a prediction of risk behavior including variables of personality traits and road environment. The number of questions to each group, and how the answer is obtained are shown in Table 2. An explanation is presented below.

Table 2: Composition of the questionnaire

Questions group	Number of questions	Number of items	Answer options
Sociodemographic profile	7	-	List of options (discrete data)
Driver experience	4	-	
Self-evaluation and of other drivers	1	6	
Urban environment	2	12	
Highway environment	3	11	
Anger	1	14	5-points Likert scale
Sensation seeking	1	7	
Risk perception	1	20	
Risk behavior	2	40	

3.2.1 Driver and road environment characterization

The first block of questions, "Sociodemographic data and history as a driver", consists in characterize the sociodemographic profile and the driver's experience. Therefore, questions were asked about: the place where people live (country, state and city), age, gender, schooling and income. After the first pilot test, two questions were added: marital status and whether the person has a child, indicating the age of each child.

The driver's experience has been evaluated by questions about: i) how long the person drives (year); ii) how many miles the person drives weekly; iii) how many times the person was fined in the last three years and what were the reasons, and lastly; iv) if the individual was involved in traffic accidents in the last 3 years, and if yes, the accident severity (property damage only, slight or severe injury or fatal).

It is also part of this block the question of evaluation of drivers' ability to drive and their view of others, adapted from Delhomme (1991). Responses are obtained on a Likert five-level scale, where 1 is "Strongly Disagree" and 5 "Strongly Agree".

The group of questions "Familiarity on different road environment" is composed of four questions that assess the urban road environment and highways frequently used by individual

with the use of images or indication of items. In the urban context, the investigation is about i) the height of the constructions and widths of the roads; and ii) the infrastructure description as reported by the driver. About the road context, it stems from the analysis of i) frequency that individual drive on highways; ii) the level of service of the roads that the individual usually drive; and iii) the quality of the road pavement.

Answers will be expressed on a Likert scale indicating the frequency on a 5-point scale, where 1 is "Never" (I never drive on a similar road) and 5 is "Very often" (I very often drive on a similar road).

3.2.2   *Risk taking behavior characterization*

The "Yourself as a driver" block consists of five questions to investigate personality traits and attitudes that, as described in the literature, are positively correlated with drivers' risk behavior (Yang *et al*., 2013; Schwebel *et al*., 2006; Ulleber and Rundmo, 2003). The objective is to identify how much the driver take risks in the traffic, from self-declared answers, in the perspective of characterizing the levels of risk behavior.

The validated questionnaires of Taubman *et al.* (1996 apud Yagil, 2001) and Deffenbacher *et al.* (1994) investigate the personality traits of sensation seeking and anger, as previously mentioned. As seen in the literature, these traits are positively related to risk behavior in traffic, and measuring them assists in the characterization of the risk taking behavior.

Two questions were elaborated from the interview results. The first was "For each of the sentences below, indicate how often you have adopted these behaviors in the last year". Twenty sentences were elaborated to investigate the frequency that the individual adopts risk behaviors related to the use of the cell phone while driving, speeding, crossing the red light, not wearing a seatbelt or ignoring other traffic rules, following close, change lanes without signaling or without looking at the rear view mirror and driving tired.

The second question investigates the risk perception with the same sentences of the previous question, but in other perspective: "According to you, the behaviors below are ...". The answer is in a 5-points Likert scale, where 1 is "not risky" and 5 is "risky".

The DBQ version used in this paper investigates the frequency of unsafe behaviors classified as errors, aggressive violations and ordinary violations. These factors are associated with the involvement of traffic accidents.

4   PILOT TEST RESULTS AND DISCUSSIONS

Two pilot studies were conducted to test the questions and scales of the questionnaire with participants from Brazil and Portugal, six from each one. Table 3 shows the descriptive statistics of the sample of the two tests. Both samples were compound by 50% of each gender. There were five individuals that drives motorcycle and car in the first pilot study and just one in the second. The kilometers drove per week is less in the second pilot sample than the first one.

Table 3 – Sample descriptive statistics

	Pilot test 1					Pilot test 2			
	n[a]	Mean	SD[b]	Min	Max	n[a]	Mean	SD[b]	Min	Max
Age	12	31.08	5.63	25	46	12	34.75	8.92	21	53
Time of car drive license	12	10.58	5.79	2	22	12	14.25	8.52	3	33
Time of motorcycle drive license	5	15	6.04	7	22	1	3	0	3	3
Km/week (car)	12	204.83	246.24	28	800	12	160.58	132.55	10	450
Km/week (motorcycle)	5	63.08	151.20	0	600	1	100	0	100	100

a) n-number of participants of the sample b) SD-Standard deviation

As mentioned before, participants were instructed to make notes on any questions, suggestions or comments they might have regarding the questions and how to respond. All the participants stated that the questionnaire was quick and easy to answer, which made them think about the way they are driving and the questions are within their reality. After analyzing the results of Cronbach's alpha, the variability of the responses and the comments of the participants, some changes were made to the second pilot test.

The reliability of the scales was tested with Cronbach's alpha in questions related to driver behavior. It was not necessary to invert any items from the scales, since all had the same tendency of response. The results are shown in Table 4 and commented below.

- The driver ability was evaluated in two subscales, one considering the self-evaluation, and another where the other drivers are evaluated. Both showed good results in terms of Cronbach alpha in the first pilot test. In the second test, the alpha of the items related to self-evaluation decreased due the item "I am a very good driver", which presented less variability in the response than the first test. Considering that the results of the first test were better and that the participants made no comments on these items, the validation of this question will be carried out together with the validation of the questionnaire constructs;
- The driver's anger scale score proved to be reliable in both tests, presenting a similar result to the alpha (0.800) found by Deffenbacher *et al.* (1994);
- There was also a reduction in the alpha related to sensation seeking on the second test. As these items initially presented a satisfactory value, the results can be related to the characterization of the sample;
- Behavior frequency and risk perception were created and proved to be reliable in both pilot studies, both of which reached the highest alpha in the tests.

Özkan *et al.* (2006) applied the alpha to the three different parts of DBQ, obtaining the following results: ordinary violation (0.73-0.85) errors (0.62-0.75) and aggressive violation (0.59-0.74). In the first pilot study, the best alpha was of errors (0.70) followed by aggressive violation (0.47). Three items measured aggressive violations, instead of the original four, because item 12 was deleted of the evaluation for not displaying any variation. The items of ordinary violation had a negative value for the alpha (-0.40).

All DBQ items was reviewed by four individuals from each country that were invited to evaluate the translation and improve the items. Of the 20 used items, 13 were modified in the Brazilian and Portuguese versions. In the second test, almost all items were improved in terms of Cronbach alpha.

Also regarding DBQ, the item about alcohol consumption, which was initially expressed by "Driving when you suspect you may be above the legal limit of alcohol in the blood", was modified in the Brazilian version to "Driving after consuming alcoholic beverage". The Brazilian Law 11,705/2008 in Article 165 provides a fine for drivers driving under the influence of alcohol, without specifying a limit.

Regarding the analysis of response variability, in the first pilot study, four items related to alcohol and drug use did not present any variation. In the second pilot study, only one item did not show variation, the item 3.5, where the person is asked about how often they used some type of drug and drove.

Table 4: Cronbach alpha results

Items	Pilot test 1			Pilot test 2		
	Cronbach Alpha	Cronbach Alpha (Standardized items)	N of items	Alfa de Cronbach	Cronbach Alpha (Standardized items)	N of items
Drivers ability	0.572	0.560	6	0.685	0.644	6
Self-evaluation	0.714	0.709	3	0.386	0.232	3
Other drivers evaluation	0.646	0.639	3	0.699	0.714	3
DAS	0.805	0.821	14	0.866	0.868	14
Sensation Seeking	0.697	0.752	7	0.484	0.543	7
Behavior frequency	0.797	0.811	17	0.840	0.847	19
Risk Perception	0.924	0.921	16	0.940	0.942	20
DBQ - all items	0.473	0.635	19	0.845	0.846	20
DBQ - error	0.703	0.746	8	0.792	0.792	8
DBQ - aggressive violation	0.474	0.501	3	0.470	0.366	3
DBQ - ordinary violation	-0.404	0.069	8	0.704	0.704	8

All comments of the participants in the two phases were evaluated, and some changes were made. One of the comments was about the use of the English term "Bluetooth" in sentences about how often they used cell phones while driving in urban areas or highways. The person reported not having understood, so the word was replaced by the more popular use, hands-free. Another observation was about the discomfort people may feel to inform their income, so we emphasize even more in the questionnaire statement that the answers will be confidential and anonymous. Besides these ones, other changes were undertaken such as inclusion or exclusion of items in the answer options, adding more questions, changing the way the sentence or structure of the questions' answer, and so on.

The statement of the questions related to the evaluation of the road environment were rewritten with the objective of making them clearer and more objective, avoiding difficulties of interpretation. The first image of the question about the urban context has been changed to adapt to the reality of the two countries. In both pilot tests the responses presented variability, as shown in Table 5. Cronbach's alpha was not applied to this set of questions because their purpose is not to evaluate trends but to characterize the road environment.

Table 5: Descriptive statistics of road environment questions characterization

Variable	Pilot study 1			Pilot Study 2		
	M[a]	SD[b]	V[c]	M[a]	SD[b]	V[c]
12. a)	4.17	0.937	0.879	3.36	1.027	1.055
12. b)	3.92	0.996	0.992	4.09	0.701	0.491
12. c)	2.67	1.670	2.788	2.91	1.221	1.491
13. a)	1.25	0.622	0.386	1.18	0.603	0.364
13. b)	1.50	1.000	1.000	1.73	1.191	1.418
13. c)	2.50	1.446	2.091	1.91	1.221	1.491
13. d)	3.17	1.193	1.424	2.55	1.368	1.873
13. f)	4.33	0.651	0.424	4.27	0.905	0.818
14. a)	3.33	1.231	1.515	4.00	1.000	1.000
14. b)	3.83	0.937	0.879	3.36	0.924	0.855
14. c)	1.75	0.866	0.750	1.27	0.647	0.418
15. a)	2.25	1.357	1.841	3.25	1.288	1.659
15. b)	3.67	1.073	1.152	3.50	1.243	1.545
15. c)	3.67	0.888	0.788	3.08	1.311	1.720
15. d)	3.58	1.379	1.902	3.75	1.288	1.659
16. a)	4.58	0.900	0.811	4.50	0.905	0.818
16. b)	4.33	0.888	0.788	4.42	0.900	0.811
16. c)	4.33	0.651	0.424	4.42	0.900	0.811
16. d)	3.67	0.985	0.970	3.50	1.243	1.545
16. e)	4.75	0.622	0.386	4.42	0.669	0.447
16. f)	4.67	0.651	0.424	3.67	0.888	0.788
16. g)	4.92	0.289	0.083	4.33	0.778	0.606
16. h)	4.67	0.492	0.242	3.92	0.900	0.811

a) M-mean b) SD-standard deviation c) V-variation

5. FINAL CONSIDERATIONS

More than a quantitative analysis, developing and evaluating questions for application of a questionnaire requires a critical qualitative analysis. Initially, the purpose of each question and the best way to get the answer according to the study objectives should be carefully planned.

The questionnaire should be tested for comprehension, that is, whether people are actually interpreting the questions and answers according to the purpose they were created. For this, the first step is to test the consistency of the questions. It is essential to carry out pilot tests to obtain qualitative data based on the comments about the interpretation of the participants of the sample, and quantitative data that base the analysis of sensitivity and reliability of the questions and scales.

The reliability analysis with Cronbach's alpha was very important to validate the questions due to the changes made in the original scales of the validated questionnaires and the two questions

that were created. The result of the second pilot test demonstrated that the developed questionnaire meets the criteria of sensitivity and reliability and it is ready to be applied. After the application of the questionnaire and obtaining of the desired sample, a validation step of construct should be performed using Principal Components Analysis to confirm the dimensions of the constructs and evaluate the internal consistency, such as the one performed by Dourado *et al.* (2017).

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Cintia Isabel de Campos (cintiacampos@usp.sp)
Transportation Engineering Department, São Carlos Engineering School, University of São Paulo
Av. Trabalhador São-carlense, 400 – São Carlos, SP, 13566-590
Cira Souza Pitombo (cirapitombo@gmail.com)
Patricia Delhomme (patricia.delhomme@ifsttar.fr)
Sara Ferreira (sara@fe.up.pt)
Elisabete Fraga de Freitas (efreitas@civil.uminho.pt)