As Ciências Sociais Aplicadas e a Interface com vários Saberes

Atena Editora
Ano 2020

Wendell Luiz Linhares
(Organizador)

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2020 *by Atena Editora*

Editora Chefe: Profª Drª Antonella Carvalho de Oliveira
Diagramação: Geraldo Alves
Edição de Arte: Lorena Prestes
Revisão: Os Autores

Atena Editora
Ano 2020

Atena Editora
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Dados Internacionais de Catalogação na Publicação (CIP)
(eDOC BRASIL, Belo Horizonte/MG)

C569 As ciências sociais aplicadas e a interface com vários saberes [recurso eletrônico] / Organizador Wendell Luiz Linhares. – Ponta Grossa, PR: Atena Editora, 2020.

Formato: PDF
Requisitos de sistema: Adobe Acrobat Reader
Modo de acesso: World Wide Web
Inclui bibliografia
ISBN 978-85-7247-978-3
DOI 10.22533/at.ed.783202801

1. Ciências sociais – Pesquisa – Brasil. I. Linhares, Wendell Luiz.

CDD 301

Elaborado por Maurício Amormino Júnior – CRB6/2422

Atena Editora
Ponta Grossa – Paraná - Brasil
www.atenaeditora.com.br
contato@atenaeditora.com.br

APRESENTAÇÃO

A presente obra, ao abordar as diferentes interfaces das Ciências Sociais Aplicadas, reforça uma de suas características, a qual, cada vez mais vêm ganhando destaque no campo científico, sendo ela, a interdicisplinaridade. Neste sentido, o e-book intitulado “As Ciências Sociais Aplicadas e a Interface com vários Saberes”, configura-se numa obra composta por trinta e um artigos científicos, os quais estão divididos em três eixos temáticos. No primeiro eixo intitulado “Direito, Políticas Públicas, Representações Sociais e Mídia”, é possível encontrar estudos que discutem e apresentam aspectos relacionados tanto ao direito e os procedimentos penais, quanto ao processo de constituição, aplicação e avaliação de Políticas Públicas e a construção de Representações Sociais de sujeitos a partir de veículos midiáticos específicos. No segundo eixo intitulado “Administração, Marketing e Processos”, é possível verificar estudos que discutem diversos elementos que compõem a grande área da administração e como ocorrem determinados processos numa empresa. No terceiro eixo intitulado “Educação, Práticas Pedagógicas e Epistemológicas”, é possível encontra estudos que abordam de maneira crítica, diferentes práticas pedagógicas e epistemológicas, promovendo assim, uma reflexão histórica e social sobre o tema. O presente e-book reúne autores de diversos locais do Brasil e do exterior, por consequência, de várias áreas do conhecimento, os quais abordam assuntos relevantes, com grande contribuição no fomento da discussão e avanço dos temas supracitados.

Portanto, é com entusiasmo e grande expectativa que desejo a todos uma boa leitura.

Wendell Luiz Linhares

SUMÁRIO

CAPÍTULO 9

NEW ACCESS TO BOMBINHAS: COST AND BENEFIT ANALYSIS FOR EACH OPTION

Data de aceite: 17/01/2020

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ABSTRACT: Mobility is one of the main challenges of modern cities, becoming even worse if financial resources are rare and natural or artificial obstacles are present. This is the case of Bombinhas, a city of northeast of Santa Catarina, in south of Brazil. It has around of 15 thousand continues habitants but, due to its beautiful beaches, usually receives hundreds of thousands more in summer. As result big traffic jams are registered year before year on the only paved access to the city: through Bombas' hill. Since the last decade, the Santa Catarina Government in association with city hall have been discussed the construction of a second access to change this scenario. However consensus about paving another land access, through Zimbros' hill, or a construction of a tunnel has not achieved. This article brings to light topics about this issue, calculating estimations for preliminary cost and execution time besides values for minimum travel time between Porto Belo (border city) and reference points inside of city. While parametric estimation (PE) was utilized to define the preliminary cost a critical path method (associated with NTNU prediction method for Drill and Blast and DNIT/SICRO method for pavement tasks) was utilized to define the execution time, the minimum travel time was obtained through relation between distance and maximum velocity on path. As expected the more expensive and more time-consumption execution option (which connect Porto Belo with Sertãozinho by a tunnel) has the minimum travel time in all scenarios. The reduction is around (50 – 60) % in all path analysed in comparison with worst one. Similar, but worse performance, are obtained with connection between Zimbros and Porto Belo by smaller tunnel. Options which involve paving show to be cheaper and faster to be executed, but the minimum travel time improvement show to be not so significant comparatively. Special attention should be given for option which connects Sertãozinho and Porto Belo downtown. The low maximum velocity on sequential road system and the proximity with actual access put in doubt the efficiency of solution. This number together with numerical criteria of decision can help to find the more adequate option for Bombinhas and region.

KEYWORDS: Mobility, Cost estimation, Time execution estimation, Minimum travel time.

1 I TRAFFIC IN BOMBINHAS AND PLANS TO NEW ACCESS

Bombinhas is a city located in northeast of Santa Catarina, one of three state of south Brazilian region. It has area superior of 34.000 km^2 and more than 14.000 habitants. Due to tourism, main economic activity, its population usually is multiplied by several times in summer. As illustrated in figure 01 this seasonal demand overloads the principal access to the city, creating big traffic jams. On Leopoldo Zarling Avenue, one of the most important of the city, the operational speeds are usually near of 50 km/h but in summer it is reduce for values near of 5 km/h.

As the enlargement of actual access, though Bombas' hill, and its sequential road system are not a practicable option, the authorities responsible decided for a new access in a different region of city. According Gollnick (2016) and illustrated in figure 02, the first option is to pave a road system though Zimbros' hill in a total of 8,7 km. This option will connect Sertãozinho neighbourhoods with Porto Belo downtown (in extension of 2,5 km) and Santa Luzia neighbourhoods (in extension of 6,2 km).

Another option is the construction of a tunnel under Zimbros' hill and, in this case, two options of path are possible: one starting in Sertãozinho neighbourhoods and another starting in Zimbros neighbourhoods. While the first one demands a 3,0 km tunnel, the second demands a 2,2 km tunnel construction.

One alternative to guide the decision process about the new access is the analysis of preliminary cost estimation, time of execution estimation and minimum travel time estimation between Porto Belo and the main destinations in Bombinhas.

Figure 1- Bombinhas access though Bombas Hill and Leopoldo Zarling Avenue, one of the most important avenues of city, in summer.

Source: Secretária de Turismo de Bombinhas (2015)

Figure 2 - Alternatives to new access of Bombinhas. In Green, the road over Zimbros Hill and, in purple, the two path option for a tunnel.

Source: Gollnick (2016)

2 I INDEXES CALCULATION METHODS

2.1 Minimum travel time

The minimum travel time for each option can be calculated by the sum of time consumed in all parts that compose the path, considering the same initial point (Santa Luzia neighbourhood) and as a final point the main destinations in Bombinhas city (Bombas, Bombinhas and Mariscal beaches). Santa Luzia neighbourhood was chosen because it belongs to the path of four new access options. The table 01 shows each part of four paths and its lengths and velocities.

New access option	Part of total path		Part of total path		Part of total path	
	Length, [km]	Velocity, [km/h]	Length, [km]	Velocity, [km/h]	Length, [km]	Velocity, [km/h]
Access option 1 – Including pave road between Sertãozinho and Porto Belo downtown	Santa Luzia to Porto Belo downtown		Porto Belo downtown to Sertãozinho		Sertãozinho to Bombas/Bombinhas/Mariscal	
	5,0	30	2,6	40	3,5/4,9/5,2	60
Access option 2 – Including pave road between Sertãozinho and Santa Luzia	Santa Luzia to new access entrance		New access entrance to Sertãozinho		Sertãozinho to Bombas/Bombinhas/Mariscal	
	1,3	60	7,2	40	3,5/4,9/5,2	60
Access option 3 – Including tunnel construction between Zimbros and Santa Luzia	Santa Luzia to tunnel entrance		Tunnel entrance to Zimbros		Zimbros to Bombas/Bombinhas/Mariscal	
	1,3	60	2,2	80	6,4/8,0/5,8	60
Access option 4 – Including tunnel construction between Sertãozinho and Santa Luzia	Santa Luzia to tunnel entrance		Tunnel entrance to Sertãozinho		Sertãozinho to Bombas/Bombinhas/Mariscal	
	1,3	60	3,0	80	3,5/4,9/5,2	60

Table 1 - Distances and velocities between the several points in the path of four new access options.

2.2 Preliminary cost estimation

As the road connecting Santa Luzia - Porto Belo downtown, Santa Luzia - tunnel entrance point (same point that starts the road connecting Santa Luzia and Sertãozinho) and the roads linking Zimbros and Sertãozinho to Bombas, Bombinhas and Mariscal beaches already exist, the main cost involved are related to pavement and tunnel construction (according to each option analyzed). Earth works and slope containment services are not considered.

An alternative to determine the preliminary cost estimation is the application of Parametric Estimation (PE) Cost methods. According Menard (2017), in PE teams divide a project in units of work and then determine the cost of each unit. By multiplying the number of units by the cost per unit, it is possible estimate the total cost of the project. This technique is best for projects that involve repetitive tasks, as infrastructure projects.

In this analyse the main activities composition for paving and tunnel construction are identified and unit cost determinate using a database maintained by Brazilian government called SICRO, found in DNIT (2017). It is a tool created to keep the definition of costs up to date and able to establish the best parameters to refer the preparation of budgets for road and infrastructure projects. It is regionalized and updated every month. In this work was utilized the version of September of 2017 for Santa Catarina state. Tables 2 until 5 highlight the unit cost and total work to be executed together with description of each activity for all access options.

Due to non-existence of composition related to Drill and Blast (D&B) excavation method (standard excavation method for hard rock[1] in short tunnels) in SICRO, the unit cost and total work utilized estimation utilized Kolymbas (2005) and ANTT (2009) as reference. While Kolymbas (2005) according application, describe normalized cross section that multiplied by total length define the total excavation volume, ANTT, (2009) brings value compositions related with D&B for tunnels of different size in Brazil.

As the values present in ANTT, (2009) are related of 2009, a correction factor of 1,59 was utilized to update the composition value. It corresponds to accumulation of Civil Construction index, called CUB (in Portuguese *Custo unitário Básico*), widely used to correct construction civil contracts in Brazil. Furthermore the cross section of reference tunnel are different of 66,53 m^2, the cross section define as more adequate for Bombinhas's project. A correction factor of 0,48 (cross section area/ cross section area of reference tunnel[2]) was utilized for this reason. The preliminary cost estimation can be found by addition of product between unit cost and total work

1 According DNPM (1986), the region of excavation are part of Porto Belo Granit-Gneiss zone.

2 The most adequate area for Bombinhas's project are 66,53 m^2 while the reference tunnel has 139,00 m^2 of cross section area.

of all compositions.

Description	Un	Unit cost, [R$]	Total work
Adjustment of subgrade	m^2	0,70	28.750,00
Soil Subbase course granulometrically stabilized with material of field	m^3	7,19	8.552,12
Base or subbase of gravel graded with commercial gravel	m^3	97,10	2.861,38
Asphalt emulsion primer	m^2	0,22	25.600,00
Revetment surface	t	86,98	3.450,52
Acquisition Asphalt Cement CAP 50/70	t	1.643,69	207,03
Acquisition Diluted Asphalt CM 30	t	2.533,46	30,72
Transport of bituminous material	tkm	0,91	121.728,74

Table 2 - Main activities of paving task for access option that includes connection between Sertãozinho and Porto Belo downtown (access option 1) with cost unit and total work.

Description	Un	Unit cost, [R$]	Total work
Adjustment of subgrade	m^2	0,70	71.300,00
Soil Subbase course granulometrically stabilized with material of field	m^3	7,19	21.209,27
Base or subbase of gravel graded with commercial gravel	m^3	97,10	7.096,21
Asphalt emulsion primer	m^2	0,22	63.488,00
Revetment surface	t	86,98	8.555,48
Acquisition Asphalt Cement CAP 50/70	t	1.643,69	513,33
Acquisition Diluted Asphalt CM 30	t	2.533,46	76,18
Transport of bituminous material	tkm	0,91	301.831,37

Table 3 - Main activities of paving task for access option that includes connection between Sertãozinho and Santa Luzia (access option 2) with cost unit and total work.

Description	Un	Unit cost, [R$]	Total work
Underground excavation and loading of top heading material (classe I)	m^3	99,93	58.246,40
Underground excavation and loading of invert material (classe I to IV)	m^3	47,91	87.819,60
Drilling for Bolts in first class material with diameter of 120 mm	m	14,91	13.200,00
Steel bolts with UTS of 750 MPa and diameter of 25 mm	m	92,32	13.200,00
Transport by truck with 14 m^3 of capacity – paving roads	tkm	0,51	759.543,20‡
Sprayed concrete with fck=30 MPa	m^3	463,92	11.000,00
Concrete pavement, thickness of 0,20 m	m^2	90,03	20.900,00

Table 4 - Main activities of tunnel construction for access option that includes connection between Zimbros and Santa Luzia (access option 3) with cost unit and total work.

Description	Un	Unit cost, [R$]	Total work
Underground excavation and loading of top heading material (classe I)	m^3	99,93	79.836
Underground excavation and loading of invert material (classe I to IV)	m^3	47,91	119.754
Drilling for Bolts in first class material with diameter of 120 mm	m	14,91	18.000
Steel bolts with UTS of 750 MPa and diameter of 25 mm	m	92,32	18.000
Transport by truck with 14 m^3 of capacity – paving roads	tkm	0,51	1.037.868
Sprayed concrete with fck=30 MPa	m^3	463,92	15.000
Concrete pavement, thickness of 0,20 m	m^2	90,03	28.500

Table 5 - Main activities of tunnel construction for access option that includes connection between Sertãozinho and Santa Luzia (access option 4) with cost unit and total work.

2.3 Time of execution estimation

As the transit situation gets worse year after year, short time of execution is an important characteristic of best alternative, reducing the financial, social and environmental damage caused by this lack of mobility. The definition of execution time of an infrastructure project is a task that can be made by utilization of critical path method (CPM). It is one of the several project management tools available and is directly linked with management time of project, having the time reduction as priority.

According Tavares et al. (1996) critical activities (or tasks) define the critical path, revealing the sequence of tasks that define the duration of the project. With this, is possible to get the necessary information to elaborate a chronogram taking into account the necessary resources due to the constraints associated with the critical tasks, achieving a balanced management of resources throughout the project. While for execution time in tunnel construction was utilized the method proposed by Norway University of Science and Technology (NTNU), for pavements tasks was adopted the method proposed by National Department of Infrastructure of Transport (DNIT) in association with productivity references tables, called SICRO (periodically published by Brazilian government).

2.3.1 NTNU method

The last edition of NTNU method for excavation executed by Drill and Blast method was published in 2006 by Dr. Shokrollah Zare. In the method the total time is define by sum of individual time of: (1) drilling and charging, (2) ventilation, (3) loading and hauling and (4) scaling and reinforce phases. The operation (1) and (3) are divided into three different categories of time, i.e. fixed lost time (rig time), proportional operational, time and incidental lost time.

To operationalize were utilized a set of graphics, that can be found in Zare (2006), and several parameters. It was considerable geological proprieties (e.g. drilling rate index, blastability rate index, rock wear quality), detonation characteristics (e.g. explosive type proprieties, number of detonation lines), detonation plan (e.g. pull, hole position and diameter), geometrical tunnel characteristics (e.g. Shape, Size, length), equipment characteristic (e.g. number of drilling rod, loading capacity) besides performance working team. Table 6 shows the execution time for one cycle of Drill and Blast process. The total time can be found through multiplication between cycle time and ratio of length (2.200 meters for option 3 and 3.000 meters for option 4) and pull (define as 5 meters).

Description	Un	Time
Drilling and Charging	min	157,82
Ventilation	min	17,00
Loading and hauling	min	153,43
Scaling and reinforce	min	118,25

Table 6 – Execution time for each phase of Drill and Blast process.

2.3.2 DNIT/SICRO method

The total time of pavements tasks was result of multiplication between productivity indexes and amount of work. While the indexes come from reference tables (SICRO), the amount of works utilized the DNIT method for its definition. According DNIT, (2006) method utilized the capacity of support of subgrade and total number of passage of standard axis to define the thickness of each layer. A set of graphics and equations were utilized to execute the process, Tables 7 and 8 show the values of productivity and amount work to be executed.

Description	Un	Productivity, [Un/h]	Total work
Adjustment of subgrade	m^2	841,000	28.750,00
Soil Subbase course granulometrically stabilized with material of field	m^3	216,260	8.552,12
Base or subbase of gravel graded with commercial gravel	m^3	113,180	2.861,38
Asphalt emulsion primer	m^2	1.125,000	25.600,00
Revetment surface	t	83,000	3.450,52

Table 7 - Main activities of tunnel construction for access option that includes connection between Sertãozinho and Santa Luzia (access option 4) with productivity and total work

Description	Un	Productivity, [Un/h]	Total work
Adjustment of subgrade	m^2	841,000	71.300,00
Soil Subbase course granulometrically stabilized with material of field	m^3	216,260	21.209,27
Base or subbase of gravel graded with commercial gravel	m^3	113,180	7.096,21
Asphalt emulsion primer	m^2	1.125,000	63.488,00
Revetment surface	t	83,000	8.555,48

Table 8 - Main activities of tunnel construction for access option that includes connection between Sertãozinho and Santa Luzia (access option 4) with productivity and total work

3 I RESULTS AND ANALYSIS

The procedures describe allowed the definition of three indexes. The first showed, in figure 03, represent the minimum travel time between Santa Luzia neighbourhoods, in border city of Porto Belo, to references points in Bombinhas.

It is possible note that for all paths the minimum travel times are observed at option 3 (associated with the construction of a tunnel linking Sertãozinho and Santa Luzia). While the time consumption to go from Santa Luzia to Bombas is 7,05 minutes, the time consumption to Bombas and Mariscal are 8,45 and 8,75 minutes respectively. These values are much smaller than found in the option 1 which involve the paving of road linking Sertãozinho and Porto Belo downtown. In this option, the

travel time are between (19,10 – 17,40) minutes, increasing in more than 150% the travel time.

As expected the faster access option are the most expensive. This is illustrated in figure 04. While for the execution of option 4 is necessary more than 25 millions of reais, the execution of option 1 demand only 1,19 million. These situations are even more evident when analysed the time execution estimation (possible by analysis of figure 05). While the option 4 requires, at least, 363 days to be execute, the option 1 requires only 20 days. The others options shows performance between these extremes, with the option 3 (tunnel between Santa Luzia and Zimbros) more likely with option 1 and option 2 (paving road linking Sertãozinho and Santa Luzia) more likely with option 1.

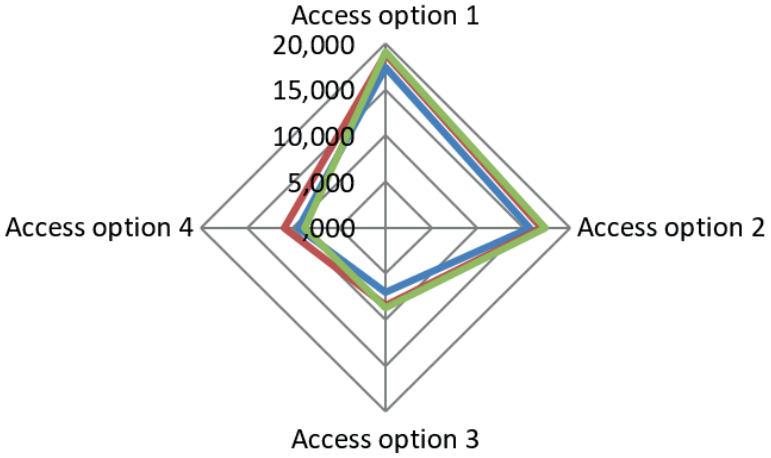

Figure 3 - Minimum travel time, [min], between Santa Luzia and reference point for the four access options

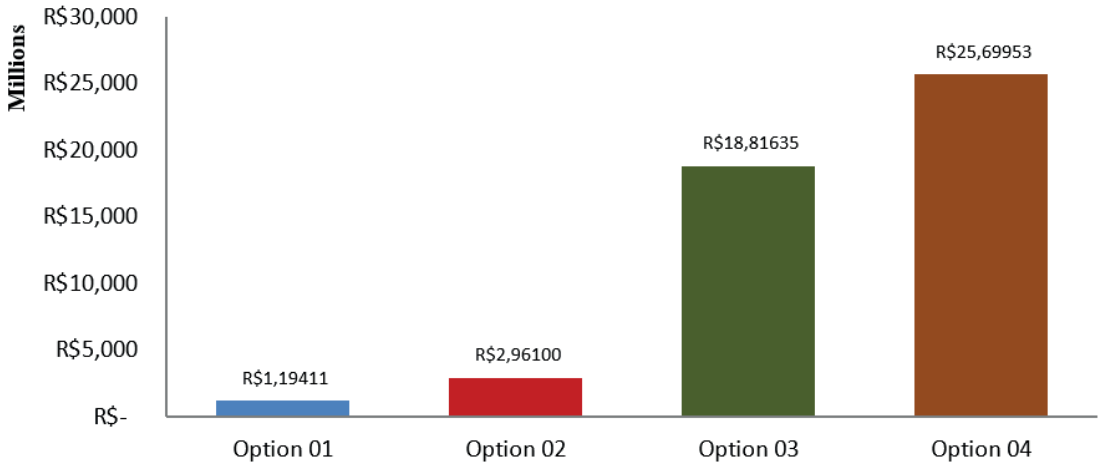

Figure 4 - Preliminary cost estimation, [millions of reais], for execution of each access option

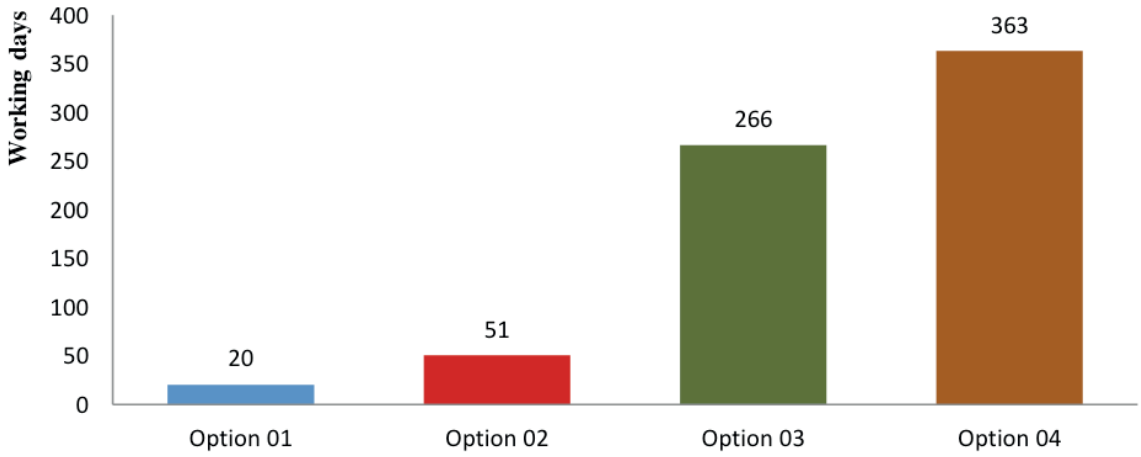

Figure 5 - Time execution estimation for each access according critical path method.

It is worth to say that preliminary cost and time execution estimation are in accordance with other enterprise executed in south of Brazil. According to the Ministério Planejamento (2018) one example is the tunnel under the Formigão's hill in Tubarão, Santa Catarina. This tunnel has total cost of 54,4 million of reais and length of 900 meters. Its execution, furthermore, takes more than 2 years. In similar way and according Horostecki (2016) the paving of Governador Celso Ramos Avenue, in Porto Belo City, has a total budget of 11,9 millions of reais for 6,9 km of drainage and paving works and the execution will take around of 10 months.

4 I CONCLUSIONS E FINAL CONSIDERATIONS

The mobility situation of Bombinhas requires a fast and adequate process of decision to guide the city for a better level in mobility terms. From the options available the minimum travel time was found in the which one that involve tunnel construction but the preliminary cost and total time of execution estimation show them virtually prohibitive. The paving options, however, show worse minimum travel time but the low preliminary cost estimation (only 3,75 and 1,51 millions of reais) and small execution time (51 and 20 working days) put them as short time solution. Also it is worth to say that the choice among mobility approach should consider more variable like environmental and social impacts that are not discussed in this work.

These results and arguments together with an adequate, systematic and transparent process of decision can guide the responsible authorities on search by the best alternative.

5 I ACKNOWLEDGMENTS

This work received financial support of Brazilian Government through CNPq

(National Council for Scientific and Technological Development), FINEP (National Study and Research Founding Agency) and Civil Engineering Department of Santa Catarina Federal University.

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