The impact of road infrastructure failures on traffic conditions and travel behaviour in urban areas – the case of the Lazienkowski Bridge in Warsaw

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Abstract. This article deals with the problems of failures of transport infrastructure sections and their consequences. The article presents the research problem of assessing the impact of the fire on Lazienkowski Bridge, in Warsaw, on the travel behaviour of city residents as well as traffic conditions in the city. Changes occurring directly after the bridge's failure during the period up to several months after the event were analysed. In order to assess the consequences of the failure, data obtained from traffic measurements on selected bridge crossings and interview surveys carried out among city residents were used. The results of the surveys proved that the exclusion of the Lazienkowski Bridge from traffic resulted in a significant increase in traffic volumes on other bridges, especially neighbouring ones, and resulted in longer rush hours on the bridge crossings in question. 42% of the city's residents felt the negative consequences of the failure in the form of worse conditions of travel and 36% of the residents reported a longer travel time to work/school. The failure also caused changes in travel behaviour as regards the choice of means of transport, travel route or not travelling altogether. The consequences of the failure affected, to the greatest extent, the residents of areas most functionally connected with the bridge.

1 Introduction

All the key elements for the proper functioning of the city are based on transport and transportation services. Accordingly, the development of transport infrastructure is an inseparable element of urban development. It is determined primarily by the need to improve difficult traffic conditions and transport accessibility of urban areas. A new road connection or bridge crossing contributes to many changes, including the travel behaviour of residents, and aims to reduce losses generated by inefficient transport systems [1]. Damage or failure of a transport infrastructure element, especially where the element is important for peoples' security and development and ensures the continuity of an area's economic and social life, may be equally important as the emergence of a new connection,

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and at the same time have a lot of consequences [2]. From this point of view, bridges may be important elements of the urban transport infrastructure.

Bridge failures have been occurring since their earliest construction thousands of years ago, and much of the technical knowledge associated today with bridge engineering is based on their earlier failures [3]. There are many causes and mechanisms of bridge failures. These factors are most often classified as natural factors (flood, scour, earthquake, landslide, wind, etc.) and human factors (improper design and construction method, collision, overloading, fire, corrosion, lack of inspection and maintenance, etc.) [4]. In many cases, failure results from several causes combined [5].

Failures of bridges in use can cause specific consequences, the scale of which may vary depending on the importance of these structures for transportation, as well as the extent and location of damage [6]. The consequences of bridge failures can be broadly divided into: human, economic, social and environmental. Human consequences can include: fatalities, injuries and psychological damage [5]. Economic consequences refer to rebuilding costs, traffic delay costs, access and traffic management costs, casualty costs, repair costs and some other indirect costs [7]. Social consequences are related to loss of reputation, erosion of public confidence, undue changes in professional practice, while environmental – to CO_2 emissions, energy use, pollutant releases and environmental clean-up/reversibility [5].

This article deals with the problems of failures of sections of transport infrastructure and their consequences. The article presents the research problem of assessing the impact of bridge fire on the travel behaviour of city residents as well as traffic conditions. Changes in travel behaviour and traffic conditions cause specific costs and/or benefits for persons, transport infrastructure managers, transport operators, etc., referring to the above-mentioned economic consequences of bridge failures. The article analyses changes in travel behaviour and traffic conditions occurring directly after the bridge failure, up to a few months after the event. Section 2 presents the object of the study, and sections 3 and 4 the methods used to investigate the consequences of the failure and the results of the studies. Section 5 is a summary of the analyses carried out.

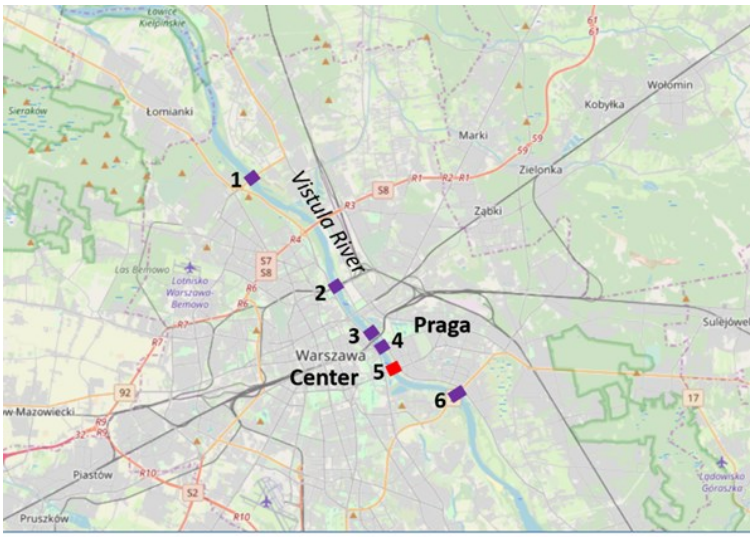
2 Description of the object of the study

The study conducted in this article refers to the fire on the Lazienkowski Bridge, located in Warsaw (Poland), a city inhabited by 1,769,529 residents [8]. The residents of Warsaw perform nearly 3.35 million journeys every day, 80% of which are non-walking [9]. The city is divided in half by the Vistula River (Figure 1), which is crossed by 9 bridges. Of all trips made by Warsaw residents, 23.2% are connected with crossing the Vistula, and about 775,000 take place every day via bridges over the river.

Trips that cross the Vistula are much more often performed by the residents of districts located on the right side of the river. 47% of all their travels, 62% of their travels to work and 36% of their travels to places of study take place via the Vistula [9]. In the case of residents of left-bank Warsaw, these values are definitely lower and amount to respectively: 11%, 13% and 6%. This spatial travel distribution results from the administrative, service and cultural location of the city centre in its left-bank part. Among travels across the Vistula, 55.9% are performed by public transport, and 37.2% by passenger cars.

The Lazienkowski Bridge is one of the most important bridge crossings in Warsaw. Together with the Lazienkowska Route (a GP class road, a collision-free route with a maximum speed of 80 km/h), it creates a very attractive connection between left- and right-bank Warsaw (the location of the bridge against the background of the city is shown in Figure 1). According to the results of traffic measurements by the Municipal Roads Authority in autumn 2014 [9], over 104,643 vehicles crossed the Lazienkowski Bridge

during the weekday. At that time, it was the second most-loaded bridge in Warsaw, just after the Siekierkowski Bridge, over which 111,442 vehicles/day passed.



1 – The Bridge of Maria Sklodowska Curie
2 – The Gdanski Bridge
3 – The Swietokrzyski Bridge
4 – The Bridge of Poniatowski
5 – The Lazienkowski Bridge
6 – The Siekierkowski Bridge

Fig. 1. Location of selected bridges against the background of Warsaw. Source: Authors' own study based on: www.openstreetmap.org.

As a result of fire on 14 February 2015 (Saturday), the Lazienkowski Bridge was seriously damaged and closed for traffic. The lack of such an important road crossing caused very high traffic accumulation on alternative routes, in particular on neighbouring bridges and streets leading to them. Due to huge traffic difficulties, to improve bus transport, on 22 February (Sunday), the Municipal Authorities introduced separate bus lanes on the Bridge of Poniatowski and routes bringing traffic to it: Al. Jerozolimskie and Wal Miedzeszynski. Bus lanes functioned during the morning rush hours (in the direction of traffic to the centre) and in the afternoon (in the direction of traffic to Praga). A separate bus lane towards Praga was in operation until 1 March 2015. In addition, in order to get traffic moving (minimize the problem related to blocking intersections by drivers) and enforce compliance with the rules resulting from the new traffic organization, the Police deployed posts in the most traffic-laden streets, in particular those bringing traffic to the bridges adjacent to the Lazienkowski Bridge. 8 March 2015 is also a date of importance for the conducted analyses, as it was the date on which the central section of the 2nd metro line was opened, providing a new connection between the left- and right-bank Warsaw by public transport, enabling the service of part of the travels made across the Vistula.

In order to assess the effects of the Lazienkowski Bridge fire, data obtained as a result of the following studies were used: traffic measurements on selected bridge crossings and surveys carried out among residents of the city. The fire on Lazienkowski Bridge coincided with the intended comprehensive study of traffic and travels in Warsaw, conducted as part of the Warsaw Traffic Survey. Studies of this type are a very important element supporting the process of planning the development of the urban transport system. Initially, the authorities of Warsaw considered the suspension of studies in connection with a serious failure of the transport system, but eventually it was decided to carry out additional research

describing the impact of the bridge failure on the travel behaviour of residents. These studies complemented the classical approach and helped to take into account changes in travel behaviour for the entire city. This gave us very good research material, the results of which are presented in the next two sections.

3 Traffic measurements and their results

The traffic measurements were taken by the Municipal Roads Authority in Warsaw (ZDM) [9] at measuring points located on five bridges: the Swietokrzyski Bridge, the Bridge of Poniatowski, the Siekierkowski Bridge, the Gdanski Bridge and the Bridge of Maria Sklodowska Curie. The locations of these bridges are shown in Figure 1. The measurements were carried out for 24-hour periods on the following dates:

- 23/02/2015 (Monday) – to examine traffic conditions after the bridge fire, taking into account travel lanes for buses implemented on the Bridge of Poniatowski;
- 02/03/2015 (Monday) – to additionally examine traffic conditions after the bus lane on the Bridge of Poniatowski in the direction of Praga was removed;
- 09/03/2015 (Monday) – to additionally examine traffic conditions after launching the central section of the second metro line.

In order to compare traffic conditions after the fire with those before its occurrence, data from ZDM traffic measurements carried out in October 2014 were used.

During all the above-mentioned tests, when carrying out traffic measurements, the number of all vehicles passing through a given measuring point in both directions was recorded.

Summary results of traffic measurements carried out on five Warsaw bridges are presented in Table 1. Analysing the results, it can be noted that the bridges in operation managed to take over a total of 64,299 vehicles/24h in both traffic directions (if compared with results from October 2014 and 09/03/2015). This means that of the up to 104,000 vehicles/24h that crossed the Lazienkowski Bridge before the fire, 40,000 vehicles/24h are missing. Users of these vehicles could change to trams, buses, and to the metro (after the completion of the central section of the second line). According to data provided by Metro Warszawskie on 19/03/2015, 106.701 passengers used the underground railway every day. The opening of the section of the second metro line resulted in improved traffic conditions and the possibility of changing the means of transport to travel to the other side of the Vistula River for the many thousands of people who had previously travelled over the Lazienkowski Bridge.

Table 1. The comparison of daily traffic volumes on selected bridges. Source: [9].

Bridge name	**Direction of travel**	**October 2014**	**23/02/2015**	**02/03/2015**	**09/03/2015**
		[veh/24h]	[veh/24h]	[veh/24h]	[veh/24h]
Swietokrzyski	Centrum	11,177	16,764	17,236	17,271
	Praga	13,438	17,555	18,721	19,124
the Bridge of Poniatowski	Centrum	28,938	36,118	37,343	37,662
	Praga	27,444	37,813	39,212	40,037
Siekierkowski	Centrum	57,676	70,315	69,117	71,085
	Praga	53,766	67,626	66,639	67,979
Gdanski	Centrum	29,758	28,399	29,081	29,325
	Praga	30,354	34,269	34,371	34,557
the Bridge of Maria Sklodowska Curie	Centrum	38,399	35,014	36,754	35,810
	Praga	41,058	43,121	43,211	43,457
TOTAL	Centrum	165,948	186,610	189,531	191,153
	Praga	166,060	200,384	202,154	205,154

Disabling the operation of the Lazienkowski Bridge had a major impact on the increase in volume, especially on neighbouring bridges, i.e. centrally located, and on the streets that direct traffic to them, and as a consequence on the traffic conditions in the city's transport system. The following bridges have taken over the most vehicles in the new traffic distribution on bridges: Siekierkowski Bridge (27,622 veh/24h), Bridge of Poniatowski (21,317 veh/24h) and Swietokrzyski Bridge (11,780 veh/24h). In the case of these three bridges, significant increases in traffic volumes were recorded in both directions, i.e. towards the city centre and towards Praga. On the Siekierkowski Bridge, the traffic volume in the direction of the centre increased by about 13,000 vehicles/24h and remained at a level of 70,000 vehicles/24h, while in the direction of Praga, the traffic volume increased by approximately 14,000 vehicles/24h and remained at a level of 67,000 vehicles/24h. On the Bridge of Poniatowski, the traffic volume in the direction of the centre increased by about 8,000 vehicles/24h (remained at a level of 37,000 vehicles/24h), while in the direction of Praga the increase approximately 12,000 vehicles/24h (remained at a level of

39,000 vehicles/24h). In the case of Swietokrzyski Bridge, the traffic volume in the direction of the centre increased by about 6,000 vehicles/24h (remained at a level of 17,000 vehicles/24h), while in the direction of Praga, the traffic volume increased by approximately 4-5,000 vehicles/24h (the volume remained at a level of 18-19,000 vehicles/24h).

On the Gdanski Bridge and the Bridge of Maria Sklodowska Curie, the direction of the centre was marked by declines in traffic, especially visible in the case of the latter crossing (a decrease of approximately 2,500 vehicles/24h). On the other hand, in the direction of Praga, traffic increased on both bridges (by approx. 4,000 vehicles/24h for Gdanski Bridge, and around 2,000 vehicles/24h for the Bridge of Maria Sklodowska Curie). It should be noted that due to the reconstruction of another bridge crossing - the Grota-Roweckiego Bridge, the closure of the Lazienkowski Bridge and the quite significant traffic difficulties associated with it, the Gdanski Bridge was doubly loaded with traffic transferred from both these crossings from both north and south. In turn, the Bridge of Maria Sklodowska Curie, which is the northernmost crossing over the Vistula River in Warsaw, was also burdened by additional traffic transferred from south, which was connected with the reconstruction of the Grota-Roweckiego Bridge. Small changes in traffic volume during the day suggest a slight impact of the closure of the Lazienkowski Bridge on the Bridge of Maria Sklodowska-Curie.

The introduction of separate bus lanes on the Bridge of Poniatowski, Aleje Jerozolimskie and Wal Miedzeszynski did not affect negatively on individual transport. Traffic measurements show that in the busiest peak hours, both in the direction of traffic towards the centre and towards Praga, a similar number of vehicles passed through the Bridge of Poniatowski as in 2014. Undoubtedly, this was largely due to the Police activities mentioned in section 2, aimed at getting traffic moving and disciplining drivers at particular intersections of the Aleje Jerozolimskie and many other places heavily loaded with traffic. Removing the bus lane from the Bridge of Poniatowski that operated during the afternoon rush hour in the direction of Praga resulted in a slight increase in traffic on this bridge crossing by approx. 1,300 vehicles/24h.

As a result of the additional traffic load, the traffic peak hours on the bridges analysed have lengthened. The most noticeable, negative changes have been recorded on the Bridge of Poniatowski and the Siekierkowski Bridge. Detailed results of traffic measurements for those two bridges are shown below.

3.1 Results of measurements on the Siekierkowski Bridge

Analysing the results of traffic research shown in Fig. 2, it can be noticed that after the Lazienkowski Bridge was closed, the largest increases in traffic volume on the Siekierkowski Bridge towards the centre were recorded during the morning peak at 6:00 am (from 4,000 vehicles/h to almost 6,000 vehicles/h) and between 9:00 am and 2:00 pm. In 2015, the morning peak traffic, compared to 2014, started an hour earlier and extended in fact until the afternoon rush hours (values above 4000 vehicles/h). The starting density of the morning peak at 6:00 am was 4,000 vehicles/h in 2014, while the March traffic measurement indicates as much as almost 6,000 vehicles/h. The traffic volumes between 9:00 am and 2:00 pm are higher by around 1,000 vehicles per hour compared to 2014.

In turn, the largest increases in the volume of traffic on the Siekierkowski Bridge towards Praga (Figure 3) were recorded in the hours of the extended afternoon peak, in other words between 11:00 am and 7:00 pm (around 1,000 vehicles per hour). The afternoon peak traffic (values above 4,000 vehicles/h) starts two hours earlier and ends one hour later than in 2014.

The above changes in traffic during the morning and afternoon rush hours were caused by the transfer of a significant part of the traffic from the Lazienkowski Bridge to the Siekierkowski Bridge, which is a bridge crossing over the Vistula closest from the southern side to the Lazienkowski Bridge.

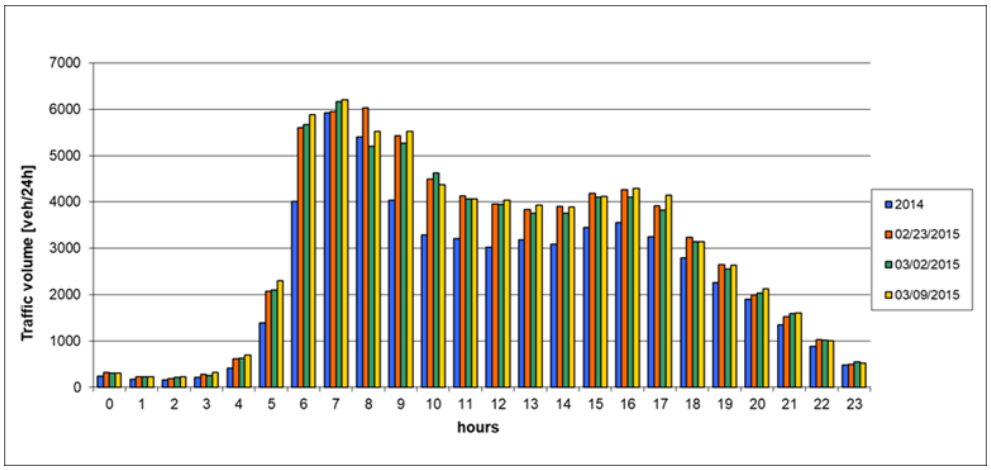


Fig. 2. Traffic density at different hours of the day on the Siekierkowski Bridge; direction: City centre Source: [9].

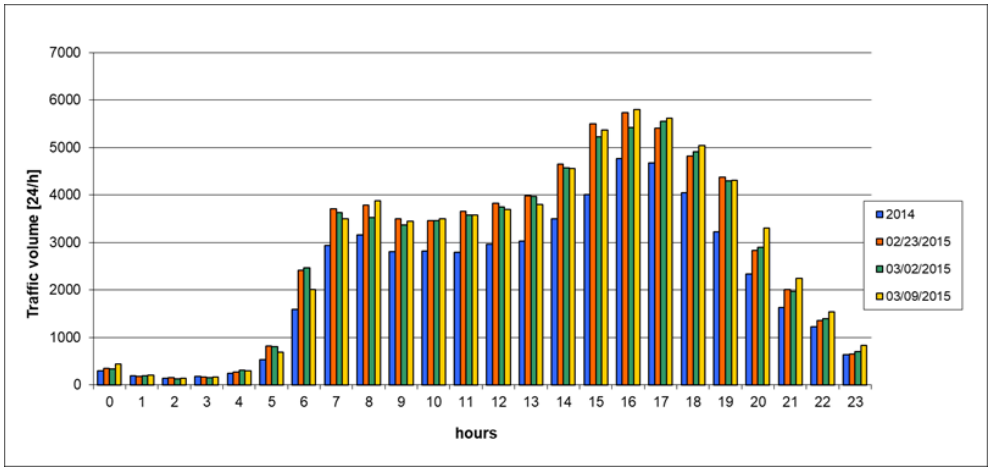


Fig. 3. Traffic density at different hours of the day on the Siekierkowski Bridge; direction: Praga Source: [9].

3.2 Results of measurements on the Bridge of Poniatowski

The largest increases in traffic volume on the Bridge of Poniatowski towards the centre were recorded during the morning peak, i.e. at 6:00 am (from 1,500 vehicles/h to 3,000 vehicles/h) and between 9:00 am and 2:00 pm (Fig. 4). The morning peak traffic extended in fact until the afternoon rush hours (values above 2,000 vehicles/h). A substantial value of traffic volume of 1,500 vehicles/h was recorded as late as at 8:00 pm. For comparison, in 2014 the afternoon peak lasted from 7:00 to 9:00.

On the other hand, in the direction of Praga, the largest increases in the value of traffic volume were recorded during almost the entire day, i.e. between 6:00 am and 10:00 pm

(Figure 5). The afternoon peak traffic started in fact from the morning rush hours and lasted from 7:00 am to 9:00 pm (values around 2,000 vehicles/h). A high traffic volume (almost 1,500 vehicles/h) was recorded rather late, at 10:00 pm. For comparison, in 2014 the afternoon peak lasted from 3:00 pm to 6:00 pm.

The above changes in traffic during the morning and afternoon rush hours, which lasted almost 24 hours a day, were caused by the transfer of a significant part of the traffic from the Lazienkowski Bridge to the Bridge of Poniatowski. The Bridge of Poniatowski is a bridge crossing over the Vistula closest from the northern side to the Lazienkowski Bridge.

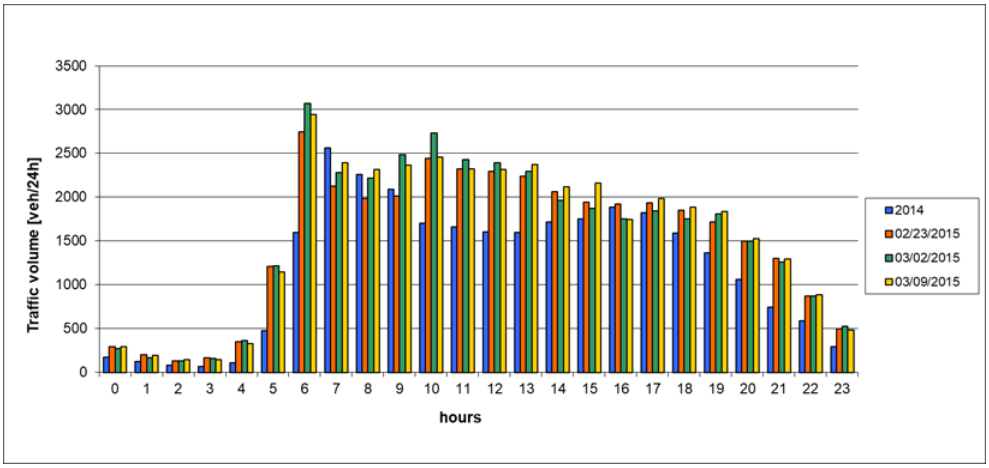


Fig. 4. Traffic density in different hours of the day on the Bridge of Poniatowski; direction: City centre Source: [9].

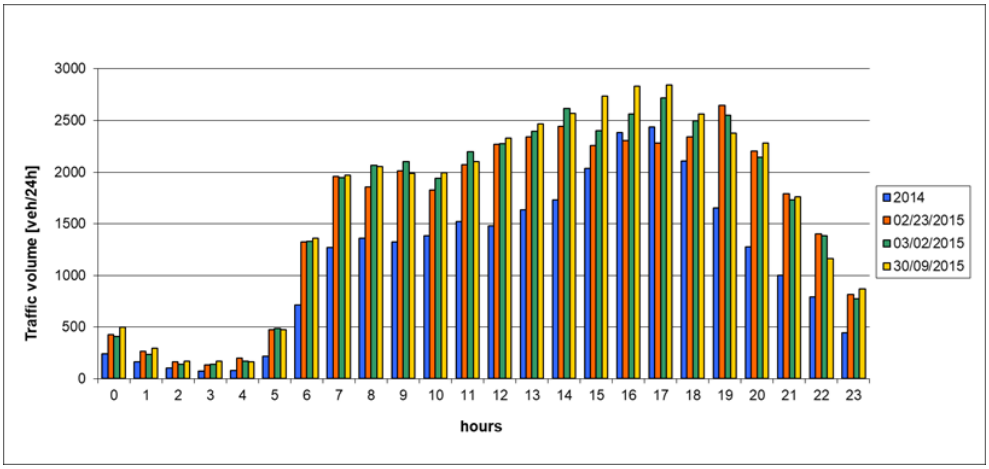


Fig. 5. Traffic density in different hours of the day on the Bridge of Poniatowski; direction: Praga Source: [9].

4 Survey studies and their results

The assessment of impact following just after the bridge fire was also performed based on the results of the Warsaw Traffic Survey (WBR) and interview surveys carried out within its scope: (1) telephone interviews with city residents dedicated strictly to changes occurring as a result of bridge failure [10], (2) questionnaire interviews carried out in households of residents of areas functionally most connected with the bridge [9]. The results of both surveys are presented below.

4.1 Telephone interviews with city residents on changes arising as a result of the failure

The telephone interviews were conducted among Warsaw residents aged 15 and over [10]. The survey involved 1,100 respondents. The aim of the survey was to obtain information on the change of travel behaviour of Warsaw residents after the closing of the Lazienkowski Bridge, taking into account the behaviour associated with crossing the Vistula and place of residence of the respondents. Particular attention was paid to the behaviour of the inhabitants of areas which, based on the Warsaw transport model of 2005, were considered functionally most strongly connected with the Lazienkowski Bridge (these areas were marked with a darker colour in Figure 6). The respondents also expressed their assessments in respect of the changes. The survey was carried out from 19 to 30 March 2015, in the period of about a month after the failure.

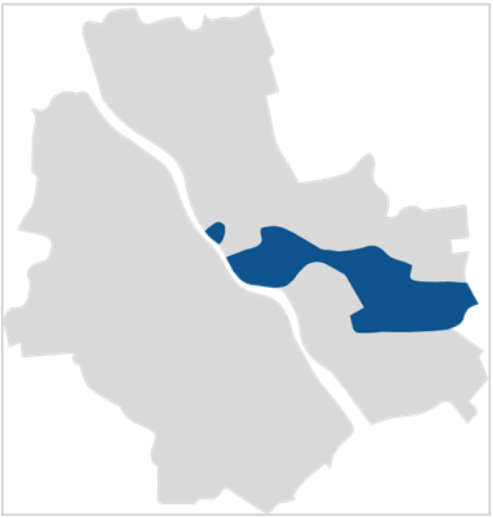


Fig. 6. Areas functionally most strongly associated with the Lazienkowski Bridge. Source: [9].

The results of the survey prove that the closure of the Lazienkowski Bridge did not change the frequency with which the inhabitants crossed the river in travels to work and school, however, people who previously travelled to the other side of the river sporadically and for reasons other than work or school were clearly less frequent (before the fire 1/3 of respondents crossed the Vistula for other purposes only once or not crossed it, while after bridge closure this behaviour was already declared by every second respondent) [10].

During the last 3 months before the Lazienkowski Bridge fire, the main bridges used in respondents' travel to workplaces and schools located on the other side of the river were bridges: Lazienkowski, Bridge of Poniatowski and Siekierkowski (respectively 21%, 18%

and 14% of trips), while after its closure, this traffic was taken over primarily by the Bridge of Poniatowski, which was used for 30% of trips. Other bridges used to a large extent after the failure were Siekierkowski and Gdanski bridges (respectively 15% and 12% of trips). The same regularity in the use of bridges was noted in the travels of residents for purposes other than work or school.

The respondents were asked whether, as a result of closure of the Lazienkowski Bridge and changes in the organization of traffic, their movements around Warsaw were worse, better or unchanged. Although 52% of all respondents indicated that their movements around the city were unchanged, a high percentage (42%) found them worse (Table 2). Worse conditions of movement were declared primarily by residents of right-bank Warsaw (51% of inhabitants) and people crossing Warsaw to work/school and for other purposes (44% and 46%, respectively). Residents of left-bank Warsaw and persons not crossing the river in their travels felt slightly less negative effects. However, according to survey results, the most negative changes affected the residents of the areas most functionally associated with the Lazienkowski Bridge, among whom as many as 69% indicated a change for the worse, and only 22% declared no change.

Table 2. Respondents' assessment of the conditions of movement after the closing of the Lazienkowski Bridge. Source: [10].

Type of respondents	Sample size	Answers [%]			
		Better	No change	Worse	Difficult to say
People travelling to the other side of Warsaw to work/school	358	3	39	54	4
People not travelling to the other side of Warsaw to work/school	742	1	58	36	5
People travelling to the other side of Warsaw for a different purpose than work/school	691	2	48	46	4
People not travelling to the other side of Warsaw for a different purpose than work/school	409	2	61	32	5
Inhabitants of right-bank Warsaw	367	2	40	51	7
Inhabitants of left-bank Warsaw	733	1	58	37	4
All respondents	1100	2	52	42	4

As a result of closing the Lazienkowski Bridge and changes in traffic organization, the travel time to work/school remained unchanged for 60% of respondents doing this type of travel, extended for 36% (on average by 23 minutes) and shortened for 2% (on average by 10 minutes) [10]. In particular, people travelling to work/study places on the other side of the river (52% of persons) and residents of right-bank Warsaw (44% of inhabitants) experienced the increase in travel time (Figure 7).

The smallest consequences in the form of changes in travel time were felt by people who do not travel to work/school to the other side of the Vistula.

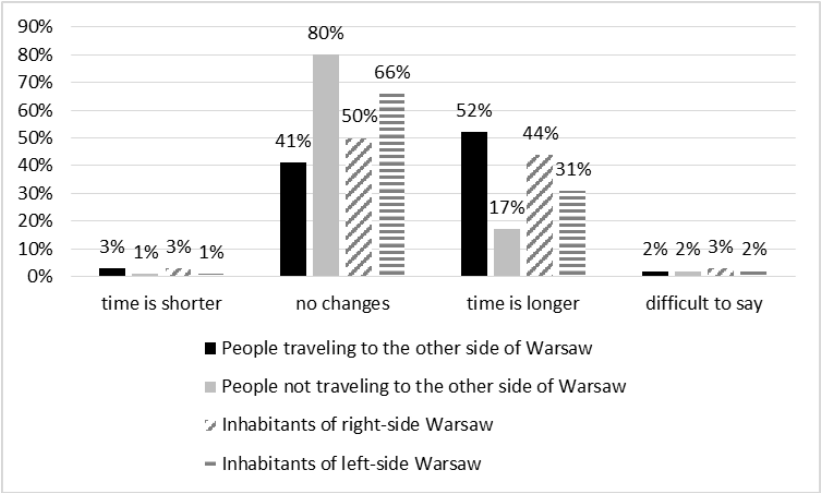


Fig. 7. Residents' assessment of changing travel times to work/study locations. Source: [10].

Changes in travel behaviour resulting from the failure occurred in people travelling to the other side of Warsaw to a greater extent (Table 3). A change of route when travelling to work/school was declared by 24% of all respondents and 38% of people travelling to the other side of Warsaw. Comparing the behaviour of the residents of right- and left-bank Warsaw, 32% of those living on the right-bank and 18% of those living on the left-bank changed their itinerary.

After the bridge was closed, car, bus and tram remained the most popular means of crossing the river, and for obligatory travel the car's share dropped in favour of public transport. A change in means of transport during travel to work/school was declared by 14% of all respondents and 21% of people travelling to the other part of Warsaw (Table 3), while in 41% of cases there was a change in the type of public transport, and in 23% of cases of giving up the car for public transport. According to the results of the survey, 21% of residents of right-bank Warsaw and 9% of residents of left-bank Warsaw travelling for obligatory purposes changed the means of transport.

Changes in the form of giving up travelling around Warsaw were recorded in 19% of all respondents (Table 3), and these were to involve in 29% of cases – shopping, in 28% – entertainment, in 18% – private meetings, in 16% – work, and in 15% – visits to the doctor. More often, people travelling to the other part of Warsaw to work/school and for other purposes as well as right-bank residents of Warsaw withdrew from travelling (24% of right-bank residents vs. 16% of residents of left-bank Warsaw). Moreover, this type of change was observed among 31% of the residents of areas most connected with the bridge.

Table 3. Changes in travel behaviour after the closing of the Lazienkowski Bridge Source: [10].

Question	Type of respondents	Sample size	Answers [%]		
			Yes	No	Difficult to say / Not applicable
Change of route when travelling to work/school	People travelling to the other side of Warsaw	349	38	61	1
	People not travelling to the other side of Warsaw	317	8	91	1
	All respondents	665	24	75	1
Change of means of transport during travel to work/school	People travelling to the other side of Warsaw	349	21	78	1
	People not travelling to the other side of Warsaw	317	6	93	1
	All respondents	665	14	85	1
Giving up travelling around Warsaw	People travelling to the other side of Warsaw to work/school	358	26	71	1
	People not travelling to the other side of Warsaw to work/school	742	14	84	2
	People travelling to the other side of Warsaw for a different purpose than work/school	691	22	76	2
	People not travelling to the other side of Warsaw for a different purpose than work/school	409	12	87	1
	All respondents	1,000	19	79	2

4.2 Results of survey among residents of areas functionally most strongly connected with the bridge

A few months later, a survey carried out among the residents of the areas functionally most strongly associated with the Lazienkowski Bridge (being part of the basic interview surveys carried out in households during WBR) [9], confirmed the results of the above study. 1,381 respondents were asked about changes in the way of getting to places of work, study and other destinations. The survey was conducted in the period from April to June 2015, so in the period from 2 to 4 months after the occurrence of the failure.

The results revealed that 4 out of 10 people from among 62% of working residents of right-bank Warsaw, who go to work on the other side of the Vistula, changed their way of getting to work after the bridge was closed. The share of passenger cars in their travels fell from 57% to 43% in favour of journeys made by collective transport (increase from 43% to 55%) and to a small extent by bicycle (increase from 0.4% to 2.3%).

As the number of pupils and students who, going to the place of study, must cross the Vistula River, is much smaller than the number of people working and travelling from the right-bank part of Warsaw to the left-bank side, there were only 54 people studying on the left side of the Vistula in the additional survey sample. In this group, the closure of the Lazienkowski bridge changed the way of getting around for almost every third person. According to these survey studies, in the case of non-compulsory travel, about 80% of respondents did not change their way of getting to places of shopping or entertainment, others went on a different route or to another place.

5 Conclusions

The exclusion of traffic from the Lazienkowski Bridge caused immediate and enormous difficulties for individual and public transport, especially on neighbouring bridges and on the streets that direct traffic to them. The Lazienkowski Bridge is one of the most important and most traffic-laden bridge crossings on the Vistula River, which is why neighbouring bridges have been exposed to additional traffic of 104,000 vehicles/24 hours. They managed to take over 62,299 vehicles/24h in both traffic directions. According to the interview survey, users of other vehicles could change to trams, buses, subway or stop crossing the river. The following bridges have taken over the most vehicles in the new traffic distribution: Siekierkowski, the Bridge of Poniatowski and Swietokrzyski. The consequences of the event affected the Gdanski Bridge and the Bridge of Maria Sklodowska Curie the least. The hours of peak traffic on the analysed bridges have been extended, and the largest changes of this type have been recorded on the Bridge of Poniatowski and Siekierkowski Bridge. The introduction of dedicated bus lanes on the Bridge of Poniatowski did not have a negative effect on individual transport, and the elimination of the lane operating during the afternoon rush hours towards Praga resulted in slight increase in traffic at this bridge crossing.

The results of the interview survey show that the closure of the Lazienkowski bridge did not change the frequency with which the residents crossed the river on obligatory travels, but clearly people who previously did this sporadically and for purposes other than work or school travelled less frequently to the other side of the river. Nearly half of the residents (42%) experienced negative changes after the failure regarding the conditions of movement, and the time of travel to work/school extended for 36% of them, on average by 23 minutes. The residents of right-bank Warsaw, including the areas most functionally connected with the Lazienkowski Bridge, were more severely affected by changes that occurred due to the failure. About 14 percentage points more people on the Praga side of the river than on the left bank declared that it was more difficult to move. Almost 70% of the residents of the areas most connected with the bridge also indicated worse travel conditions.

Closing the bridge caused changes in travel behaviour. The change of route when travelling to work/school was declared by 24% of the residents, the change of means of transport in obligatory journeys (changing means of public transport or shifting from a car to urban transport) was declared by 14% of the residents, while 19% of them declared stopping at least one trip. The most significant changes were observed for residents of right-bank Warsaw, including those living in the areas most functionally connected with the bridge.

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