

THE EFFECTS OF THE 1976 EARTHQUAKE IN THE SOČA RIVER BASIN

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The Anton Melik Geographical Institute of the Slovene Academy of Sciences and Arts of Ljubljana has among its tasks that of recording and attempting to explain from a geographical perspective various major natural disasters which occur in Slovenia. The consequences of the 1976 earthquake are the first major earthquake disaster effects analyzed by the Institute. The work demonstrated that the methodology for examining natural disasters has not been sufficiently studied and developed. A new set of problems had to be faced and could not be solved in a completely satisfactory manner. In the future, much more attention must be devoted to developing geographical methods for studying natural disasters and applying the findings in practice. The work carried out attempted to record and explain as completely as possible the consequences of the earthquake in the most severely stricken areas.

Various kinds of natural and other disasters occur relatively frequently and, therefore, must be taken into consideration and dealt with as typical phenomena for any social community within some larger regional context. For the most part disasters and catastrophies have in common the two properties that they are space and time specific. The spatial aspect is related to the extent of the disaster and to other influences in process at that time in the affected region and subareas of it. The temporal aspect of the crisis can be very different. A distinction can be made between the time duration of the occurrence or event and the period necessary for recovery. This second period of time can last years or even decades, depending upon the circumstances and the severity of the impact of the event in a specific region.

The earthquake of 1976 was the most severe one in Slovenia in this century. The next most severe was that of the 7th degree MCS in the Kozje area in 1974. See Table 1. A stronger earthquake occurred on April 14, 1895, with the epicenter in the neighborhood of Vodice (the well-known Ljubljana earthquake), estimated at 7th to 9th degrees MCS. The disaster striking the Soča River Basin in 1976 was the strongest earthquake in Slovenia in the last 81 years. Within the epicentral region itself this earthquake was considerably stronger and more

disastrous than that of Ljubljana in 1895. The 1895 earthquake, however, had comparatively more extensive consequences for the Slovenes, occurring in the central part of Slovenia and causing considerable damage. However, if one takes into consideration the vast impact of the earthquake in the Soča River Basin, the particular problems of that region, and in addition the consequences suffered in the Venetian Slovenia, Resia and Gorica areas, this event was undoubtedly one of the greatest affecting the Slovenes in recent centuries.

Table 1

The Earthquakes Occurring in Slovenia from 1956 to 1976,
Having a Strength of 6th Degree MCS or More*

Year	Number of Shocks Stronger than 6 MCS	MCS	Date	Commune (Area)
1956	16	7.5	Jan. 31	Ilirska Bistrica
1963	84	7	May 19	Litija
1964	74	6	March 18	Ilirska Bistrica
1973	53	6	Dec. 12	Škofja Loka (Polh. Dolomiti)
1974	100	7	June 20	Šmarje near Jelse (Kozje area)
1976**	478	8	May 6	Tolmin, Idrija
		8	Sept. 15	N.Gorica (The Soča River Basin)

*Statistical Yearbook of the SR Slovenia 1976, The Institute of Statistics, the SR Slovenia, Ljubljana

**Hržič, 1977

The Stock of Dwellings in the Soča River Basin, and the Consequences of the Earthquake

In the Soča River Basin there were relatively few structures made of reinforced concrete. The predominant buildings were old houses, mostly built of stone, with lime mortar and wooden roofs. According to the data of the census of population and dwellings of 1971 [Popis stanovništva...1972] 50.4 percent of the dwellings in the commune of Idrija were built before 1918, 46.6 percent in the commune of Tolmin, and only 22.4 percent in the commune of Nova Gorica. Dwellings built between 1915 and 1945 comprised 30.5 percent of the dwellings in the commune of Tolmin, and 7.7 percent of those in the commune of Idrija. Dwellings constructed between 1946 and 1960 account for 9.7 percent in the commune of Tolmin, 17.4 percent in the commune of Idrija and 18.5 percent in the commune of Nova Gorica. There is a great difference between the communes in the proportion of new dwellings built from 1960

to 1971; 12.3 percent in the commune of Tolmin, 21.9 percent in Nova Gorica and 23.4 percent in Idrija. Approximately half the dwellings in the communes of Tolmin and Idrija before the earthquake were more than 50 years old. Only in exceptional cases had reinforced concrete or other up-to-date materials been used in such dwellings. Slabs made of reinforced concrete and other similar construction elements were introduced for the most part only after 1946. Before the earthquake, approximately 80 percent of the dwellings in the commune of Tolmin were built in the traditional manner, without the use of concrete, iron, bricks, or similar materials.

The considerable differences between individual places reflect urbanization and village stagnation. At Borjana 79.3 percent of the dwellings date from before 1918, 86.9 percent at Breginj, 100 percent at Podbela, 94.3 percent at Volarji. The percentage of the dwellings built before 1918 in Borjana is a little lower than in other neighboring, less urbanized places because part of the village was carried away by a snow avalanche on February 14, 1952 [Gams, 1955]. An entirely different picture is presented by the more urbanized places where there is a considerably smaller proportion of dwellings built before 1918. In 1971, 53.7 percent of the dwellings at Kobarid were from this period, but only 12.8 percent at Tolmin. Other factors account for some differences such as at Stanovišče where 95.8 percent of the dwellings have been reconstructed after 1946, since the village was burnt down during the war. In reconstructing Stanovišče in most cases the original ground-plans were preserved to the largest possible extent using the existing ruins and not materially improving the quality of the buildings. Similar situations exist in Žaga, completely destroyed during the First World War and heavily damaged again in the Second World War [Uršič, 1968]. The final picture of the damage, including that from the original earthquake on May 6 and the additional destruction caused by the second earthquake on September 15, 1976, can be estimated by the seismic effect caused by a shock of 9th degree MCS scale at the most severely impacted places of Breginj, Podbela, Žaga, Ladra-Smast, etc., and by the effect caused by an 8th degree shock at other heavily damaged places of the Upper Soča River Basin.

The Direct Effects of the Earthquake in the Region

The very first reports testified to the extensive destruction caused by the earthquake in the communes of Tolmin, Idrija and Nova Gorica and to the widespread disruption in neighboring areas in Italy, and to the severe damage suffered by the Slovenes living across the frontier. In a matter of moments, many people lost their homes, since many houses were destroyed or heavily damaged. In the most heavily stricken places the people took refuge in various kinds of emergency shelters in the open air. In less impacted places people found refuge at night in emergency shelters erected near their homes. These self-provided shelters were one of the most startling visual evidences. They were built mostly of a wide variety of light and simple materials displaying great ingenuity and inventiveness on the part of individuals [Križnar, 1977]. Gradually, as organized assistance appeared people were moved from these primitive emergency shelters, mostly covered with polyvinyl, to proper tents, automobile trailers, and wooden shacks. Alongside some of the most impacted places entire new settlements appeared with relatively well-arranged emergency dwellings, with a "main street", shops, perhaps a restaurant in an old bus, water-supply,

electricity, etc. Such provisional settlements occurred at Podbela, Stanovišče, below and above Breginj, in gardens and in the sports grounds of Kobarid, and a number of other places.

With the construction of prefabricated houses in the winter of 1976/77, the population started relocating into permanent dwellings. In response to this distress, and particularly after the second strong earthquake in September, the entire Slovene public rendered assistance in many different ways. The whole Yugoslav people joined in the broadly organized solidarity action as did numerous Yugoslavs living abroad. Working establishments and individuals temporarily lent their automobile trailers on a temporary basis. Efficient relief and reconstruction efforts were accelerated at the end of September and the beginning of October when the Republic Coordination Headquarters for the reconstruction of the Soča River Basin started its successful operations. Cleanup and reconstruction efforts were hampered by impossible weather conditions, as there were more hours of rain than of sunshine that Fall with many heavy downpours. More than 3,000 workers from all over Slovenia and the rest of Yugoslavia came to the region to lend assistance to the earthquake-stricken population.

In the most heavily stricken communes of Tolmin, Nova Gorica and Idrija the damage was surveyed and assessed in a relatively short period of time. Special Commissions for the purpose were organized which included, in addition to technical construction experts, representatives of the local communities. A special survey of damage was also organized by the Monument Conservation Service. A report on the consequences of the earthquake in May 1976 was drawn up using a uniform methodology for the communes of Tolmin, Nova Gorica and Idrija. The methodology was prepared by the Institute for Testing and Research in Materials and Structures of Ljubljana [The Report...1976]. It was developed and supplemented on the basis of experiences acquired by the drafters in surveying the consequences of earthquakes in the Kozje area and elsewhere in Yugoslavia.

Each structure was individually inspected and appraised in one of three categories relating to the degree of its further usability as shown in Table 2. The survey which was designed primarily for assessing the quantitative extent of the damages suffered by individual settlements would immediately form the basis for operations for demolition and removing debris. It was completed on June 18, 1976. At later dates, the basic original survey materials were supplemented by a number of amendments and corrections (the manuscript materials prepared by the communal services) which were taken into account as much as possible. After the second stronger earthquake in September 1976 the first survey was supplemented and revised gradually in January and February, but the data processing has not been performed, and it has remained in manuscript form (February, 1977). The additional supplements and revisions resulting from the second survey have not been processed and merged with the data from the first survey.

Table 2
Classification Scheme for Damage Assessment

Category	Usability	Description of the Condition of the Construction
1	structure habitable	main structural elements damaged, lesser damage to other parts of the structure
2	structure temporarily uninhabitable, habitable only after repair	main structural elements damaged, damage to other parts of the structure, repairs economically justified
3	structure to be demolished	demolition, partial demolition or heavy damage to the main structural elements, repairs not economically justified

The damage caused by the earthquake was tabulated in two classifications:

1. the costs of repair of structures classified in the first and second categories,
2. the numbers of structures placed in the third category - those to be demolished since their repair is not economically justified.

It has been unfortunate that the value of these latter structures were not assessed, to have provided a more complete evaluation of the damage.

It is regrettable that the survey covered only the structures damaged by the earthquake. For this reason, the survey materials have lost considerable value, for it is impossible to make appropriate relative comparisons. Attempts were made to eliminate this deficiency in the analysis in various ways, but were not entirely successful. It was not possible to obtain reliable data on the number of structures damaged and on their characteristics. Future similar surveys should take account of this, and a special record and survey of non-damaged structures should also be carried out. This was not taken into consideration when the damage assessment was taking place, for understandable reasons; at that time it was impossible.

Assessment of Damage to Existing Developments

The total number of structures damaged in the communes of Idrija, Nova Gorica and Tolmin, according to the data from the first survey, was 9226 (Table 3). In the communes of Radovljica, Škofja Loka and Ljubljana-Center the communal services assessed the damage through Local

Communities or Departments for Constructional-Communal Matters and Communal Civil Defense Headquarters (handwritten or typed material for the communes of Radovljica, Skofja Loka, Ljubljana-Center). In the commune of Radovljica it was ascertained there were no less than 356 damaged structures, of which 342 were, using the criteria for the Soča River Basin, classified in the first category, 11 in the second category, and 3 structures were so badly damaged that they had to be demolished. In the commune of Skofja Loka 95 structures were damaged, and in the local community of Ljubljana-Center 31 structures.

Table 3
The Number of the Structures Damaged by the Earthquake
in Slovenia in 1976

Commune of	Degree of Damage			Total
	1st category	2nd category	3rd category	
Idrija	463	316	34	813
Ljubljana-Center	31	-	-	31
Nova Gorica	2082	625	214	2921
Radovljica	342	11	3	356
Skofja Loka	59	26	10	95
Tolmin*	3003	1744	785	5532
(Tolmin**)	(3516)	(1365)	(1455)	(6336)
First Survey Total	5980	2722	1046	9748
Including the 2nd Survey for the commune of Tolmin	6493	2343	1716	10,552

*The data for the commune of Tolmin including supplements of the first survey, before the September series of the earthquakes.

**The data for the commune of Tolmin after the September series of the earthquakes, the second survey.

An accurate count of the damaged structures cannot be ascertained. The data indicated in the summary table rely on the surveys for the communes of Tolmin, Idrija and Nova Gorica, and in addition whatever reports made by the communal services that could be collected. According to the available data and the first supplemented survey for the commune of Tolmin there were, up to the month of September 1976, 9748 structures damaged in Slovenia. By substituting the second survey for the commune of Tolmin the final incomplete number of damaged structures rises to 10552. Between the first and the second survey the number of the damaged structures in the commune of Tolmin rose by 804 or



Figure 1

Earthquake Damage in Breginj, Yugoslavia, 1976

Demolition of an old house badly damaged by the earthquake at Breginj. It was particularly difficult for aged people who lost their homes to accustom themselves to new living conditions.



Figure 2

Earthquake Damage at Podbela, Yugoslavia, 1976

A demolished wall of an old house at Podbela constructed in the traditional manner. It was built without use of concrete or other more up-to-date construction materials.

by 14.53 percent. Considering this increase and the fact that outside the most stricken areas the damage has not been listed in such detail (for instance in the communes of Ljubljana, Vič-Rudnik, Aidovščina, etc.) it is safe to state that the final number of structures damaged by the earthquake in 1976 was approximately 15 to 20 percent larger than the number indicated. It is estimated that most of this increase falls in the first category of damage. As a result of the earthquakes, a total of approximately 12,000 structures were damaged in Slovenia. The Report on the removal of the consequences of the earthquake in the Soča River Basin (December 11, 1977) states that after the September earthquake a total of 11,224 structures were damaged in the communes of Tolmin, Nova Gorica and Idrija. This indicates extraordinarily extensive damage. In total the survey tabulated 1716 structures assessed as so heavily damaged their repair was not economically justified. Based upon this figure we estimate that there were in Slovenia as a whole from 1750 to 1850 such structures. In the second category of severely damaged and temporarily unsafe there were 2343 structures which means that by the end of the earthquake activity there were in Slovenia as a whole 2250 to 2350 such structures. In total in Slovenia approximately 4000 to 4200 structures were temporarily or permanently unusable, which means approximately 30 percent of all structures listed as damaged. Other structures suffered minor damage and were usable.

The finding that some 15 percent of the structures were so damaged that they had to be demolished surprisingly checks with the detail quoted by Pavlin [1895] regarding the earthquake at Ljubljana on April 4, 1895. That earthquake, with its epicenter in the neighborhood of Vodice, had the strength of the 8th to 9th degree on the MCS scale [Shebalin, Karnik, Hadžievski, 1965]. Pavlin reports on the damage: "The best picture of the entire disaster can be made by taking into consideration the estimates formed by the experts on the structures. They say that some twenty-five percent of all the houses should be partially or completely demolished, sixty-five percent should be radically repaired or reconstructed, and only the remainder could be restored to their original position at small cost". J.R. [1896] says about the same earthquake in a booklet: "There is a large portion, almost 20 percent of the houses, that should be, in any case, pulled down. Half of them should be reconstructed and repaired, before enabling them again to be safe habitations." Further, he goes on: "At first the damage was much underrated, as the damage cannot be seen from outside. Most houses suffered in their internal parts; the vaults cracked, the vault buttresses were broken, the ceilings collapsed, the staircases became dangerous, the iron reinforcements were all twisted. Every day new damage is found, and the final assessment of the damages will certainly be even much greater."

This was also the case with the damage in the Soča River Basin, for, prima facie, except for the most devastated places, it was not apparent the damage was extensive. The similarity is not surprising. The quality of the construction of housing in 1895 in Ljubljana and its surroundings did not differ essentially from the numerous older structures in the Tolmin area today, except, of course, in larger and more urbanized places.

The analysis of the number of damaged structures by local communities shows that the most severely stricken area was the Breginj

Corner including the two communities of Breginj and Borjana. This western-most part of Slovenia was nearest to the epicenter. A somewhat smaller number of damaged structures occurred across the Soča Valley in the community of Ladra-Smast. In the Soča Valley between Bovec and Kobarid the most impacted communities were those of Žaga and Srpenica. The Basin of Bovec itself was considerably less impacted than the Soča Valley between Kobarid and Most-na-Soči. In this part of the Upper Soča River Basin which in general was less stricken the most damaged places were around Kobarid while those around Tolmin were much less so. A relatively high degree of damage occurred in the Bača Cleft (Baška grapa). The Bača Cleft as a whole was more damaged than the communities in the neighborhood of Tolmin, but less than the places in the surroundings of Kobarid. In the Sentvid Plateau, at places on the river Idrijca and in the Cerčno area there was considerable damage, however, considerably less than in the areas already mentioned. The only area having the same degree of damage as Kobarid and its community was the Goriška Brda (Gorica Hills), the most damaged area in the commune of Nova Gorica. Similar or lower levels of damage were found in Banjščice, Trnovski gozd (the Trnovg Woods) and in the Vipava Valley. Exceptions are the communities of Cepovan and Dornberk, whose greater damage was, probably, influenced by local tectonic and geological conditions. Of the three communes dealt with the Karst was the least impacted area, which can be explained by its more stable geological basis, and, in part, by its greater distance from the epicentral region.

In addition to the estimated damage, losses to the economy and other activities is ascertainable. In the commune of Tolmin alone the income of the social organizations was reduced by 24,386,000 dinars. The earthquake disrupted the entire activity of the region. On the other hand, however, the reconstruction assistance gave a strong impetus to the region as a whole. Similarly, as in the cases of the earthquakes of Skopje and Banja Luka, we can expect the development of the region to be promoted and changes from the past facilitated.

Analysis of Earthquake Impact by the Index of the Share of the Population Without Shelter

The number of damaged dwellings and the extent of the damage is only one index, since the total damage to all types of structures must be taken into account. A deficiency of the index of damaged structures as a measure of impact is the fact that the total number of non-damaged structures is unknown and the percentage or ratio cannot be found. The analysis of the population that is temporarily or permanently without shelter is much more indicative (Map 1), in spite of its having, in the case presented here, certain deficiencies that could not be completely eliminated. Categories were assigned according to the percent of population without shelter as shown in Table 4.

After the May series of earthquakes (the first survey) in the commune of Tolmin 4599 inhabitants were temporarily or permanently without dwellings, in the commune of Nova Gorica 2324, and in that of Idrija 1409, for a total of 8332 persons.

Table 4

Analysis of Population Without Shelter

Category	Percent Population Without Shelter	Number of Communities
1	over 50%	8
2	30 - 50	4
3	10 - 30	12
4	2.5 - 10	12
5	under 2.5	3
6	- 0 -	3

Of these, 1365 people, or 16.38 percent of the population had lived in structures assessed in the third category, to be demolished. In the commune of Tolmin the dwellings of 969 inhabitants had to be demolished and those of 3630 inhabitants were in the second category of damage; temporarily uninhabitable and requiring major repairs. In the commune of Nova Gorica 328 inhabitants had dwellings requiring demolition while the remaining 1966 lived in dwellings of the second category. In the commune of Idrija 1341 inhabitants had lived in structures in the second category and only 8 inhabitants were from dwellings to be demolished (the third category).

In the commune of Tolmin the number of structures in the third category rose by 53.95 percent after the September shock, between the first and the second surveys. Therefore, we estimate that after the September series of earthquakes there were in this commune alone approximately 2000 persons without dwellings. The situation in the two other communes was similar where, according to our estimates, the dwellings of 2700 to 3000 persons were so badly damaged that they had to be demolished. The number of the persons in structures of the second category was reduced by the extraordinary increase in the third category after September from 6967 to 5500, or by approximately 20 percent. The total number of 8332 inhabitants temporarily or permanently without shelter in May increased after the September earthquakes by approximately another 10 percent.

Lacking accurate data, we can estimate only approximately that there were in Slovenia 9000 to 9200 people for a longer or shorter period of time without shelter. It was necessary to construct new homes for approximately one-third of these inhabitants, or 3000 people, and it was necessary to reconstruct the previous dwellings for approximately 6000 people through major repairs.

The Impact of the Earthquake in Terms of Social and Demographic Characteristics of the Local Communities in the Commune of Tolmin

Slovenia has experienced in recent decades a decline in the traditional agrarian structure. Consequently rapid changes have been taking place also in the demographic structure of the Slovene population. There has been a considerable decrease in the peasants as a