Lessons learned after 1998 and 2004 earthquake in Posočje region

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Summary

Some information about lessons learned during reconstruction of Posočje region after earthquakes in 1998 and again in 2004 are presented. Both earthquakes were moderate (M 5.6 and M 4.9) and luckily haven't claim death victims. But the extent of damage to the buildings and infrastructure was great. More than 3.000 buildings were reported damaged after the 1998 earthquake and about 1.800 buildings in 2004. Some of the reconstructed buildings were damaged again and that raise questions in public about reconstruction efficiency.

Because the Posočje region is underdeveloped but tourist attractive region of Slovenia, the government in 1998 set up a grant scheme to help residents reconstruct their houses. The height of the grant depends on damage, public interest (ie. cultural heritage) for particular building and financial possibilities of the owner. For management of the reconstruction projects the government set up a State Technical Office. The tasks of the Office are from damage assessment and performing quick cost estimates to managing reconstruction projects (from design, construction and supervision) to accountancy.

After analysis of the earthquake 2004 damage (specially damaged reconstructed buildings), some shift of renewal goals were made. The necessity of the Office remained and there were no big differences in recommended reconstruction techniques. But there were changes to grant schema – the split of costs between owner, insurance companies and government and about threshold when building is better to be replaced instead of reconstructed. Reconstructions have to be designed now according to Eurocodes (after 1998 that was not necessary due to 'natural disaster remedy article'). Together with more strict control of works we consider that the reconstruction effort will prove successful when (if) another earthquake happens.

Keywords: reconstruction, stone masonry, grant, cost, eurocode

Introduction

In the last 32 years the Posočje region had been three times struck by earthquake. After every earthquake the reconstruction and revival efforts were great and it takes years for area to regain vitality. Fortunately, none of those three earthquakes claimed death victims in Slovenia. But in the 1976 earthquake the Slovenian territory was spared because the epicentre was in neighbouring Friuli area (Italy) where more than one thousand people lost their lives. Historical recordings also shows that large scale earthquakes are possible in Slovenia such as the devastating one that occurred in 1511 (estimated M6.9 and X by MSK).

In **1976** a series of earthquakes in Friuli (the strongest two were 6.5.1976 with M 6.2 and 11.9.76 with 6.4) heavily damaged also Posočje region where 13.000 people were suddenly found homeless. Approximate 4.200 buildings were temporary or permanently unusable out of 12.000 buildings that were damaged. The largest impact was in villages of Breginjski Kot, where about 80% of buildings were not safe for occupancy and had to be demolished.

In **1998** (12.4.98) the earthquake of magnitude M 5.6 (VIII to IX EMS) with epicentre near Bovec in Slovenia shake the wider area. About 4.000 buildings were reported damaged, 3.000 of them were residential. About 500 buildings were reported as unsafe for living and temporary housing for those residents had to be provided. The entire villages close to the epicentre were heavily damaged (see Fig.1).

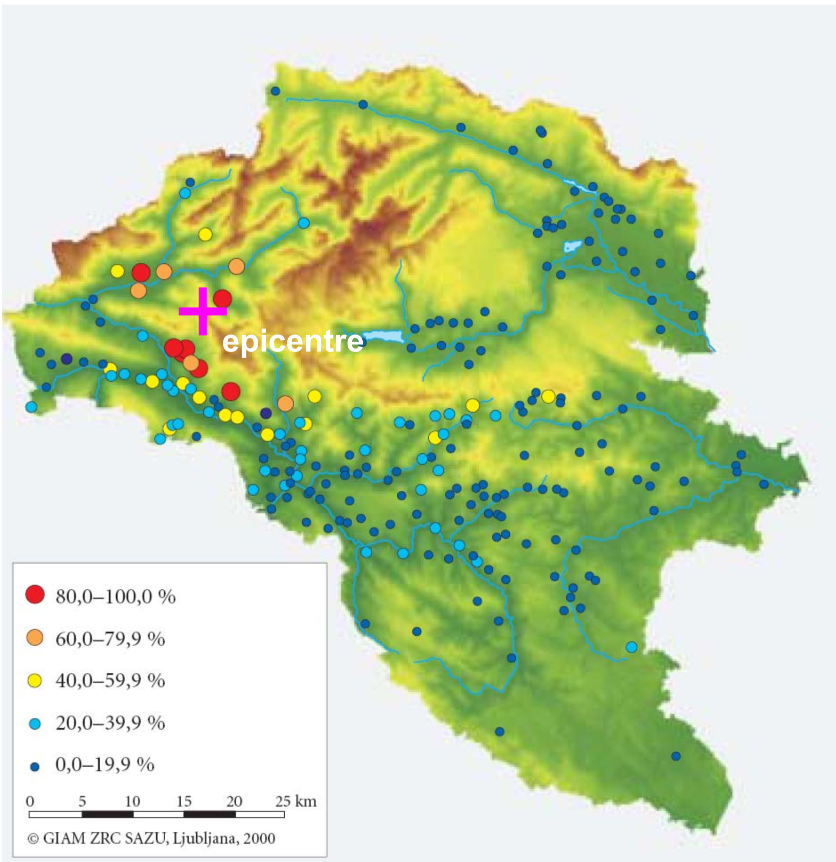

Fig. 1. Proportion of damaged houses after 1998 earthquake (Orožen Adamič, 2001)

In **2004** (12.7.04) M 4.9 once again tested the nerves of the people and the earthquake resistance of buildings. This time it was more contained due to the fact that it was a shallow earthquake (10 km) and so most damage occurred in the vicinity of Bovec. From the recordings of accelerations it was seen the strange phenomena that due to local geological conditions the earthquake shaking was locally very strong (0.47g) but luckily short. There were 1.900 buildings inspected and 1.800 reported damaged to some level. 20 residential buildings were considered as unsafe for occupancy. After the assessment of damage, 620 buildings entered the governmental aid program for reconstruction.

Main difficulties and opportunities

After the earthquake in 2004 (being the third earthquake that struck the area in last 32 years) and observed damage, people questioned how to rebuild their's homes for safer future.

Objectives of the post-earthquake actions

- Immediate actions of search and rescue (also assessing the extent of damage to buildings and infrastructure)
- Support post-earthquake reconstruction of damaged buildings and infrastructure while maintaining public interests (architectural landscape, cultural heritage and economics) as high as possible.

For the first objective the emergency plans are prepared on local as well as state level and they were tested to some extent. We say to some extent because luckily during the earthquakes only few buildings totally collapsed and none of them were occupied at the time. So the rescue part of operations was not needed (although the units were prepared). But emergency operations like assessment of building's safety for occupancy, arrangement of temporary housing and removal of dangerous buildings (or parts, for example cracked chimneys) take place for few weeks.

After emergency phase the reconstruction phase begins. In the beginning the political agreement of how the help will be distributed was needed. The technical consensus of relevant design procedures and reliable reconstruction works (best practice) was made easy accessible and propagated to the public. Due to sudden increase of construction work needed it was decided to control the maximum prices of typical works by government decree. Each time after the Posočje earthquake the reconstruction phase took years. There were several reasons for this: availability of work force (which is bottleneck at the beginning), unsolved proprietarily rights on buildings that were planned for reconstruction and low financial capacity of owners (both reasons tend to stall the renewal process).

Main difficulties

- earthquake non-resistant typical building in the area (dominantly stone masonry)
- underdeveloped area (relatively low financial funds of owners)
- change of legislation (about technical aspects of construction as well as arrangements for renewal funding)

Typical buildings of the region are earthquake low-resistant

Main difficulty during post-earthquake renewal was that typical buildings in the area have very low earthquake resistance. On the other side many of them form the cultural heritage that should be preserved.

The building stock consists mainly of old stone masonry houses as the area was underdeveloped in the past. Old one or two stories high houses built largely from two-leaf stone masonry with weak lime mortar and with wooden floors dominated.

A lot of houses date to the period of reconstruction after the First World War. Many houses were demolished during the WWI as the military front lines were across this area. Due to shortage of building material just after the war, the quality of construction from that period is not very good. Therefore most of the damaged buildings were about 100 years old, built of stone-masonry, with a ground floor and a first floor without basement. The plan lay-out of the walls was relatively satisfactory in most cases. The average thickness of the walls was about 70 cm, and their total cross-sectional area in each direction of the building sums to about 10 % of the total floor area. On the basis of the results of the "in-situ" tests it was found that the compressive strength of the original walls was about 0.5 MPa, and their tensile strength was about 0.1 MPa.

The walls consisted of locally obtained, unfinished stone. They were usually built with an inside and an outside layer, made of larger stones, whereas the interior space was filled with rubble and poorly distributed lime mortar, whose typical compressive strength, determined in laboratory tests, rarely exceeded 0.5 MPa (Tomaževič et al., 1999).

The floor structures, between storeys, were usually wooden. In cases where such floor structures had become weak, or else after the 1976 earthquake, they had, in some cases, been replaced by reinforced-concrete floor slabs. These slabs were usually constructed in such a way that their weight was transferred onto the inner diaphragm of the load-bearing walls, with a bearing area approximately 15 cm wide. They were not connected to the outer diaphragm of the walls, and so, when the 1998 earthquake occurred, the movement of the slab and the wall was not co-ordinated. For this reason in many cases the external diaphragm then buckled and failed.

Quite a lot of damage occurred to walls due to poor foundation conditions, resulting in differential settlement. The great majority of buildings had no foundations as such, but were constructed directly upon the underlying subsoil, usually only at a shallow depth. As rain-water flowed down hillsides towards the rivers at the bottom of the valleys, the fine particles were frequently washed away so that cavities occurred beneath the walls, causing settlement which was magnified by the large vertical component of the earthquake.

Damage also occurred to roofs and chimneys. Usually, the roof structures of older buildings were not anchored into the load-bearing walls. In area around the village of Bovec the roofs of typical buildings are built at a fairly steep angle, and are not trussed. Some of the free-standing chimneys are between 5 and 7 metres high, so that as the roof rocked the chimney collapsed, together with the end walls of the building.

Changes in legislation (technical and funding)

After the first earthquake in May of 1976 buildings in villages of Breginjski Kot were damaged, but to such extent that reconstruction plans were viable and were developed to preserve unique architectural composition of old buildings around main squares. But the second earthquake in 1976 cut in before reconstruction really begins on larger scale. After the second earthquake in September of 1976 there were new building razed as well as damage propagated on previously less cracked buildings. The cumulative damage was high. In some villages 80 % of buildings needed to be reconstructed. As the winter was coming the works had to start rapidly and the quickest and cheapest possibility was the construction of wooden prefabricated houses. The whole parts of villages were demolished and in theirs place the new buildings were erected. Mainly houses were demolished due to damage extent but some were also removed because they had common wall with demolished buildings or they obstruct building site. After the reconstruction of area had been finished a lot of polemics and criticism were raised concerning the way of reconstruction. It was quick and low budged but some valuable architecture had been lost. Just one row of houses around old centre of Breginj was kept, reconstructed and turned into museum after 25 years to show the unique old architecture of the region.

With this lesson learned it was decided that during reconstruction after 1998 earthquake the characteristic architecture of the local buildings and village centres should be preserved. Meaning that repair and strengthening works had priority over the construction of new buildings. Nevertheless the reconstruction measures had to fulfil the required seismic safety. At that time the legislation allowed that typical reconstruction works could be done on the grounds of only notification of works to the administration. As this was much quicker procedure than regular design with applying for construction permit, about 80% of buildings after 1998 event were reconstructed in such way.

The government on 12.06.1998 declared the *Post-earthquake Reconstruction of Structures and Development Promotion in Posočje Act* with main goal to help residents of Posočje region to rebuild theirs homes and also to help local business overcome the difficulties caused by the earthquake (subventions for reconstruction of non-residential buildings and other instruments of support). The height of the grant to owners depends on damage, public interest (ie. cultural heritage) for particular building and financial possibilities of the owner (how much loan he can get, if the building have earthquake insurance fund, etc.). In 2004 modifications were made to the *Act* and it was turned into more general act: *Elimination of Consequences of Natural Disasters Act* (2005).

After the 2004 earthquake some (33) of the newly (after 1998) repaired buildings were damaged again (but none of them collapsed). There were two independent commissions of experts investigating the situation and the conclusion was that in 6 cases (out of 1.400 reconstructions) not all needed reconstruction measures were designed or all planned works were not performed. In general the proposed methods for reconstruction prove to be adequate. However it was stressed that reconstruction measures should be more thorough (which usually means expensive) and that the supervision of works must be stricter. Also the change in legislation (*Construction Act*) now demands construction permit for all works that affects load-bearing structure or capacity of building. The consequence is that regular design plans must be prepared which takes some time but proposed solution is usually more sustainable.

Because many owners already exhausted their funds for reconstruction after 1998 earthquake all costs of second reconstruction (if needed) after 2004 event is covered by government grant. For buildings that were first time damaged the governmental subvention is between 40 and 60%.

From 1.1.2006 the European standards for construction design (Eurocodes) were accepted in parallel with existing codes. After the 1.1.2008 the old codes are withdrawn and proof of construction safety must be done according to Eurocodes principles. It turned out that the requirements for earthquake resistance are much higher so many of old masonry buildings cannot meet them even with extensive and expensive reconstruction. Therefore many buildings are rather demolished and replaced with new ones due to economic reasons. In the *Post-earthquake…Act* the limit when replacement of building is better solution is defined as when the costs of reconstruction exceeds 60% of the costs for new building with size (living area square meters) depending on the number of affected families and residents. Costs of new building also include the costs of removing the old damaged building.

Main opportunities

- update building stock to safer construction practise
- develop/revitalize the area (for tourist use)

Upgrade building stock to safer construction

Under usual circumstances (and due to high costs of reconstruction works) people tend not to see the deficiencies of their houses in terms of seismic safety. A moderate earthquake stir up the consciousness and many people became aware of the problem. With the stimulation from the government many decided to upgrade the earthquake resistance of their's houses. Thus in the possible future earthquake events the vulnerable stock of buildings is diminished and the effects of disaster decreased.

Revival of the area

As the Posočje is the Slovenian underdeveloped area a quick public agreement was reached that beside financial means to support reconstruction of resident buildings there should be also support for economy of that region. Financial grants to companies were provided and funds for all costs of reconstruction works of cultural heritage objects were assured.

Methods and techniques used

Action steps from earthquake to revival

In general the main steps were similar in all three cases as they would be after any major disaster:

1. immediate actions (emergency: informing public, search and rescue, provision of emergency food, shelter and medical assistance)
2. recovery (restoration of essential services and vital infrastructure, provision of temporary housing)
3. reconstruction and revival

First two steps were started immediately after the earthquake occurrence and were carried out by Civil Protection and Disaster Relief Forces (local as well as state level).

Immediate actions

were performed by Civil Protection and Disaster Relief Units, which are part of Ministry of Defence and are activated during major disasters. Their's operations are defined in *Protection Against Natural and Other Disasters Act*:

- Informing public; to prevent anxiety or even panic, main information about earthquake (vicinity, magnitude, registered number of victims..) is broadcasted thru media channels (radio, television, web)
- Search and rescue victims
- provide (organize the delivery) the emergency food, shelter and medical assistance
- Assessment of immediate safety for damaged buildings; teams of engineers did a quick survey of damaged buildings in respect to further occupancy. Unsafe buildings are marked and occupants advised to leave into emergency shelters.

Recovery

During the second phase of emergency operations the following tasks were performed:

- organizing temporary housing (in existing non-damaged buildings, containers, tents). After 1998 event an existing tourist capacities of the area (apartments, rooms) were temporary used together with ad-hoc villages of containers.

- cleaning debris from main communication routes
- demolishing the buildings (or parts of them) that are hazardous for public safety
- restoration of local infrastructure (power lines, water supply, etc.)

Reconstruction and revival

Reconstruction is in the domain of Ministry of Environment and Spatial Planning while the revival of the area (business, infrastructure) is in domain of Ministry of Economy. The goal of reconstruction is to provide sustainable solution so that reconstructed buildings would withstand the strongest earthquake expected in the area without collapsing. To handle renewal process in the field, the government organised the "State Technical Office" (STO), whose tasks are:

- training design and contractor's staff; since such works are not frequently encountered by designers and workers, the STO organized a number of workshops, with the participation of leading experts from research institutes and universities. Only those designers who took part in these workshops were permitted to tender for design or work within the framework of post-earthquake renewal.
- assessment of damage and provisional proposal of reconstruction measures;
- advice about funding arrangement; the amount of available financial aid depended not only on the scope of damage occurring to individual buildings but also on the purpose for which the building was being used, and the number of inhabitants. Not all costs could be covered by non-returnable financial aid, so that owners had to provide some of the money needed, which they obtained in various ways
- design of less demanding reconstruction; during the period of greatest activity as many as 100 engineers and other experts were employed by the STO preparing design documentation for the repair and strengthening of less damaged buildings
- design by regulations (handed over to external design companies; Members of Slovenian Chamber of Engineers)
- regulatory process (getting approvals); the design of repair and strengthening works involving measures affecting the load-bearing structure or external appearance of individual buildings had to be performed in accordance with the requirements of the existing Slovenian building code, i.e. only by firms which have been registered by the Slovenian Engineering Council. This design work was therefore outsourced to various engineering companies
- supervision of reconstruction works; experts from the STO were authorized to monitor the quality of executed works, the quantities of executed works, and the summary of costs involved

Revival plans for the reconstruction of non-residential buildings and infrastructure (roads, bridges, water supply and sewage) are also part of STO work while subventions to business are governed by Ministry of Economy.

Organisation of reconstruction

The execution of repair and strengthening works after the 1976 earthquakes showed up as insufficient. The problem is illustrated by the surprising discovery that out of 173 buildings damaged beyond the point of repair in 1998 earthquake, 76 had already been previously rebuilt. Even more eloquent is the fact that 26 buildings were destroyed that had been rebuilt immediately following the 1976 Friuli earthquake in the period between 1976 and 1980. It is obvious that too little attention was paid to strengthening the buildings during the reconstruction work at that time. Apart from the replacement of timber floor structures with reinforced-concrete floor slabs, and, to a certain extent, the grouting of some stone-masonry walls (cracked walls were frequently just re-plastered) other important repair and strengthening works were not carried out. Unfortunately, in many cases the new reinforced-concrete floor slabs were not properly anchored into the load-bearing walls, and so were unable to provide sufficient resistance to seismic forces.

The earthquake of 1998 showed up all the mistakes which had been made during the previous repair and strengthening works on stone masonry buildings. Reinforced-concrete buildings, however, withstood the earthquake well, and it was encouraging to see that modern masonry buildings, which had been built according to the Slovenian seismic code (mostly confined masonry), as well as older masonry buildings which had been properly repaired and strengthened after the previous earthquake, also did not suffer damage.

Due to all the mistakes which occurred during the works carried out after the earthquake of 1976, and taking into account the good performance of properly repaired and strengthened buildings, the government of the Slovenia decided to be stricter in its approach to repair and strengthening works following the earthquake of 1998. In the case of masonry buildings only those principles of repair and strengthening were used which had been proved to be reliable and are described later in the text. To better control the reconstruction process the special department was established by the government (STO). Technical responsibility for this project was given to the Civil Engineering Institute ZRMK, which has very extensive experience in both the design and execution of post-earthquake renewal works. Organizational responsibilities were assumed by local design company "Projekt, d.d.", of Nova Gorica, while Ljubljana University's Faculty of Architecture took on responsibility for architectural landscaping.

The fact that the government decided to use normal legal procedures with regard to the obtaining of administrative building permits and in solving ownership and other problems involved in post-earthquake renewal had a significant effect on the way in which the STO was organized, and on the speed at which this renewal could proceed.

Financial aid from the state was, in the case of 1998 post-earthquake renewal, limited to the renewal of the load-bearing structure of buildings. Such works were classified as "S-designs", which meant that after these works were completed the building would be able to withstand the seismic loads expected for the local area with a sufficient factor of safety. The "S-designs" also included the costs of installing electrical cables, as well as water-supply and heating pipes, and the costs of floor coverings excluding the final layer.

Complains about reconstruction (covered by S-design) being finished but still unsuitable for living due to exhaustion of financial funds before craftsman works could finalize building lead to change of governmental grant arrangement. After the 2004 earthquake all costs that are needed to restore living conditions are used as the basis for subvention calculation.

Technical measures for reconstruction

Before renewal works could begin, it was necessary to prepare and to uniform the technical principles which would ensure the same approach for all affected buildings. On the basis of experience obtained over many years by experts of the ZRMK Institute, who had participated in previous post-earthquake renewal projects (in Friuli and Montenegro), technical instructions were prepared for designers and contractors for the repair and strengthening of earthquake-damaged stone- and brick-masonry buildings with timber floor structures. The basic principles remained the same as that used in 1976, after the first earthquake. This involves the tying together of the building at the level of individual floor structures, the grouting of the walls with a cement-based grout, and if necessary, the strengthening of foundations, as well as the repair of roofs and chimneys. The purpose of these works is to ensure that, when such buildings are repaired and strengthened, they will be able to withstand earthquakes with an intensity of up to degree VIII (a=0.2g), which corresponds to the requirements of the Seismic Map of Slovenia, for a return period of 475 years. It was found that buildings which had been correctly repaired and strengthened after the 1976 earthquake had withstood all later earthquakes without damage occurring. Best proof was during 1976 when immediately after the first earthquake (in May) in Friuli two buildings (which had otherwise been destined for demolition) were strengthened in the village of Bardo, Italy, according to the instructions given by ZRMK. After the second earthquake occurred in September 1976, with the same intensity as the first, both buildings survived without any damage occurring.

Before starting the post-earthquake renewal of Posočje, two research projects were initiated. The first project (Ribičič, 1998) was concerned with the effects of the earthquake on buildings due to different geological and geomechanical ground conditions, whereas the second project (Tomaževič et al, 1999) described the effect of the earthquake on buildings, people and the environment, and included in-situ tests of typical stone-masonry walls (in their original and strengthened states), which were performed on five buildings.

<u>Masonry (stone and brick)</u>

The most important parameter involved if the walls of a masonry building are going to be able to withstand severe seismic loads is the walls' shear resistance. The size of this resistance depends on the structural characteristics of the walls, and in particular, on their tensile strength. By means of suitable structural measures it is necessary to ensure that this shear mechanism can be established and exploited in the best way possible, so that local failures and loss of stability do not occur before the shear resistance of the building's walls has been fully used. From the practical point of view, the following measures are the most important:

Tying together the walls at the level of individual inter-storey floor structures: the walls have to be tied together at the level of floor structures either by means of a RC slab or by using **steel tie-bars**. In this way it is ensured that the structure will behave as a whole, the horizontal load will be distributed to the walls according to their stiffness, and the walls will be protected against excessive rocking and possible failure in the out-of-plane direction.

Grouting the walls: due to the typical construction of the masonry two-leaf walls, there is a lot of cavities in rubble between outer and inner wall section. By grouting the walls using cement grout, their characteristics can be significantly improved. The results of the "in-situ" tests, carried out on typical walls of this area, have shown that the tensile strength and shear modulus of such grouted walls increases by between 100 and 150 %. Work on site, as well as the results of tests carried out in the laboratory, showed that it is best to carry out systematic grouting of all load-bearing walls, over their whole height. This is because it has been shown that partial grouting, usually of just the corners of walls, is difficult to carry out, and makes the walls' structure non-homogeneous. Grouting is performed after the walls of the buildings have been tied together. The grout mixture is injected into the wall through steel tubes, which are fixed into previously drilled holes in the wall, and are usually arranged about 50 cm apart over the whole surface area of the wall. If good results are to be obtained then it is important that experienced personnel are used.

Strengthening the foundations: in the case of weak foundations it was necessary to widen or deepen them, which was achieved by constructing a reinforced-concrete tie-beam along the outside edge of the foundations. This new tie-beam was anchored into the existing foundations by means of transverse anchors. If there had been a weakening of the sub-soil beneath the foundations due to washing out of the finer fractions, it was in some cases possible to perform grouting of the sub-soil, but only if there was no danger of the grout flowing deeper into the ground.

Construction of **RC tie-beams** at the level of the eaves: in order to improve the connectedness of the walls at roof level, and eliminate the possibility of uncontrolled movement of the roof elements and the possible failure of head-walls, tie-beams were sometimes constructed at the level of the eaves, which anchored the roof structure onto the load-bearing walls.

Brick masonry with deficiencies

Older buildings with brick masonry walls have similar problems as listed above and also similar solutions. Steel ties are used for connecting the wall together, where needed the strengthening of foundations is performed, cracks in walls are widened and then filled with mortar. A lot of masonry buildings from period before 1975 suffered extensive damage due to inadequate design. Many times the reinforced concrete ties (of confined masonry) were not built, unsuitable brick blocks (with horizontal perforations) were used for load-bearing walls and non-engineered appendices or walls removals were done. In brick masonry one of possible measures is to install missing vertical RC ties at the corners of building and on edges of newly in-build load-bearing walls.

<u>Reinforced-concrete structures</u>

Modern RC structures (frame or wall) have not been structurally damaged during 1998 and 2004 earthquakes. In some cases there were problems with secondary elements (ie. collapsed hanging ceiling and cracked partition walls).

<u>Prefabricated wood based houses</u>

Have performed very well during 1998 earthquake (thou there were not many of them), but due to importance of preserving architecture they haven't been widely used in reconstruction. After the 2004 earthquake preserving the architectural values loose importance to economy of renewal so some houses were replaced by prefabricated wooden houses (24 till now). Even thou the replacement is still more expensive than reconstruction people valued more the higher earthquake resistance, better functionality and thermal insulation of modern prefabricated houses over traditional masonry.

What we learned during renewal efforts after three earthquakes in the same area?

The earthquakes which hit the Posočje (Soča river region) in last 32 years were not the strongest which could be expected according to recent seismological predictions and maps for this area. Nevertheless they caused a lot of damage to buildings, and in particular to the older stone-masonry buildings which make up the majority of residential buildings in this area. The earthquakes certainly provided a serious warning about what could happen if sufficient preparations were not made for an earthquake of even greater strength. For this reason, the decision of the Ministry that all reconstruction work must be carried out thoroughly and consistently (but because of that more slowly) was appropriate. This is the only way to reduce the possibility of worse damage occurring during a future earthquake.

The fact that buildings which had been properly repaired and strengthened after the 1976 earthquakes, with the application of tie-bars and cement-grouting of their walls, withstood the 1998 and then 2004 earthquake with hardly any damage, and also comparisons between the costs of repair and strengthening works and those of replacement by new buildings, showed that the overall approach to post-earthquake renewal, where priority was given to reconstruction, was correct. But the balance between benefits of reconstruction and replacement must be done per each case considering costs, heritage value, functionality for residents and other aspects.

It is particularly important that buildings, recently built according to requirements of Slovenia's seismic code, survived the earthquake practically without any significant damage.

By the end of the year 2000 (in two years after 1998 earthquake) a total of 1.200 buildings, having first priority, had been repaired and strengthened within the framework of organized post-earthquake renewal. These made up 90 % of all buildings with planned repair and strengthening works. A total of 55 million Euros, including both non-refundable financial aid from the state, and money provided by the owners of buildings, have been spent. More than half of this sum was spent on typical smaller houses.

Key Lessons Learned:

- the system in force of Civil Protection and Disaster Relief cope with immediate and recovery actions for such magnitude of disaster without serious problems
- technical solutions for reconstruction proved adequate if the execution was thoughtfully done
- buildings constructed up to modern codes withstand moderate earthquakes very well
- the balance between benefits of reconstruction and replacement must be done per each case considering costs, heritage value and functionality for residents to optimize for sustainable solution for residents and public interests

Additional use of the organization already in place

Between earthquakes another disaster hit the area in year 2000. A big landslide Stovže swept away 6 houses (damaged another 23) in Log pod Mangartom and claimed 7 deaths. Search and rescue were again organized and held by Civil Protection and Disaster Relief Units. The administrative works for constructing 9 substitute houses and renewal of village infrastructure was later trusted to STO as it was already operational in the area.

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