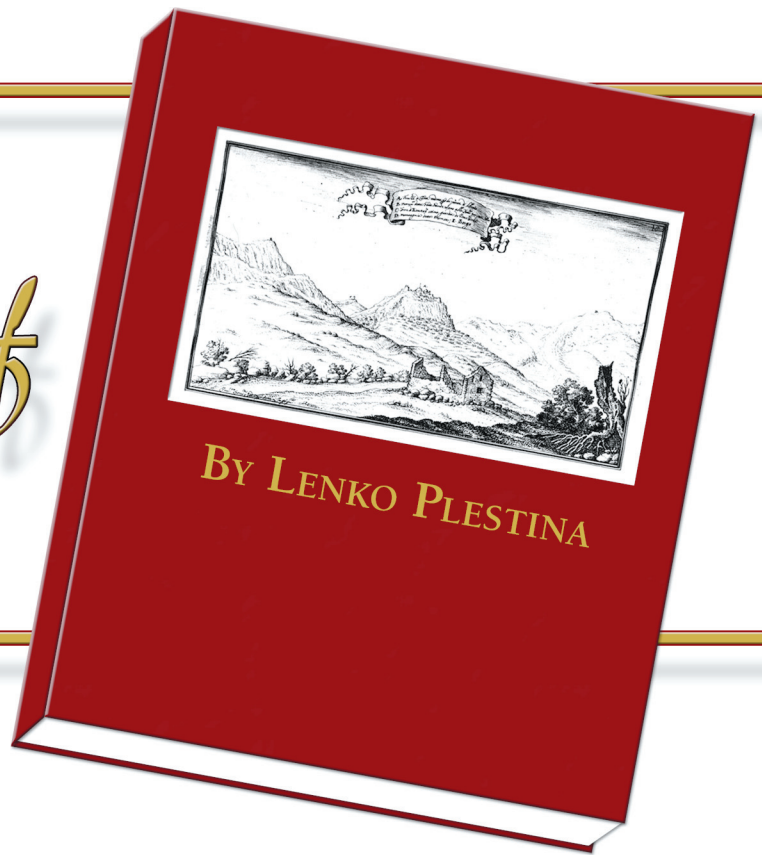


The House Roof Story



INTRODUCTION

In the coastal area of the east Adriatic, in Croatia, there are many old stone houses. Chiseled stone blocks, 60 cm or thicker, were once used for external protective and load-bearing walls. Slanted stone tiles were used on pitched roofs. In the medieval towns of the southern Croatian province of Dalmatia, most of the homes were made this way. (In fact, Dubrovnik is the only town in that region whose roofs sport a predominance of red clay tile roofs.) In other towns, stone tiles have been gradually replaced with red tiles so that these days the image of traditional authentic architecture is light grey stone walls and red tile roofs offset by green shutters (Figures 1a and 1b).

Since World War I, homes are no longer built with stone tiles, and the process of replacing the old ones with red tile roofs has spread from the towns to the rural areas. There remains a heritage of old-style

homes, but many are now deserted, and those still inhabited often lack modern comforts and are in bad condition. Still, those that endure show the legacy of the expression of old craftsmen's skills and maintain a romantic and attractive aura.



Figure 1: Neighboring stone and clay tile roofs common to the area.

OLD STONE ROOF DECAY

Location

The old house I inherited from my family is near the city of Split, the second largest city in Croatia, with a population of 300,000. Split is famous for its palace, built by the Emperor Diocletian between 295 and

Editor's Note: This article was developed from a presentation made at the 2nd International Symposium on Building Pathology, Durability, and Rehabilitation held in Lisbon, Portugal on Nov. 6-8, 2003. Originally submitted to Interface by Justin Henshell, FAIA, CSI, the saga, as he notes, "illustrates the problems of building owners throughout the world who have tried to solve complicated roofing problems without the help of a roof consultant," despite the fact that Mr. Plestina is an architect.



Figure 2: Site of Plestina home, looking north toward Diocletian's Palace, shown in a 1668 drawing by Giuseppe Santini.

305 AD (see Fig. 2). Nearby, on the pass between the mountains of Mosor and Kozjak, 4km from the sea and 180m above sea level, on the 43.5° north parallel, is the town of Klis. It is there that my house is located, eight miles by air from Diocletian's palace (see Fig. 3). The climate here is mild enough to grow fig and olive trees, and harsh enough to demand a proper wood supply for the winter

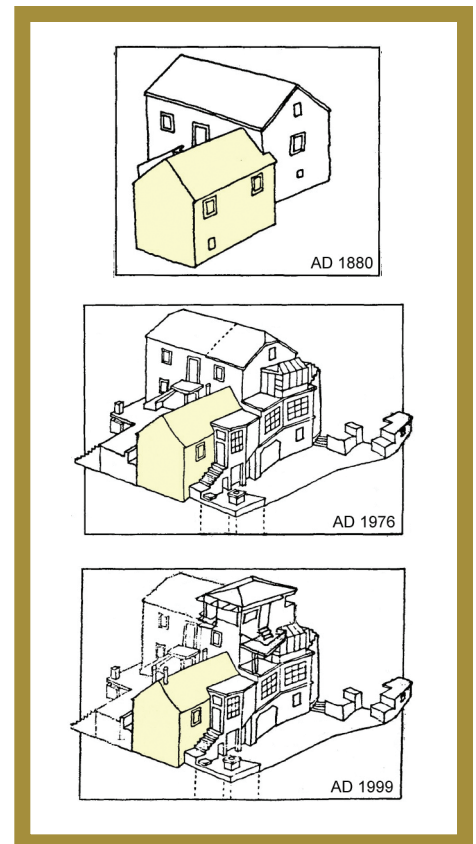
days, where snow sometimes decorates the roofs.

This article is about the problems I encountered with the old house I inherited and how I eventually solved my problem.

The house was built in 1880 by my great grandfather near those of his brothers and other relatives. The pitched-roof house had a ground floor (utility) area, first floor (living), and attic (storage), measuring 5.8 by 3.8 meters inside. It was an addition to an older house he had built. Later growth involved several small additions (4a, 4b, and 4c). My father and mother lived in the house until 1970. I inherited it in 1980 but did not properly maintain or care for the house. In 1997, I realized that the structure was in critical condition.



Figure 3: Current view from the Klis fortress to the city of Split. The circled area is the author's home.



Figures 4a, 4b, and 4c: Subject building, when built in 1880; in 1976; and 1999.

Roof characteristics

The traditional stone roof was made of stone tiles inserted between wooden rods (split poplar) fixed with wrought iron nails on wooden rafters (axed poplar and pine), and bonded with plenty of lime mortar. This sort of roof demands maintenance with limewater pouring every few years, so by 1997, the color was changing from white to grey. The roof had been neglected for more than thirty years. Some pieces of mortar and some stone tiles had fallen out. Cracks were by then noticeable, leakage had appeared, and some wooden construction was in danger of collapse. Something had to be done (Figures 5a and 5b).

Possible solutions

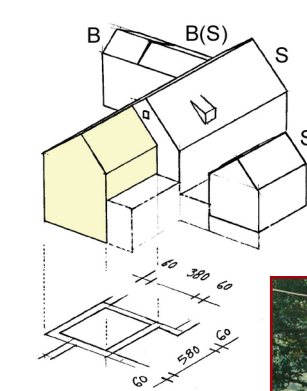
Dealing with stone tiles is an old craft, and there are no more stone tile craftsmen. Neither is there proper material to recreate the old style. I considered the possibility of taking off the entire roof – both stone tiles and wooden construction – and then making a new, reinforced, concrete, pitched slab, then cleaning the tiles of the old mortar and using them simply as mock-ups

over the concrete. But this would have been a very expensive enterprise. Also, this might be considered as a sort of visual rather than architectural solution.

Another, much cheaper solution was to cover over with clay tiles, as many people in the neighborhood had done with their homes. The existing wooden construction could be used in part, or new rafters, sub-laths, and tiles would be installed. There was no insulation underneath, and the unused attic had served as a thermal insulator. Since there had been no obvious complaints about such roofs, it seemed a good idea to renovate mine in this way. It seemed that it would be a cheap, swift, and common solution to provide a better-protected house.

RENOVATION WITH CLAY TILES

In August 1997, after the local patron saint's (St. Rocco) day, a roofer and his assistant started working on the roof. The larger stone tiles were saved, with some to be used later for paving. Trash and small broken pieces were to be placed later in the house foundation as a sub-layer for the concrete slab, in the base of an entrance ramp, and even in the garden.



Figures 5a and 5b: Configuration of roofs from the south. S = stone; B = tiles; B(S) = tiles (ex. stone).

Wooden split laths were removed (see Figures 6a - 7b). A few rafters were torn; others had lost their shape but could be reused. New 5x8cm rafters were laid and connected with the old ones. New eaves were made of existing stones and fixed with concrete to both old and new rafters. 3x5cm-laths were placed for tile sub-layers, tiles were set, and the connections between the roof and neighboring walls were mortared.



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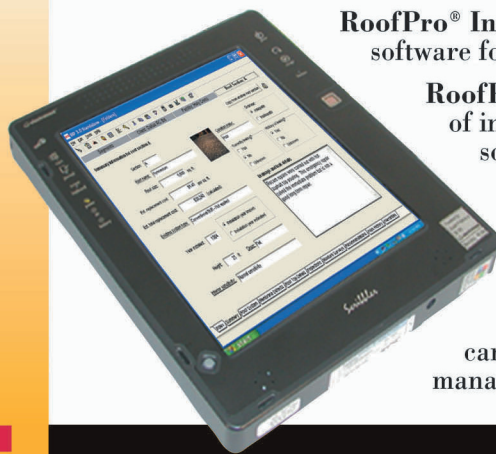
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Figures 6a and 6b: Beginning of work; taking stone tiles down from the roof.



All this work was done in five days. The cost of materials and work was about 1200€. (A euro was then worth approximately \$1.10 American).

PROBLEMS OF THE RENOVATED ROOF

After repairs were completed, heavy autumn rains came, and unexpected problems occurred. The beautiful roof did not resist leakage, and water dripped through. Leaks became my obsession in the following

years. The roof had a really fine slope – almost 45° – and tiles had been laid very neatly (Figure 8) but...

I was unable to determine if the tile quality was bad.

Perhaps they were made of porous material or the joints had been poorly done. The tile manufacturer came for an inspection and tried to deny responsibility and buy time. To save my nerves, I rejected any idea of going to court, hoping that I would find some simple solution. I was not in a hurry because this house was only part of a larger dwelling unit that I used for vacation only. That was the reason I did not act promptly. At one time, the manufacturer was willing to change the tiles, but not to make new eaves

or finish the connection with the walls. In time, I gave up my demands of the manufacturer and began to try other solutions.

I tested some unused tiles for porosity, and those were OK, but that didn't mean that all those on the roof were good. If only some of them had been bad, the whole roof would have had the same problem. But I thought at that time that the joints were not correct. Although I was warned that covering the joints was not a good idea, without a better idea at the time, I decided anyway to fill up the slanted joints with ceramic cement glue, leaving the horizontal joints free (Figures 9a and 9b). Contrary to my expectations, the problem was not solved. Then I decided to cover the joints from the inside. The problem and leaks persisted.

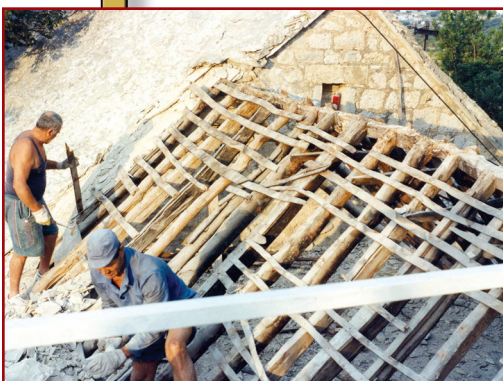
I then concluded, after the joints were filled with cement glue and mortar, that the problem was the porosity of some tiles. I thought that spreading the silicon liquid over the tile would stop water from pouring in. It was done, but without any effect (Figures 10a and 10b). All of these "healing" attempts increased the costs by another 500€.

MISTAKES

In reviewing the problem, I realized I had made several mistakes.

Ignorance of the weather conditions

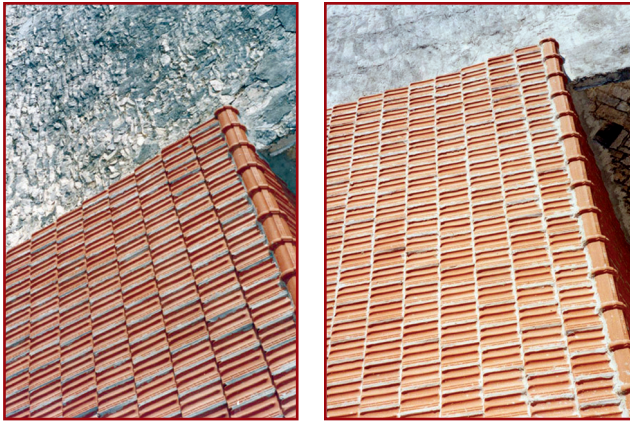
In this area, dry weather can last for months, followed by heavy rains in autumn. Fierce thunderstorms, when the water is pouring from the sky, might happen in all seasons. This is an area where the strongest winds on the east Adriatic are blowing. North, dry winds called bura often whistle through at speeds of 200 km/h. Southern winds (jugo) blowing from the sea are wet, sometimes bringing rain for days. The worst are storms with intense rain and strong



Figures 7a and 7b: New rafters added to the old; new eave reinforced by concrete.



Figures 8: The roof is finished, but....!



Figures 9a and 9b: Corrective attempts with cement glue and mortar from outside.

wind, when the rain comes horizontally. It is a real challenge for roofs.

My impression had been that all roofs in the area were quite resistant to weather conditions, but that was not actually true. Many neighboring houses were deserted, and special attention was not paid if some dampness appeared. Nice weather and dry wind following rainy days heals those buildings, making them dry again.

Ignorance of contemporary standards

Contemporary standards do not allow one drop of water to pass into the interior, and that is something of which one should be aware. If I had been, I would have provided a proper underlayment.

Bad attempt with cement glue and mortar

After the initial mistaken repair, and finding the roof was still not waterproof, I should have removed all of the tiles. They had been fixed with nails, and it would not have been difficult to get them free from the laths. Then, proper roof construction could have been done. Instead, filling the joints with cement glue and mortar had caused all the roof surfaces to become one monolithic slab, and it was now

almost impossible to remove it without significant damage to the wooden construction and lots of waste in broken tiles and material. This mistake made me think about how to solve the problem without tearing down this failing roof.

Absence of proper diagnosis

I had made a bad inquiry and never discovered the proper cause of leakage. I had to concentrate more on the problem. If I had cooperated more with roof specialists, I'd probably have had a better knowledge of the problem, and, of course, its cure as well.

POSSIBLE SOLUTIONS

All this time, I could have taken down the entire roof and had it properly reconstructed. This would mean not only tearing down the monolithic tile covering and breaking it into pieces, but quite probably ruining the wooden sub-construction. I wanted to avoid this mess and a lot of work and expense. The other solution was to recover the existing roof.

My first idea was to cover the roof with lime-cement mortar juice and to create a visual impression similar to the previous roof. This would require subsequent care every few years, which was not desirable. Also, this would create a hybrid and unauthentic texture of old stone roofs.

Another idea was to cover the roof with some sort of waterproof fabric to create an impression similar to the Bulgarian environmental artist

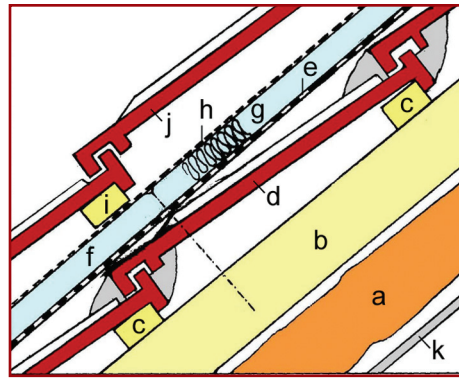
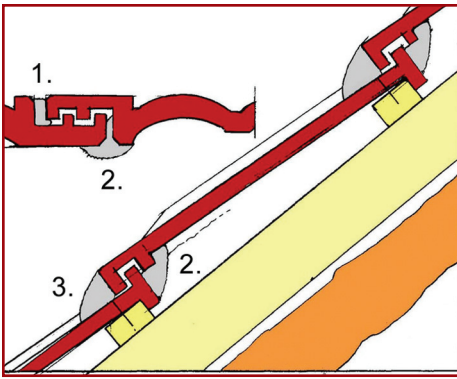


Figures 10a and 10b: Corrective attempts from inside; attic boards and joists were later removed.



Christo's wrappings, but this seemed more a temporary than permanent solution.

Another idea – to put white corrugated aluminum over the roof – looked fine to me. This solution would have been quite good,



Figures 11a and 11b: Attempts were made to stop water at points 1, 2, and 3 with cement glue and mortar and to recover the a) old rafter, b) new 5x8 rafter, c) 3x5 lath, d) brick tile, e) bitumen sheeting, f) counter-lath, g) thermal insulation, h) plastic foil, i) lath, j) brick tile, and k) ceiling.

and I considered it very seriously. It would be a contemporary, modern solution. But later I became a bit unsure, mostly because of what it would look like in relation to other homes in the neighborhood, so eventually I gave up that idea.

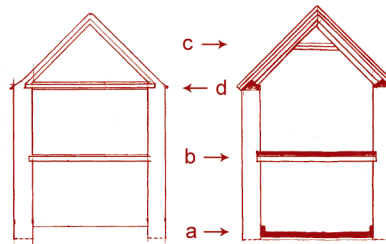
FINAL CHOICE

The final decision was to put new brick tiles over the existing roof.

Spatially, to enlarge the height of the interior space, the attic joists were removed (Figures 12a and 12b). But before taking them off, the building was reinforced with concrete slab on the soil between the foundations with reinforced slab between the ground and first floor, and with partial upper connections of rafters.

The previous stone tile load over the wooden construction was about 200 kg/m². The new tile load was about 70 kg/m². It meant that new reinforced construction had quite a bit of spare strength for new loads. They were, first, tar insulation sheet (roofing felt) all over the roof; and then laths at 3x5 cm and counterlaths at 3x5 cm for new tiles. In between laths, thermal insulation was laid and protected with vinyl foil.

The problem of how to fix new laths for the existing roof was solved with 20cm length nails. Holes were drilled on the positions of the rafters underneath, and nails were easily inserted (Figures 13a and 13b). Two workers completed this job in four days in February 2001 – almost three and a half years after repair had first begun. Luckily, I did not need this space badly, so I could



Figures 12a and 12b: Old and new section and interior space.





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Figure 13a: Bitumen sheeting with laths.

Figure 13b: Later penetration of two chimney tubes (protected with 2 mm lead sheet). So far, it works perfectly.



take time to think about it and search for the best solution. The costs of material and work amounted to 1900€.

CONCLUSION

The problems with this roof could have been avoided if I had done it properly the first time. Only a small additional amount of work and investment would have saved me many worries, additional problems, and expense. It meant that after the slanted stone tiles and split wooden rods had been removed from the roof and additional rafter reinforcements had been installed, all roof surfaces had to be covered with wooden boards, roofing felt, lath, counter-lath, and tiles. In that case, every drop of water passing

through tile layer would have been stopped and drained into the eaves.

This solution would have only prolonged the work for one day with a small increase of cost for additional material. In-

stead of $1200 + 500 + 1900 = 3600\text{€}$, the cost might have been about 1600€. Of course, many lost days would have been avoided.


The moral for a similar enterprise is: think three times before you start. 



Figure 14: The roof repair is finally done properly.

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Figure 15: Under the new roof: the living room.

Lenko Plestina

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