Antonino Giuffré

EVOLUTION OF THE SEISMIC CODES IN ITALY

Abstract

Italy is a seismic region and we can find document of ancient seismic culture. The first true seismic code was promulgated by the Bourbons in 1785, and it was applied for law, but it did not give rise to a popular seismic culture. The current Italian code is quite ineffective with respect to the requirement of preservation of historical meaning in the ancient towns, and the problem of the possibility to formulate a code able to suggest proper interventions techniques is discussed in the paper. A double format is illustrated: a general code which only supplies the methodology and gives the basic rules for the mechanical survey, and a "practice code" elaborated by the local authority and directed to the problems of the local urban fabric.

Some reference is supplied on the proposal for the Eurocode n.8 at present in discussion.

Italy is a country strongly affected by earthquakes. Most of its territory is subjected to their action, mainly its meridian and central part.

Memory of earthquakes comes from the antiquity and from time to time it has been tragically renewed. Seneca wrote about the causes of this phenomenon after the earthquake of Pompei in 62 (or 63) b.C., but the remedies he proposes don't go over the philosophical acceptance of the damages.

For many times the only response to the earthquake has been given by the builders of the houses, without help from the authority. It is likely that the simple builder in the old time of the Middle Ages thought how to improve the quality of its masonry in order to make it stronger against earthquakes.

Who is used to study the historic buildings knows the rules formulated by Rondelet and reproduced by all the treatises of the 19th century, referring the thickness of the lateral walls of the churches; Rondelet derived his rule from the observations of ancient fabrics in Rome. It is evident in Calabrian region for the middle-age churches, and in Campania too, referring to churches of the 18th century, that they have walls almost twice thicker than the ones described by those rules. The seismic culture suggested to the original builders to increase the thickness present in the previous churches of Rome in order to satisfy the local seismic requirements.

But in more recent time the authority started to promulgate regulations to achieve a general reduction of the seismic risk.

In the central Italy the regions of the Apennines contains several ancient towns, from Citta`di Castello to Norcia and L'Aquila, severely stroke by earthquakes, and it is not difficult to find in their archives ancient edicts of the authorities where prescription were promulgated referring to particular actions to do, or not to do, in the emergency of an happened earthquake: how to use the rubbles of the destroyed buildings, not to rebuild the typical bow-windows of the medieval towns, to change the way of opening the doors from outward to inward, and so on.

Prescription that have often left their mark on the feature of the towns.

Such occasional interventions were laid down because of some particular necessity, but the first organic body of rules I can quote was issued by the government of the Kingdom of the two Sicilies in 1785, after the awful earthquake that shook the Calabrian region in 1783.

That earthquake was the second, in the century, after the Lisbon earthquake in 1755, which troubled the confidence of Europe in the provident nature.

But if after the first one, educated men as Immanuel Kant had to debate the philosophic problem of the harm, as Seneca had done, the second produced a crop of scientific hypotheses and technical proposals.

Vivenzio, a doctor at the Borbonic court, just after the earthquake had the charge to suggest how to build the houses in order to make them resistant against seismic action. And he presented the drawings of the famous "casa baraccata", a wooden framed technique similar to those used in north Europe. The wooden frame was infilled with masonry, it was "reinforced masonry" with wooden reinforcement. Vivenzio looked through the damaged houses and evidently understood the weak point of the usual masonry building: the lack of connections. We don't know where he had had the opportunity to see the constructive techniques he suggested, but it is evident that his proposal punctually fills an all inadequacies, it appears as a truly safe way to build in seismic area.

In 1785 the government proclaimed a law with several measures related to the seismic safety, and the duty to apply the new technique of building.

Can we impute to the "casa baraccata" the meaning of an evolution in local technique? I don't think so: it was applied as a forced necessity and it was forgotten as soon as possible maintaining the ancient, usual, unconnected masonry technique.

I would assert that the little success of the intelligent proposal of Vivenzio properly derives from having been given by low, as the taxes the Bourbon government used to levy. He imposed a technology completely new, never practised in that area, and people didn't like it.

Some years ago Tobriner, a professor of University of California, interested in Italian seismic architecture, found in a little town of Calabria a "casa baraccata" in demolition. He could observe the frame of wood put inside the walls but lacking of the regular connections at the corners: the builder had not understood the static of that structure.

Other seismic rules promulgated by the local authority can be quoted in 1785 in Citta' de Castello, and in 1860 in Norcia. In these cases the prescription were nearer to the popular idea, given by local technicians and directed to details typical of the local architecture. They were more effective.

The historical towns have generally grown through the spontaneous building of the people and its constructive techniques are the fruit of a local culture as deeply-rooted as the language. For this reason the houses have remained similar for centuries, and the seismic provisions have been accepted only if they appear as little improvements of the usual way of building.

When the seismic code have been as authoritarian as the Borbonic one was, it was neglected or it had the power to radically change the town.

I can quote the town of Messina in Sicily, on the strait which divide the island from Calabria. It had been an ancient and rich town, which, in spite of the frequent earthquakes had kept its feature. The 1783 earthquake damaged it seriously, but it was repaired and regained its elegance. The technique of the "casa baraccata" was completely neglected, and so every seismic provision, and the early morning of 28 December of 1908 a strong earthquake stroke it and caused extremely serious damages.

At that data the Italian government was already sound. A committee was installed and in a very short time the first Italian modern seismic code was promulgated.

Under the action of this code, in ten years, the traditional feature of the town was finally cancelled. Nobody, born in Messina after the '20, can have an idea of the ancient town.

Nevertheless the first Italian code was not bad (I can resolutely assert comparing it to the modern codes) since it provided a very intelligent and effective guide to the designer. But it was a code directed to the new building and quite unrelated to the historical town.

So the modern codes are. They disregard the presence of an historical town as support of the new building. It has been said that mechanical problems are independent from the history, but the mechanisms, the structure of the buildings, do depend.

In fact the international codes today, and the Italian one in 1909, have a model of building to which they are intrinsically referred. At the beginning of the century it was a two or three story reinforced masonry buildings, with the walls as distant as the traditional urban fabric used, rectangular in plant and like a block separated by the near buildings. Nowadays the building referred by the code is a reinforced concrete or steel frame in form of parallelepiped, or a parallelepiped box, without limit in height.

It is good everywhere, it can be placed in each town.

The modern codes are unable to distinguish the local peculiarities of the historical towns, in fact they have been formulated for the new buildings and they have not the duty to take on a politic of continuity with the old town: they properly deal only with mechanical problems concerning the bearing structure of the buildings. Even the seismic effectiveness of the building as a whole is out of their duty.

The modern codes can't help the preservation of the historical town; the historical town can be destroyed without contradict them.

The historical buildings present different typology of structure, different seismic behaviour, different weak points to be improved than the modern ones. It is necessary a special item of the code devoted to the strengthening of the historical buildings.

We have, in Italy, such a code, made after the earthquake of Friuli and several times updated, but it is lacking of a mechanical understanding of the masonry structure: for the safety check it simply refers to the items relative to the new buildings. It doesn't faces the problem of the local characteristics, nevertheless it offers some methodological guide to the survey of the actual feature of the building.

The most important quality is the introduction of a distinction between two different possibilities depending from a list of conditions: to make the building "adequate", or simply to "improve" its resistance. The first way, required when some change in occupancy or in structural feature is foreseen, is practically impossible: it require to check the structure following the rules given for new buildings, but those rules agree with reinforced concrete structures and they are without meaning if referred to a masonry building.

The second way leaves the designer free to demonstrate an improvement in the structure consequent from his intervention. So it is possible to be consistent with the actual feature of the construction. It is evident that the only positive feature of this code is the possibility to be cautions without contravene to it.

Now, the elaboration of the Eurocodes will require a revision of the national codes, so the attention has been moved on this new possibility.

An attempt to formulate a seismic code devoted to historical urban fabrics, is going on as a section of the Eurocode number 8. A draft has been already discussed and I will present it in short.

But before I find useful to refer to the questions placed by this conference:

1) Peut-on envisager de mettre au point des règlements qui, en s'accrochant aux techniques traditionnelles encore efficaces, favorisent la récupération de la culture sismique locale?

2) Comment produire des règlements antisismiques qui, tout en ayant une validité générale (nationale, voire européenne), permettent de récupérer les techniques traditionnelles locales?

I think I could give a correct answer to these questions after a clarification.

I am not directly interested to recover the traditional techniques: they had their validity in a different context of economy and life; but I am deeply interested to the preservation of the historical town, and the technical with which they have been built bear witness of the local culture.

I would express the first question in this way:

1. *Is it possible to formulate a code which, accounting for the fruits of the original local seismic culture, regulate the interventions in such a way to obtain the preservation of the buildings and to keep their use if still effective?*

The second one is a very topical question too, because of the differences existing among the buildings related to geographic area, or time of construction, and because of the usual trend, of the modern codes, to neglect the local characteristics and to promulgate arranged in advance models.

The question would had been so formulated:

2. *Which format, if any one, would be suitable for a seismic code generally valid but able to allow the comprehension and the preservation of the local seismic culture?*

I will go, as I can, to answer such questions starting from the second one. It is true that strong differences exist from place to place in building the walls and assembling the houses, differences depending from local material and local technical usage. But it is also true that the mechanical behaviour depending from the lack of connection between the facade walls and the transverse ones plays every where a similar role: the exterior walls are pushed out from the earthquake and they overturn.

It is a general requirement to check such connections and to compensate for their lack with suitable devices, nevertheless the actual feature of the building is not so general and it is not possible to suggest a general way to intervene.

The only think that can be considered as general is the method of analysing the building and deriving, from its actuality, the suggestion for the intervention.

So the format of such a code should be divided into two parts: a general one, on which only a methodology is presented, together with some indications on the main mechanical problems: it should list all the required actions.

The second part shall be elaborated on the place. It should contain a description of the peculiar characteristics of the local constructive techniques, and list of suggestions related to possible interventions to be adopted in different situations inside a well localised set of buildings.

This second part is more properly a "practice code", cured by the communal authority, different from a place to an other.

Of course whereas the general part can be elaborated once and for all, from a suitable committee, the second part is a duty of the local authority like the town-planning scheme, and it is possible that for many time some town is lacking in practice code. To avoid the lack of guide-lines the general part should contain the methodological way to face the local problem too.

In this way the conflict between general validity and local requirements is in some way arranged.

The first question regards the way to intervene, and it concerns the practice code. For this reason I have preferred to answer this question after having spoken about the format of the code.

The practice code shall contain suggestions for the interventions. the problem is: which kind of interventions is correct to adopt in order to fulfil the requirement of preservation?

The reasons for the degradation of a building can be very different, but they can be unified in the formula of "lack of maintenance". The opportunity of this position become evident when the problem of the repair is faced: every intervention on a historical building, if it is devoted to the use, should be formulated as a maintenance, an ordinary or extraordinary maintenance according to the conditions of stability.

It is suitable to clarify that we are spiking about the ordinary houses in the urban area of historical town.

The maintenance has been usually carried out with the same material of the original, only replacing the degraded elements, or strengthening them, without change in the original feature.

Of course the maintenance modifies some portion of the original building, but in same way as 20 or 50 years before other portions have been modified; going on the time maintenance makes the building to renew its parts, but its originality persists, since it is not done by the single respects such usage the preservation is fulfilled.

Some problem arises when we want to guarantee the seismic safety and we think the building seriously ineffective. In this case we could find the necessity to introduce strong over-structures.

First of all we should be realistic in our judgement on the resistance of the building against earthquake. We have seen many historical masonry buildings destroyed by the earthquake, but more only damaged. The building object of our analyses will be destroyed or only damaged? The answer is not easy from a direct mechanical way, but something can be said if we accept the experimental evidence of the effects of past earthquakes. We should know more than the actual feature of the building: the behaviour of similar structures during the earthquake gives an indispensable feed-back, and we can base on it our judgement.

If we have good reasons to intervene the problem of the local seismic culture arises. With reference to the area of the study the seismic culture should be known: the practice code should inform the designer on it, and the effectiveness of the traditional intervention should be understood; perhaps they can be still adopted.

Some of traditional devices are normally employed: the steel ties placed in order to connect the exterior walls to the transversal ones have been used in the past and they can be used now too.

The section 1.4 of the Eurocode number 8 concerns strengthening and repair, and part of it is devoted to the masonry buildings in historical towns.

This part has been drafted in agreement with the reflections presented above. It is addressed to the designer of the single intervention and to the communal committee charged to carry out the practice code.

The first step of the prescribed procedure concerns the technical survey. The comparison with other similar constructions is recommended, in order to collect the most information on the local technique and its behaviour.

The second step is the judgement of the quality of the masonry, which can be done comparing the wall to a list of required details. These are general details, taken by the treatises, on which an analysis devoted to understand their mechanical effectiveness has been carried out.

The third step is devoted to the analyses of the structural assemblage: a list is supplied too and the research of the possible weak points is prescribed. The analysis has the aim to point out the possible collapse mechanisms, which can be derived by the observation. Numerical checks are possible and the code presents some possibility referring to a static analysis of the resistance to horizontal forces equal to the 80% of the pick ground acceleration.

The last step concerns the design of intervention devices able to control the collapse mechanisms, chosen in such a way that it became part of the original structure as in maintenance activity.

Of course the interventions can't be illustrated in a general code, since they concern local situations, and only indicative examples have been reported.

This proposal is the most updated attempt to arrange a guide for the interventions in historical centres, respectful of the historical value of the original techniques and attentive to achieve the safety which allows the houses to be inhabited.

Nevertheless the only way to preserve the historical towns is the love of their inhabitants, that should avoid to demand to make modern the house demolishing the walls or opening large windows, and the intelligence of the engineers, that should find the way to strength the building using the same structural language of the original builders.

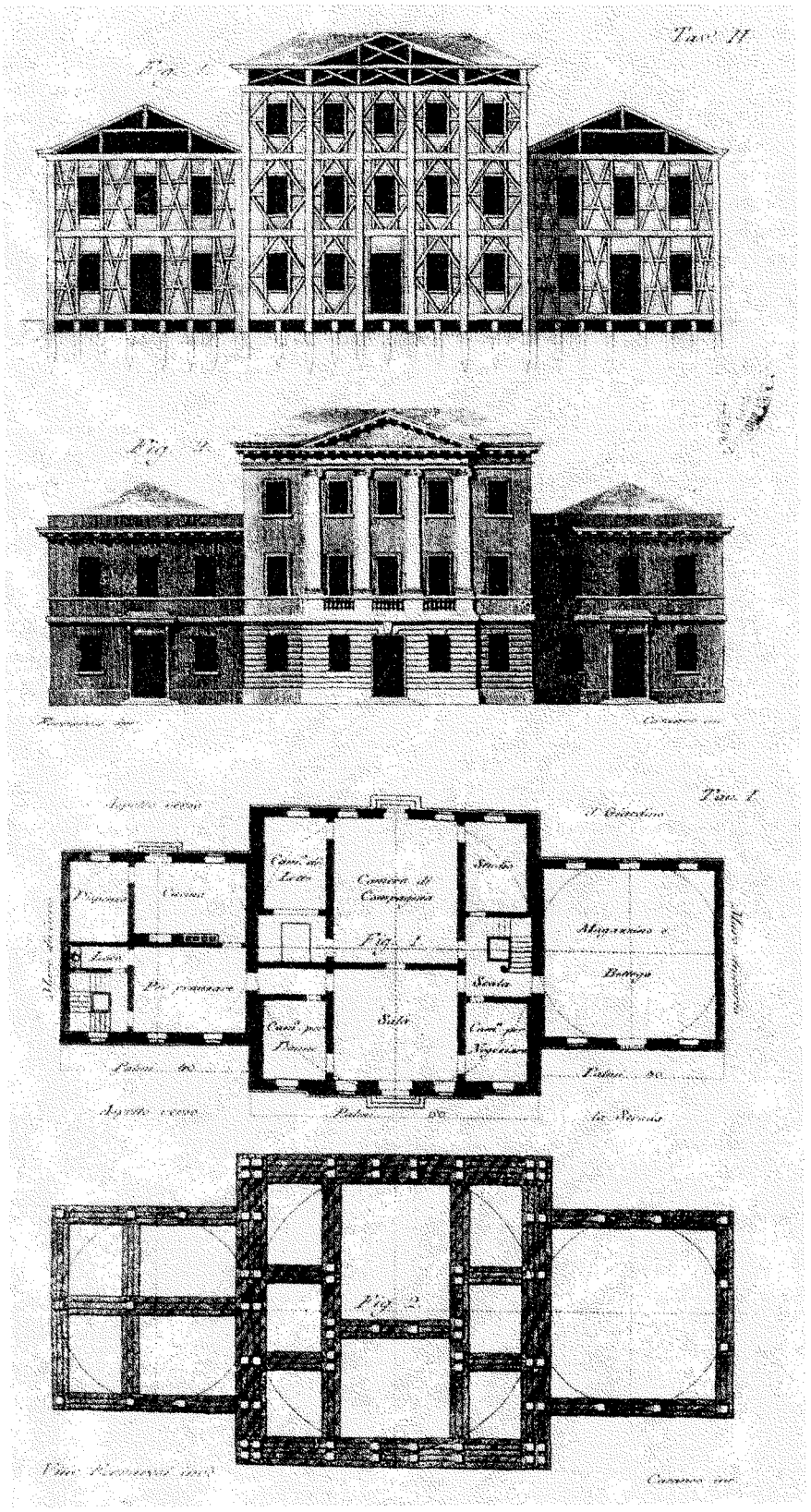


Plate 1 Design of "casa baraccata" as proposed by Vivenzio in 1785. (from: C. Barucci, La casa Antisismica, Roma 1990)

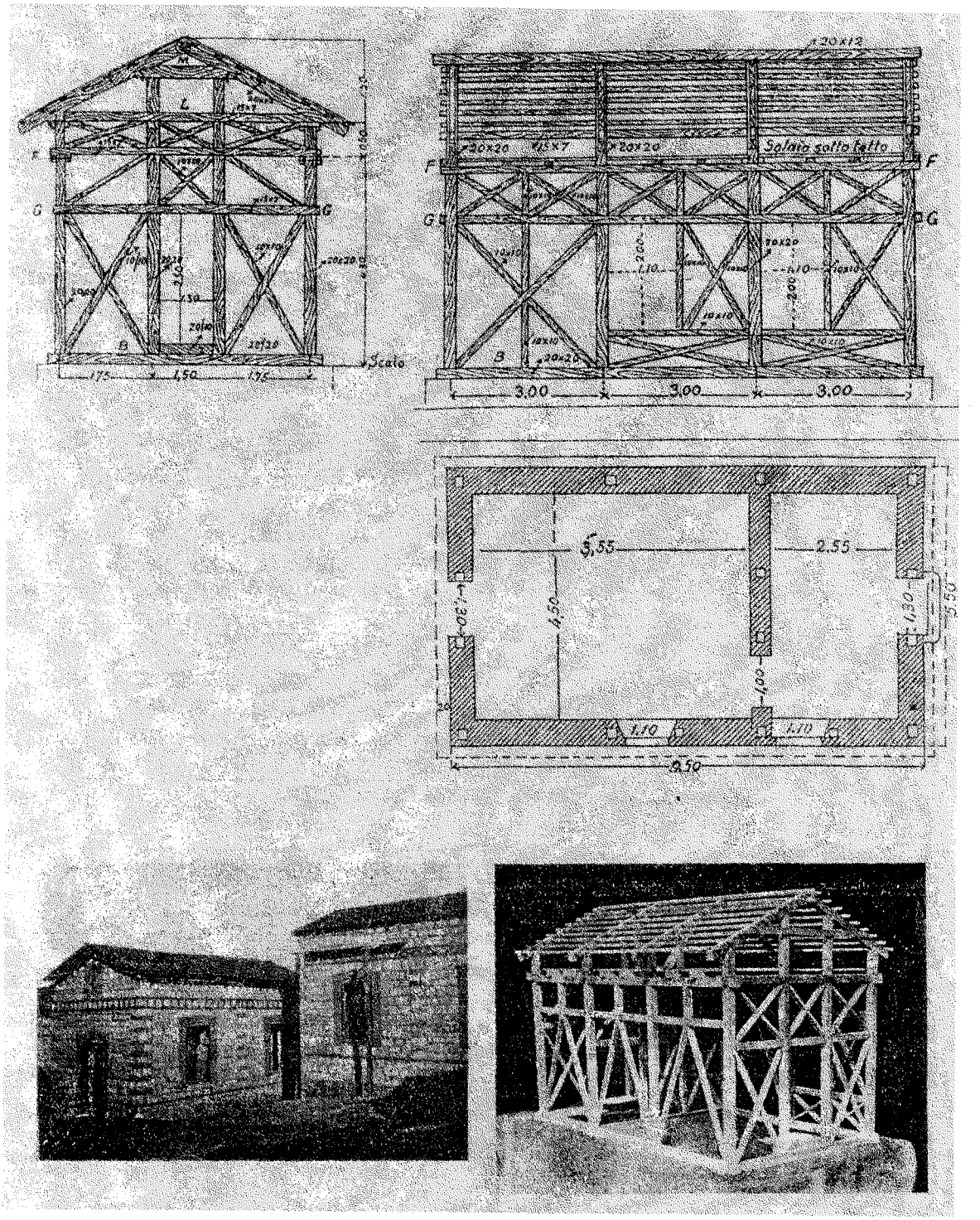


Plate 2 "Casa baraccata" in Castrolibero; section and plan of the wooden structure; picture of two houses; model. (from: C. Barucci, *op. cit.*)

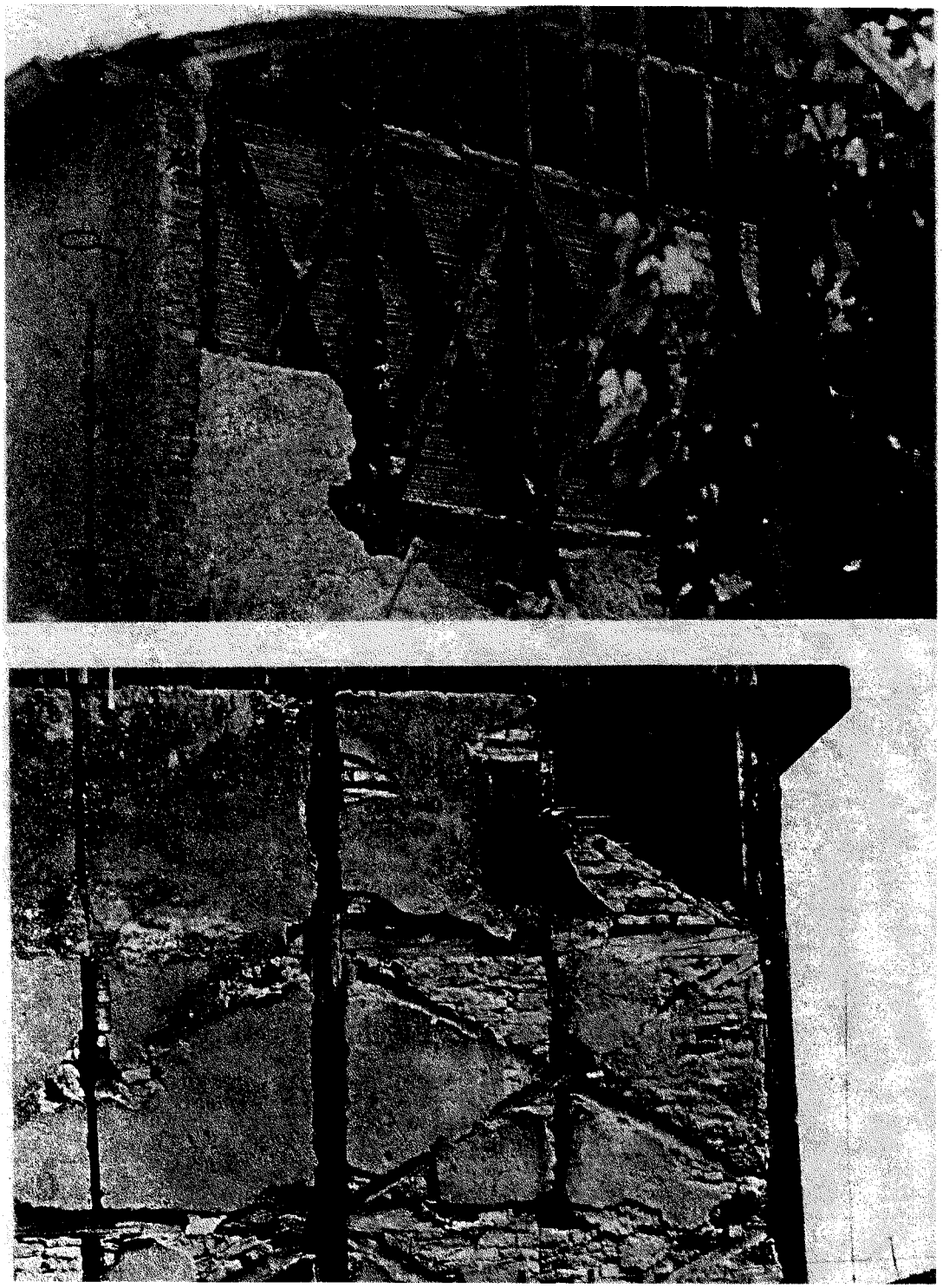
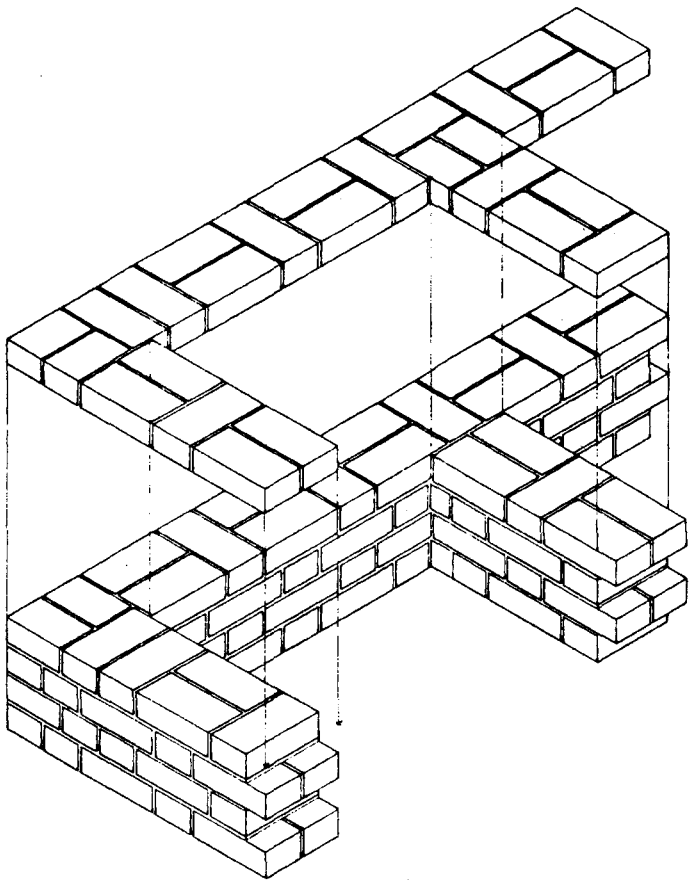
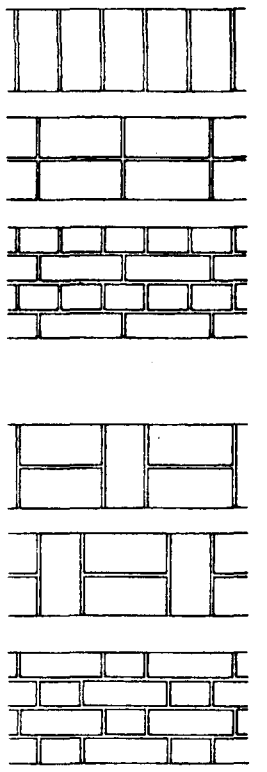
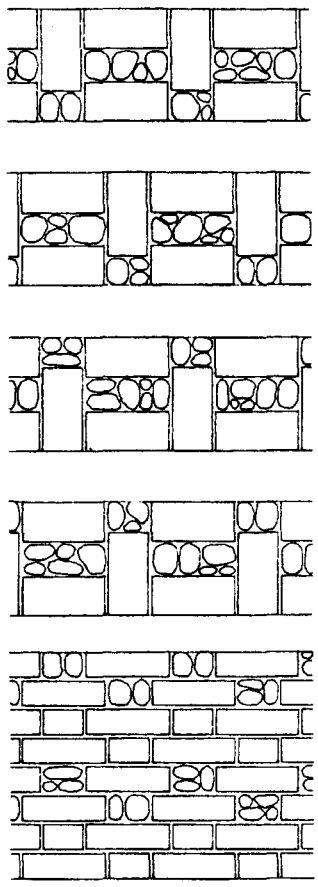


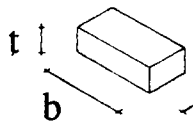
Plate 3 Damaged walls of "case baraccate" in Reggio Calabria. (from: C. Barucci, *op. cit.*)

REBUILDING WALLS IN SQUARED UNITS

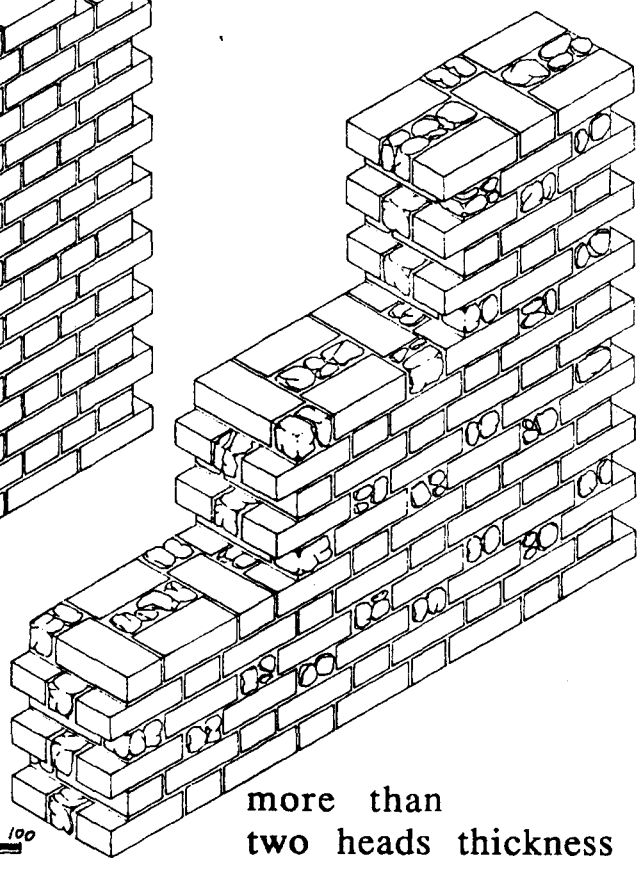








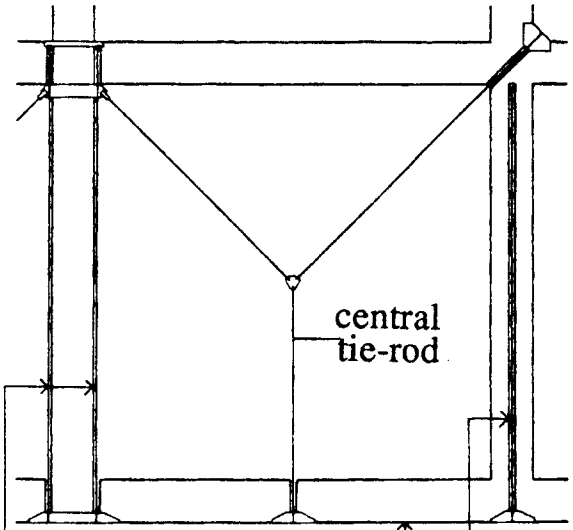
two heads thickness

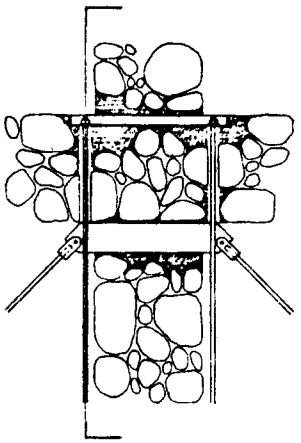


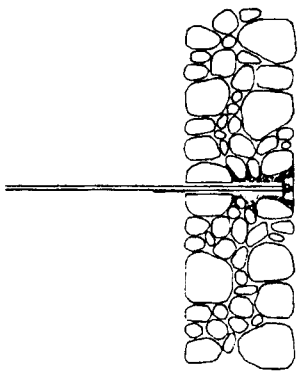
more than
two heads thickness

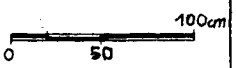
ARRANGEMENT OF TIE-RODS

Anchorage in next room





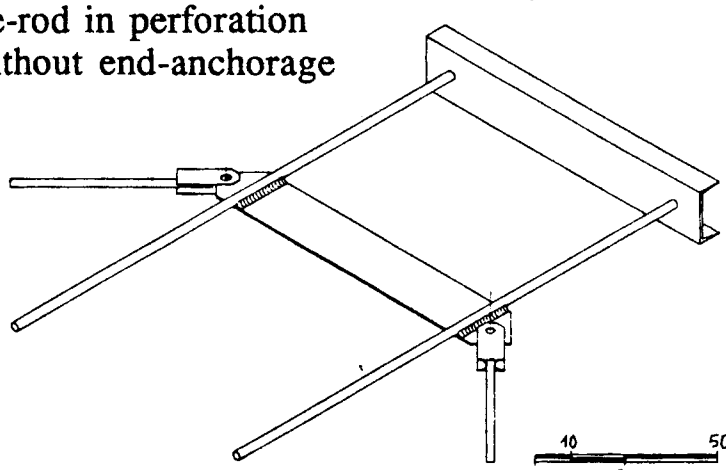




double tie-rod on both the sides of the transverse wall

Facade wall kept by tie-rod

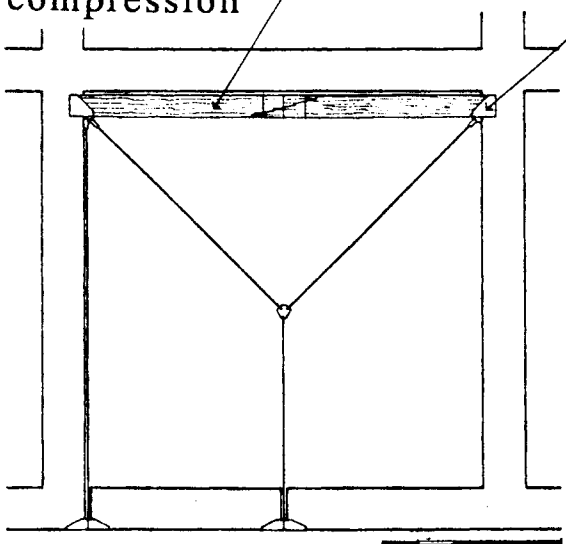
tie-rod in perforation without end-anchorage

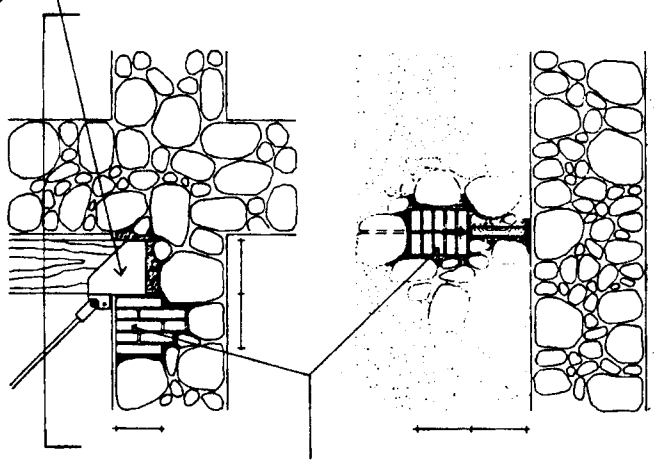


Anchorage inside the room

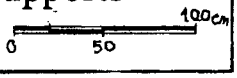
wood board in compression

metal box



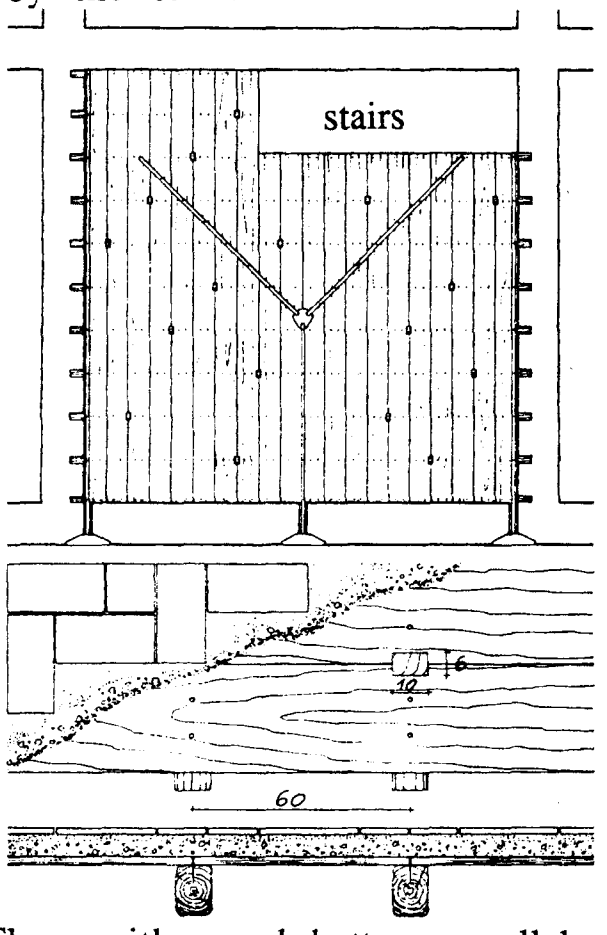


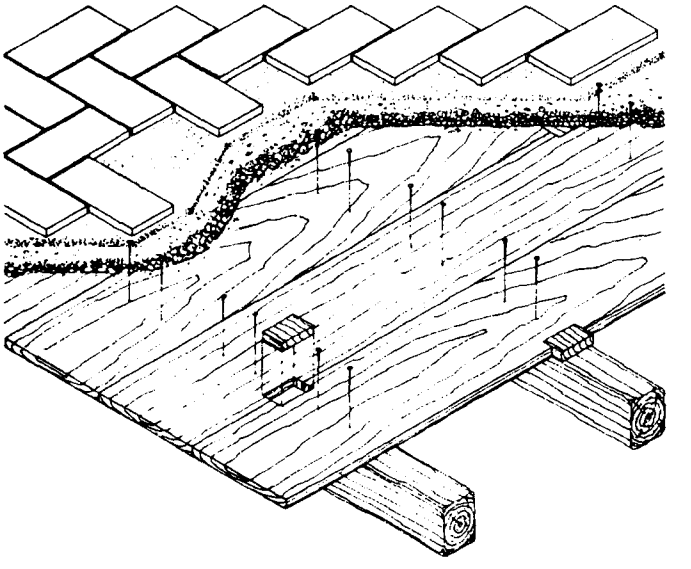
Restoring the wall at the supports of the board



ARRANGEMENT OF TIE-RODS CONNECTED TO THE WOOD FLOOR

Floor with wood battens parallel to the facade not interrupted by the stairs

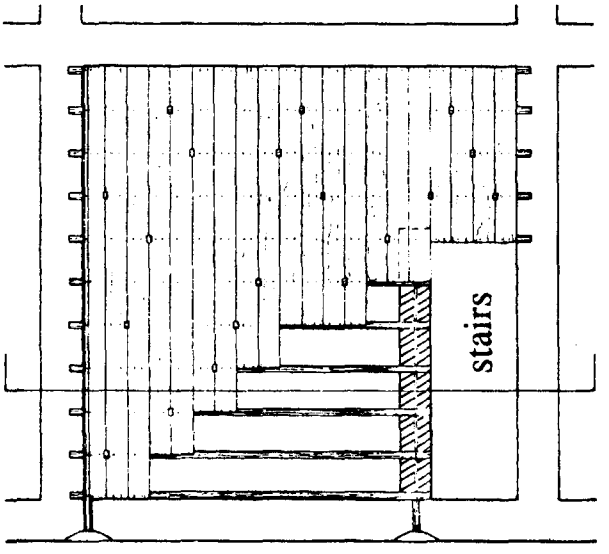


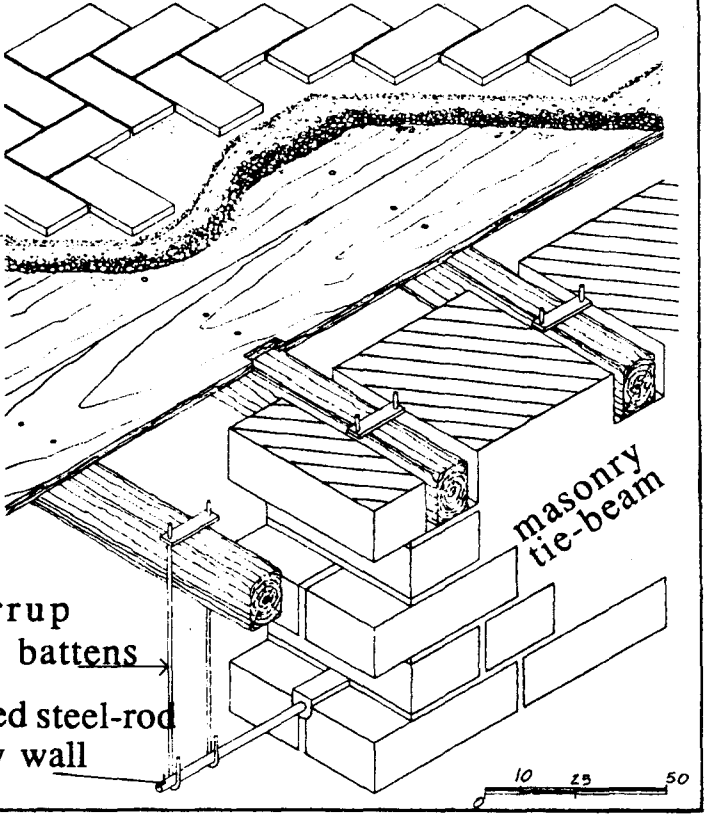


Tie-rods in flat steel 50 x 8 mm nailed to the boards

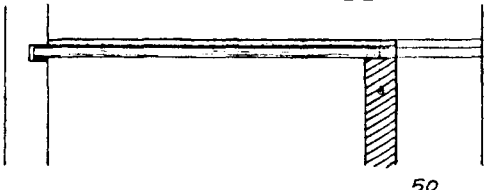
Boards nailed to the battens and connected by small wedges

Floor with wood battens parallel to the facade interrupted by the stairs

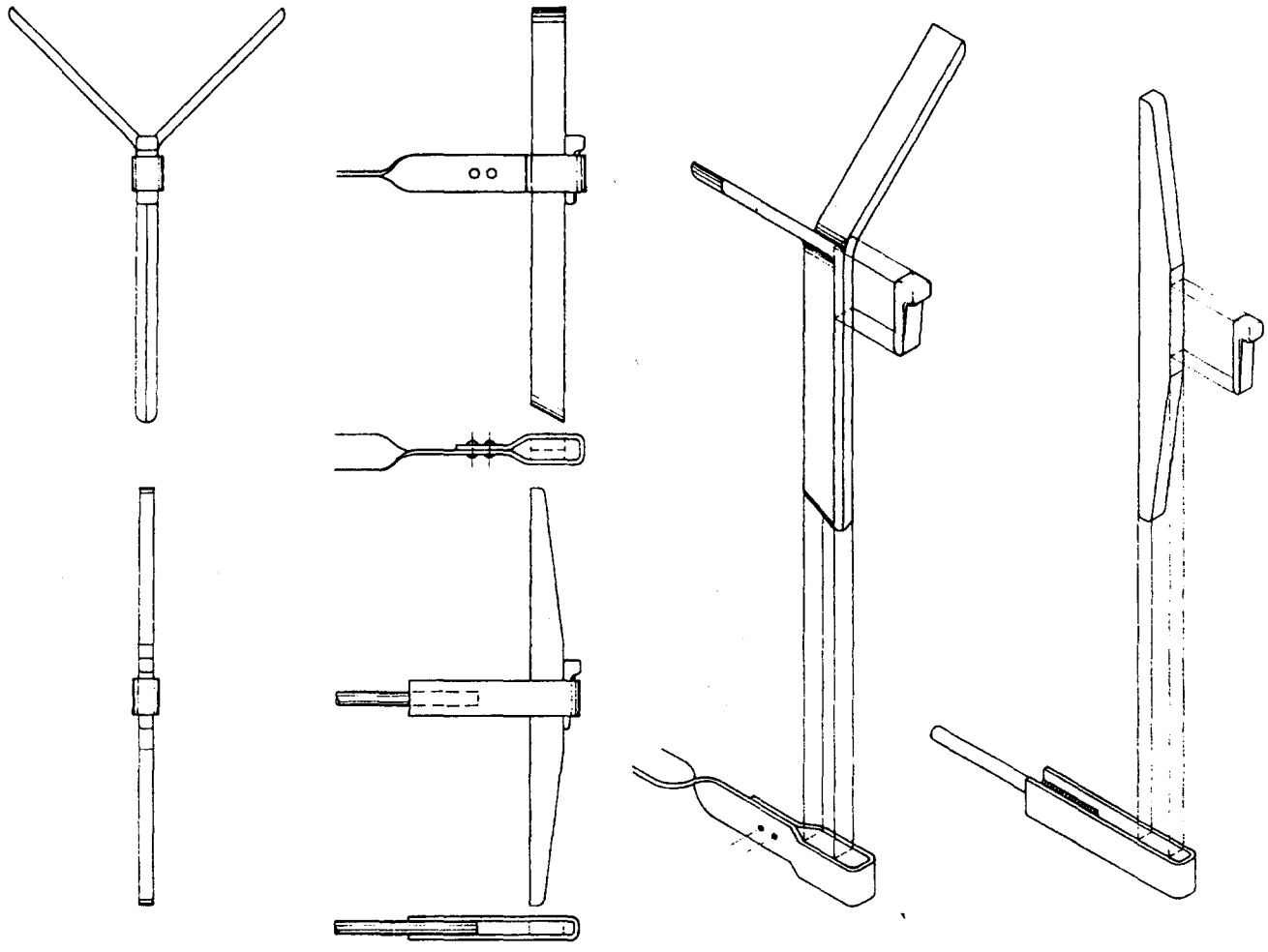




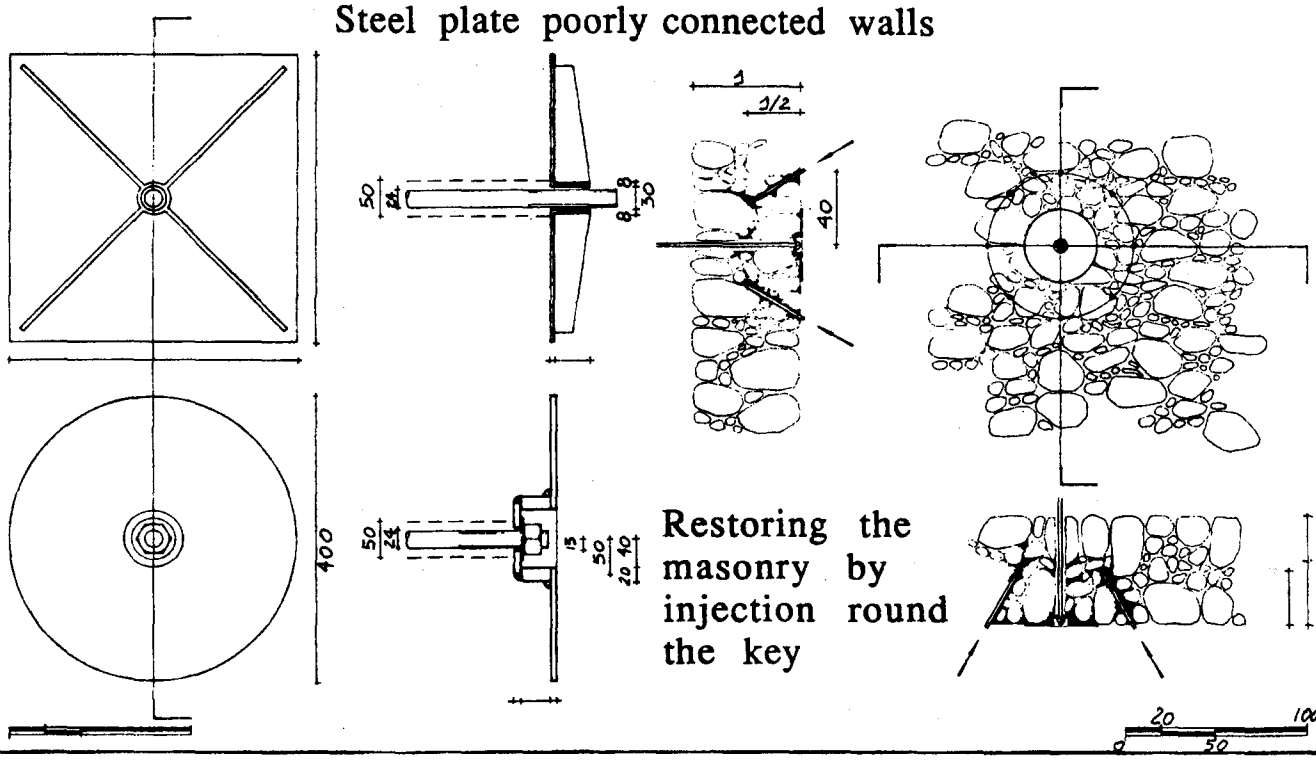
inserting a wall to support the floor



Traditional steel key for well layered masonry

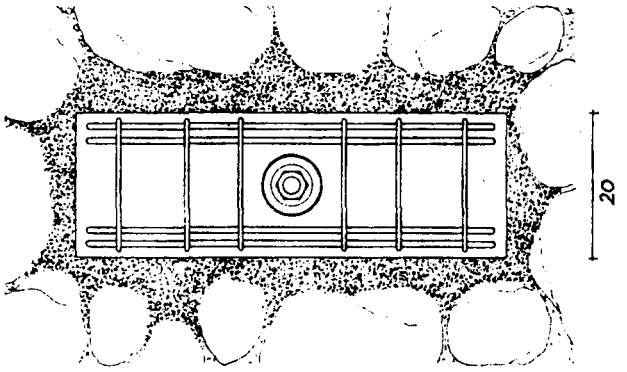


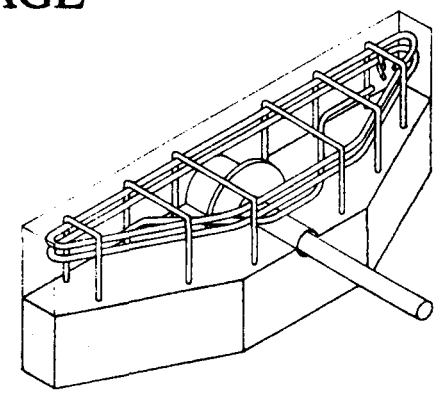
Steel plate poorly connected walls



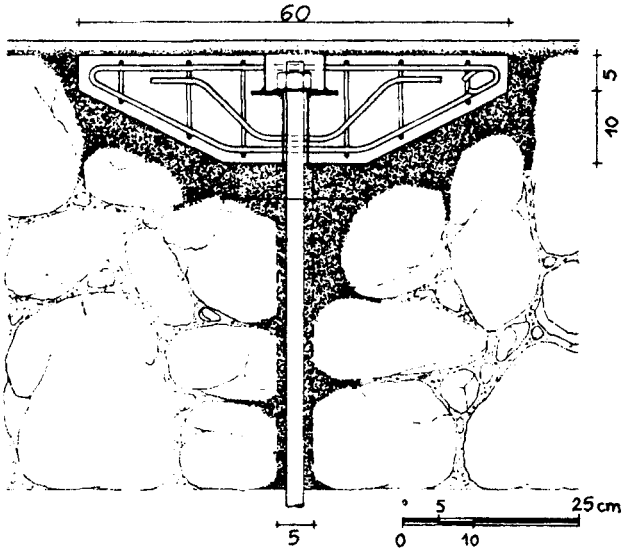
Restoring the masonry by injection round the key

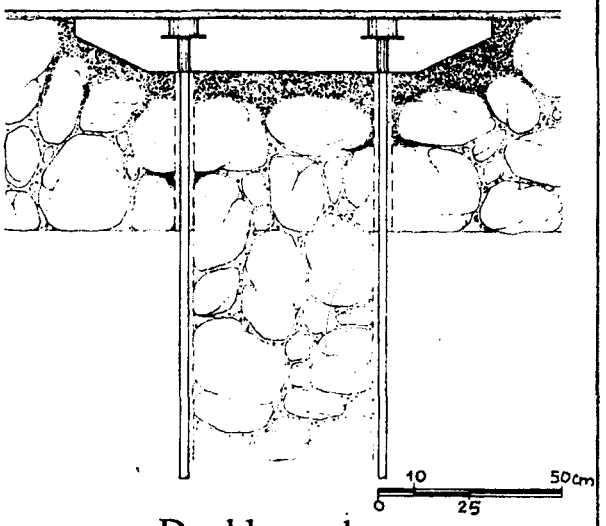
PRECAST REINFORCED ANCHORAGE



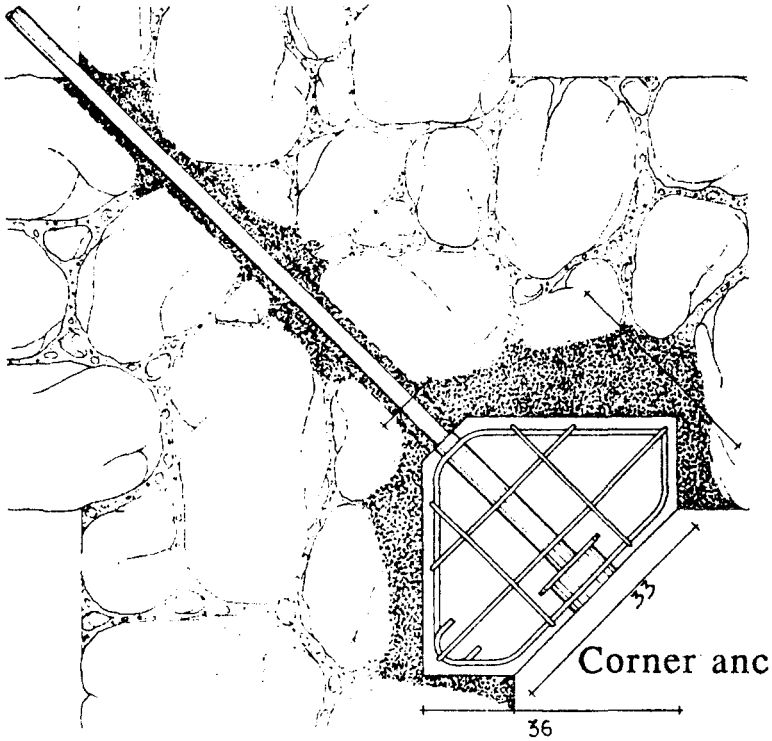


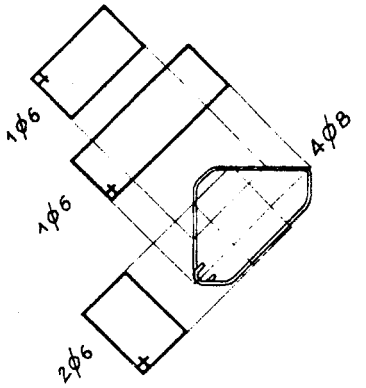
Single anchorage

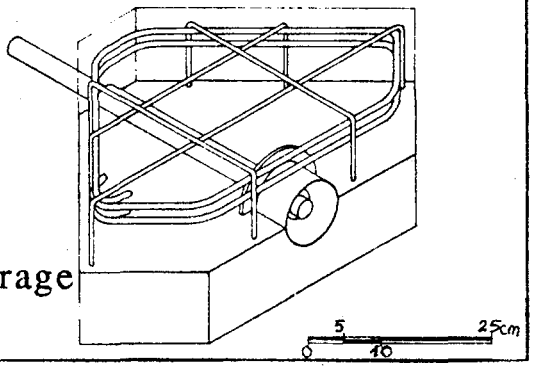




Double anchorage

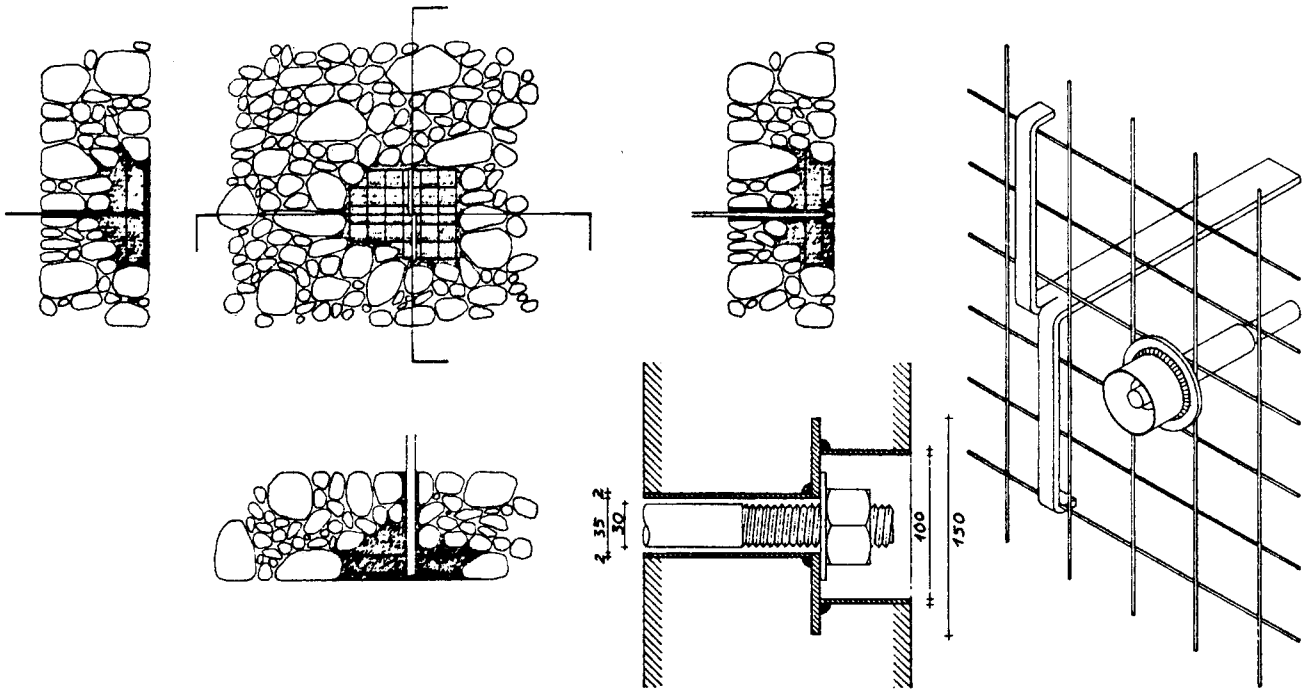






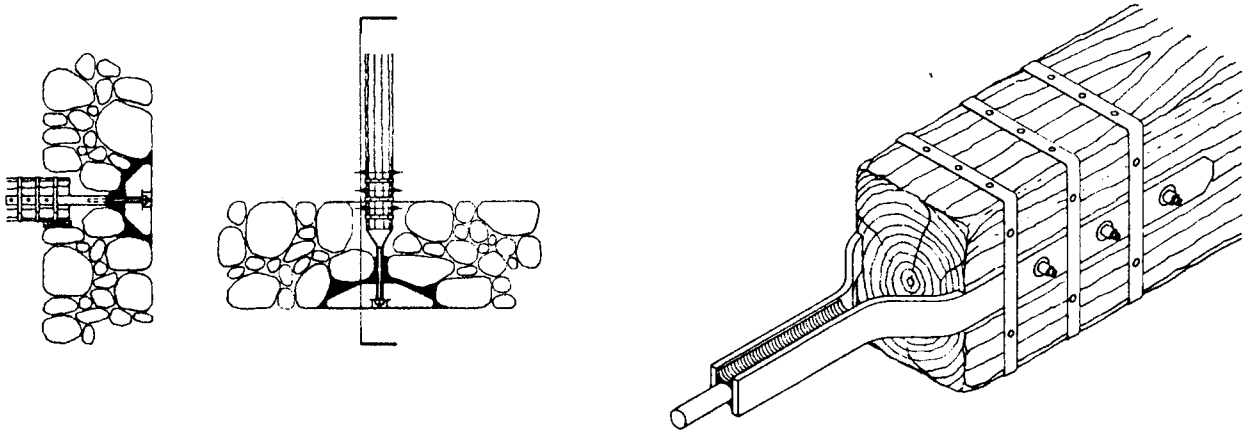
Corner anchorage

REINFORCED CONCRETE ANCHORAGE MADE IN BREACH



Pipe inserted in cast

Anchorage with wood tie-rod



Anchorage with steel [beam to be adapted inside the building

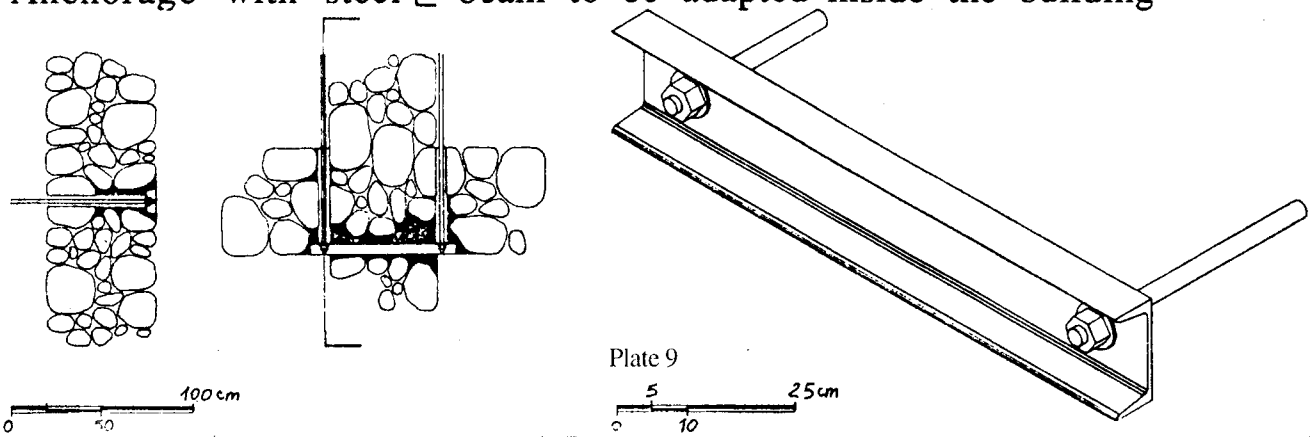
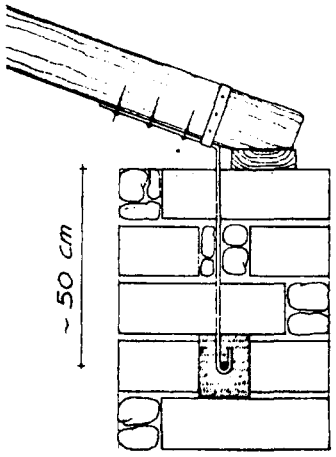
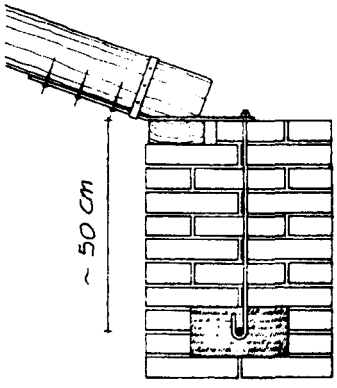


Plate 9

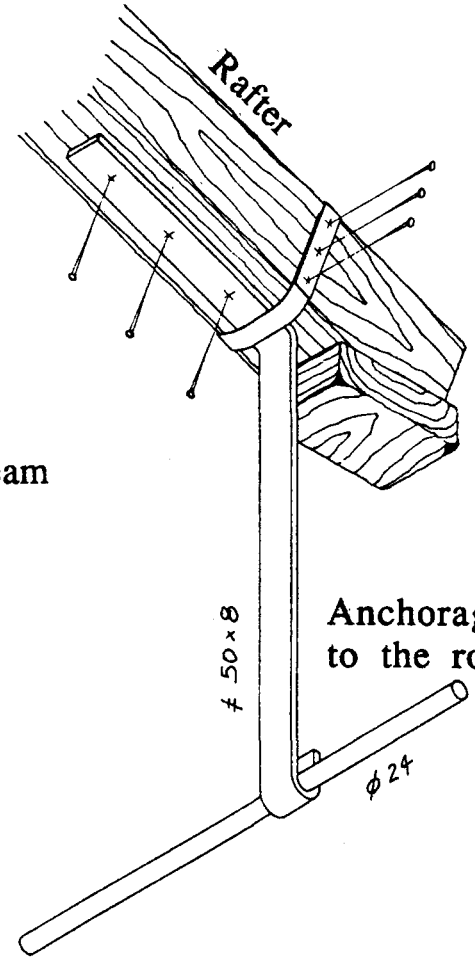
THE MASONRY TIE-BEAMS ON THE TOP OF THE WALL

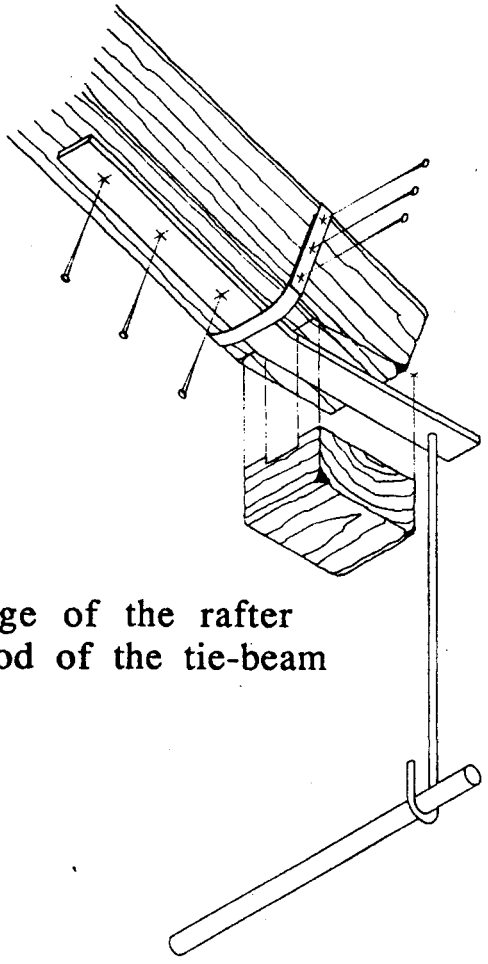


Squared stone tie-beam

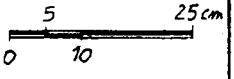


Brick tie-beams

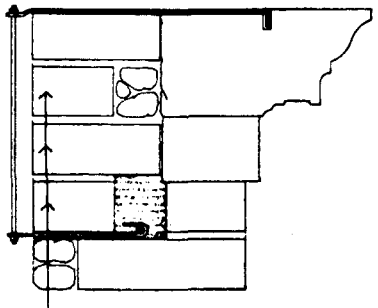




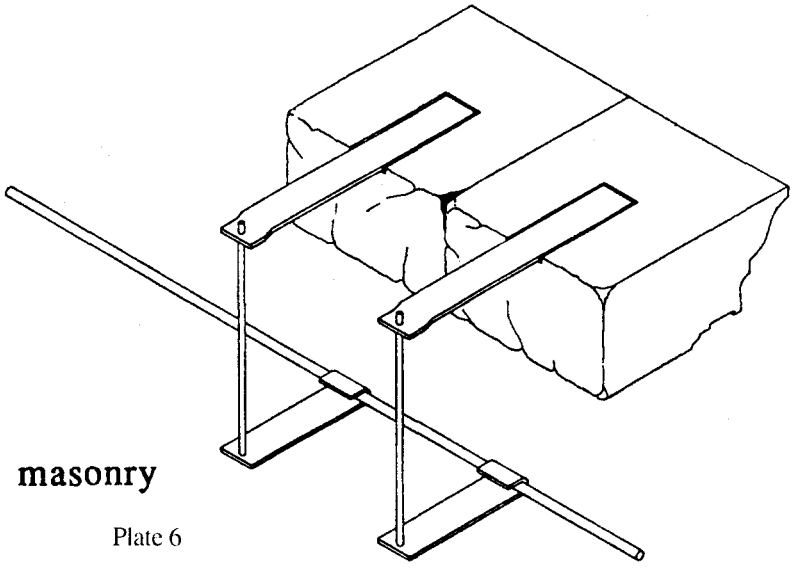
Anchorage of the rafter to the rod of the tie-beam



Anchorage of stone cornice



Well arranged new masonry



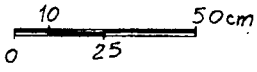


Plate 6