*ΤΣΙΑΤΙ [tsiatí] means "roof" in the secret language of craftspeople in Greece

ΤΣΙΑΤΙ*

Handbook on renovating a traditional timber roof

ΒΟΥΛΟΥΚΙ

'Boulouki' Itinerant Workshop on Traditional Building Techniques

Repurposing a rural school towards a community centre for traditional & sustainable building practices

The **School**, located in the mountainous area of Tzoumerka in NW Greece, has been recently granted to ***Boulouki*** – *Itinerant Workshop on Traditional Building Tehniques* from the local public authorities, in order to develop research and training programmes on a long-term basis, after many years of organizing diverse activities for professionals and the local community. The building which was abandoned for many decades becomes a hub for developing a local ecosystem that will study, enhance and apply the lessons of traditional knowledge into contemporary construction practices; a living lab for tackling environmental issues and fostering the sustainable development of the wider region of Epirus, Greece and the Balkans.

This **handbook** summarizes the process of repurposing the School's roof through a double training program for young professionals, focusing on the traditional and sustainable practices that can be replicated in similar projects elsewhere. The creation of the handbook was supported by INTBAU Grassroots Grants Programme.

Implementation

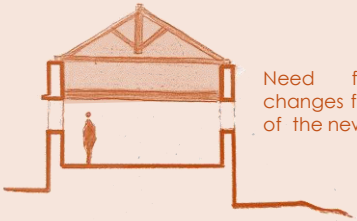
Handbook curation: Orestis Apostolatos, Panos Kostoulas
Architectural study, Energy efficiency study & organisation: Grigoris Koutropoulos, Panos Kostoulas, Athena Siafaka
Structural study: Michalis Prodromou
Scientific advisor: Eleftheria Tsakanika

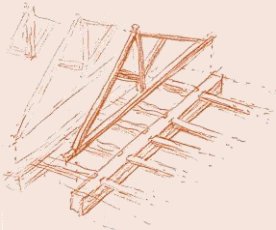
1. Architectural Study

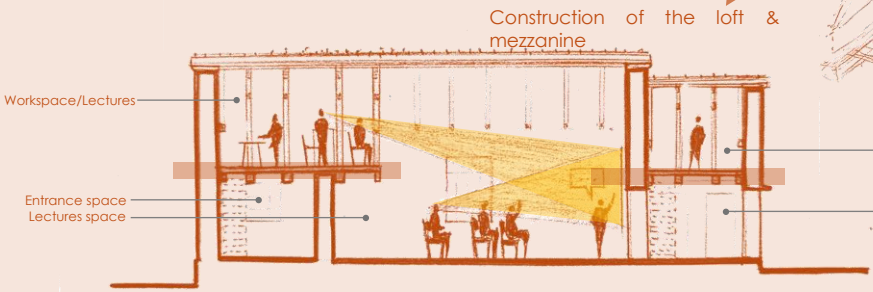
Picture of the main space before and after the first actions and the addition of the mezzanine

Existing situation (Old School)

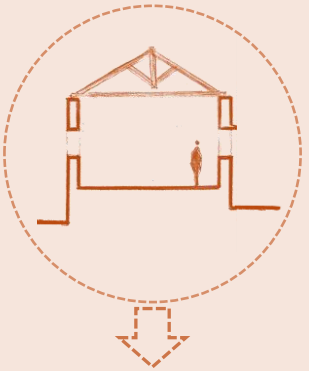
The study suggests the rehabilitation and reuse of the School, including the construction of 1 loft and 1 mezzanine with the modification of the roof trusses, as well as the addition of insulation and waterproof layers. This configuration provides more workspace and an accommodation area.





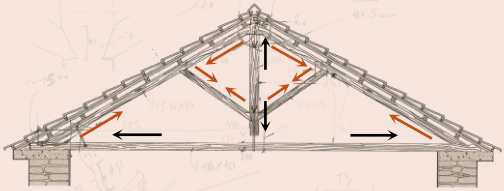


2. Structural Study

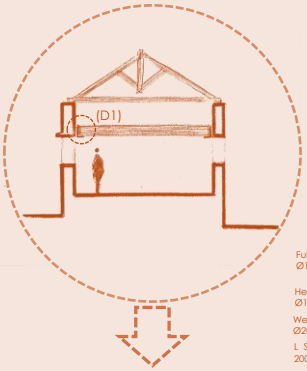


Existing situation (old trusses)

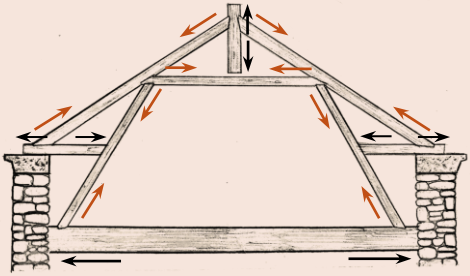
The old timber was mildly deteriorated by wood-eating insects and moisture, but retained its structural integrity. The creation of the lofts required modification of some trusses to free up space at an ordinary height up to 2,30 m.



Survey of the existing roof



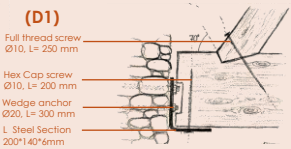
The mezzanine and the loft consist of the primary and secondary timber beams, rested on L shaped steel beams, which are anchored on the stone masonry (D1).

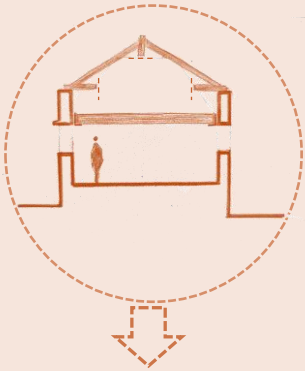


The modified trusses of the loft areas

Compression
Tension

(D1)

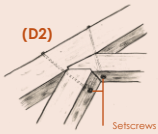


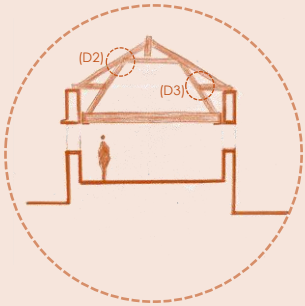


Parts of the old trusses are getting cut and removed, to be reused. The struts and part of the king-post are removed, while the tie beam is cut and part of it is used as the collar tie.

Modifications and cuts on the existing (old) trusses

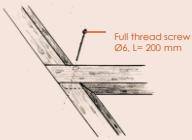
(D2)





Two diagonal timber elements connect the collar tie, the rafters and the old parts of the tie beam with the new tie beam, at the loft's level. The new design the roof trusses (similar to a hammer beam truss) provides enough height for the loft.

(D3)



The new structure (hammer beam truss) after the modifications

3. Energy Efficiency - Insulations

Following an extensive research on low environmental footprint insulation materials, two different solutions were proposed and implemented; one for each separate roof, as a means to experiment with different materials and monitor them in real case studies, as well as train young professionals on each application.

Roof A

- Soft flexible wood fibre boards are cut into custom pieces and fixed between the battens, on top of the wood lining.
- Rigid wood fibre boards are laid on top of the soft wood fibre and the battens. They are connected with each other with a prefab male-female joint, resulting to a unified surface withought thermal bridges. The rigid boards are certified as rainproof when placed on an inclined surface (min 15° pitch).

Roof B

- Two consecutive layers of sheep wool that is cut into custom pieces are placed between battens.
- Cork boards are applied on top of them forming a unified surface avoiding thermal bridges. Due to their porous surface, a waterproof membrane is placed on top.

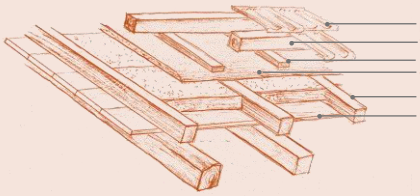
A. Soft wood fibre pieces are placed from ridge to eaves to avoid sliding on top of them while fixing.

A. Rigid wood fibre boards are placed from eaves to ridge. Attention needed to the edges while connecting each other to avoid damage.

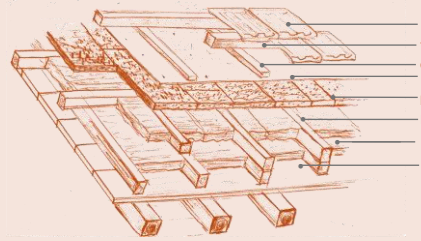
B. Layers of sheep wool between the battens. The wool is cut in slightly bigger pieces, in order to be tightly fixed.

B. Boards of cork applied. Attention needed while placing to avoid cracks.

Roof A



Roof B



Comments

(1) The natural materials that were used to insulate the roof similar performance with some conventional materials like polystyrene.

(2) Wood fibre is a natural material, made from compressed wood waste, a by-product of wood industries.

(3) Natural insulations, such as cork and wood fibre have less CO2 impact; even a negative emissions can be achieved since they originate from trees, that absorb carbon dioxide during their lifespan.

(4) Sheep wool is an organic, renewable, recyclable and biodegradable by-product of agricultural activities. Thus, the levels of water required for its production, as well as CO2 emissions relate to the whole life cycle of the livestock.

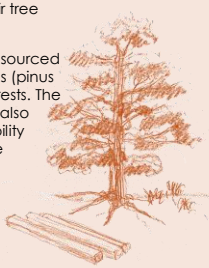
	EXPANDED POLYSTYRENE (EPS)	STONE WOOL (MW)	CORK	SHEEP WOOL	WOOD-FIBRE BOARDS
Thermal conductivity λ (W/m*K)	0,034	0,035	0,036 – 0,040	0,038	0,038 (1)
Specific heat capacity C (J/Kg K)	1450	1030	1900 – 2100	1750	2100
Origin	Petrochemical industry	Mineral resources	Natural	Organic – By-product	Natural – By-product (2)
CO2 Balance	2,5-5 kg CO2 / kg of material	2,7 kg CO2 / kg of material	0,08-0,15 kg CO2 / kg of material	1,8 kg CO2 / kg of material	0,5-1,5 kg CO2 / kg of material (3)
Quantity of water needed in the production	0,1-0,5 L/kg	0,1-0,4 L/kg	665 – 766 L/kg	1700 L/kg	665 – 766 L/kg (4)
Life cycle	100 years – Recyclable	50 years - Recyclable	30 – 50 years Recyclable/Biodegradable	50+ years Recyclable/Biodegradable	25 – 50 years Recyclable/Biodegradable

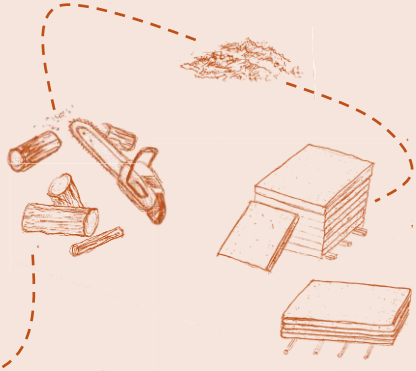
Use of local and natural materials

Timber

The existing, old timber was sourced from local fir tree forests.

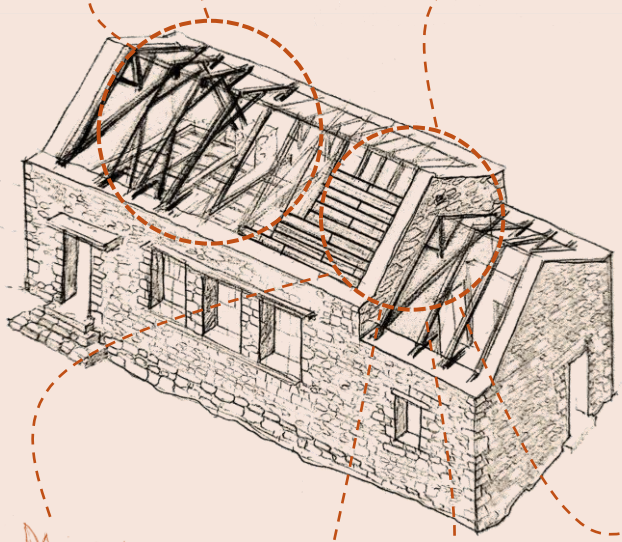
The new timber was sourced from black pine trees (pinus nigra), from local forests. The use of local wood is also part of the sustainability consciousness of the project.





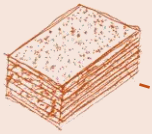
Wood-Fibre Boards

- Wood fibres are made from wood shavings, wood chips, all sorts of wood waste, broken down to fibres held together with natural (lignin resin) or other chemical binders (polyurethane based).
- There is a wet and a dry process of manufacturing: The wet process is more eco-friendly, since the wood's own natural lignin binds the boards. The dry-processed wood fibre insulation boards, produced with small amounts of chemical binders are lighter and can be formed in greater thicknesses.



Cork

- Natural material obtained from cork oak trees.
- Mainly produced in Portugal.
- Cork is extracted by pruning and removing the external bark of the tree, without damaging the wood.
- After grinding the material, the process is followed by steam welding to shape the boards

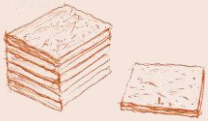


Linseed oil

- Natural material extracted from flaxseeds.
- Linseed oil is used from ancient times to nourish wood surfaces while sealing and protecting them against moisture.

Sheep Wool

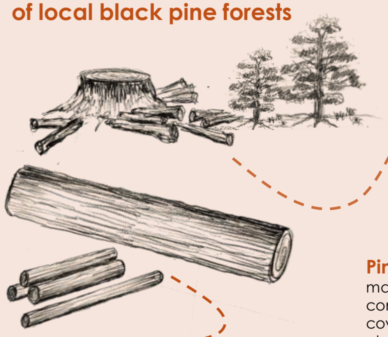
- Organic (by)product
- The composition of insulation related materials vary from pure natural sheep wool to small percentages of added polyester fibres for bonding, as well as biocides to avoid moth.
- Respiration: ability to absorb and release moisture without affecting its thermal insulation performance.



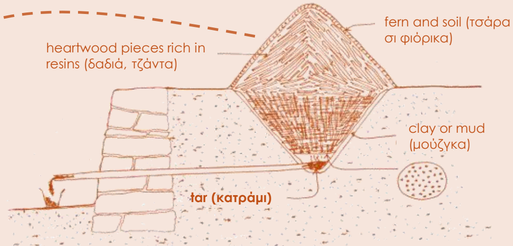
* Pine tar

- Natural material, extracted from pine trees.
- Protects the wood from infestation and moisture
- Combined well with linseed and turpentine oil.

Traditional management of local black pine forests



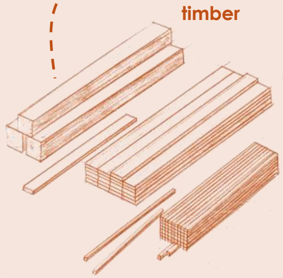
*Production of pine tar



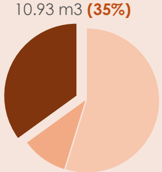
Pine tar is produced by the dry or destructive distillation of fatwood, the inner resinous part of mature pine trees (pinus nigra). The wood pieces are stacked in a radial formation, in a reversed-cone shaped ground, which is covered with a layer of clay or metal sheets. The wood pieces are covered with fern and soil, in order to achieve the best possible anoxing conditions. A pipe is placed under the wood pieces to collect the thick dark liquid pine tar.

Pine tar is a traditional product of sustainable forest management, using leftovers or logging activities. The trunk and big branches of the black pine tree are locally processed and cut to be used as timber and woodworking. The application of pine tar protects wood from infestation while still being highly hydrophobic; a method of enhancing the properties of the wood with its own extracts.

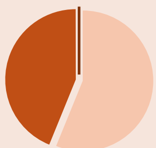
Structural timber



Production of materials



Origin of materials

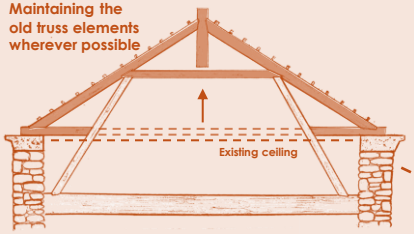


List of the materials used for the project

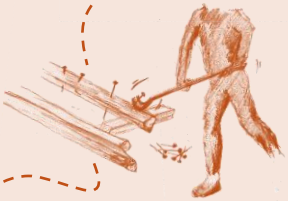
Material - Product	Supplier	Quantity	Units	Application	Local Production	Local process	Natural material	By-product
A. STRUCTURAL								
1. Structural Timber	Timber Sawmill Ioannis Didaskalou (Vovoussa, Greece)	16	m3	Loft construction, loft floor, roof lining, modifications in trusses, roof battens	√	√	√	
2. "L" Steel sections	Olga Ntalia (Arta, Greece			Support for the wooden loft construction and connection to the stone masonry		√		
B. THERMAL INSULATION OF ROOF								
3. Insulating material of compressed natural wood fibre, flexible 50 mm	Gutex (Germany)	121,04	m2	Insulation of big roof				√
4. Insulating material of compressed natural wood fibre, rigid 35 mm	Gutex (Germany)	117,62	m2	Insulation of big roof				√
5. Insulating material of sheep wool, 50 mm	Calma Acoustics (Greece)	64,26	m2	Insulation of small roof			√	√
6. Insulating material of natural cork	Amorim (Portugal), Fotis Home (Greece)	33,07	m2	Insulation of small roof			√	
C. WATERPROOFING OF ROOF								
7. Waterproofing membrane (SOLITEX MENTO PLUS)	Pro Clima (Greece)	34,47	m2	Waterproofing of the small roof				
8. Airtight adhesive tape (TESCON VANA)	Pro Clima (Greece)			Connection between the membrane and the small roof elements				
9. Pine tar	Zisis Pashalis (Distrato, Greece)	45	lt.	Coating of wooden surfaces (roof battens)	√	√	√	√
10. Turpentine oil	Fotis Home (Arta, Greece)	30	lt.	Coating of wooden surfaces (roof battens) with a pine tar -turpentine oil mixture			√	
D. MAINTENANCE OF WOODEN SURFACES								
11. Linseed oil (Raw)	Construction materials Kosta-Lias (Ioannina, Greece)	75	lt.	Wood coating (mortises, floor boards, roof boards, battens)			√	
E. ROOF WINDOWS								
12. Roof windows (skylights) with wooden frame, dimensions 0,90 x 1,20 m.	Eurotechnica, Tsialos (Katerini, Greece)	2	pieces	Roof skylight	√		√	
F. SCREWS – SUPPORTS - SETSCREWS								
13. Screws, supports, setscrews etc.	Rothoblaas, Vidopolis (Ioannina, Greece), Construction materials Kosta-Lias (Ioannina, Greece)			Wood connections, Stabilization of the steel supports to the wall, screwing the roof tiles on the battens				
G. ROOD COVERING WITH TILES								
14. French type tiles (Dilaveris Factory)	Oldstore Vrouvas Ioannis (Tripoli, Greece)	300	pieces	Small and big roof covering	√	√		
H. GUTTERS								
15. Gutters made of galvanized sheet metal of rectangular and round cross sections	Ydrometalloumin-Bobogiannis, Krikonis Theocharis (Ioannina, Greece)			Replacement of old gutters		√		
I. MORTARS - FILLINGS								
16. Sand		0,75	m3	Mortar for bricks and tiles	√	√	√	
17. Lime		0,25	m3	Mortar for bricks and tiles	√	√	√	
18. Polyurethane foam	Fotis Home (Arta, Greece)			Gap filling between stone wall and steel structure				
19. 2 components epoxy resin	Rotholblaas, Fotis Home (Arta, Greece), Construction materials Kosta-Lias (Ioannina, Greece)			Stabilization of the anchors in the stone wall				
20. Cement mortar				Combination with stones and gap filling between the steel sections and the wall	√			
J. REUSED MATERIALS								
21. Wood from old trusses – tie beams (fir timber)	Reuse (parts of the old trusses that were modified)	0,213	m3	Modifications of the trusses, wooden guardrail	√	√	√	
22. Old batten (fir timber)	Reuse (old roof mattens after removing the nails)	0,015	m3	Wooden guardrail	√	√	√	
23. Tiles	Reuse (roof tiles that were cleaned)	1700	pieces	Small and big roof	√	√		
24. Bricks	Reuse (internal wall that was demolished)	0,12	m3 (60 pieces)	Filling the gap between roof battens and the concrete base	√	√		
25. Stones	Reuse (part of internal wall that was demolished)	few stones		Gap filling between the steel sections and the wall	√	√	√	

Maximum use and reuse of old elements

Maintaining the old truss elements wherever possible

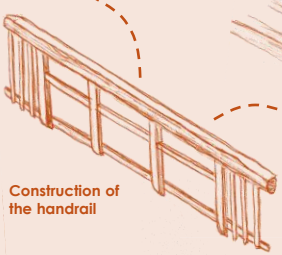


Conservation and modifications of the removed pieces



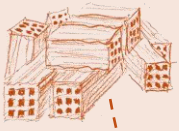
Removal of the nails from old battens and ceiling boards

Construction of the handrail

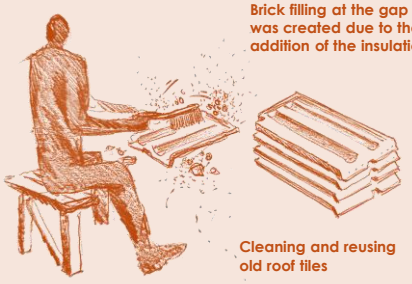


Careful demolition of stones and bricks from the internal walls

Reuse of bricks

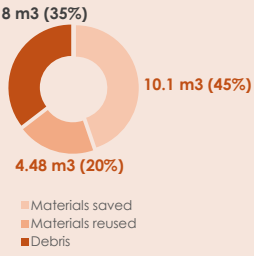


Brick filling at the gap that was created due to the addition of the insulation

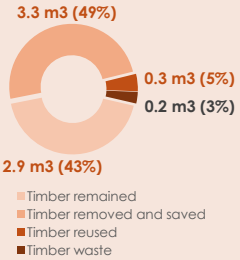


Cleaning and reusing old roof tiles

All materials

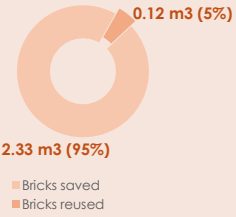


Timber

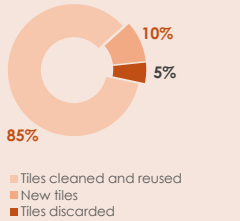


Some of the existing timber needed to be either cut or completely removed, in order to construct the lofts and insulate the roof. After trying to keep the maximum amount and length of the existing timber, some elements were removed (pieces from the trusses, boards from the ceiling, roof battens) and a few of them were reused for secondary constructions such as the handrail of the loft. The rest of them were conserved and stored so as to be reused for upcoming projects.

Bricks



Roof Tiles

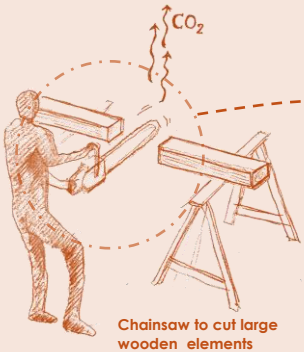


Since one partition wall was demolished and another one lowered to the level of mezzanine, a lot more building materials, bricks and stones, were carefully dismantled and cleaned in order to be reused. Most of the bricks were built on top of the gable end to cover the area between the concrete and the tiles that were elevated due to the insulations thickness. The roof tiles were also cleaned and repositioned on the roof. Only a few were damaged and replaced by similar reclaimed tiles.

Materials re-used	Origin	Quantity	Units	Application
Timber from old trusses – tie beams	Parts of the old trusses that were modified	0,213	m3	Truss modifications, wooden handrail
Old battens	Old roof tile battens	1,5	m3	Wooden guardrail
Tiles	Roof tiles that were cleaned	1700	pieces	Small and big roof
Bricks	Internal brick wall that was demolished	0,24	m3	Row of bricks between the new roof battens and the concrete base
Stones	Internal stone wall that was partially demolished	0,1	m3	Fill-up between the "L" section of the loft and the wall

Materials removed	Origin	Quantity - Volume	Units
Stones	Internal stone wall that was partially demolished	4,06	m3
Bricks	Internal brick wall that was demolished	2,45	m3
Plaster	Internal sides of the wall	1,4	m3
Mortar	Concrete base under the roof	1,8	m3
Timber	Roof trusses	0,59	m3
	Roof batten	1,00	m3
	Ceiling boards	100,97	m2

Use of hand tools



Chainsaw to cut large wooden elements (beams)

Use of electric or fuel tools

+ time saving
+ accuracy
- CO2 emissions
- electric energy consumption
- dangerous

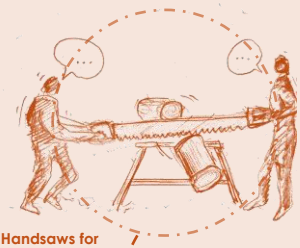
Drill for screws

Sanding wood boards

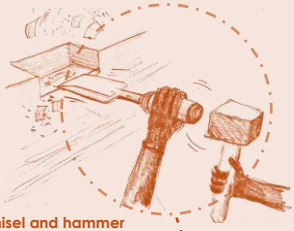
Circular saw for wood cutting and notches

Use of hands-on tools

+ improvement of personal technical skills
+ understanding the material
+ no CO2 emissions
+ exercise
- time consuming
- sometimes exhausting



Handsaws for wood-cutting



Chisel and hammer to form mortises and notches

Wood adze to form the edges of wood connections and notches

Forming notches using an electric circular saw

Stable circular saw for wood-cutting

Cutting wood using a chainsaw

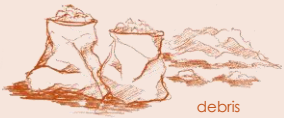
Cutting wood using a 2-person traditional saw

Forming wood connections of the roof trusses using an adze

Worksite management


timber


stones


debris

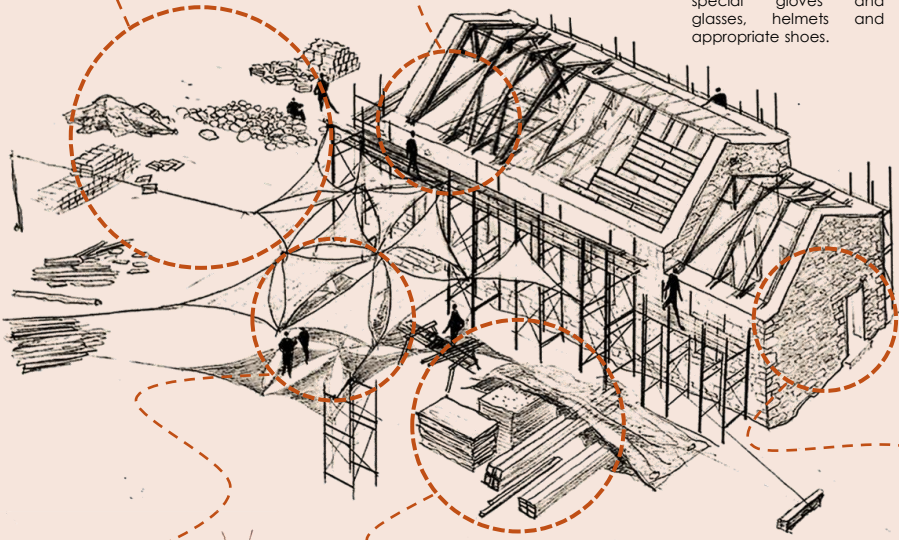
Waste management


bricks and tiles

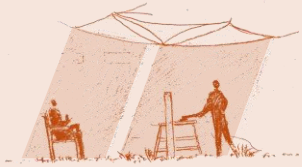
After dismantling and demolishing, old materials are sorted, cleaned, properly stored, and protected from the weather. They should be categorized according to their type (stones, timber, bricks, etc.) to facilitate their reuse on the construction site or in future projects. Any heavily damaged material that cannot be reclaimed or recycled is collected as debris. Other waste is also separated in recyclable and non-recyclable bins.

Safety

Ensuring physical safety on-site requires the adaptation of safety rules, providing instructions for the safe use of tools, securing the worksite with scaffoldings as well as personal protective equipment, including special gloves and glasses, helmets and appropriate shoes.

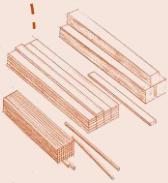


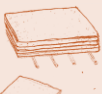
Shadow



Shady spaces are needed not only for working outside but also for breaks that maintain a more comfortable work environment.

Organisation of new materials





Most of the new materials (timber and insulations) are stored outdoors, waiting outside to be installed. Waterproof tarps are needed to protect them from moisture and rain. Short-term working stockpiles can be placed within reach and remain accessible during the construction process.

Organisation of tools

Tool managers keep track of the tools. Cleaning and storing the tools at the dedicated right place after each work-day is crucial for their maintenance, as well as the workflow.

ΒΟΥΛΟΥΚΙ

'Boulouki' Itinerant Workshop on Traditional Building Techniques