Veronika SHENDOVA

# Protection of Cultural Heritage from Man–Made and Natural Disasters

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## Natural Disasters:

•wind, hurricanes, typhoons, tornadoes, heavy rain, landslips, avalanches and earthquakes

•cannot be prevented but can be anticipated

## Man-made Disasters:

•war, terrorism including bomb threats, riots and panic, gas explosions, release of harmful matter

•preventable, but with unpredictable extent of damage that they might cause should they occur.

## Cultural Heritage:

- key element for the history and the identity of the society, contributing to its economic and other well-being
- deserve special attention due to their individual historic, architectonic, documentary, economic, social and even political or spiritual value



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# Cultural Heritage

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# Cultural Heritage

**Skopje earthquake, 1963**

**Montenegro earthquake, 1979**



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**Pagan earthquake, Burma, 1975**



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**L'Aqvila earthquake, Italy, 2009**



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**Ladak, India**



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**Anghor, Cambodia**



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# Cultural Heritage

## Dubrovnik – the shelling of 1991-1992

Dominican Convent,
XIV century

Palace Dordic-Mayneru,
XVII Century

Clock Tower
XV century



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**Bosnia and Herzegovina - armed conflicts 1992**

**Blown up Church of the Holly Trinity, Mostar**



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# Cultural Heritage

## Prilep, Leshok - armed conflicts 2001

"Old Carshi" Mosque, XV century
Prilep

St. Atanasie Church XIX century, Leshok



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# Cultural Heritage

## Kosovo - armed conflicts, 2004

**St. Marry Ljevishka, XIV century**



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# Disasters - Cultural Heritage

Whether the consequences of the armed clashes are so specific that they should be separately treated?

Are or are not the consequences from war devastations similar or the same as the consequences from earthquakes and catastrophic fires as far as the cultural heritage is concerned?

When damage or destruction of cultural historic monuments is considered, the reason does not play a primary role anymore!



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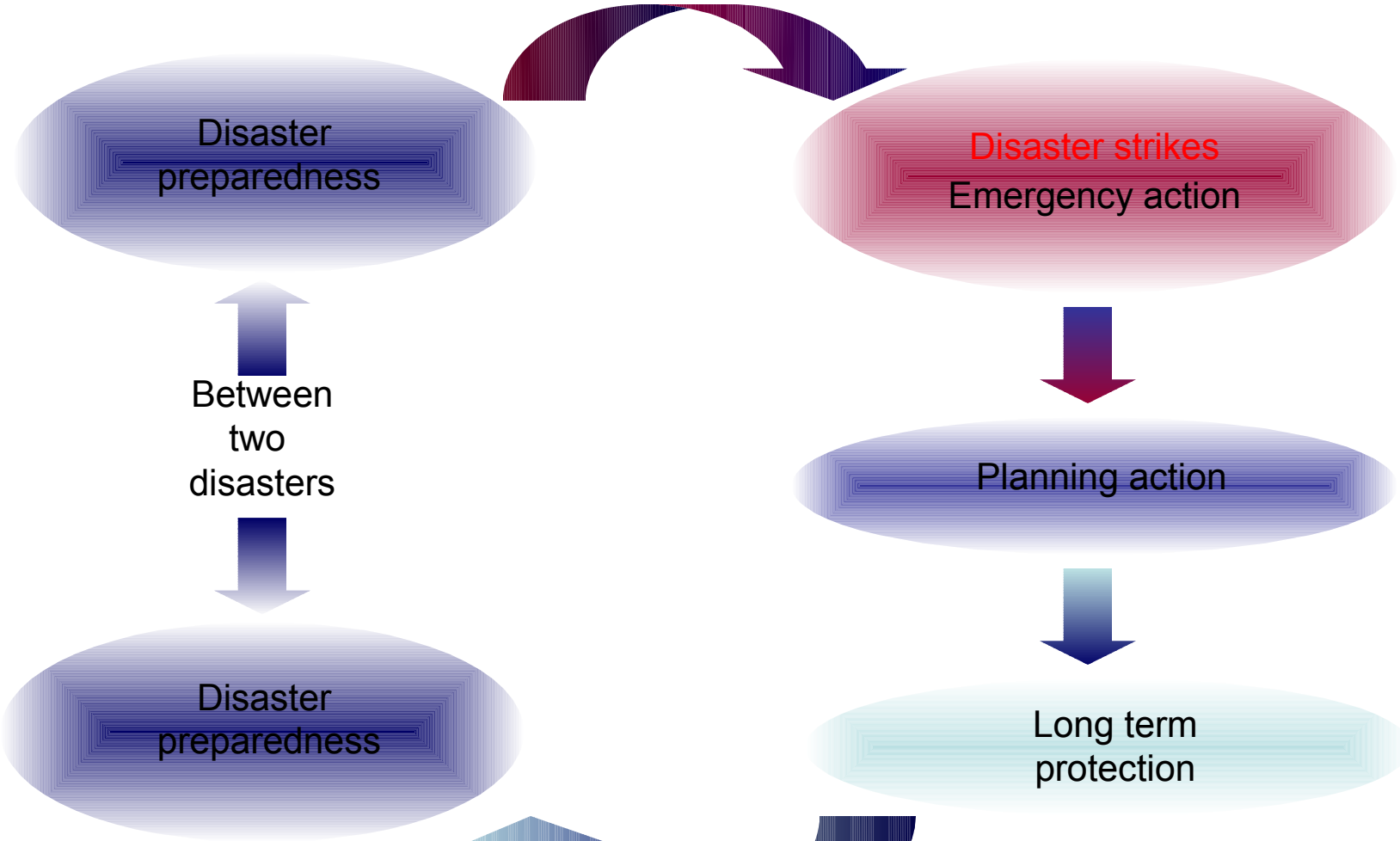
# Cultural Heritage: Protection & Reduction of consequences



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Disaster preparedness

Disaster strikes

Emergency action

- ample administrative and professional actions:
(documentation, recording, acceptable risk, town planning, disaster planning, maintenance, emergency preparations, inspections, public educations, professional training)

- when there is indication for armed clashes:
(marking of the monuments, sending messages to the enemy, information and including of mediators)

- *Quick inspection of damaged monument:*

- quick identification and classification of the damage with damage evaluation,
- labeling or transportation of all movable cultural property,
- coordination of the work of conservators, architects and engineers.

- *Temporary actions for protection of as much cultural property as possible:*

- temporary consolidation of the monument structure,
- immediate protection against weather,
- fire fighting, prevention of damage due to penetration of water and prevention of loosing of works of art,
- cooperation with local civil and military authorities

*Disaster damage in depth assessment*

# Disaster damage in depth assessment

*objective* - to present a uniform procedure for examining and reporting on damage of buildings, establishment of database on disaster effects and to present a methodology for analysis of damage and estimation of economic losses.

*primary purpose* - to assure an adequate volume of data for local and national authorities for decision making and undertaking of economically justified and technically consistent measures for reduction of disaster consequences in a uniform manner.

*special form* for damage assessment for immovable cultural property - containing all the specific characteristics for classification of damage and usability and extrapolation of the data for economic loss analyses.



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- *Data collection on the damage and damage assessment for each damaged monument,*
- *Preparing of the survey documentation for each damaged monument,*
- *Establishment of priorities and decision making for the program of restoration, repair and strengthening,*
- *Setting up of multidisciplinary teams to propose projects for repair, reconstruction and strengthening of damaged monuments.*

# Establishment of priorities and decision making

*Successfully protection of a historic structure* - only a team of experts from different profiles, each of them being completely competent for their profession, but sufficiently flexible to accept the arguments of the others

*One of the main tasks and problems* - to answer the question as to how far we should go as to the level of safety on one hand and the extent of the intervention on the other

*To state the definitions:* Historical Building – Monument, Conservation, Restoration, Consolidation, Stabilization, Anastylosis, Repair, Strengthening, No intervention

*Decisions for repair and strengthening* - thoroughly clarified and justified in advance



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~~"Code for Historical Buildings and Monuments"~~

"Guide", "Recommendations", "Resolutions", "Charter"

and

# Scientifically based methodology for repair and strengthening of historic buildings and monuments in the process of their protection



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# *IZIIS' integrated approach for repair and strengthening*

- Definition of expected seismic (or other) hazard
- Definition of soil conditions and dynamic behavior of soil media
- Determination of structural characteristics and the bearing and deformability capacity of existing structures
- Definition of criteria and concept for repair and/or strengthening
- Selection of structural methods, techniques and materials
- Determination of the response of repaired and/or strengthened structures
- Definition of field works, execution and inspection



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# *IZIIS' integrated approach for repair and strengthening*

- **Materials:**

✓ reversible interventions - only a few limitations

✓ irreversible interventions - additional compatibility of new with old materials and their durability.

- **Methods**: detail analysis of existing structure

✓ sufficient bearing and deformability capacity - only *repair*

✓ not sufficient bearing and deformability capacity - *strengthening*
(increase of the strength or/and deformability)



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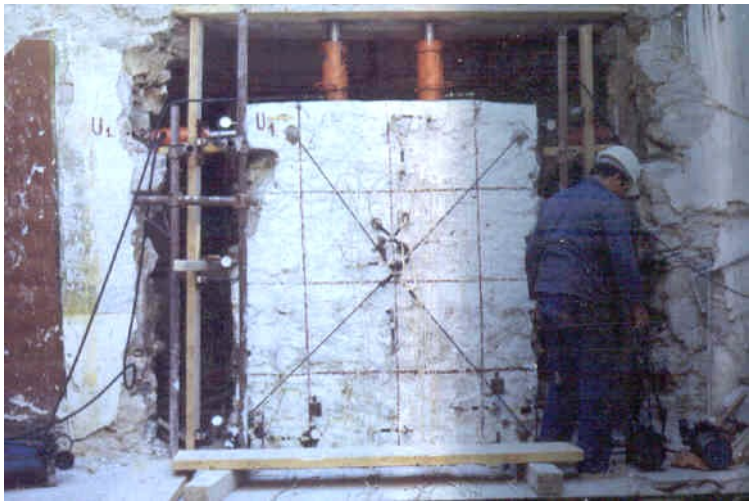
# *Renovation of old towns along Mediterranean coast after the 1979 earthquake*

- Extensive studies, experimental and analytical investigations for searching of the optimum conditions and methods for reconstruction, repair and strengthening of structures
- Classification of the buildings into structural units
- Determination of the methodology for structural repair and strengthening

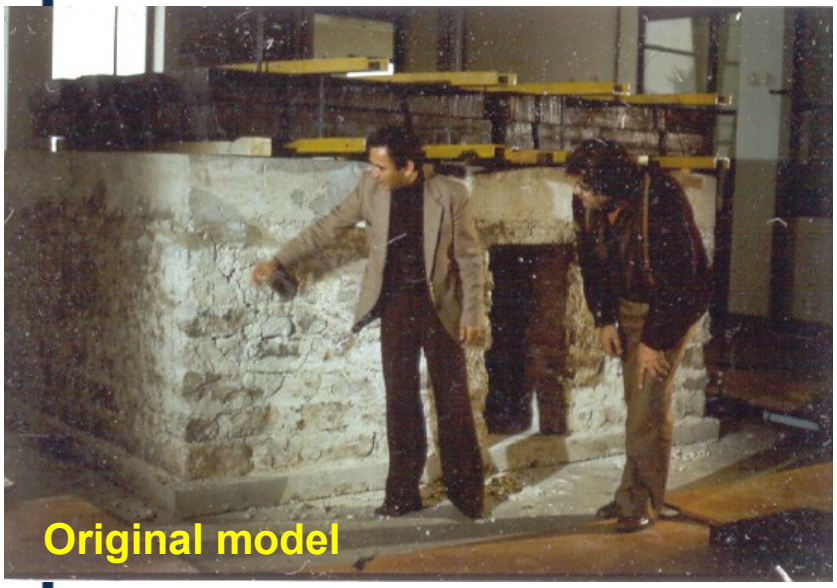


- *Sacral structures* - rebuilding, introducing of horizontal and vertical ties, injection and strengthening of foundation.
- *Residential and other buildings* - inserting of RC floor, belt courses, strengthening the lower stories by RC jackets, injection of walls using cement emulsion and strengthening of foundations

# The old town of Budva (experimental investigation; 1980-1981)

- Shaking table testing of 1:2 scaled model of a typical single story building applying the 1979 Petrovac earthquake

- Repaired (by injection) model suffered less damage

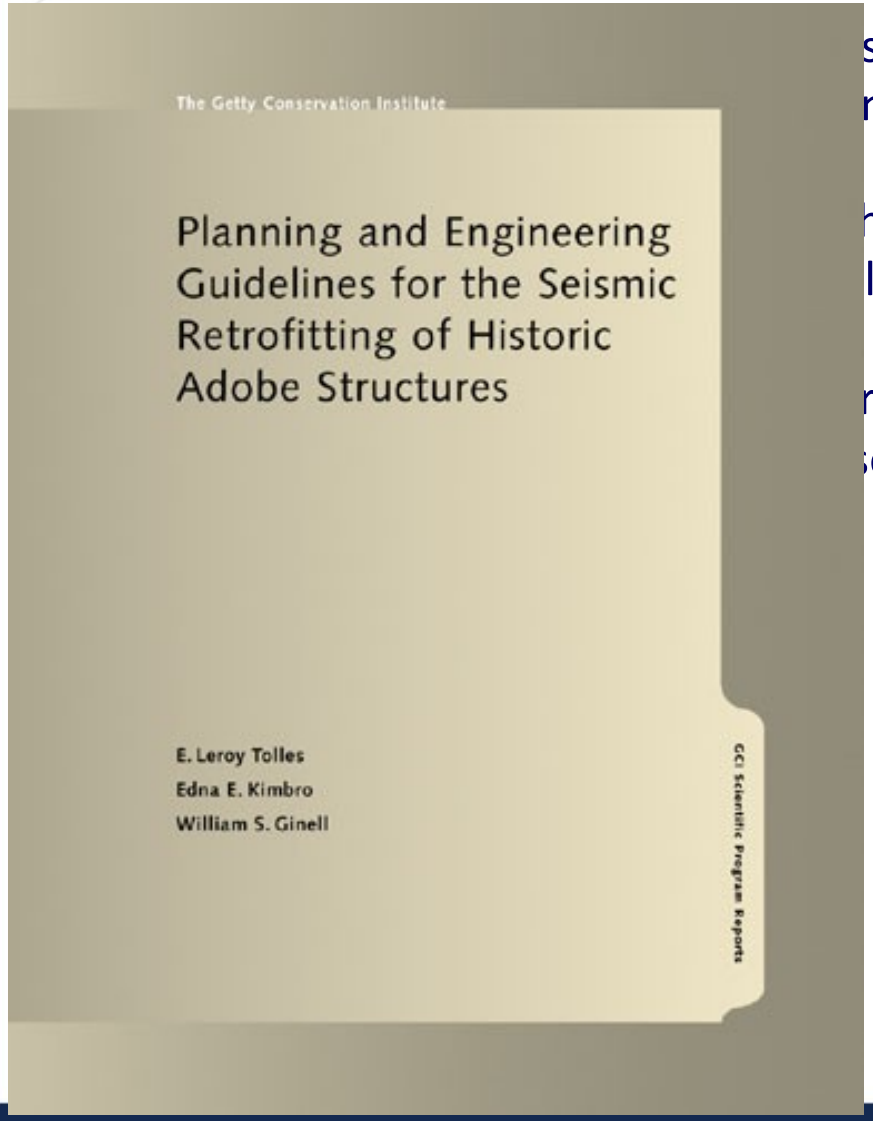


# The old town of Budva, (implementation; 1981-1982)

**During the reconstruction**

**Today**

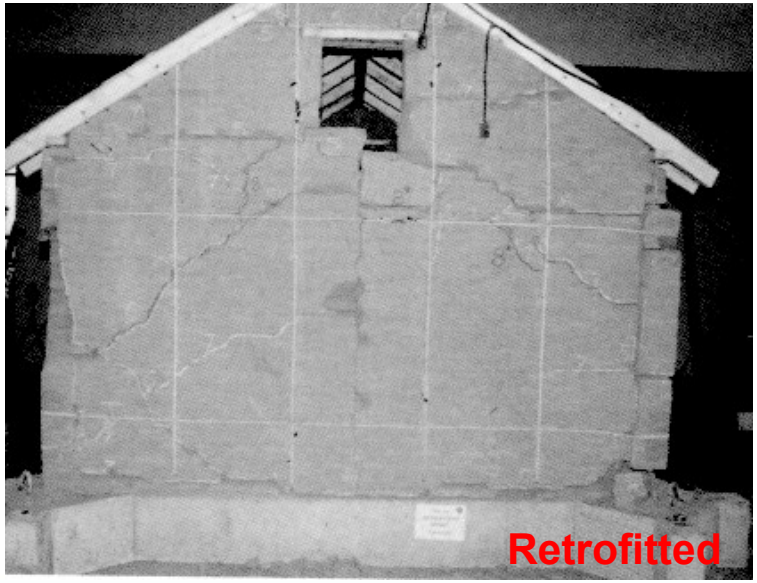
# Retrofitting of Historic Adobe Structures in California




sting of two large-scale models (1:2
n *tapanco*-style building, (dimensions

.....practical aspects for technologically feasible, minimally invasive and inexpensive techniques for stabilization of adobe buildings

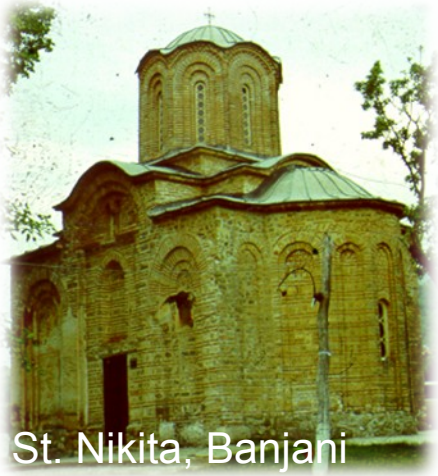
he second model - retrofitted with a
l straps, center cores, and partial
r core rods proved very effective in
se



# Repair and Strengthening of Byzantine Churches

- *Typology*
- *Existing state*
- *Interventions*
- *Authenticity*

St. Marry, Matejche


St. Nikita, Banjani

St. Marry Zahumska

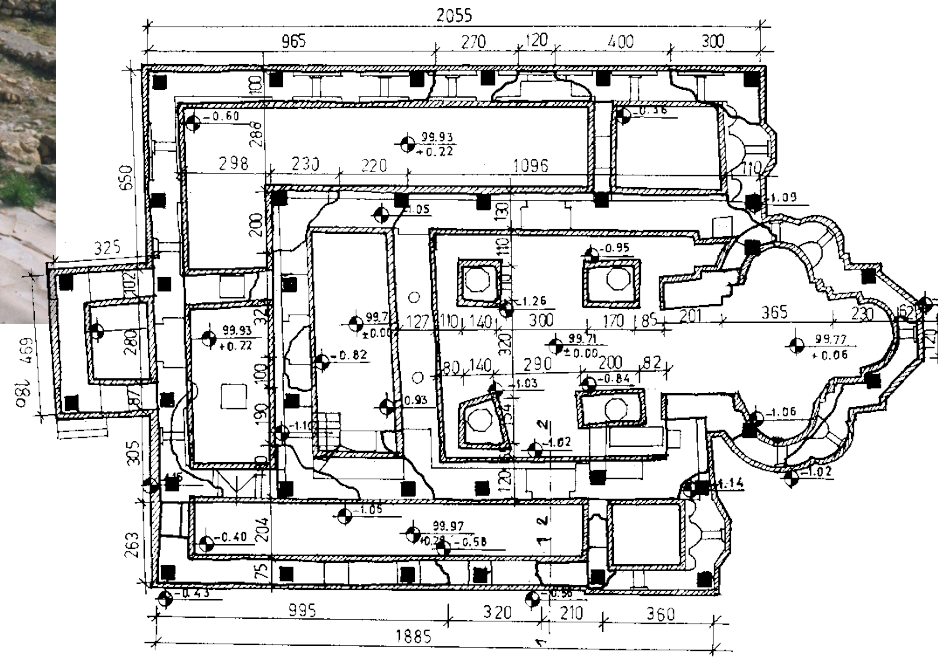
St. Nicolas, Psacha

# Traditional Technology vs. New Technology

# Traditional Technology vs. New Technology

# Consolidation and Reconstruction of the Structure of the St.Pantelymon Church in Plaoshnik, Ohrid, 2001

*implementation*



# Consolidation and Reconstruction of the Structure of the St.Pantelymon Church in Plaoshnik, Ohrid, 2001

# Reconstruction, Seismic Strengthening and Repair of the St. Athanasius Church in Leshok

# Phase 1 - July 2002

-Providing architectaral documentation

-Cleaning up and identification

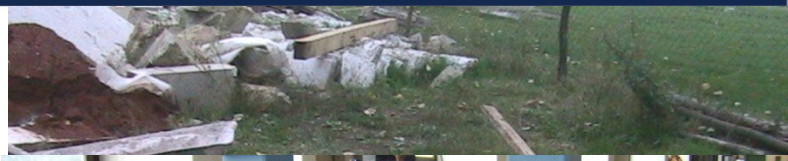
-Urgent preventive measures

-Archeological investigations

-Chemical analysis

-Other investigations

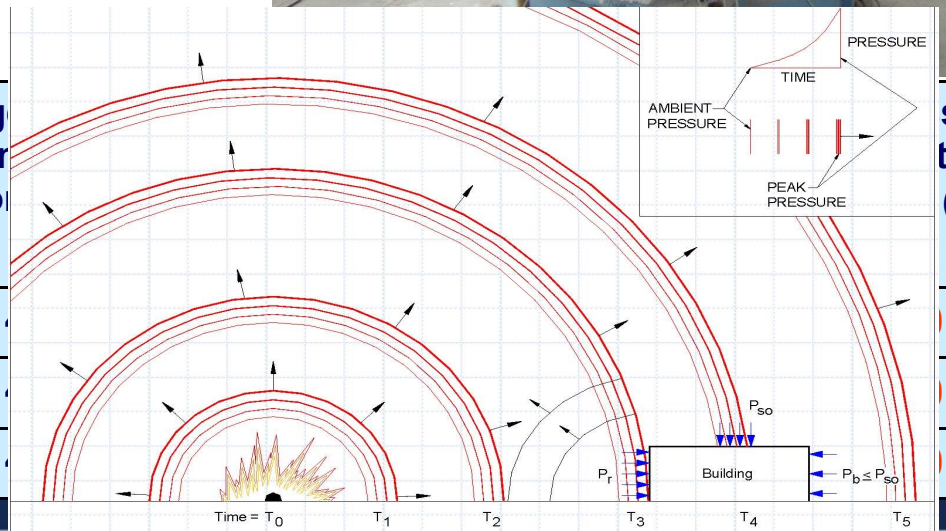
# Real seismic and blast resistance of the church



- Correctly defined input values:
  - built-in materials
  - geometrical data
  - mathematical model

- Quantification of blast effects:
  - main characteristics
  - loading of structures exposed to blast effects

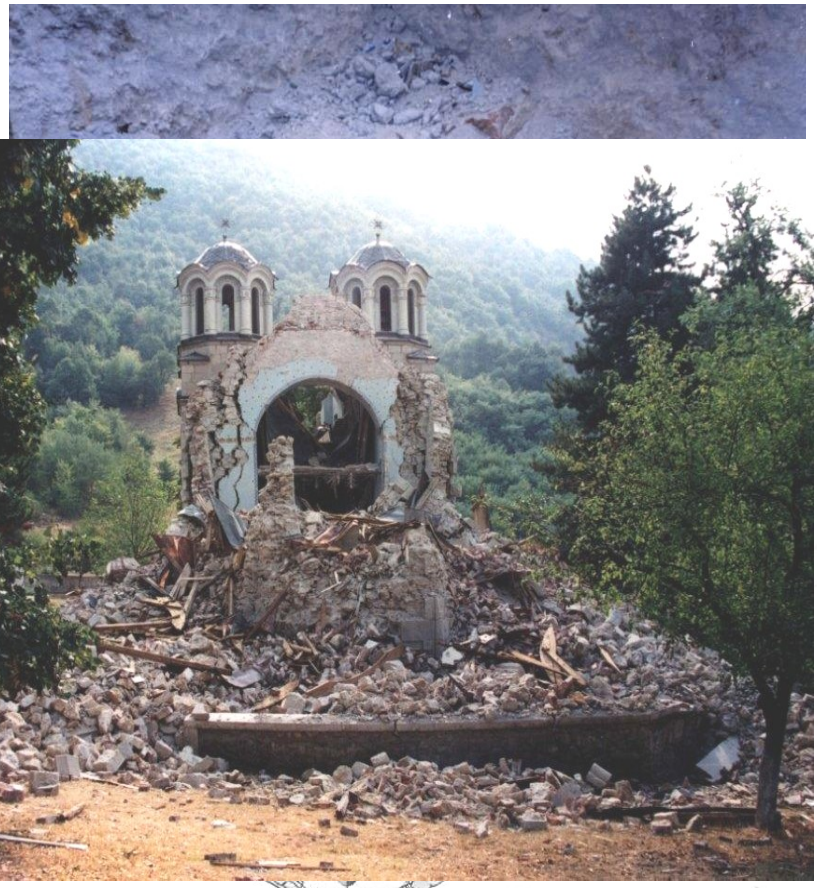
| Wall element | Ag<br>eler<br>(mo | sive<br>th<br>(kPa) |
|---|---|---|
| W1-1 | | |
| W1-2 | | |
| W1-3 | | |



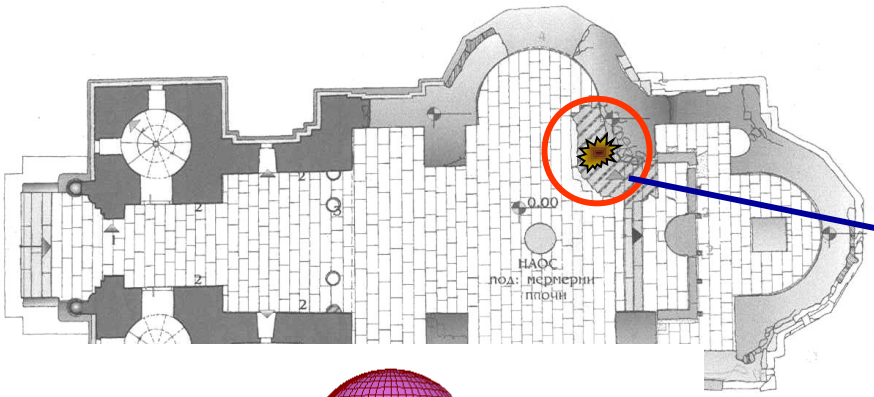
# Reconstruction of the explosion and the failure of the church

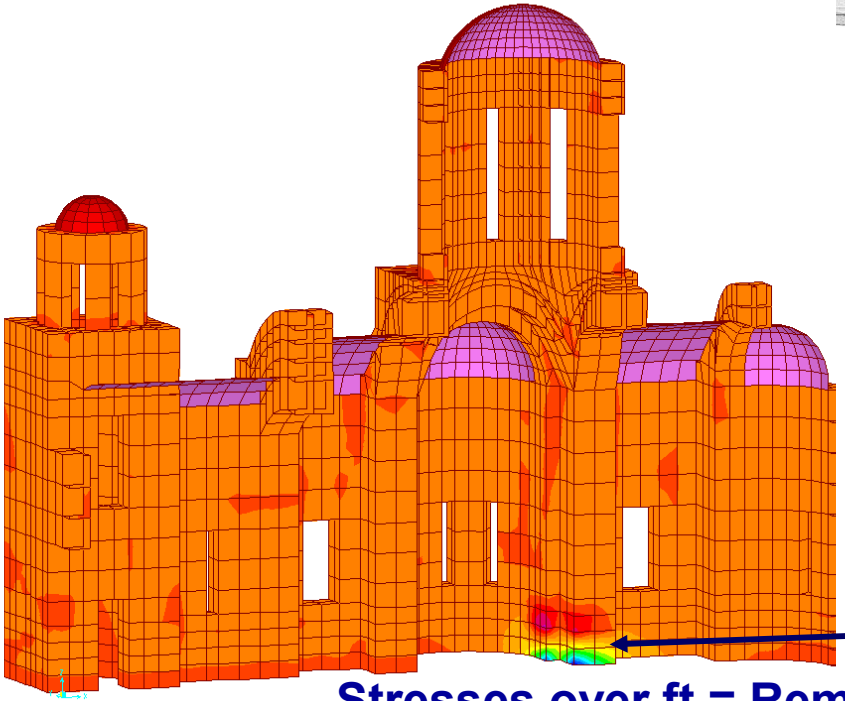
## Assumptions:

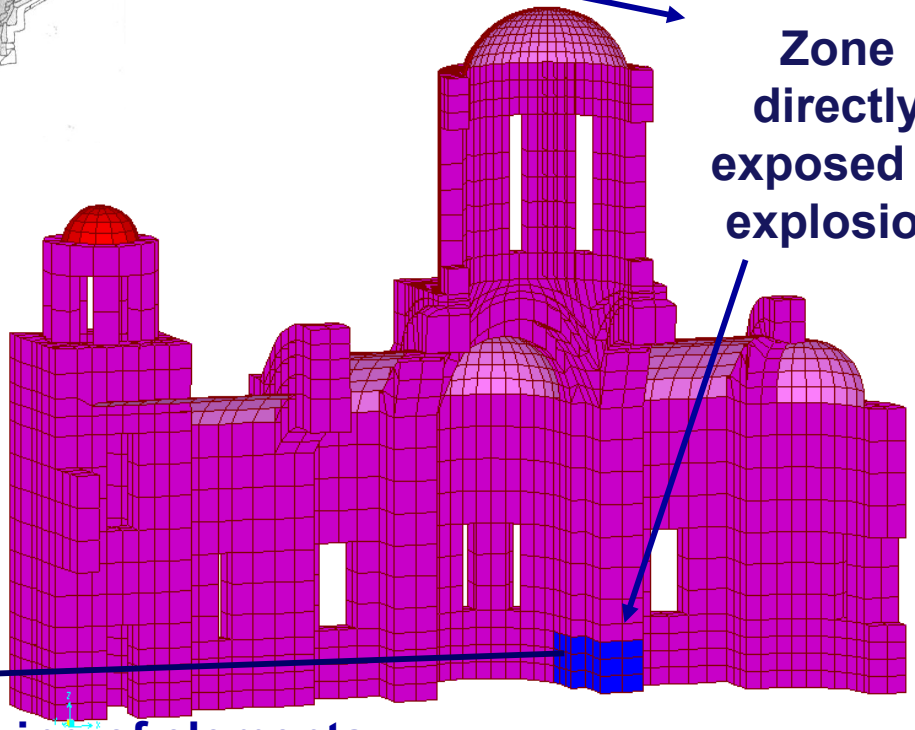
- Location of the explosive
- Type and Quantity of the explosive
- Failure mechanism
  - progresive collapse
- Additional limitations
  - very short distance
  - temperature



# Analytical investigations



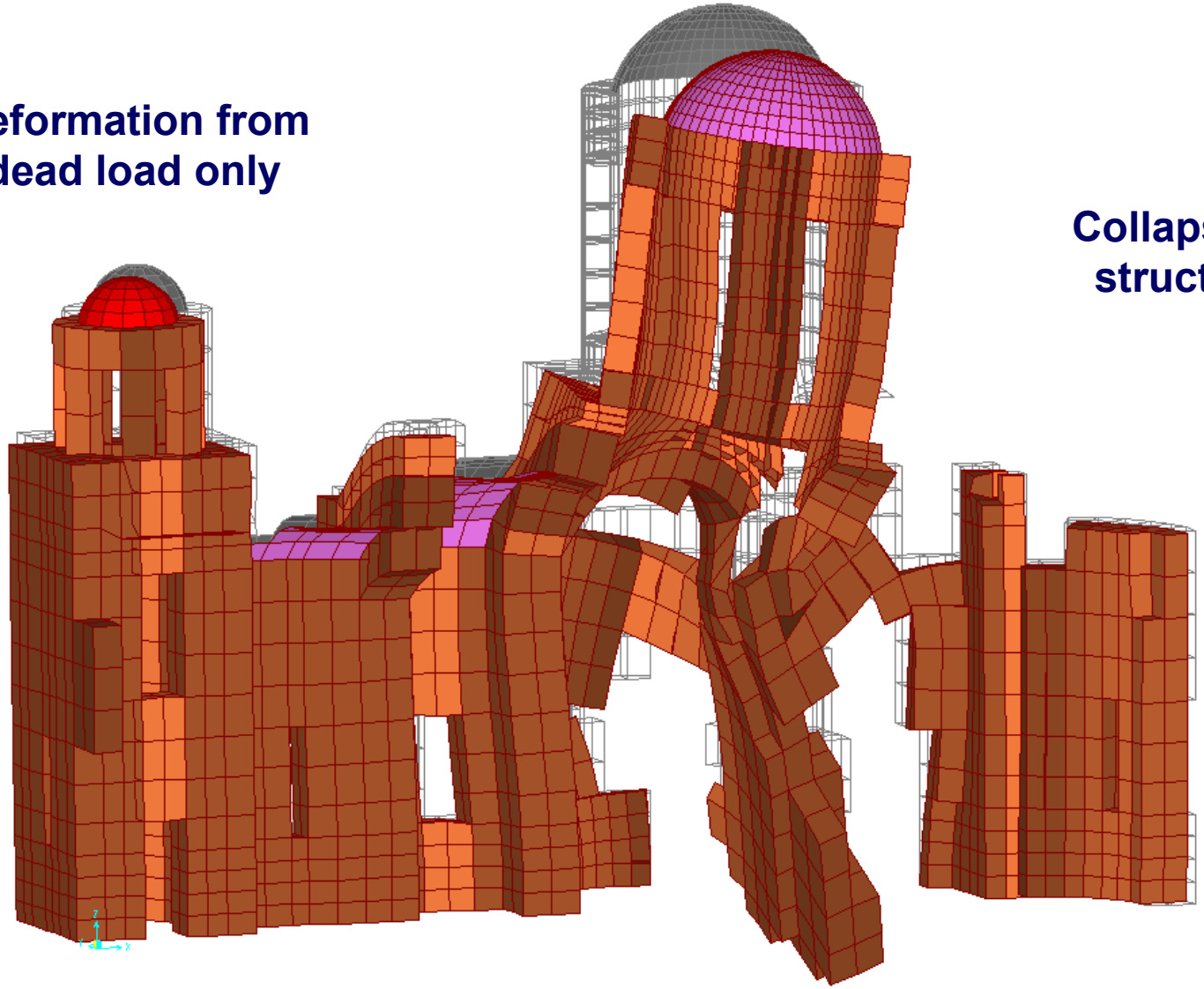





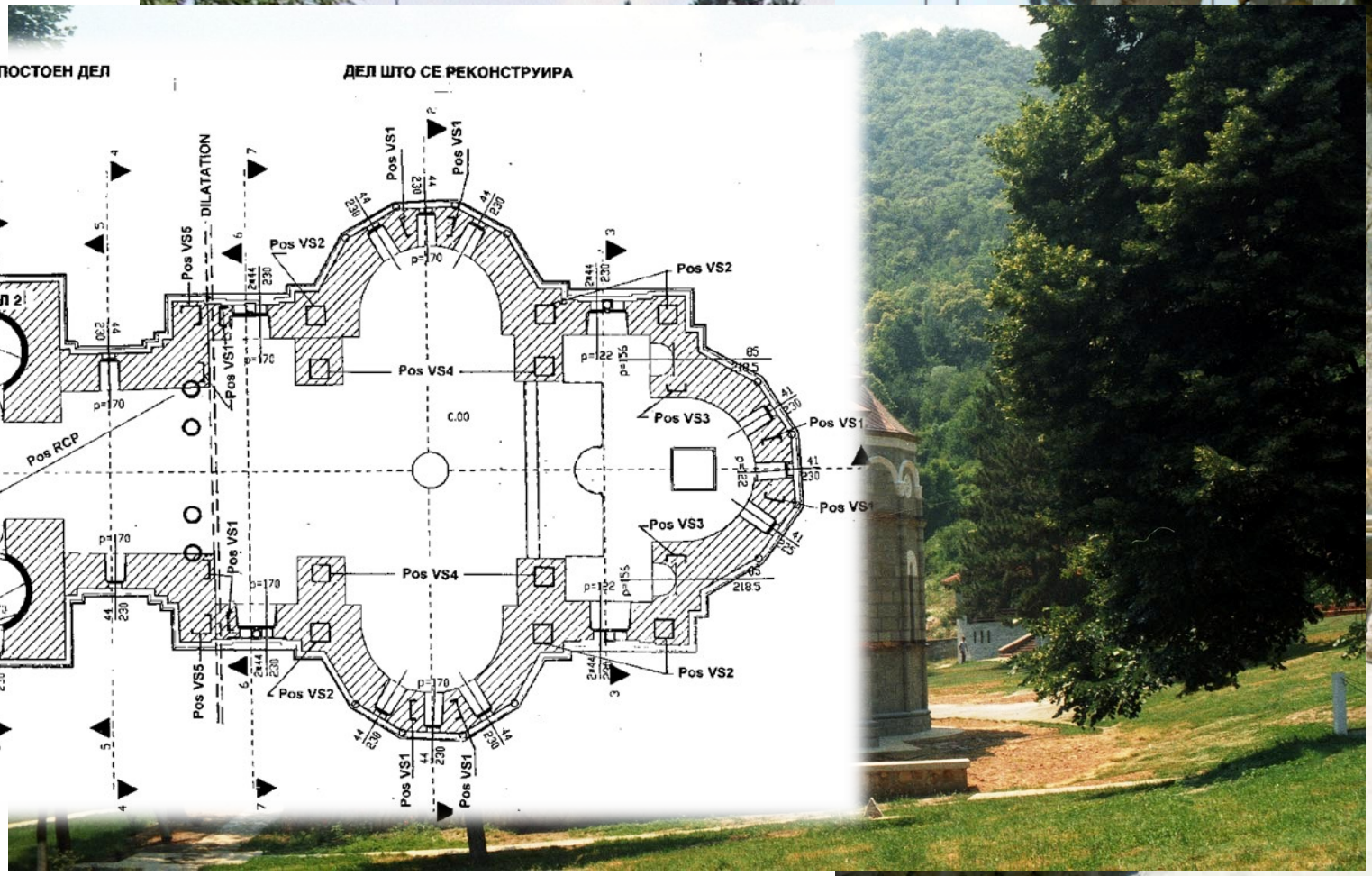
Zone directly exposed to explosion

Stresses over ft = Removing of elements

# Progressive collapse mechanism



# Reconstruction, Seismic Strengthening and Repair of the St. Athanasius Church in Leshok, (2004-2006)



# Reconstruction and Seismic Strengthening of the Blown Up Church of the Holy Trinity in Mostar (2011…)

2011

# Shaking table testing of the mosque model (2006-2007)

- 1:6 scaled model according to "gravity forces neglected " principle

**Phase 1- testing of original state**

- **Phase 2**

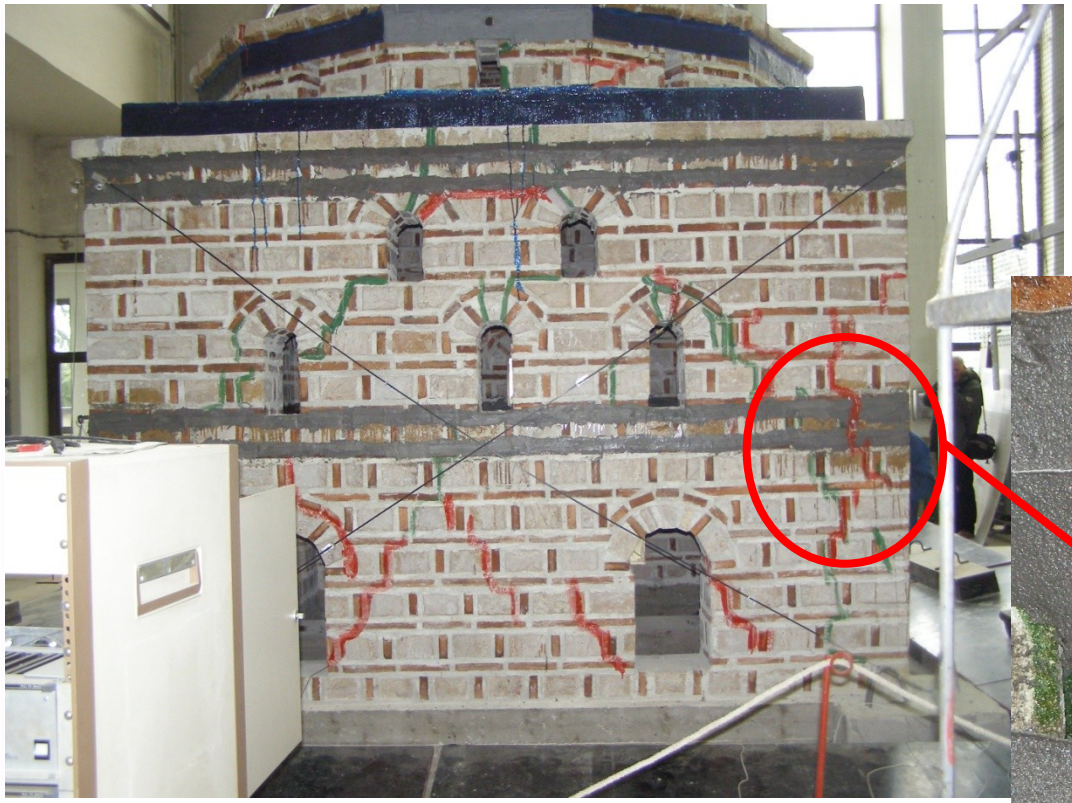
  **Testing of strengthened model by:**

  - CFRP rods in the longitudinal mortar joints
  - CFRP wrap around tambour and base of the dome

# Earthquake Protection of Historical buildings by Innovative Techniques

## EU FP6 – PROHITECH Project (2004 – 2007)

- **Testing of strengthened model**



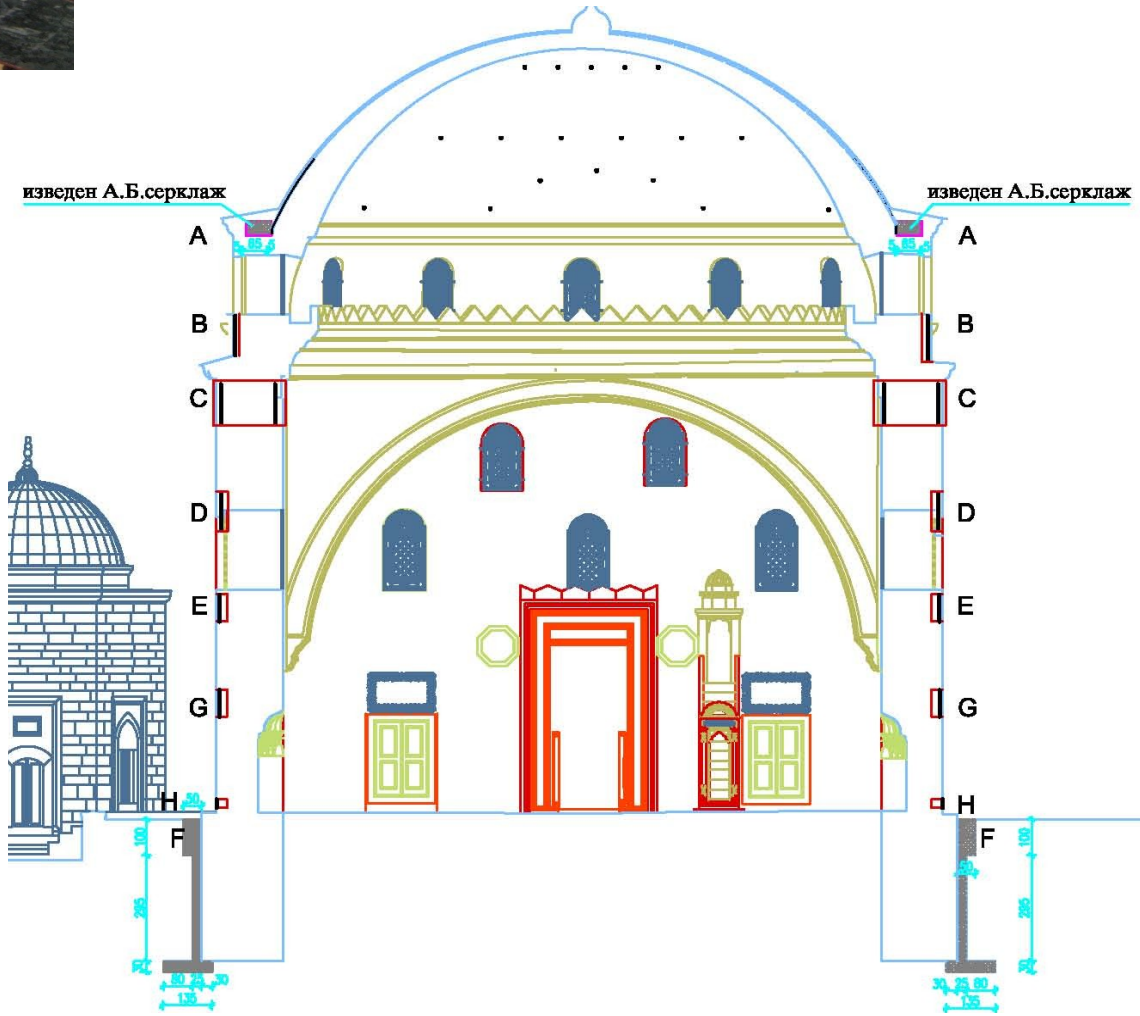
***The applied strengthening was very efficient even for higher input excitation***

# Mustafa Pasha Mosque in Skopje

- One of the biggest and best preserved Ottoman monuments in Skopje and Balkan
- Damaged by Skopje earthquake in 1963 (domes, east facade, minaret)
- Today - cultural historic monument of extraordinary importance

**after 1963 Skopje Earhquake**

# Repair and Seismic Strengthening of Mustafa Pasha Mosque (2007 -2010)




DOME Structure (A)

CFRP wrap in a layer of epoxy glue within a width of 2.9m

BEARING WALLS

(B,C,D,E,G,H)

CFRP bars in an epoxy mortar layer

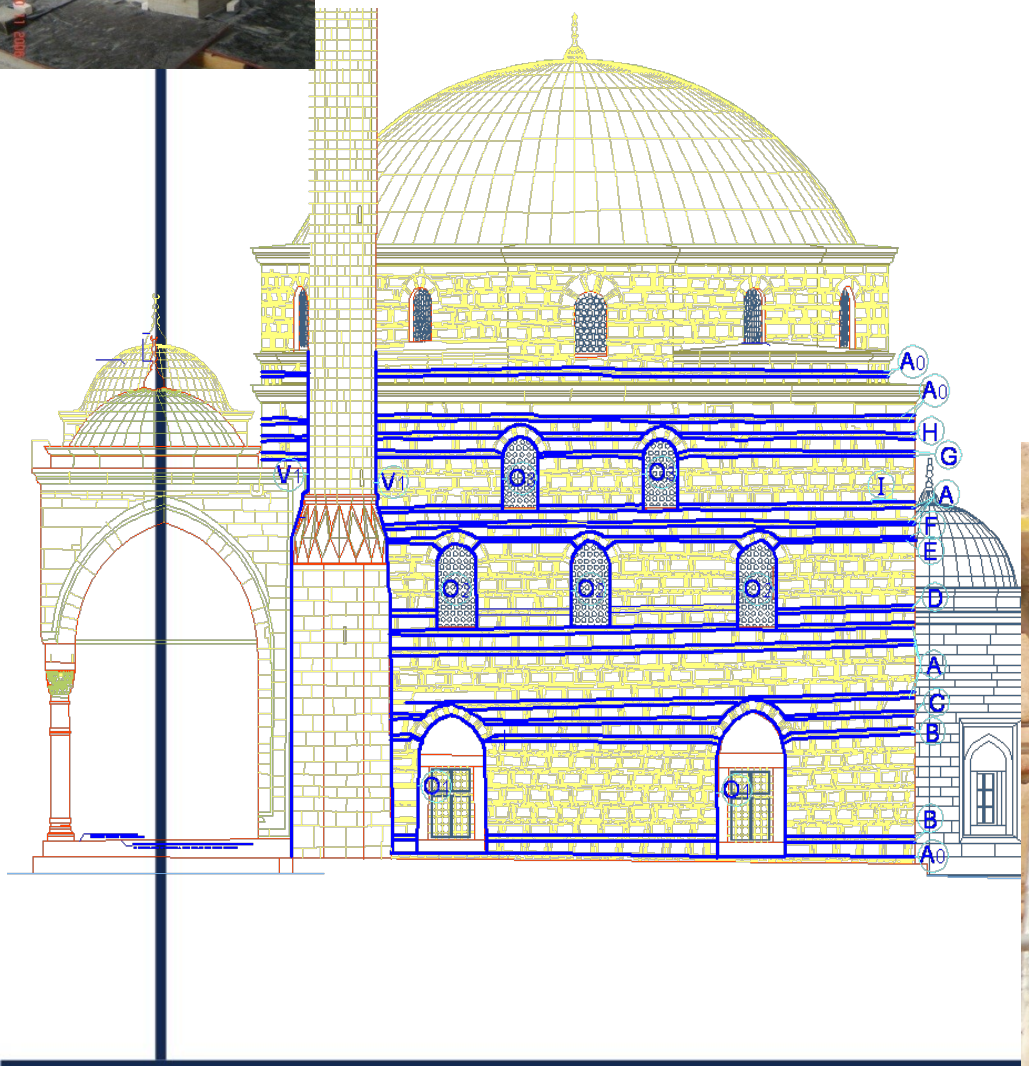
FOUNDATION (F)

RC wall on the external side bellow the terrain and down to the foundation level

# Repair of minaret

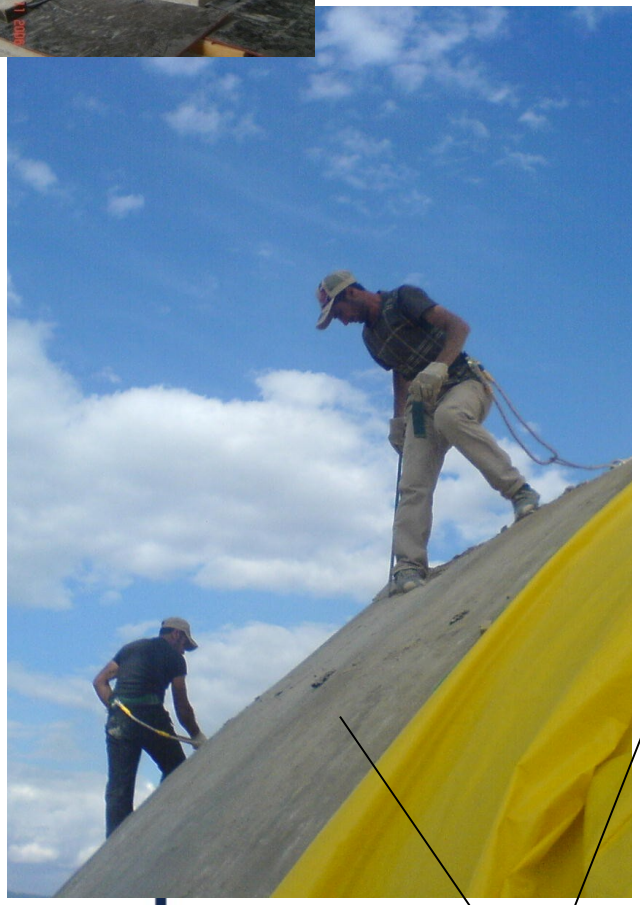
# Strengthening of the foundation

# Strengthening of bearing walls




- ✓ Cleaning of all joints on the outside with a depth of max 7-8 cm
- ✓ Placement of CFRP bars (d=1cm) in an epoxy mortar layer
- ✓Filling of the joints with pointing lime mortar

# Strengthening of the dome



Removing of cement cover

Existing RC belt

# Strengthening of the dome

Temporary roof

Removing the cement injection from 1965

# Strengthening of the dome

Injection of cracks with lime based mixtures

# Strengthening of the dome

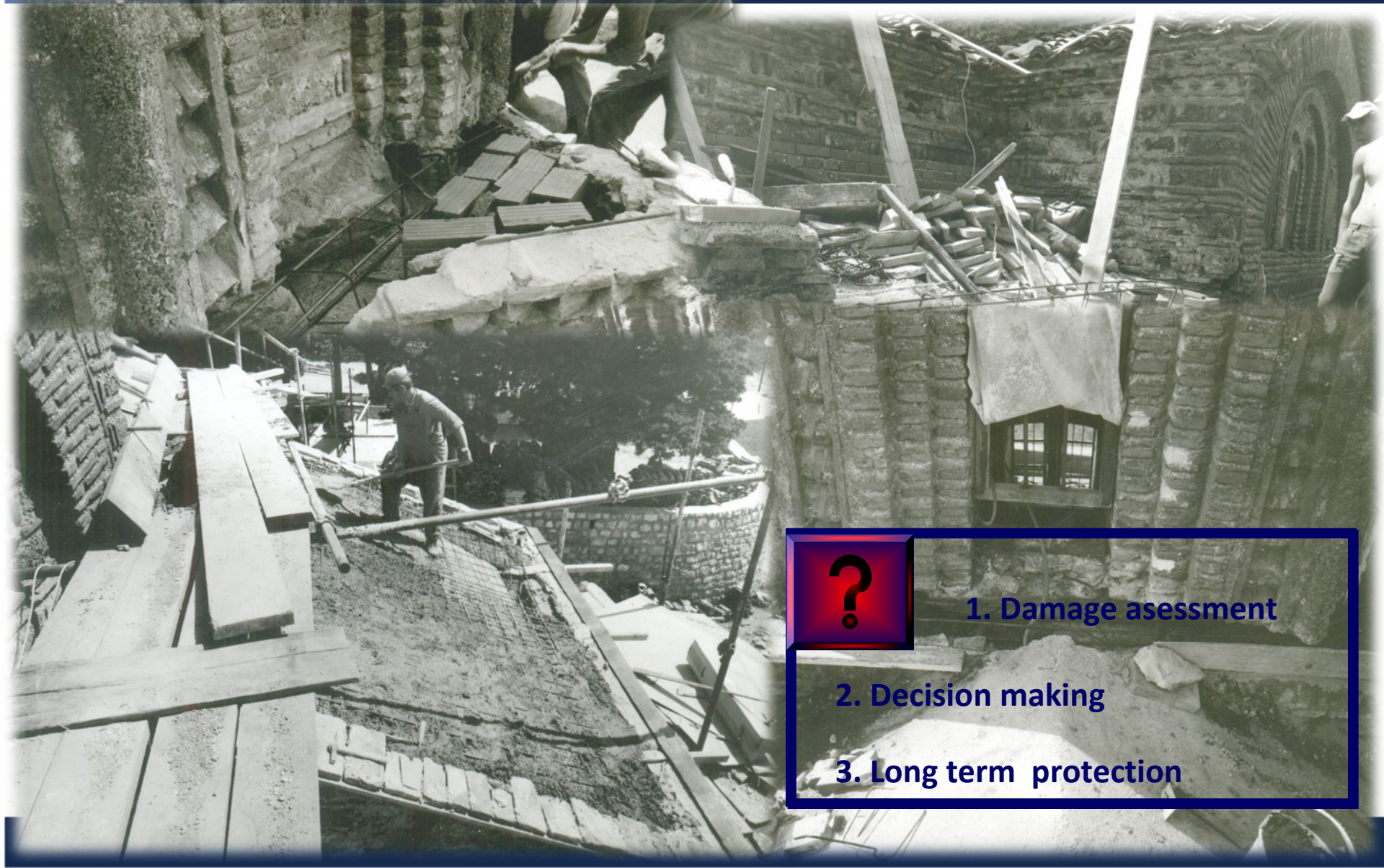
Coating of existing rc ring

Coating of entire dome with a protective layer of lime mortar

Roofing with lead plates

# Next Project, (2011…)
# St Marry Perivleptos, Ohrid

# St Marry Perivleptos, Ohrid
# Interventions, 1985



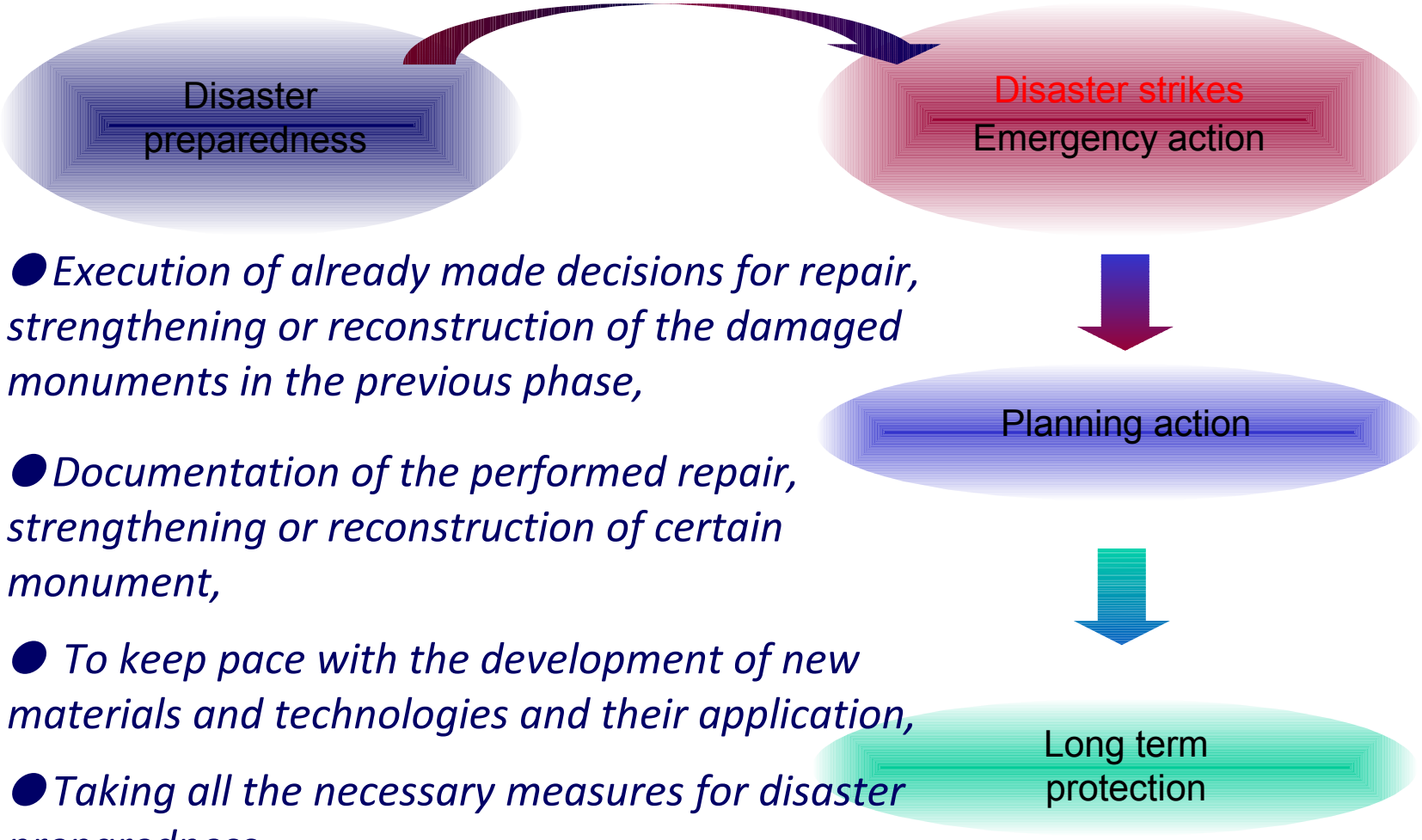
?

1. Damage asessment

2. Decision making

3. Long term  protection

# Cultural Heritage: Protection & Reduction of consequences




- *Execution of already made decisions for repair, strengthening or reconstruction of the damaged monuments in the previous phase,*
- *Documentation of the performed repair, strengthening or reconstruction of certain monument,*
- *To keep pace with the development of new materials and technologies and their application,*
- *Taking all the necessary measures for disaster preparedness.*



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# Cultural Heritage: Protection & Reduction of consequences

Disaster preparedness

Disaster strikes

Emergency action

We mustn't allow that either *the globalization process* or any other social, political, economic or technological process *take place in the world, ignoring the genesis* of development of the human environment and the achievements of the human civilization in its course.

Planning action

Long term protection

Disaster preparedness

THANK YOU!



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