The need for integrating Structural / Seismic Upgrade of Existing Buildings, in parallel with Energy Efficiency Improvements

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"INTELLIGENT / SMART BUIDINGS" =

SAFE, SOUND and SUSTAINABLE BUILDINGS

" - The Three S Approach - "

1. Summary

- The majority of the existing building stock in many European countries built in the 80s, 70s or earlier lack of modern design standards including the basic requirements for seismic safety and energy efficiency.

- Thus, based on their date of construction, the vast majority are deficient both in terms of energy and seismic resistance. This creates the need for the society (government, public and engineers) to take actions to keep and maintain the building stock in operational, reliable and resilient state, in order **to ensure primarily the safety of the users.**

- In civil engineering this ongoing process is achieved by updating the design codes to incorporate aspects studied after extensive research, laboratory work or identified through shortcomings in real hazard situations. **In addition to safety, nowadays the comfort of the users is of prime importance**. To satisfy the required comfort levels, the user should consume energy, in the form of heating, cooling etc.

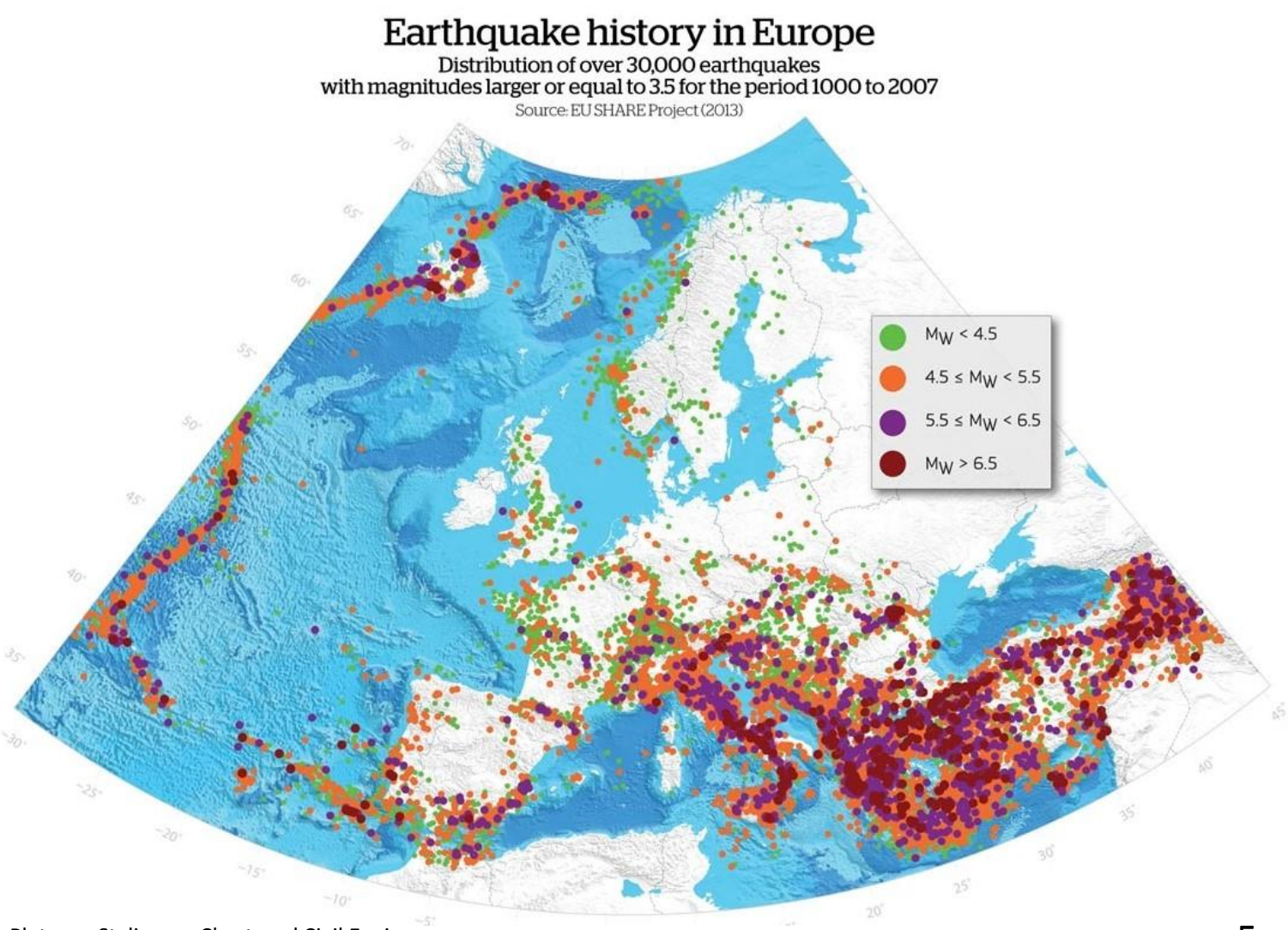
- Therefore, this ongoing trend to satisfy these conditions, results in new buildings which are safer, more economic to operate, more secure and more sustainable **(to satisfy the three S approach).**

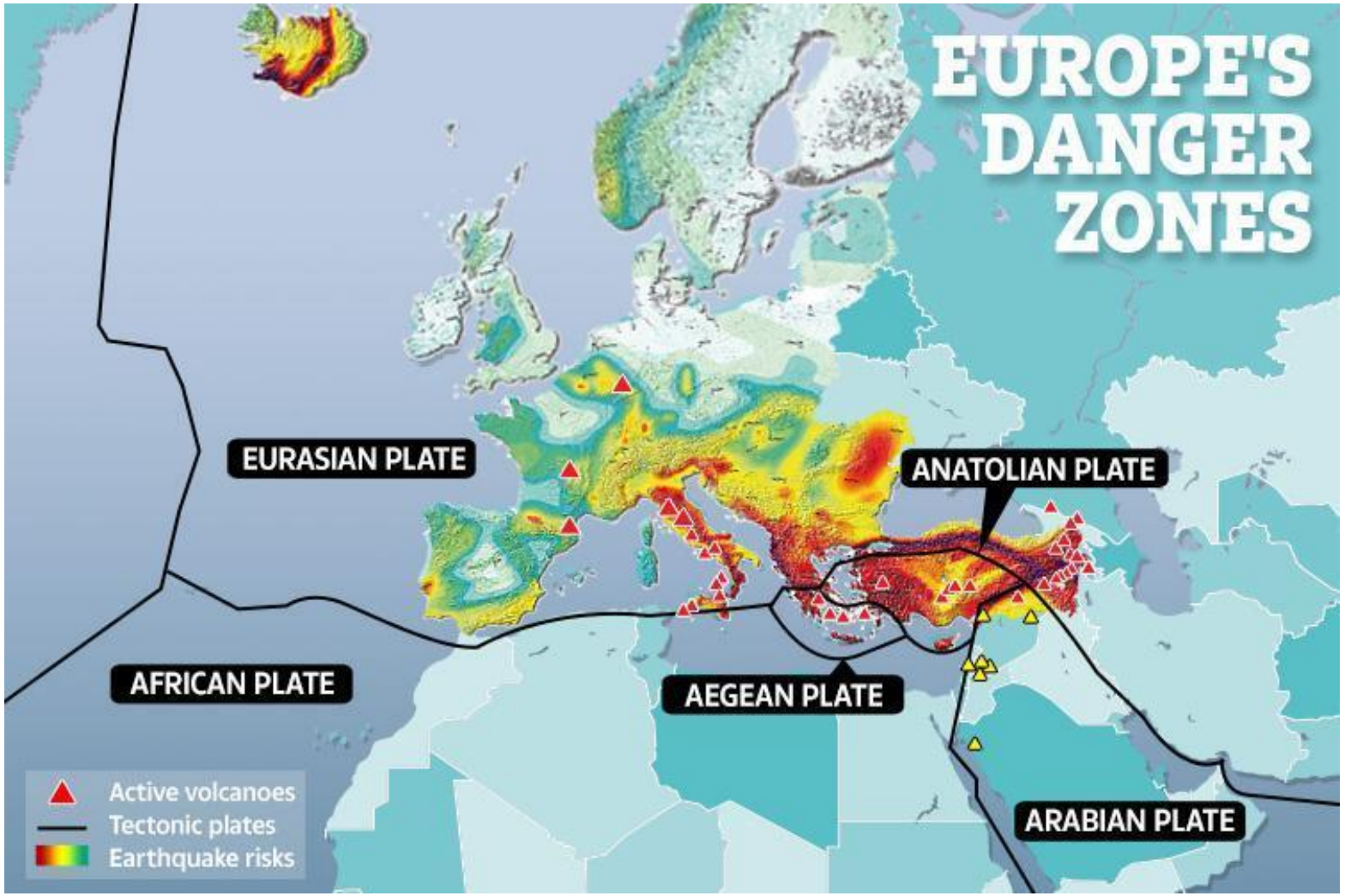
- However, the current building stock of Europe comprises of structures that have been designed and constructed over a long period of years, spanning some decades ago. For traditional masonry buildings this can be more than 100 years.

- A BPIE (Buildings Performance Institute Europe) survey [BPIE, 2011] revealed that a significant amount, over 40% of the existing building stock in EU is over 50 years old (only around 17% is constructed after 1991), i.e. exceeding firstly their design life and secondly are constructed during a period that Seismic knowledge and standards were very limited and energy performance guidelines were non-existent.

- Thus it is easily understood that for this “aging” group of existing buildings, key challenges lie ahead, regarding their structural safety, sustainability and energy performance.

- The structural performance of buildings is related to their stiffness and strength as well as their ability to undergo non-linear (ductile) deformations. The extent to which a building can resist loads depends mainly on the characteristics of its lateral load resisting structure L.L.R.S. (i.e. columns, beams and walls). Most existing buildings do not pose significant lateral resistance and require upgrading to increase the efficiency of one or more of the above.


Earthquake history in Europe
Distribution of over 30,000 earthquakes
with magnitudes larger or equal to 3.5 for the period 1000 to 2007
Source: EU SHARE Project (2013)
M_W < 4.5
4.5 ≤ M_W < 5.5
5.5 ≤ M_W < 6.5
M_W > 6.5


EUROPE'S DANGER ZONES
EURASIAN PLATE
ANATOLIAN PLATE
AFRICAN PLATE
AEGEAN PLATE
ARABIAN PLATE
Active volcanoes
Tectonic plates
Earthquake risks

- In the case of the aging existing buildings, the lack of consideration at the design and construction stage, for the seismic effect means this building stock is more vulnerable to earthquakes. In addition, as it is exceeding its design life of 50 years, it means that along with strengthening interventions to improve the seismic performance, durability and structural assessments should also be carried-out to ensure functionality and thus safety and comfort for the users.
- In addition to safety, in the last decade the importance on the energy front has been highlighted; increased energy consumption lead to adverse environmental impact (e.g. climate change). Therefore, for the building sector the energy efficiency term is introduced, which is highlighted by the Europe's aim to reduce by 2020 the Greenhouse emissions by 20% and achieve 20% energy savings [EPBD recast, 2010/31/EU].
- The building sector accounts for large energy consumption in EU with the European households using nearly the 70% of the consumed energy in the form of electrical energy. A survey by BPIE (2011) on energy consumption revealed that the older building stock is the main contributor to this. Thus in the EU the main policy regarding the energy use in buildings is the Energy Performance of Buildings Directive (EPBD, 2002/91/EC) initially issued in 2002, and re issued in 2010.
- Therefore, it is evident that there is a big portion of the existing EU building block that is under-designed, both regarding their seismic capacity and also their energy performance, since is well below the national minimum requirements set in the last fifteen years and **therefore in need of structural and energy renovation to remain operational and safe.**

- To improve the seismic performance/capacity of existing buildings that have not been designed according to the earthquake standards of Eurocode EC8, a variety of techniques based on the typology of the building and the level of the required strengthening are currently used.
- For RC structures, the seismic retrofit techniques are generally divided to local and global methods [JRC 2014a]:

Local methods are concentrated in improving the performance of particular structural members and most commonly include the strengthening of the column-to-beam joints, column and beam jacketing and column and beam strengthening with advance materials such as fibre reinforced polymers (FRP) or combined with new technology such as the textile reinforced mortar (TRM) technique, or with traditional R.C. jacketing.

Global methods may be provided with the addition of shear walls and/ or foundations strengthening, which will lead to the change of the type of the structural system.

- Regarding the energy performance level of buildings, it is influenced by a number of factors including the installed heating/cooling systems, the climatic conditions and the building envelope. The energy demand of buildings can be reduced by improving the insulation of the envelope, increasing the thermal capacity of the building and by using energy efficient systems in the building's operating processes (e.g. heating). Therefore, any potential energy saving measures are inter-related with these factors, with greatest focus on aging/ ‘’old’’ existing buildings which have the largest energy consumption due to insufficient insulation of the building.

- The insulation of the envelope can be drastically improved by reducing the energy loss from windows and doors and by insulating the walls and the roof. For the latter, the level of improvement depends on the thickness of the provided insulation and the properties of the insulating material, although thick insulating layers are unfavorable due to limitations in space, aesthetics reasons and other technical constraints [JRC 2014a].

- Currently, from a sustainability perspective, emphasis is placed on developing an integrated structural and energy design methodology for new buildings that should be preferred over individual actions, to ensure a **Sustainable Structural Design (SSD).** Such approaches like the SSD methodology **will ensure that new buildings satisfy both structural safety and energy efficiency targets.**

- However, for existing buildings, especially of a certain construction age, the problem of seismic and energy inefficiency is of primary importance and a similar in concept approach is required to provide upgrading on both fronts. Only the last few years it is acknowledged that independent retrofit actions should be integrated to enhance the overall performance.

- Unfortunately the current practice prescribes and promotes upgrading solutions that isolate each deficiency and proposes solutions to enhance/upgrade any of the two items (either energy efficiency improvement or structural seismic upgrade) separately.

Given that buildings in some European regions experience frequent seismic activity and high temperature variations, it becomes a necessity to proceed with upgrading or retrofitting measures as part of a major refurbishment process.

These measures are expected to improve the resilience of the existing building stock in an economically feasible way, reduce the operational expenses and contribute to the sustainability of the society and the environment and offer safer buildings to people (**Home**).

As it is well known to all Engineers that if buildings are cladded and insulated, **then they may look new, but their underlying structural issues remain, hidden, unseen and unassessed and may become life-threatening, especially in case of a major seismic event and may lead to a collapse or failure.**




If that occurs, then <u>all EU money spent</u> for energy Upgrades and refurbishment of buildings <u>would be lost</u>.

<u>However, the economic risk is redundant compared to the potential injury and loss of life.</u>

2.0 The new trend is … *smart financing for smart buildings.*

But, a building can only be called smart once it is safe, sound and sustainable.

The starting point must be ***all*** *state/government buildings and all buildings of high importance,*

as categorized in the Eurocodes, as well as buildings that concentrate, or are used or visited by a lot of people.

3. Scope

- Our aim is to ensure sustainability, resilience and safety of existing buildings through structural or seismic upgrading against seismic and other dynamic actions and also enhanced energy efficiency.

- The solution provided should follow a holistic approach to address these issues simultaneously and link individual retrofit/upgrading activities in an integrated procedure. One of the most important issues, which defines the way of living, **is safe, sound, and sustainable buildings (the three S approach), …. And that is a basic Human right.**

- That is why we decided as ECCE to create a firm position paper, in order to convince E.U. member states and Brussels to grant funding for the Structural and / or Seismic Upgrade of the buildings, together with the grants given for the upgrade of the energy performance of buildings, under Directive 2010/31/EM, of the European Parliament and of the Council of 19th of May 2010.

4. QUESTIONNAIRE

Ref: 151.GE.V05.2018

QUESTIONNAIRE

Title: "The need for integrating Structural / Seismic Upgrade of Existing Buildings, with Energy Efficiency Improvements"

Dear Colleague, please complete the following questionnaire and give us all details available.
Name and Surname:
Email:

A/A	QUESTIONS
I.	General
1	Does your Country suffer from earthquake or other dynamic loading problem or other combination of dynamic loadings and if yes approximately how frequently –Please attach historical records, if possible. ☐ Yes ☐ No If yes give details. .....
2	When was the last major / serious earthquake or other dynamic event that took place in your Country that affected the stability of buildings and civil works? What was the intensity? .....
3	Were the affected buildings or civil works repaired? Do you know what was the amount of money needed in order to repair the above? ☐ Yes ☐ No If yes give details. .....
4	Please briefly explain what damages does it causes (with regard to buildings, roads, bridges, etc.) .....
5	Where there any fatalities or serious injuries? ☐ Yes ☐ No If yes give data. .....

Ref: 151.GE.V05.2018

6	What was the time needed in order to fix the damages and to reinstate smoothly operation? .....
7	Are you aware of any special measures or others means applied, to mitigate/prepare for these events in your Country? ☐ Yes ☐ No If yes give details. .....
II.	State regulations/legislations and concrete experiences.
8	Is there a legal or technical guide/regulation on Energy Efficiency Upgrading of existing buildings in your Country? ☐ Yes ☐ No If yes give details (attach as well the Regulation or legislation). .....
9	Are there any legal or technical regulations/codes related to Seismic or Structural strengthening or upgrades in your Country? ☐Yes ☐ No If yes give details (please also attach the Regulation or legislation). .....
10	Are the Eurocodes applied for seismic assessments and seismic/structural strengthening of existing buildings in your country? ☐Yes ☐ No if yes give details .....
11	Are there incentives provided by the government, to individuals, for structural upgrades / renovations / seismic upgrades in your Country? ☐Yes ☐ No If yes give details. .....

Ref: 151.GE.V05.2018

12	Have you received any training related to seismic and energy efficiency upgrading? ☐Yes ☐ No If yes give details. .....
13	Have you participated in a workshop/conference on the above topics? ☐Yes ☐ No If yes give details. .....
III.	From practice
14	What are the most common building categories in your Country, regarding existing buildings build before 2000 and how many storeys are they? .....
15	What is the most widely used construction material for those buildings? .....
16	What is the common technique/material used for energy efficiency upgrading of existing buildings? .....
17	What are the most widely used techniques/applications for seismic strengthening of existing buildings? .....
18	Do you have unmaintained, deteriorated or abandoned buildings that suffer structural deficiencies/material degradation in your Country? ☐ Yes ☐ No If yes can you please give us numbers or percentage with regard to the total? .....

The questionnaire contributed significantly to the elaboration of the Position Paper. Also the results provided by each country will be valuable data for ECCE records.

The questionnaire was divided in three parts;

Part one, was the General part with 7 questions,

Part two, was the State Regulation/ legislation part with 6 questions, and

Part three, was the Practice experience and includes 5 questions.

5. The Working Team

Contribution from all countries members of ECCE was given, since many ECCE countries have experts and Professionals in that specific field.

<u>The Basic Coordination Team is:</u>

a) Eur. Ing. Platonas Stylianou — Cyprus (P.S.), Coordinator of the working team,
b) Mr. Aris Chatzidakis — Greece, (A.C.)
c) Mr. Andreas Theodotou — Cyprus, (A.T.)
d) Dr. Nicolas Kyriakides — Cyprus, (N.K.)
e) Mr. Andreas Brandner — Austria, (A.B.)
f) Dr. Branko Zadnik — Slovenia, (B.Z.)
g) Mr. Ivan Paska — Croatia (I.P.)
h) Mr. Paul Coughlan — United Kingdom, (P.C.)

6. Expected Benefit

1. Raise awareness and demand for better and structurally sound buildings among stakeholders, governments, owners, operators and all citizens.
2. Improve knowledge and information regarding assessment and design for structural and/or seismic upgrading of existing buildings.
3. Increase funding opportunities from EU.
4. Offer a significant contribution to the community, as the need to protect the homes and build property, is a basic one that originates from antiquity.

By applying the idea expressed in the position paper, countries that possess abandoned, deteriorated or ill-maintained buildings, especially those subject to seismic hazard, can assess, evaluate and if necessary, structurally strengthen their buildings, in order to obtain the same or better structural capacity than what was mandated by the building codes and allowed by the construction practices at the time of the original construction.

Countries subject to seismic hazard can assess, evaluate and if necessary, structurally and seismically strengthen their buildings in order to obtain the necessary structural and energy capacity according to the current Eurocodes, National Regulations and Annexes and Codes of Practice.

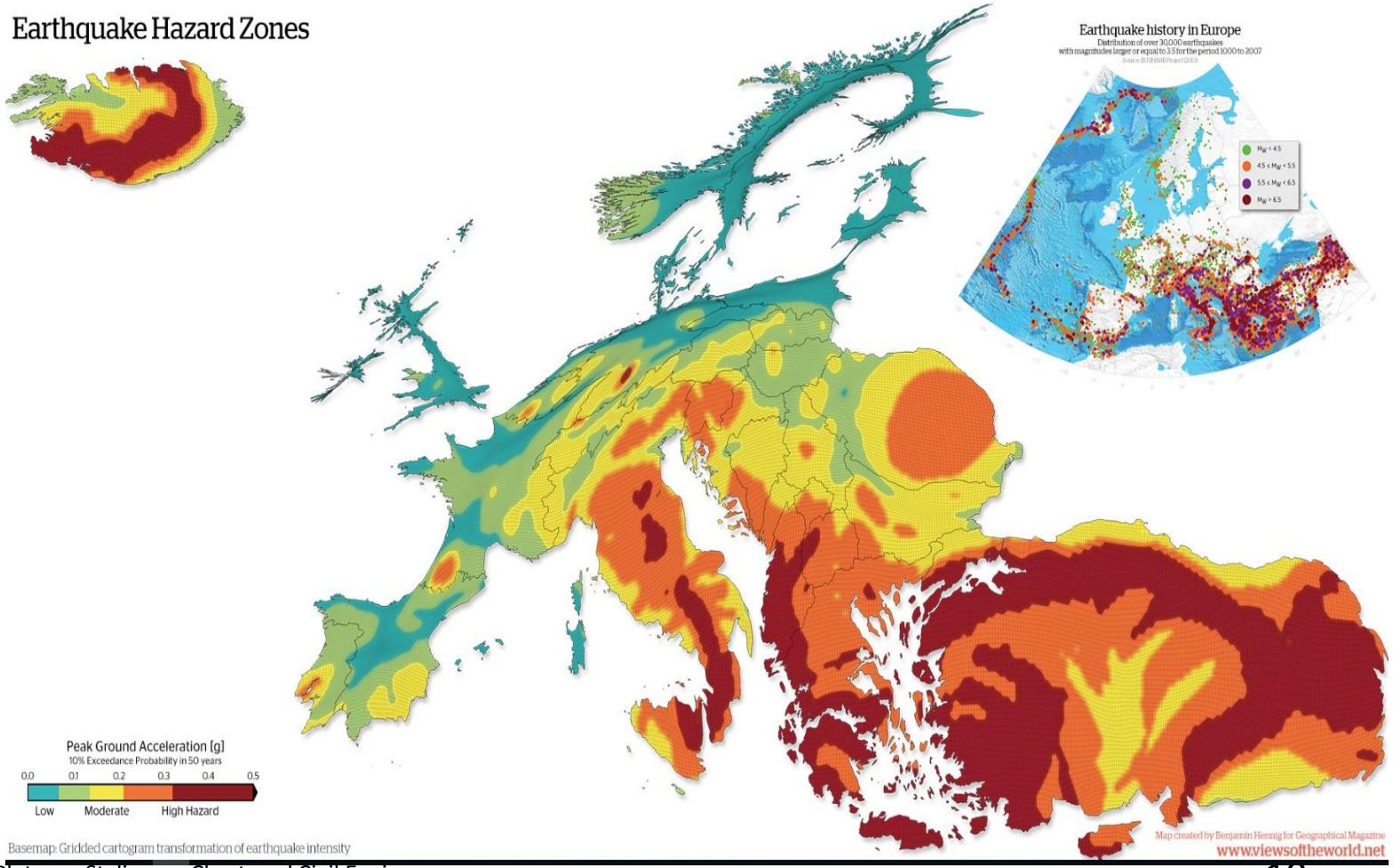
According to clause 16, of the EU Directive 2010/51/EU,

"…major renovations of existing buildings, regardless of their size, provide an opportunity to take cost – effective measures to enhance energy performance (here we must add … and structural / seismic performance…, in order to ensure safe buildings). Member states should be able to choose to define a 'major renovation' either in terms of a percentage of the surface of the building envelope or in terms of the value of the building…"

Also If, in Article 7, Existing Buildings, of the Directive, "…when buildings undergo major renovation, the energy performance of the building or the renovated part thereof is upgraded in order to meet minimum energy performance…", we add …and "evaluated and assessed for structural and/or seismically capacity and upgraded accordingly",

then as European Engineering Associations we will contribute to a much safer community with improved sustainability and lower waste of resources.

7. The biggest Earthquakes in Europe the last 20 years.



Izmit Earthquake (Turkey)-17 August 1999

- On 17 of August, 1999 at 03:01:3 (Local Time) there was a strong earthquake, M = 7.4 on the Richter Scale, with its epicentre South-West of Izmit town in northern Turkey and at a depth of 15-17Km.
- The duration of seismic vibration was 37 sec. The earthquake shook the cities of the wider area such as Istanbul, Bursa, Eskishir, Duze and Bolu.
- The impact was dramatic, 17,118 civilians died, 45,000 injured, 600,000 homeless and thousands were missing.
- The financial impact of the devastating earthquake amounts to appr 50 billion. dollars without taking into account all the long-term impact.

Earthquake in the city of Duzce, Turkey 12/11/1999

- On November 12, 1999 at 18:57:22 (local time) a strong earthquake of magnitude, Mw = 7.2. Acceleration reached PGA = 1g, as it was recorded by the accelerator in the city of Duzce.
- The deaths caused by the earthquake reached 1,000 and more than 5,000 people were injured, 55,000 were forced to leave their homes.
- The economical impact has exceeded $ 1 billion.

Earthquake in the city of Laquila (Italy)

- On April 6, 2009, a strong earthquake excitation Mw = 6.3 or 5.9 magnitude on the Richter Scale, occurred with its epicentre 7km outside of the city of L'Aquila at a depth of 10km deep.
- The earthquake was fatal and 319 people were killed, 1,600 were injured and more than 10,000 homes were damaged, 70,000 were forced to flee their homes where 30,000 were left homeless for several months.
- The economical impact of the earthquake exceeded $ 15 billion and created a major unemployment problem. But the cultural impact was also great due to of the damage or collapse of several buildings of the Medieval Period.

Earthquake of Parnitha (Athens) 1999

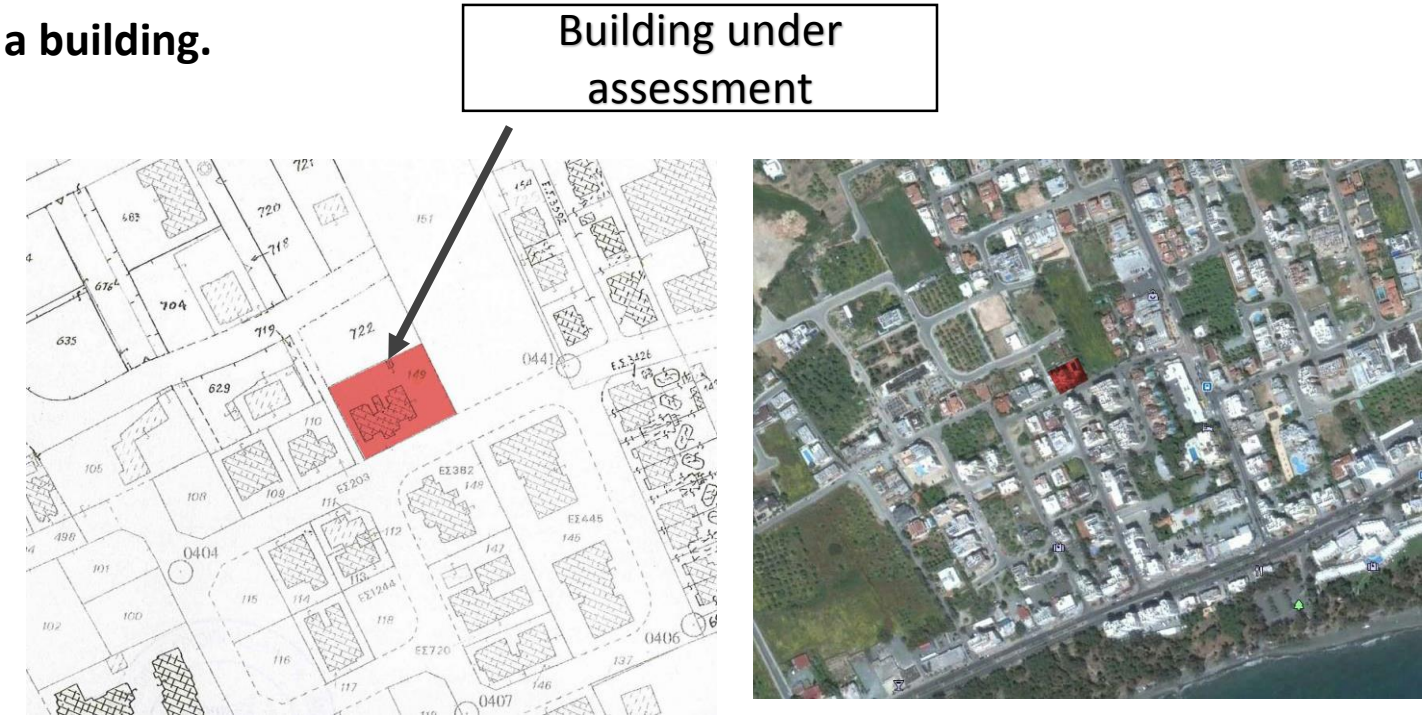
- On September 7, 1999, there was a strong earthquake excitation, M = 5.9 on the Richter Scale with its epicentre, 18km north of downtown Athens.
- The horizontal acceleration exceeded 0.5 g in central Athens while vertical acceleration reached 1 g.
- The impacts of the earthquake were dramatic, 145 people lost their lives, 2,000 were injured and 50,000 were left homeless.
- The financial impact reached $ 4 billion, with 110 buildings collapsing completely and more than 50,000 buildings were damaged.

Earthquake of Central Italy

- On August 24, 2016 there was a strong earthquake excitation, M = 6,2 on the Richter Scale with its epicentre, Southeast of Norcia, the focal depth of the earthquake was 10km.
- The impacts of the earthquake were dramatic, 299 people lost their live, more than 400 were injured and 4.500 were left homeless.
- The financial impact was appr $ 11 billion.
- The cultural impact was dramatic.

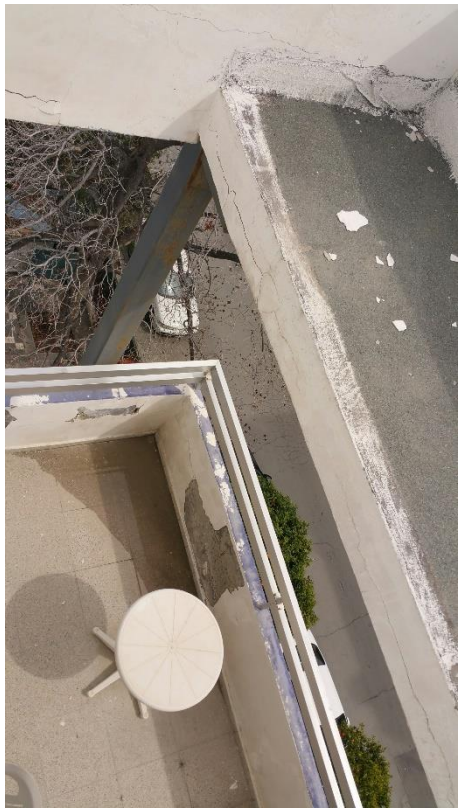
8. Typical Example of Seismic/Structural Update of a building.

- The building is situated in Germasogeia Limassol, Cyprus.
- Building was constructed around 1980.
- The existing building consisted of ground floor (used as utility area) and five floors above (used as rooms for rent), and was serving as a small business hotel.



- The situation of the building before strengthening.

More photos

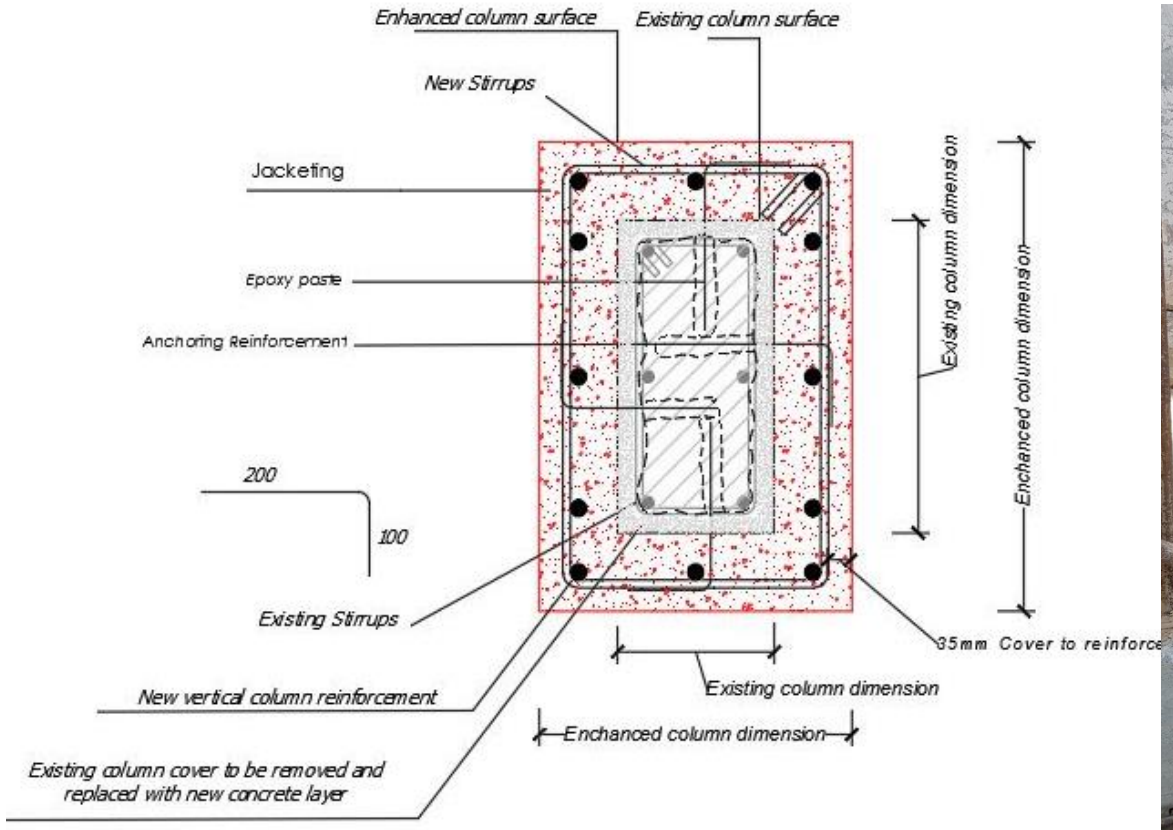





- 3D Drawings of the proposed renovated building, energy upgraded with the addition of an extra floor.

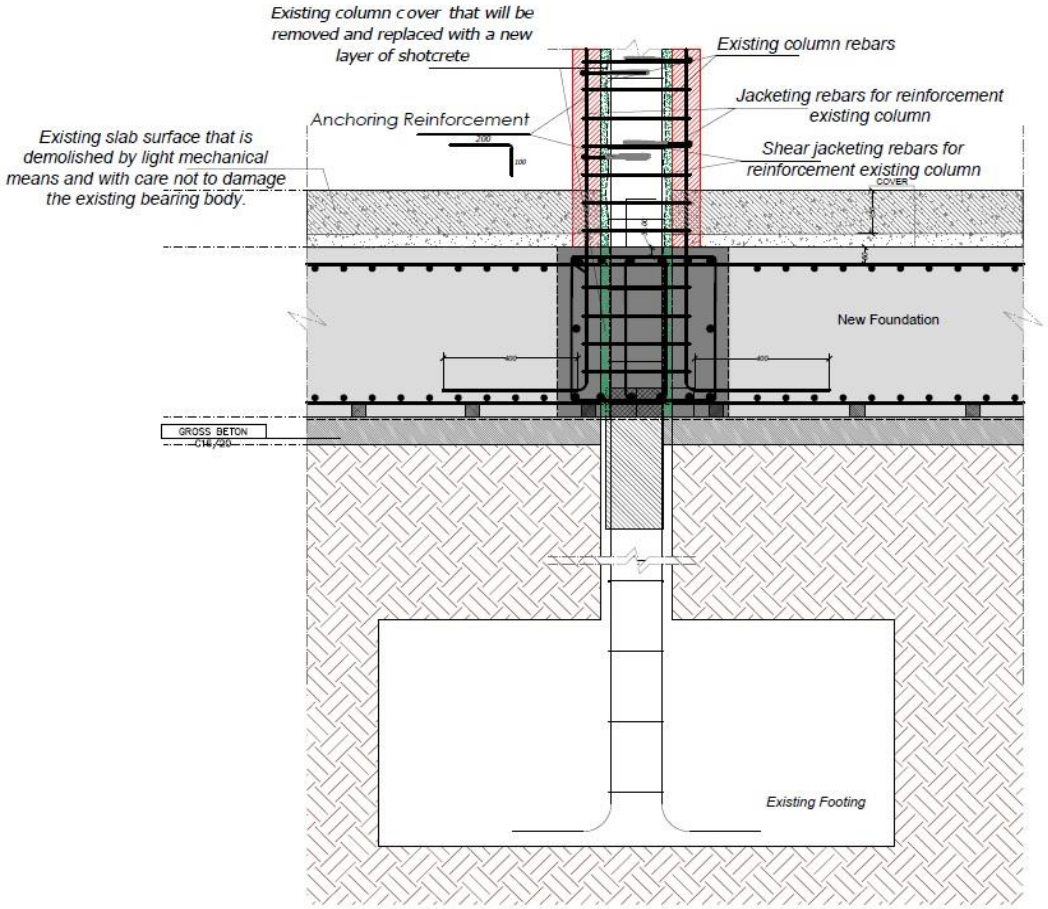
STRENGTHENING OF THE EXISTING BUILDING

(Jacketing Detail of existing columns and foundation strengthening)



STRENGTHENING OF THE EXISTING BUILDING

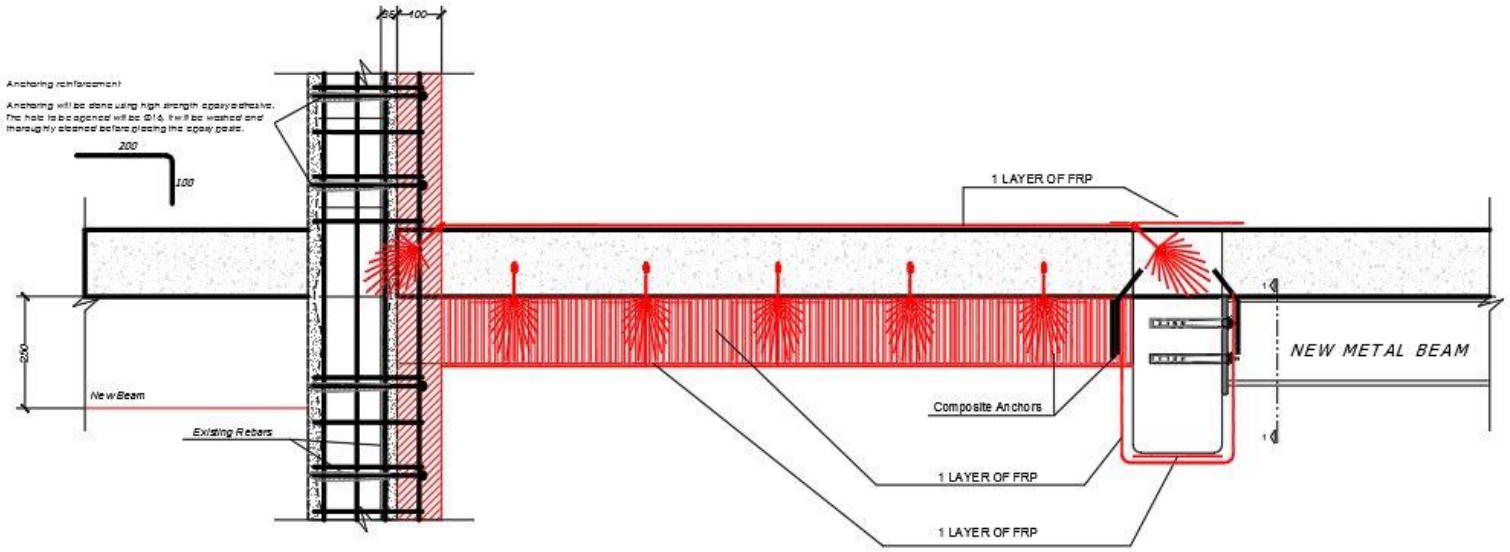
(new mat foundation which encased existing ground beams)



STRENGTHENING OF THE FOUNDATIONS OF THE EXISTING BUILDING

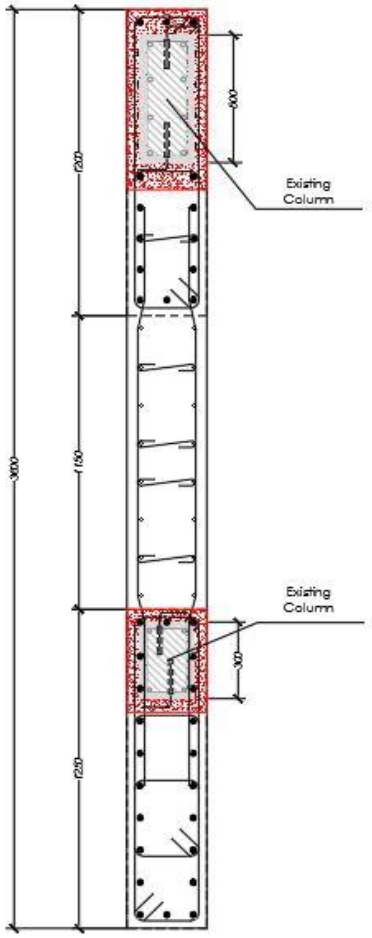
STRENGTHENING OF THE EXISTING BUILDING

(Fibre Reinforced Polymers (FRP) - strengthening of beams /slabs)



STRENGTHENING OF THE EXISTING BUILDING

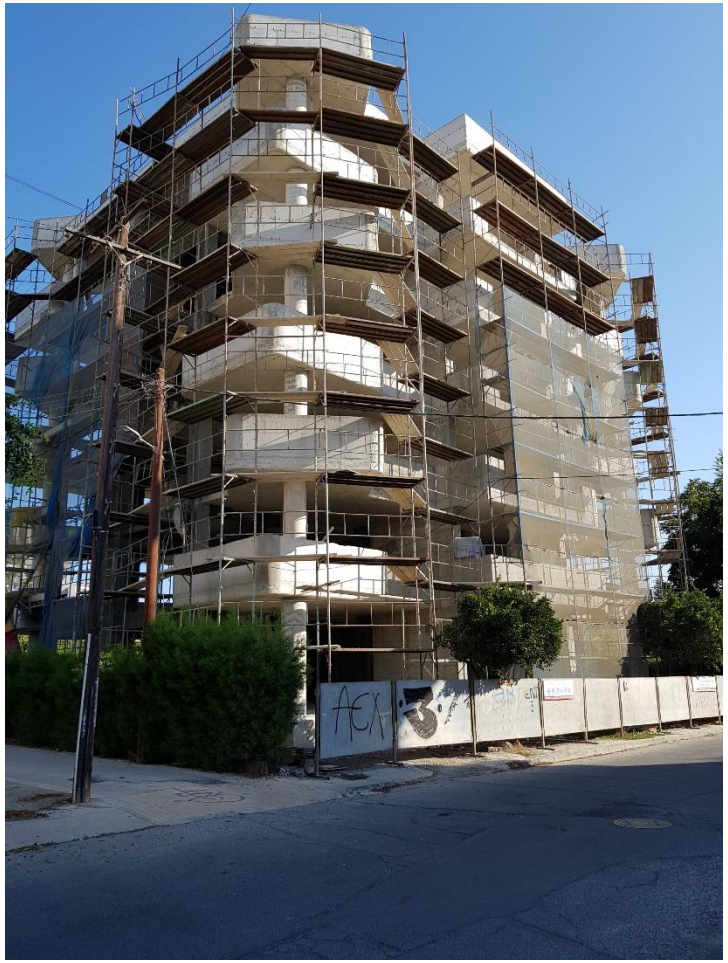
(formation of shear walls from existing columns)

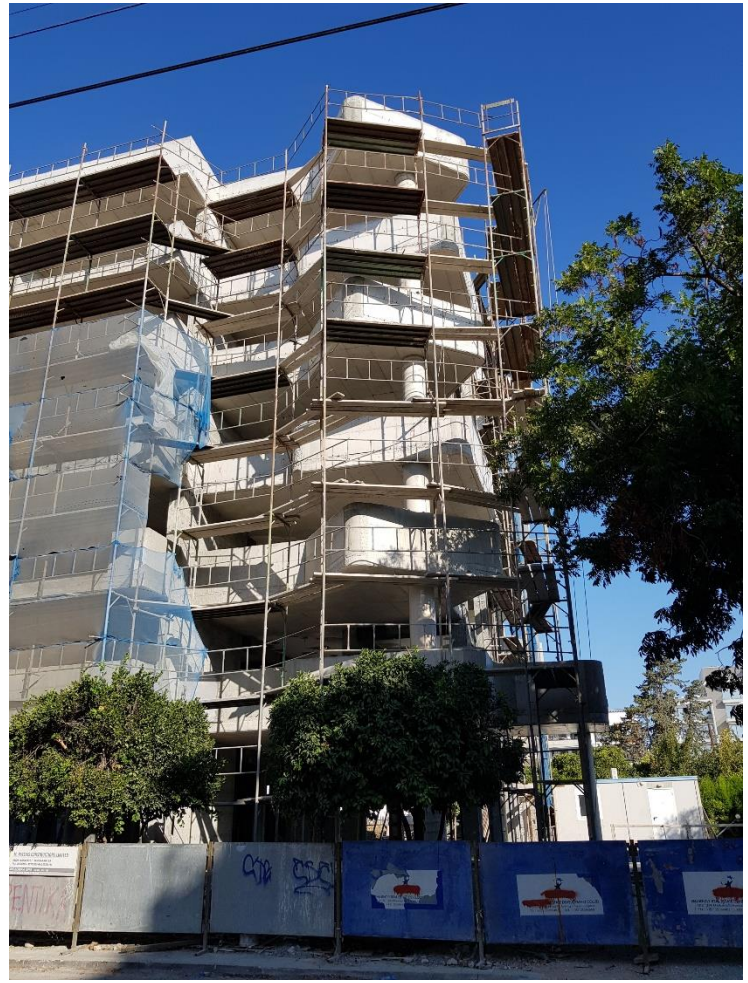


STRENGTHENING OF THE EXISTING BUILDING

(Jacketing Detail of existing columns)

- Photos after the structural/seismic strengthening





9.0 Economic aspect

- The need for investing on the upgrade of existing buildings and infrastructure is not only a humanistic duty. It is also an issue of …Respecting the value of life.
- Demolition and reconstruction programs are usually economically unaffordable.

SAFETY MUST COME FIRST

- It is reasonable to state that in countries with high seismic risk it is economically ''foolish'' to **invest on energy efficiency measures on unsafe buildings.** ….We put a new skin on an old and unsafe structure…..

- As it is well known if buildings are cladded and insulated, then they may look new but their underlying structural issues remain, hidden, unseen and unassessed **and may become life-threatening, especially in case of a major seismic event leading to a collapse.**

We need a new approach

- We need a European policy on vulnerability assessment and on retrofitting measures.

- A solution needs to be found so that funding can be given for work on structural assessment, strengthening and upgrade as well as energy efficiency work. Decision-makers need to comprehend the huge responsibility undertaken **when ruling that energy efficiency measures only,** would be funded by the EU. The new trend is smart financing for smart buildings. But, a building can only be called smart when it is safe and secure.

- **The new trend nowadays is … smart financing for smart buildings.**

But, a building can only be called smart …. once it is ….

"safe, sound and sustainable" -the three S Approach-.

- **So, as ECCE we thinking to declare year 2020 as …**

The Year of the three S Approach (ECCE Moto for 2020).

THANK YOU FOR YOUR ATTENTION!