NON STRUCTRAL MATERIALS RELATED FOR DISASTER RESISTANT MUSEUMS

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ABSTRACT:
All control mechanisms in the world try to establish new systems in a disaster to mitigate the risks. There are many engineering approaches to seismic safety for buildings. Lessons learned from many catastrophic disaster that not only structral elements but also non structral elements are essential to mitigate the loss of life and property. For buildings one of the most important issues in mitigating casualties is the set of existing buildings with non structral materials.
Govermental institutionals apply with priority classifications for construction award to consctuction companies: Building replacement or reconstruction in order to establish disaster resistant buildings or to renovate insufficient spaces, new constructions, consolidations, reorganizations, to correct project problems, to redesign projects.
As a first step a seismic vulnerability survey should be done at the buildings (include buildings stuffs, visitors and objects which are existed at exhibiton and storage areas). Earthquake engineers focus both the structural integrity of buildings and of the elements of buildings (such as dividers, decorative elements, furniture, fixtures). Knowing the vulberability of both (building and its contents) is essential to a succesfull mitigation plan.
Non structural risks mitigation strategies are essential for preparing destructive disasters. In addition to understanding the behavior of non structral materials, elements and systems, museums are selected at study project. The study summarizes a risk assesment model at the museum buildings.
Goals of the study are saving lives (visitors and personnel), museum objects , protecting cultural heritage and properties, the importance of non structural risk mitigation, awareness of earthquake engineers and groups who are involved in the construction sector.
The study methodology: Historical museum buildings risks are defined with non structral based assessment according to some risk criteria. It has been emphasized non structural risks in general risks and importance their role at mitigation against to disasters.

KEY WORDS:
Non structural materials for seismic safety, disaster mitigation of museums, historical museum buildings, vulnerability risk analysis.

1. MUSEUMS AND NONSTRUCTRAL RISKS:

Earthquakes are catastrophes which developed suddenly and caused economic and social loses. Disasters may come in a variety of shapes, sizes and intensity including: Fire, Flood, Subsidence, Structural collapse, Chemical leaks, Explosions, Adverse climatic conditions, Civil Unrest [1]
The museum buildings which the article's subject become vulnerable by disasters and artifacts can not compensate and can not return backward with harmful destruction.
The potential earthquake risk as all over the world exists %98 of the area of the Turkey. (North Anatolian Fault Zone (NAFZ) and East Anatolian Fault Zone (EAFZ) have the potential to produce earthquake activity
The city of Istanbul has hundreds of years historical past and it is a world heritage. It has many movable and immovable properties. Reducing likely risks of museum and museum artifacts is beneath earthquake engineering.
Museums preserve, interpret and promote the natural and cultural inheritance of humanity. They have a primary responsibility to protect and promote this heritage as well as the human, physical and financial resources made

available for that purpose. [2]
Earthquake engineers undertake most important role for renovation and restoration works which are done at the new museums construction and existing museums. It is emphasized that following priorities for museums:

- Defining the key areas at the building.
- Ground analysis which beneath museum building.
- The measures which supply visitors and stuffs life security.
- The measures which reducing artifacts and building materials damage risks
- Preparing evacuation plans for visitors, stuffs and artifacts.

There are two modifying various for reduction measures: Structral modifying and non structral modifying. In non structral modifying, appropriate non structral measures shall be taken to ensure the proper application of the key areas which are defined in the museum building. The term " Structural modifying" covers strengthening of main components of building. Non structural measures shall be taken at following levels in the museums:

- To apply to visitors and stuffs
- To apply to building
- To apply to artefacts

Earthquake engineers work intensely on risk mitigating modern technologies in recent years. Culture sponsoring and their increasing role as tourist attractions are guarantees for an ongoing boom in museum construction. A tradition and typology developed over the centuries, the experience gained in recent decades and cutting-edge technology all contribute to the practice of modern day museum building.[3]
All risk factors which will be applied to building must be taken consideration. It should be analyzed ground beneath museum whether prone to disasters such as earthquake and fire or not. Criteria should be defined which would ensure optimum building design.
Primarily, analyzing seismic health of building is required by earthquake engineers and according to result, it has defined priorities and reveal implementation strategies. Structural engineers and seismic engineers are invaluable and necessary for a good review of building's structure and foundation. It is also vital that these consultants understand what building's risks. Seek assistance from a structural engineer regarding both the structural integrity of building and of the elements of building (such as added gallery dividers, decorative elements, furniture and fixtures.) [4]
Vulnerable museum parts must be analyzed by museum vulnerability survey. Nonstructral systems health monitoring must be done most particularly at key areas such as exhibition and storage areas. Risks should be recorded on format survey forms. Surveys at the museums begin with categorizing the measures into 3 categories; easy, medium and hard to apply. [5]
Nonstructral partions of a building include every part of the building and all its contents with the exception of the structure in other words, everything except the columns , floors, beams etc. Common nonstructural components include ceilings, windows, office equipment, computers, inventory stored on shelves, file cabinets, heating, ventilating and air conditioning (HVAC) equipment, electrical equipment, furnishings, lights etc. [6]
If these defines apply to museum buildings, key areas come to fore in view of non structural components. Principally, life safety and secondly artifact safety are considered. Failure of fixed ceiling components (suspended ceiling panels, piping systems for fire, HVAC, lighting etc.) effect life safety as well as non compensable events of artefacts. Some of nonstructural risks as follows: Collapsing heavy case and exhibited artifacts, breaking case and building glasses, collapsing ceiling components falling into place, artifacts which suspended on walls, inadequate fire systems, using non fire resistant materials, collapsing precast concrete panels, collapsing walls, parapets, fences (stairs and entrance-exits doors), Falling components which anchore to interior surfaces.


Figure 1 Removing suspended ceiling components for pre-risk analyse of restoration project , fixtures by pillars to protect artifacts at Istanbul Fire Brigade Museum. (left) and Damage to suspended ceiling and recessed ceiling lights, Philippines, Earthquake Engineering Research Institute (right)

Building components should be specialized since museum buildings are commonly huge and multi-story complex. Particularly historical buildings which serve as museums have risks which caused by non structral components. Because , modern nonstructral components install afterward. So, they should use with earthquake engineering scientific basis and should maintain sustainability. The lack of attention to nonstructural systems and their increasing complexity have resulted in the majority of dollar losses to buildings in recent earthquakes. [7] In terms of "historical building" is defined with their construction materials, age of building, construction system, function and environment.

2. CASE STUDY

The city of Istanbul, Eminonu district museum buildings are selected as case study. Study has been emphasized; museums all operate in historical buildings likely nonstructural risk analysis and measure against to disasters and applying results as a modal to planning museum buildings.

Istanbul connects two continents. Its history has been the capital to Roman, Byzantium and Ottoman Empires and keeps its importants each term of history. Istanbul city has 32 districts and Eminonu is one of them. Eminonu district exists at Historical Peninsula which is registered as world heritage by UNESCO at 1985.

There are 16 museums at Eminonu district. Mostly are belong to Culture and Tourism Ministry and Govermental Institutions, some of them have the characteristic of private.

It is planning that many new museums projects will be conducted by Culture and Tourism Ministry at "Sur-u Sultani Project" content while expanding Topkapi Palace Museum area. Ministry will provide it till Istanbul 2010 European Culture Capital celebrating activities.

It is possible to say that age of Istanbul historical buildings changing between 1500-1600 years and 50-60 years. As construction materials which are stone, squared stone, brick, mortar, wooden and iron are used to produced its own date. Many buildings which have different functions (such as Mosque, medresah (school), tomb, palace, church, han (caravansarai), hamam (bath), residence) construction systems different from each other. Some of them carry the traces of past earthquakes most of them are neglected and need restoration. [8]

All museum buildings which serve at Eminonu district are historical buildings. Nonstructural materials are installed afterward. Among these buildings most modern non structural materials are used at Is bank Museum and Islamic Science and Technology Museum which is renewed initiated by Istanbul Metropolitan Municipality and Culture and Tourism Ministry. Topkapi Palace Museum "Holy Relics" section is modified with modern nonstructural materials and exhibition techniques at recent days. Is Bank Museum is designed disaster resistant non structural materials such as windows, doors, glasses, light fixtures, anchoring control panels and electronic devices, piping fixtures, ceiling, intallation of heating, ventilation and air conditioning systems, wall, floor materials and finishes

Figure 2 Using nonstructural materials at Is Bank Museum, Istanbul

At "The Study on A Disaster Prevention / Mitigation Basic Plan in Istanbul including Seismic Microzonation" project which is granted to JICA by Istanbul Metropolitan Municipality (IMM), " Estimated Building Damage by districts" investigation declare 14.149 total building number of Eminonu district, % 13.9 heavly, % 26.8 heavily and moderately, % 48.8 heaviliy, moderately and low likely damage. [9]
According to fire risk perspective, risk exists due to Eminonu district's 3 million population in day time and thousands shops. Fire risks are increased due to old settlement area , narrow roads, afterward installed electrical systems. In the "Istanbul Fire Risk Map" has been prepared by IMM Fire Brigade Department, it is considered last decade fire information, industrial buildings, narrow roads, forest areas, historical areas, high voltage lines. According to results of this study will be replanning location of fire brigade stations. At this study, Eminonu district is defined one of the first level fire risk areas which causes huge life and property loses start with sudden explosion. [10]

3. SEISMIC VULNERABILITY ANALYSIS

Proposed methodology for assessment of seismic vulnerability of existing historical museum buildings defines the application of a simple model to describe nonstructural risks. In this mode, it is utilized age of buildings, seismic intensity and vulnerability of collections and other risks related to buildings.
"Istanbul Seismic Intensity Map" has been prepared with JICA Microzonation projects which granted by IMM. [11] According to this map, seismic intensity of Eminonu is changing between 8-9 and 10 values.

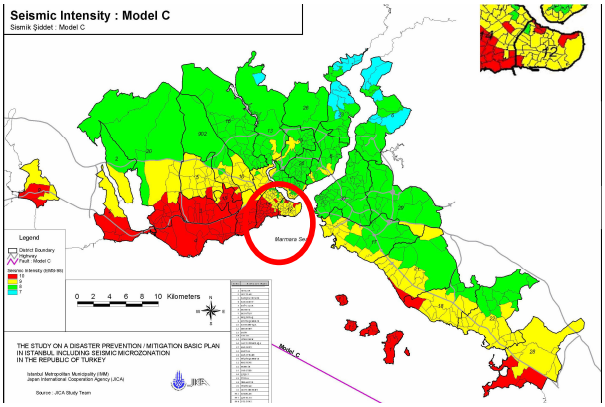


Figure 3 Istanbul Metropolitan Area Seismic Intensity Model C , JICA Report [11]

According to ground characteristic, Eminonu district has alluvium with low-loading capacity with increase probability of landslides on slopes reaching 14^{o}–15^{o} (5) and rock with highloading capacities except on the slopes (13). Areas are shown by 13 number at the map, have low risk due to high loading capacity more than areas are shown by 5 number due to likely landslides risk.

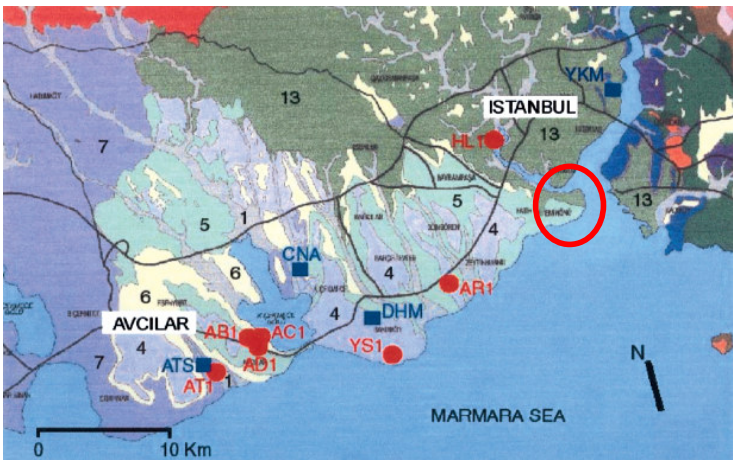


Figure 4 Istanbul Metropolitan Area Geotechnical Bearing Capacity Map [12]

Collections' characteristics, museum buildings' construction date and number of artifacts as follows:

1.TOPKAPI PALACE MUSEUM
Date of Construction: 1478 **, Number of Artefacts:** 80000 **; Collection:** Chinese and Japanese porcelains, Ottoman and Yildiz porcelains, Euroepan porcelains and silvers, glass objects, kitchen sets, kaftans, garments, objects of Imperial Treasury, Sultan's portraits, miniatures, Holy Trusts, weapons, carriages, inscriptions and architectural pieces, clocks, seals, handwritten manuscripts, fabrics and etc.

2.AYASOFYA(HAGIA SOPHIA) MUSEUM
Date of Construction: 537 **, Number of Artefacts:** 3054 **; Collection:** Mosaics, the sections of Koran, plates

3.THE GREAT PALACE MOSAIC MUSEUM
Date of Construction: 550 **, Number of Artefacts:** 126 **; Collection:** Mosaics relavant to the Great Palace

4.AYA IRINI (ST. IRENE) MUSEUM
Date of Construction: 532 **, Number of Artefacts:** 70 **; Collection:** Mosaics and frescoes

5.TURKISH AND ISLAMIC ART MUSEUM
Date of Construction: 1520 **, Number of Artefacts:** 40000 **; Collection:** Carpets, prayer rugs, Korans, hand writings, the Sultan's signatures, Turkish and Iranian miniature writings, the samples of wood art, stone works, ceramics, mosaics, mihrab and wall encaustic tile samples, glass objects, stells, inscriptions, tiles, carpet workbenches, fabrics, clothes, house goods, handicrafts, handicraft tools, nomad tents and etc.

6.TOMBS MUSEUM (120 Tombs)
Date of Construction: App. 1680 **, Number of Artefacts:** 1758 **; Collection:** Tombs

7. ISTANBUL ARCHEOLOGICAL MUSEUM
Date of Construction: 1891 **, Number of Artefacts:** 705000 **; Collection:** Stone objects and mosaics dated to Greek, Roman and Byzatium Civilizations, sculptures, columns, column capitals, architectural elements, relieves, potteries, small stone objects, terracotta figurines, metal and glass objects, coins and etc.

8.CALLIGRAPHY MUSEUM
Date of Construction: 1508 **, Number of Artefacts:** 3638 **; Collection:** Calligraphies, manuscripts and framed inscriptions, Qurans, treatises, the Sultan's monograms and etc.

9.CARPET MUSEUM
Date of Construction: 1617 **, Number of Artefacts:** 448 **; Collection:** Carpets, pileless carpets and prayer rugs

10.KILIM MUSEUM
Date of Construction: 1617 **, Number of Artefacts:** 500 **; Collection:** Kilims

11.ISLAMIC SCIENCE AND TECHNOLOGY MUSEUM
Date of Construction: 1890 **, Number of Artefacts:** 140 **; Collection:** Among the objects in the museum are replicas of inventions and discoveries by Muslim scientists dating to the period between the eighth and 16th centuries, ranging from items used in the fields of astronomy, geography, chemistry and geometrics to optics, medicine, architecture, physics and war technologies.

12.ISTANBUL RAILWAYS MUSEUM
Date of Construction: 1890 **, Number of Artefacts:** 300 **; Collection:** A variety of railway objects and photographs.

13.IS BANK MUSEUM
Date of Construction: 1892 **, Number of Artefacts:** 168 **; Collection:** Documents, banking tools, communication

devices, photos, pictures, advertisement and promotion materials, films relevant to the Is Bank

14.PTT (POST- TELEGRAPH-TELEPHONE-) ISTANBUL MUSEUM

Date of Construction: 1909 **, Number of Artefacts:** 1812 **; Collection:** Post bags, post boxes, maps, automatic stamping machines, telegraphs, telephones, switchboards, various stamps and etc.

15.PRESS MUSEUM

Date of Construction: 1865 **, Number of Artefacts:** 125 **; Collection:** Objects relavant to the press technology, newspapers, private possessions and portraits of the important journalists, skecth of the first Turkish printing house, photographs, cameras, press tools and etc.

16.REPUBLIC EDUCATION MUSEUM

Date of Construction: 1454 **, Number of Artefacts:** 450 **; Collection:** A black board which is written Turkish letters firstly by Ataturk, pictures relavant to pre republic term, school registering notebooks, diplomas dated different terms, scoring and recording notebooks, documentation related to schools, newspapers, medals and education tools. [13]

Age of building, seismic intensity, loading capacity, building density, road width, distance to fire brigade centers, number of artifacts are defined general risks.

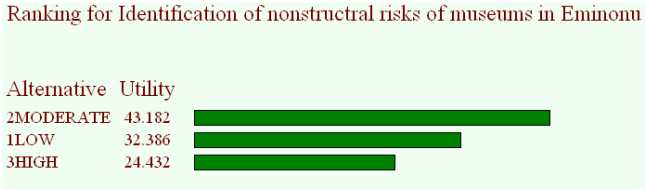
Applied to building nonstructural components and techniques are defined as earthquake and fire risks.

Risks are defined caused from nonstructral components such as building utility systems (such as electrical, mechanical, piping, smoke and fire detection, HVAC, roof solar systems) ; architectural components (such as doors, windows, ceilings, lighting, panels, parapets) ; furniture and contents (such as computer and communication equipments, storage components, shelves, furnitures) (Table 3.1.)

Risk data is shown with their total scores at risk index table. (Appendix 1)

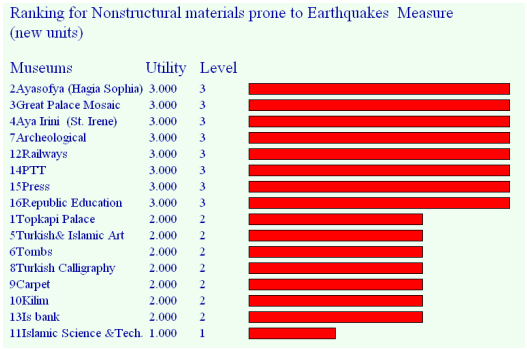
Table 3.1 Type of Risks and Criteria

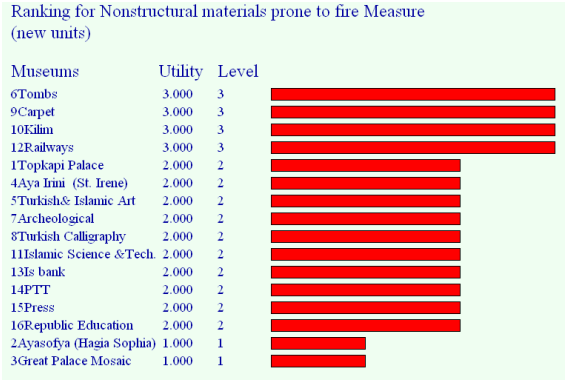
Type of Risks		Criteria:	Freq.:	Percent. (%):
GENERAL RISKS	**Age of building**	1-100 years 100-500 years > 500 years	1 10 5	6.25 62.5 31.25
	Seismic intensity	8 Low 9 Moderate 10 High	12 2 2	75 12.5 12.5
	Loading Capacity of soil beneath museum	Low loading capacity High loading capacity	8 8	50 50
	Building density	0-15.63 Low 15.64- 32.37 Moderate 32.37-170.70 High	12 3 1	75 18.75 6.25
	Road width	>15 m. width Low 7 m.-15m. width Moderate 2 m.-6 m. width High	0 14 2	0 87.5 12.5
	Distance to fire brigade centers	Low Moderate High	5 7 4	31.25 43.75 25
	Number of Artefacts	0-1000 Low 1001- 10000 Moderate >10000 High	9 4 3	56.25 25 18.75
EQ	**Artefacts prone to EQ risk**	Low Moderate High	5 9 2	31.25 56.25 12.5
	Materials prone to EQ risk (Building Utility Systems , Architectural Components, Furniture and contents)	Low Moderate High	1 7 8	6.25 43.75 50
FIRE	**Artefacts prone to fire risk**	Low Moderate High	5 7 4	31.25 43.75 25
	Materials prone to fire risk (Building Utility Systems , Architectural Components, Furniture and contents)	Low Moderate High	2 10 4	12.5 62.5 25



All data is utilized at "Logical Decision Software" which is Multi Attribute Risk Analysis Software. It is done vulnerability analysis for nonstructural components of historical museum buildings with this software. Estimated vulnerability analysis (Total risk, according to nonstructural materials prone to EQ and Fire risks) is defined for each museum.

Table 3.2 Risk Analyses





At risk analysis, if all risks weight is pegged (w=1) materials prone to EQ risk' weight (w=90) is given total risk = 47.188 (High), 43.688 (Moderate), 9.125 (Low) . With same method materials to Fire risk weight (w=90) is given total risk= 60.375 (Moderate), 24.938 (High), 16.688 (Low). (3.1.)

$$V = (wi \cdot ei) \qquad \text{for } i = 1, n \qquad (3.1.)$$

V = vulnerability level
wi = weighting coefficient
ei = vectorial value estimated for the impact element
n = total number of impact elements

CONCLUSION:

- Buildings has high risk according to vulnerability analysis, if nonstructural materials prone to EQ.
- At museum building vulnerability analysis is detected artifacts dropping risk, suspended ceiling materials dropping risk, fire risk, failure anchoring risks and breaking glass (case and windows) risks.
- Necessity of seismic isolation techniques to artifacts and building, problems related to piping and problems related with ceiling components are come to fore.

- The likely demolition of nonstructural components is a disaster and respectively disaster for surrounding components and artifacts.
- It is significant that choosing low cost and disaster resistant materials for museum buildings.
- Preventing risks which is cause by anchoring, maintenance of piping systems is essential periodically.
- Fire spaces at visitors circulation areas should be design prevent expanding the fire exhibition areas. Key areas (exhibition and storage) and evacuation corridors should be safe non-toxic material for painting, non-slippery material for floor covering, dry firefighting systems for fire fighting.
- Low cost and user friendly seismic isolators should be used at artifacts such as statues, vases which have balance risk due to their height and basement instability.
- At Seismic Risk Mitigation and Emergency Preparedness Project (ISMEP) which is conducted by Istanbul Governorship and granted by World Bank some of risky historical buildings are selected. Topkapi Palace Museum- Mecidiye pavilion, Archeological Museum Annex and Classical Building, Aya Sofya Museum, Aya Irini Monument are involved to project content due to defining their earthquake performances and applying rehabilitation projects. It is essential these efforts expanding to other risky historical buildings.
- Receiving technical advisory for reducing risks of museum key areas with disaster resistant low cost modern non structural mitigation techniques and defining strategies.
- It is essential to measure precautions disaster risks on heating, air conditioning and ventilation systems.
- Valid building codes which implement in Turkey should redesign according to nonstructural risks.

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Appendix1 Risk Index table

No.	Name of Museum	Age of Build.	Seismic Int	Load. Cap.	EQ .Art.	EQ. Mat	Buil dens	Road Wid. (m)	Dist. to fire brig.	FIRE Art.	FIRE Mat	No. of Art.	SCORE
1	Topkapı Palace M.	3	2	1	2	2	1	2	1	2	2	3	21
2	Ayasofya (Hagia Sophia) M.	3	2	3	2	3	1	2	1	1	1	2	21
3	Great Palace Mosaic M.	3	2	3	2	3	1	2	2	1	1	1	21
4	Aya Irini (St. Irene) M.	3	2	1	2	3	1	2	1	1	2	1	19
5	Turkish& Islamic Art M.	2	2	3	2	2	2	2	2	2	2	3	24
6	Tombs M. (120 tombs)	2	2	2	2	2	1	2	2	3	3	2	23
7	Archeological M.	2	2	1	2	3	1	2	1	2	2	3	21
8	Turkish Calligraphy M.	2	2	3	1	2	1	1	3	3	2	2	22
9	Carpet M.	2	2	3	1	2	1	3	2	2	3	1	22
10	Kilim M.	2	2	3	1	2	1	3	2	2	3	1	22
11	Islamic Science &Tech. M.	2	3	1	1	1	1	2	2	1	2	1	17
12	Railways M.	2	3	1	3	3	1	2	2	3	3	1	24
13	Is Bank M.	2	2	1	1	2	2	2	3	1	2	1	19
14	PTT M.	1	3	1	3	3	2	2	2	2	2	2	23
15	Press M.	2	2	3	2	3	3	2	2	2	2	1	24
16	Republic Education M.	3	2	3	2	3	2	2	2	3	2	1	25

Appendix 2 Dynamic Risk Analyse Table.