Noise Risk Management In Buildings According To The Leadership Systems In Energy And Environmental Design

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Abstract

Throughout the ages, acoustics is one of many important design considerations required for managing the noise risks within buildings to achieve the required indoor acoustical comfort and improve the building performance depending on the available materials and implementation technologies, through the latest global initiatives in involving the acoustical performance as required assessment element within sustainable rating systems such as "Leadership in Energy and Environmental Design (LEED) in United States of America or Green Pyramid Rating System (GPRS) in Egypt" in the term of indoor quality assessment, the noise risk management become a prerequisite requirement to qualify buildings and prepare it to be certified. The research illustrate a set of smart architectural precautionary practices associated with different buildings layers "site and urban planning layer, building skin layer and room separators layer". The presented study highlights the using of certified, smart and eco-friendly solutions with good treatments for joints between building elements to avoid the airborne or impact noise flanking by understanding the nature of building's function, area of treatment and sound paths scenarios to reach a set of results and generate recommendations according to the study that aid to support in upgrading the Egyptian code for acoustics works and noise control as one of the important design references with new advanced precautionary practices in managing the noise risks and helps the architect to achieve the indoor permitted noise level to qualify his designs to be LEED or GPRS certified to reach architectural and urban sustainability in the new Egyptian urban sprawl.

Keywords:
Smart solutions, Egyptian code for acoustics works and noise control, Building layers, LEED/GPRS rating systems.

الملخص:

علي مر العصور، كانت الإعتبارات الصوتية واحدة من أهم الإعتبارات لإدارة مخاطر الضوضاء في المباني وذلك لتحقيق الراحة الصوتية داخل فراغات المباني وتحسين أداء المباني بإستخدام مواد البناء وتقنيات التنفيذ المتاحة في كل عصر من العصور، فمن خلال المبادارات العالمية الأخيرة نجد تضمين الإعتبارات الصوتية المعمارية كأحد أهم عناصر تقييم جودة البيئة الداخلية بأليات تقييم المباني البيئية المستدامة الحديثة مثل نظام الليد لتقييم المباني البيئية والمستدامة بالولايات المتحدة الأمريكية ونظام الهرم الأخضر لتقييم المباني البيئية والمستدامة في مصر لكي تصبح إدارة مخاطر الضوضاء هي أحد المتطلبات السابقة لتهيئة المباني للإعتماد بيئيا باستخدام أليات التقييم. يوضح البحث من خلال هذا السياق مجموعة من الممارسات الإحترازية الذكية لكافة عناصر المبني والمقسمة لمجموعة من الطبقات والأغلفة المقترحة بما يتناسب مع موضوع الداراسة وهي " الموقع والتصميم العمراني – الغلاف الخارجي للمبنى – الفواصل

الداخلية لفراغات المبنى". تهتم الدراسة وتلقي الضوء أيضا علي أهمية إستخدام مواد البناء والحلول المعمارية المعتمدة والذكية والصديقة للبيئة مع الأخذ في الإعتبار معالجة وإحكام الفواصل بين عناصر المبنى المختلفة لتجنب التسريب الجانبي للضوضاء مع التأكيد علي الفهم الجيد لطبيعة ووظيفة الفراغات ومكان المعالجة الصوتية السليمة وسيناريوهات حركة الصوت خلال الفراغات، للوصول في نهاية الدارسة إلي مجموعة من النتائج والتوصيات التي تساهم في تطوير وتحديث "الكود المصري لأعمال الصوتيات والتحكم في الضوضاء" كأحد أهم المراجع التصميمية التي يعتمد عليها المعماري لتحقيق المستوي المطلوب للراحة الصوتية داخل الفراغات المعمارية والتي تعتمد عليها ألية الهرم الأخضر لتقييم المباني البيئية والمستدامة في مصر كمرجع داعم لعملية التقييم ببعض الممارسات الإحترازية الذكية مجال هذا البحث وذلك لحتمية تحقيق الإستدامة للعمارة والعمران للإمتدادات العمرانية الجديدة في مصر.

الكلمات المفتاحية:
الحلول الذكية،الكود المصرى لأعمال الصوتيات والتحكم فى الضوضاء،أغلفة المبنى،أنظمة تقييم المبانى البيئية والمستدامة

1. Introduction

In Egypt, the code of acoustics works and noise control that established and developed by housing and buildings research center (HBRC) in 2013 illustrates in a 7 chapters a set of practices and standards for improving acoustic performance inside buildings, these practices are traditional and did not keep pace with development and global initiatives, which need to develop the Egyptian code for acoustics to conform to the leadership systems in energy and environmental design, the research aim to support this practices with smart techniques and materials to be up to date with the development in building materials industry and global initiatives in sustainable assessment to all building elements. Therefore, the research field is studying the new smart and latest acoustical precautionary practices for enhancing the indoor quality and pillar to face the must of upgrading the Egyptian code for acoustics works as an important reference for architects and builders.

2. Research Objectives And Methodology

2.1 Research Objectives

The research main objective is to illustrate the smart acoustical precautionary practices to building elements by achieving equivalent concept between the completed element component using ecofriendly/smart solutions to upgrade the Egyptian code for acoustics works chapters and managing the noise risks to qualify buildings to be LEED or GPRS certified by achieving the following: 1- Identifying the noise terminologies sources, its path scenarios and its control areas. 2- Studying the planning options and alternatives to determine the best in improving the acoustics performance. 3- Identifying the smart solutions that have a distinctive physical properties in noise control. 4- Dividing the building to layers contains the building basic elements. 5- Determining the acoustics prerequisite requirements mentioned at sustainable rating systems such as LEED and GPRS. 6- Analyzing the acoustics code chapters to determine the areas needed to be supported and upgraded.

2.2 Research Methodology

There are three methods used to achieve the research objectives:

1- Descriptive method: There will be an introduction to noise and its terminologies from the relevant references, explaining the initiatives of specialized institutes and manufactures to develop the materials properties and architectural solutions to improve the acoustics performance, studying the prerequisite requirements that enhance the indoor quality mentioned in the sustainable rating systems. **2- Analytical method**: analyze the building layers and determine its basic elements to suggest the best acoustical options for each layer. **3- Conductive method:** Apply the main smart architectural precautionary practices produced from descriptive and analytical methods and use of (LEED) in United States of America and (GPRS) in Egypt to upgrade the Egyptian code for acoustics works as an important reference for architect and supportive to GPRS assessment.

2. Noise Control Within Buildings

There are four issues and main terminologies must be defined to manage noise risks and their impact on building performance, the first issue is defining the noise sources and its nature, the second is defining the sound path scenarios and its phenomena, the third is determining the building element that need the acoustical treatment, and the forth issue is determining the noise control area.

2.1 Noise Sources and Its Nature

The noise from traffic, equipment, railway, construction, workshops and factories leaks into building through air ducts/joints/cracks/reveals between building elements, it transmitted into buildings by both air-borne noise and structure-borne noise.

A. Air-borne Noise:

Sound that transmitted through the air, might be generated by speech, television, radio, animal sounds, and transportation.

B. **Impact Noise:**

Is a form of structure-borne sound that occurs when parts of a building structure is excited, the vibrations are transferred as sound pressure to other parts of the structure, might be generated by footsteps, scraping furniture, vibrations from loud music and plumbing, impact sound can travel through solid structures and through cavities [1][1].

2.2 Sound Path Scenarios in a Space

The sound moves through paths that form a set of phenomena which are “Transmission, Absorption, Reflection and Diffusion” as illustrated in the following Table 1. The concept of sound isolation is a reduction of sound level in case the sound passes through materials, this reduction is a result of the ability of materials absorption, reflection and diffusion.

Table.1. Sound paths scenarios through spaces, Author based on [2][2].

Transmission	Absorption	Reflection	Diffusion
			
The passage of sound from one point to another, as from one room to another, or from a street to a room.	When the sounds strike the absorbent and reflect, but the energy of reflection is reducing significantly.	When sound waves strike a surface, they reflect off of that surface and can return causing an echo.	Diffusion in simple terms is the scattering of sound energy.

These phenomena can occur individually or in combination, so the architect must understand and follow the sound paths in the space to be able to create the best scenario for taking the best architectural decision.

2.3 Building Layers and Elements

More than international organizations such as (Canadian institute of quality surveyors CIQS – The royal institute of chartered surveyors RICS-UK – Construction Economics European committee CEEC - General Services Administration GSA) worked on dividing the building into a set of basic elements, called "building elements" as illustrated in the following Table.2.

Table.2. building elements according to GSA-CEEC-RICS-CIQS organizations, Author based on [3] [4] [3-4] .

(GSA)	(CEEC)	(RICS-UK)	(CIQS)
Substructure	Substructure	Substructure	Substructure
Superstructure	Superstructure	Superstructure	Structure
Exterior Closure	Finishes	Internal Finishes	Exterior Closure
Roofing	Equipment & Services	Fittings & Furniture	Partitions & Doors
Interior Construction	External Site Work	Services	Finishes
Mechanical		External Work	Fittings & Equipment
Electrical			Mechanical
Equipment			Electrical
Site Work			Site Work

From the previous classification illustrated in Table. 2. There are many building layers included in the building elements classifications, these layers affect the noise insulation as a requirement to improve the indoor environment quality. The first layer is "Site and urban planning layer", the second is "Building skin layer" and the third is "Room separators layer" which are the separating walls/floors between adjacent rooms. Thus, it is possible to come up with a division and classification of building elements based on the layers' concept in proportion with studying acoustics and noise control as illustrated in the following diagrammed Fig.1.

BUILDING LAYERS

Site And Urban Planning Layer	Building Skin Layer	Room Separators Layer
Includes;1-Site urban planning 2-Landscaping	Includes; 1-Opaque and Transparent elements 2-Roofing 3-External Finishes	Includes; 1-Separating walls 2-Separating floors 3-Doors 4-Internal Finishes 5-Services

Fig.1. Building layers and its elements, Author.

2.4 Noise Control Area

For the best managing acoustical and the noise risks, the architect must consider the area (source – path – receiver) that need treatment in order to obtain the satisfactory results as illustrated in the Fig. 2.

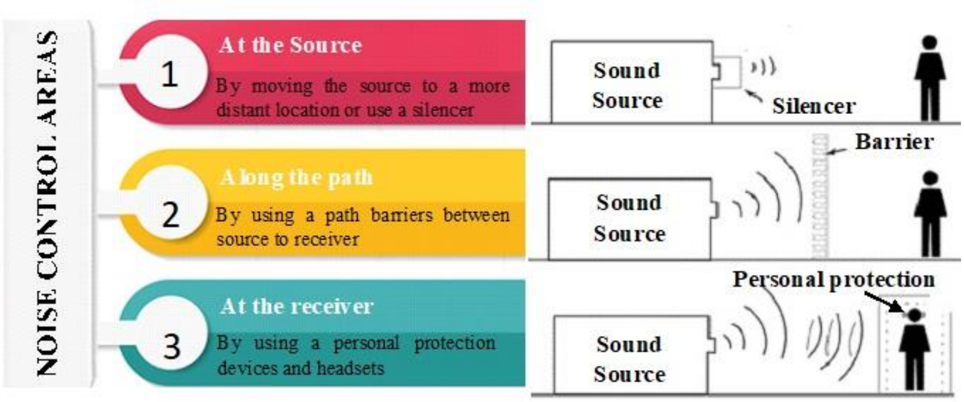


Fig.2. Noise control area, Author based on [5][5].

3. Noise Risk Management To The Building Layers

Determining the noise control area and understanding the sound paths scenarios concept are linked architecturally to suggested building's layers and thus related to its acoustical practices, the following presented part illustrate the precautionary practices to manage noise risks to achieving the satisfactory acoustical performance within buildings.

3.1 First Building Layer: Site and Urban Planning

Urban planning decisions help to control the noise along the path, there are two common urban planning options which are "grid urban planning and cluster urban planning" as illustrated in Fig.3, the cluster urban planning option is recommended, it enables to land uses and open spaces to serve as a noise barrier, in addition to the following reasons:

1- The cluster urban planning aids to increasing the distance between buildings using landscape elements (trees – walls – ground covers) as illustrated in Fig.4.

2- This option aids to distribute the site land uses by locating the noisy compatible land uses in the first raw of buildings between highway and residential building as illustrated in Fig.5, for achieving an additional noise protection by using the buildings as a noise shield.

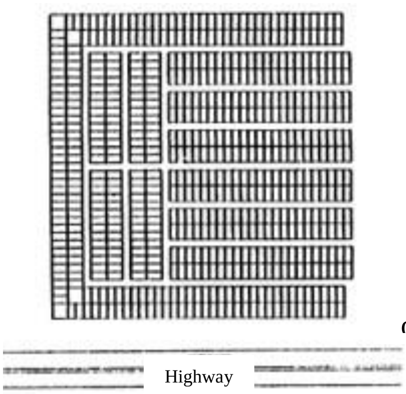


Fig. 3. Grid and cluster site planning options [6][6].

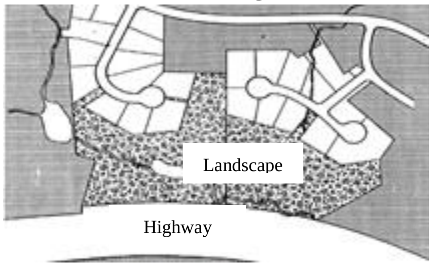


Fig. 4. Increase the distance between highway and buildings using landscape elements [6].

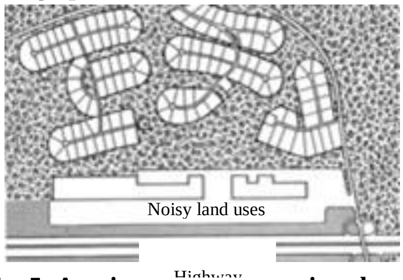
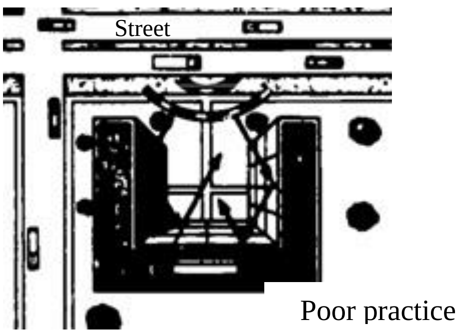


Fig. 5. A noise shield by locating the noisy compatible land uses in the first raw of buildings [6].

3- Arranging the site plan in cluster option using the curved streets with considering the hierarchy of streets width are more effective in noise reduction than straight streets.

4- Cluster subdivision provide a flexibility to buildings orientation based on shape for noise reduction, for example, the U shape building or courtyard can provide outdoor acoustic privacy as illustrated in the Fig.6.



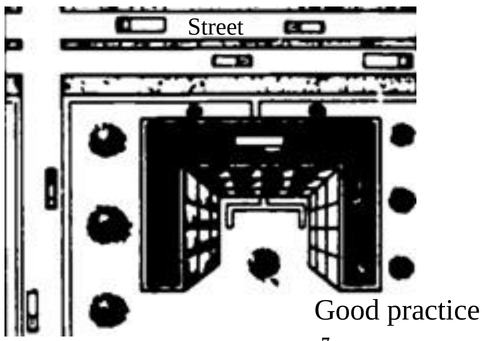


Fig. 6. U shape and courtyard orientation to obtain quite environment [7] [7].

3.2 Second Building Layer: Building Skin Layer

The exterior building skin must be smart and selective; it minimizes the outdoor noise produced by road traffic, aircraft flyovers, railroads, this element consists of opaque and transparent elements. The optimum solution to treat the skin opaque element from outdoor noise is using heavy mass materials without openings, if openings are necessary, it should be considering the following to improve the acoustical performance:

1- Break the flanking paths through the curtain wall sections (mullions) [8][8].

2- Specify fixed insulation glass units FIGUs with minimum spacing 10 mm between the two different thickness glass panels for thick gas such as sodium hexafluoride to reducing the coincidence effect [9].

3- Using solid doors with surrounded gasket [9] [9].

4- Although it's doubling cost, secondary glazing as illustrated in Fig. 7, is an effective way of improving noise reduction in case hinged or sliding windows [10] [10].

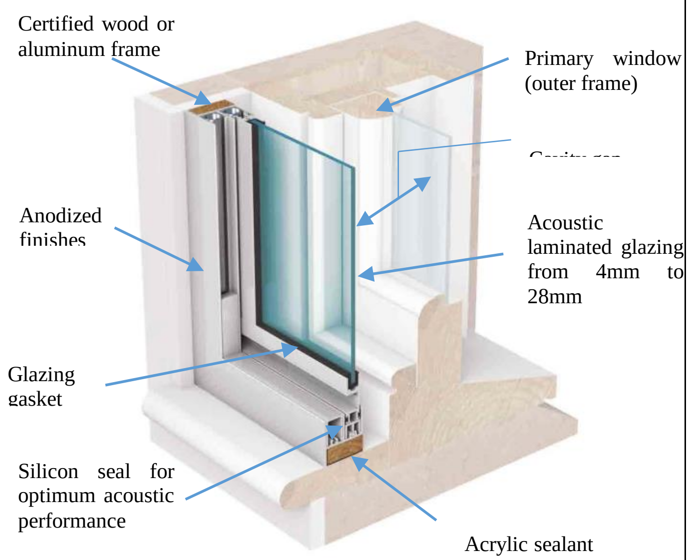


Fig. 7. Detail to Secondary glazing (hinged transparent element) [10].

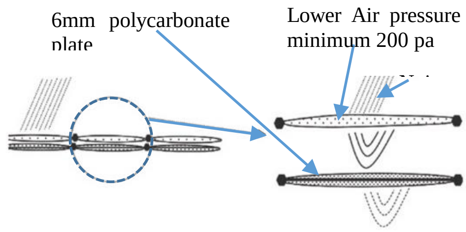


Fig. 8. Double layers ETFE as acoustic treatment option [11] [11]

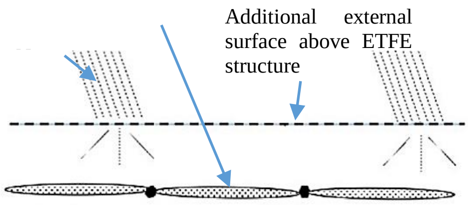
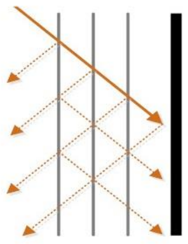
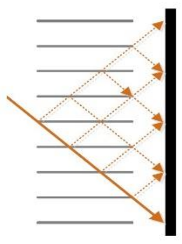
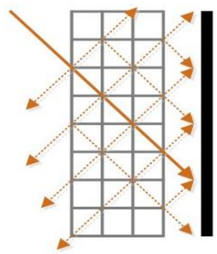
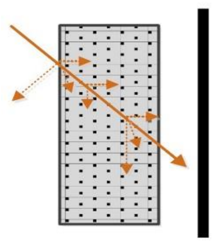


Fig. 9. External surface to reducing the rain impact noise [11].

One of the advanced smart practices in building skin is TIMs or Transparent Insulation Materials, it can be used for penetration the natural lighting through building skin with noise control and enhancing the thermal insulation ability, it can be classified into four types according to geometry structures (Absorber parallel -Absorber perpendicular -Cavity - Quasi homogenous), as illustrated in the following Table.3 [12][12].

ETFE or Ethylene Tetra Fluoro Ethylene is a lightweight fabric membrane TI material used to create curved transparent skin. It is a super-lightweight material as compared to glass; "a double layer cushion weighs only 0.70 kg/m2, whereas a single layer of glass (6 mm thickness) weighs 15 kg/m2" [13] [13] in addition to its flexibility, cost-effective, easy maintenance, water proofing, UV resistance, secured against fire, Self-cleaning, life expectancy and recyclable [14] [14]. This material mainly suitable to buildings and projects that need to enhance the sense of excitement by crowd noise such as stadiums. Acoustics is one of many design considerations required to assess if a ETFE is appropriate for other building types that require advanced acoustics performance because of it 100% acoustically transparent at low frequencies band (31.5:250 Hz) and it can absorb maximum 30% of the sound at high frequencies (500:8000 Hz), So, in case the need to enhance the acoustical performance to ETFE skin to get its benefits, use a double layer with adding a polycarbonate sound isolating sheet inboard of the ETFE cautions as illustrated in Fig.8. External surface above the ETFE structure may be added to avoid the impact noise level created on roofing system [11] as illustrated in Fig.9.

Table. 3. TIMs geometry structure, Author based on [12]

TIM types	Absorber parallel	Absorber perpendicular	Cavity	Quasi-homogeneous
TIM geometry structure				
Structure idea	Sheets are placed parallel to the absorber.	Used mainly in a solar collector's applications.	Integrated structure between parallel and perpendicular	Has a homogeneous distribution of air in material
Example of structure's materials	Profiled glass / ETFE	Honeycomb / Cellulose triacetate	Polycarbonate / SmartGlass/ PMMA acrylic	Silica Aerogel

3.3 Third Building Layer: Room Separators Layer.

Room Separators are used for separating walls between adjacent rooms (partitions) and separating floors (composite combination), including finishing that mainly helps to meet the reverberation time RT requirements mentioned in LEED 4.1 and illustrated in the following Table.4.

Table.4. RT requirements mentioned in LEED 4.1, Author based on [15] [15].

	Room type	RT at 500 Hz, 1000 Hz and 2000 Hz
1	Hotel suite	< 0.6
2	Meeting room	< 0.8
3	Conference room	< 0.6
4	Private office	< 0.6
5	Testing laboratory	< 1.0
6	Library	< 1.0
7	GYM	< 2.0
8	Auditorium	< 1.5

3.3.1 Separating Walls between Adjacent Rooms (Partitions)

Partitions are divided the building area into number of different function spaces and rooms, it is classified to separating walls between adjacent spaces and doors, it should be opaque to provide sight privacy, and able to enhance the indoor environmental quality by enhancing the partition sound transmission classification (STC) according to its adjacency combination functions illustrated in Table.5, that illustrate the minimum (STC) ratings required mentioned in LEED and GPRS by using the comparative method.

Table.5. Minimum composite STC ratings required for separating walls between adjacent rooms according adjacency combination functions mentioned in LEED 4.1 and GPRS, Author based on [15] [16] [16]

s.	Adjacency combinations functions		Minimum STC rating required	
			LEED	GPRS
1	Private	Hallway, stairway	35	48
2	Collaborative / multi-use	Collaborative / multi-use	40	45
3	Collaborative / multi-use	Private	45	54
4	Private / residential	Private / residential	45	52
5	Retail	Retail	50	45
6	Private	Confidential	50	52
7	Conference room	Conference room	50	45
8	Mechanical equipment room	Occupied area	60	52

The best way for achieving the minimum STC required for partition according adjacency combination functions to qualify buildings to be certified is considering the following:

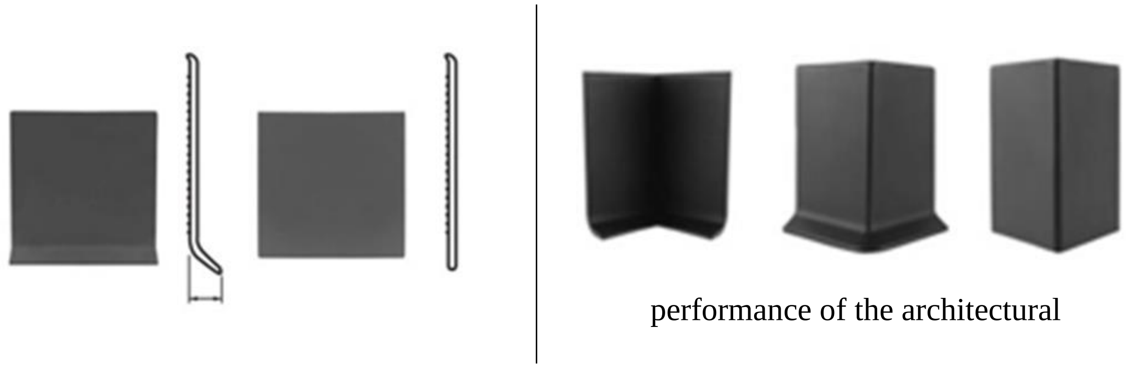
1- Design the wall with full ceiling height (above the ceiling/below the raised floor) with good room distribution by grouping the rooms that make a noise with each other and design the wall thickness with suitable material density.

2- Add a parallel wall when the main wall is a part of building structure, and in case that the space between the walls is used in laying the service pipes, a third parallel wall should be added.

3- Doors should be solid with gaskets, spaced, oriented and filled joints with high STC flexible material.

4- Secondary doors may be effective way with 30 cm minimum space between primary and secondary doors [9].

There is more than one technique for finishing walls using materials that improve the acoustical performance such as acoustic foam panels, silent pictures and art diffusor, in addition to, tightening the joints between the floor and the walls by toe base as illustrated in Fig. 10 is required to prevent the sound transmission through the separating walls between adjacent rooms.

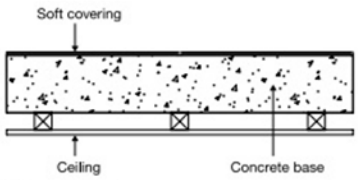


Standard Toe base 16 mm | NO Toe base | Standard inside Toe base | Standard outside Toe base | Standard no Toe base

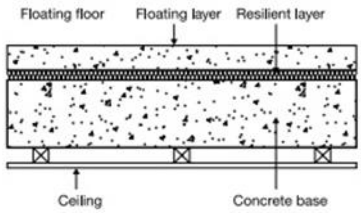
Fig.10. Types to wall base acoustical treatment [17] .

3.3.2 Separating Floors (Composite Combination Structure)

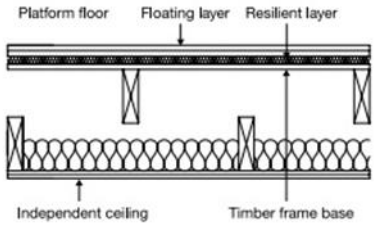
Separating floor is the element dividing the building into floors, it is affected by the impact noise mainly generated from the building equipment and travel through the building's elements, so, it is necessary to consider a composite construction types using combinations of light and heavy mass materials as illustrated in the Fig.11, with tightening the junction among separating floor and other building elements in case of the equipment located on different floors to reduce noise traveling through the building [18][17].



Floor type (1): concrete base with ceiling and soft floor covering



Floor type (2): concrete base with ceiling and floating floor layer



Floor type (3): wood frame base with ceiling and platform floor

Fig.11. Types of composite construction separating floors [18].

From the previous suggested separating floors types, the manufacturers may use another materials and designs as illustrated in Fig.12, provided that achieving the performance standard with minimum airborne sound insulation value 43 dB, and maximum impact sound insulation value 62 dB [18].

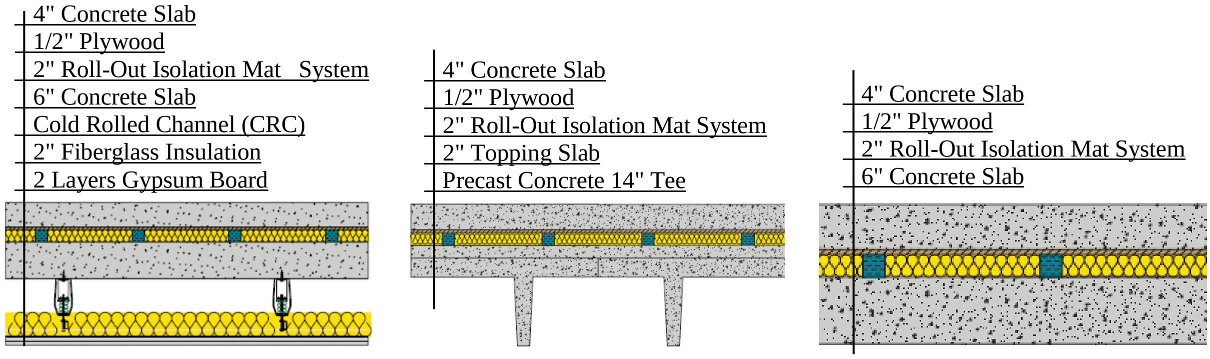


Fig. 12. Separating composite construction floor sections by Kinetics manufacturer to reduce noise travelling through structure [19].[18]

Isolate the building's equipment and services from building's structure is necessary to avoid the impact/airborne noise from travelling through the building's elements by considering the following instructions illustrated in the following Table. 6.

Table.6. Building services and equipment considerations to avoid the impact/airborne noise from travelling through the building's elements, Author based on [20][21][22] [19, 20, 21]

1	Machines	1- Balancing the machines for lower vibrations. 2- Using certified rubber/cork/fibre pads resilient or silencer base between machines and structure to reduce the impact noise effect. 3- Place the rotating equipment in the basement floor. 4- Using flexible connectors. 5- Use sound insulation for air conditioning ducts. 6- Not to place any equipment next to the windows. 7- Equipment & Mechanical systems distribution planning. 8- Air conditioning ducts must be flexible, interior cushioning and sticky exterior paint.
2	Electrical	Avoid back to back electrical outlets in separating walls between adjacent rooms.
3	Sanitary	1- If possible, the bathrooms are assembled in one place and back to back. 2- Use of flexible water supply/drainage pipes. 3- Reducing as possible bends in drain pipes. 4- Fixing pipes with resilient fixings on the building walls. 5- Use Acoustic wrapping as necessary.
4	Furniture	If possible, avoid placing kitchen cupboards/cabinets on party walls, and use soft rubber strips on all cupboard drawers.

Using underlayment acoustic treatment (Quiet floor) within concrete flooring system as illustrated in the following Fig.13 or wood flooring system as illustrated in Fig.14 can block airborne sounds (conservation, television,) and isolate the impact sound produced (moving furniture, equipment vibration,), in addition to, tightening the joints between the walls and the ceiling by cornice is required to prevent the sound transmission.

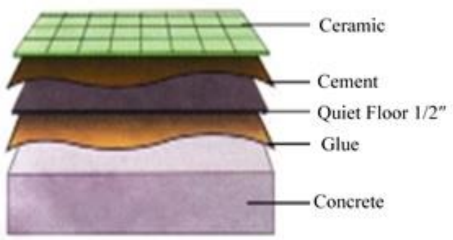


Fig.13. Model to underlayment (Quiet floor) acoustic treatment on concrete flooring system [23].

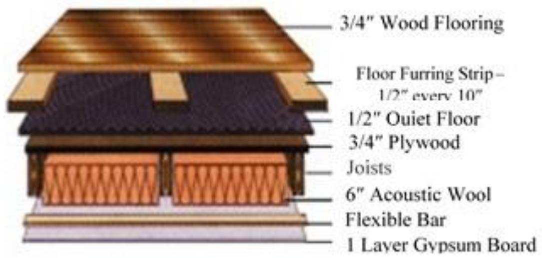


Fig.14. Model to underlayment (Quiet floor) acoustic treatment to wooden flooring system [23].[22]

For the ceiling finish, the common acoustic treatment in ceiling finishes is 60X60 acoustic ceiling tiles as illustrated in Fig. 12, in the composite construction detail.

Generally, it is necessary to fulfill the following to achieve a good acoustical indoor environment and qualify buildings to gain more assessment points: 1- Selecting a certified/eco-friendly construction materials with suitable sound insulation class STC according to adjacency combination. 2- Studying the windows location and reduce their area as much as possible. 3- Treating the cracks and joints between building component elements. 4- Using durable materials. 5- Protect the acoustical treatments from anything that might affect it negatively. 6- Using approved buildings components that have been tested by the authorities to ensure their performance.

4. Additive Elements To The Egyptian Code For Acoustics Works For Upgrading

After studying the precautionary practices to improve the acoustic performance and noise control for achieving the research objectives, the following Table.7, illustrates suggested upgrades for the Egyptian code of acoustics works with essential supportive points for noise risk management that were identified in each code chapters.

Table.7. suggested upgrades to the Egyptian code of acoustics works, Author.

Chapter No.	Chapter Title	Recommended additives to Egyptian code of acoustics works and noise control in buildings	Building layer
Chapter 1	Terminologies related to architectural acoustics	Add new terminologies such as: Building layers and elements - smart practices - Cluster and grid urban planning - Composite construction - Separating walls - Secondary glazing - Quiet floors – Recycled and eco-friendly materials – TIMs.	-
Chapter 2	Noise control methods and its benchmarks	The difference between grid and Cluster urban planning options, cluster is recommended, because it enables the buildings with open areas and landscape to serve as a noise barrier.	Site and urban planning layer
Chapter 3	Acoustic insulation principles of building's elements	1-Secondary glazing and TIMs with different structure geometries are recommended to add as some effective ways for improving noise reduction. 2-Techniques of "composite constructions" using combinations of light and heavy mass materials to reduce noise travelling through structure.	Skin layer & room separators layer
Chapter 4	Impact noise produced from building's services machines	Considerations and techniques that are necessary to avoid the impact/airborne noise produced from machines.	Room separators layer
Chapter 5	Acoustic insulation design practices and requirements	Technique of underlayment acoustic treatment fabricated from recycled materials and tightening the joints between the floor and the walls by toe base.	Room separators layer
Chapter 6	Acoustic design and implementations to special spaces	Determine the main target of interior finishes element to meet the RT requirements and improve the STC to room separators.	Room separators layer
Chapter 7	Noise measurement and tests	Upgrade the minimum composite STC ratings values required for room separators according to adjacency combination functions.	Room separators layer

Through the previous Table.7 in addition to what have been studied in this research, it is necessary to reorganize the Egyptian code for acoustics and noise control 2013, by union between the practices mentioned in code and the proposed practices by this research in nominated chapter as the fifth chapter, which is titled "Acoustic insulation design practices and requirements" to help architects, manufacturers to get the benefits from these practices and develop them easily according to project requirements.

٥. Conclusions

The research field on enhancing the acoustics performance to improve the indoor quality especially with the world initiatives on achieving sustainability and buildings economic performance for the entire building's life cycle from cradle to grave imposed necessity to develop the Egyptian code of acoustics works as one of the design reference by adding a set of sustainable concepts and introducing some design precautionary practices for noise control associated with building layers, with recommending the following:

- Rearranging the Egyptian code of acoustics works to accommodate the precautionary smart practices in nominated chapter to allow easier use of the code.
- Pursuit of studying the barriers of implementing the acoustical design practices to improve the environmental indoor quality of buildings.
- Selecting some suitable, approved and tested sound insulation materials from certified authorizations such as HBRC to ensure its efficiency.
- Working on permanent maintenance and sound insulation protection to ensure efficient performance during the building's life cycle.
- Good sealing of the joints between the different building elements by the integration of the elements, such as the integration of finishing with the envelope or internal partitions.
- Use of eco-friendly, recycled, thinner thickness and lighter materials such as Quiet floor underlayment treatment instead of sand within floors finishing layers.
- Supporting the Egyptian acoustics code with the reverberation time RT requirements, according to the room uses.
- Studying of the distribution of machine rooms in the building and choose its certified bases with approved fixture methods.
- Considering the equivalent sound transmission classification STC between different elements, such as the equivalent performance of doors with separating walls or the equivalent performance of opaque envelope and transparent elements.
- Update the minimum composite STC ratings required for building elements according to adjacency combination rooms functions in the Egyptian code and GPRS rating system.
- Generalizing the idea of acoustical composite construction by integration between light and heavy density materials.
- Using the cluster urban planning patterns, because it works to increase the distance between buildings and make an integration between buildings and landscape as a noise barrier.
- To ensure the best acoustic design practice economic performance for controlling the noise, the control area must be determined, either at the source, at the path, or at the receiver, with good understanding of sound path scenarios within buildings.

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