



APPLICABILITY OF USING RECYCLED RUBBER- TIRE MATERIALS FOR ACOUSTIC INSULATION IN BARRIERS OF RESIDENTIAL AREAS IN EGYPT

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ABSTRACT

Roadways are usually attraction locations for developing new residential projects for the availability of transportation facilities that serve reaching work, school, leisure, and shopping areas, that means locating residential neighborhoods close to traffic noise. Noise problem in Egypt is a pollution that ranks the second among the major environmental pollution problems which considered a serious issue for its harmful effects on residents and public health. Many actions can be taken to improve the compatibility of noise for any activity that affect the land use, such as noise barriers. Scrap tire rubber is widely spread everywhere, and considered as a major problem in the stream of waste materials. Providing the incentive for Egypt to get use of recycled rubber tires elements as a green product in sound insulation barriers and at the same time solving a local environmental issue. This research aims to study the applicability of getting use of recycled rubber tire materials in sound barriers for residential areas in Egypt.

Keywords: acoustic insulation, recycled rubber-tire, fences (Barriers), residential areas, Egypt.

1. INTRODUCTION

Noise problem for many residential areas is one of the impacts of daily traffic. Due to the fact that noise effects are rarely visible and difficult to quantify it is given a lower priority than other economic or environmental impacts. Principles of noise control play an important role in creating an acoustically pleasing environment (Hoda S. Seddeq, 2009). Most humans that suffer from chronic exposure to severe noise pollution are aware of its presence, and usually experience a range of problems as a result of this exposure.

The indicator used to measure sound levels is a logarithmic function of acoustic pressure, expressed in decibels (dB). The audible range of acoustic pressures is expressed in dB (A). The human ear perceives a constant increase in sound level whenever the acoustic pressure is multiplied by a constant quantity. The scale of sound levels shows that calm environments correspond to a level of 30 to 50 dB (A), and that beyond 70 dB (A) sound becomes very disruptive, Figure-1.

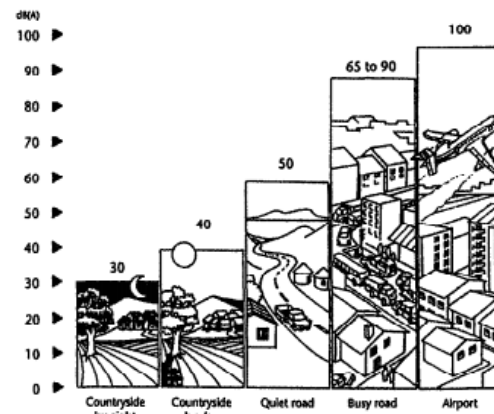


Figure-1. Scale of sound levels. (Source: Koji Tsunokawa, Christopher Hoban, 1997).

1.1 Research Problem

Egypt has witnessed increasing development of new projects, especially in major cities. This is due to the increase of population, which requires more commercial and industrial activities to be located in many residential areas, in addition of the presence of high traffic density. Noise pollution is one of the major annoying problems facing humankind. Noise considered one of the most common environmental problems all over the world.

As noise problem in Egypt ranks the second among environmental pollution problems and it is a serious issue due its harmful effects on residents and public health. Exposure to noise levels exceeding 90 dB may lead to permanent hearing loss. Noise problem impacts the development on various life activities such as social aspects, education, economic processes, and production, etc. Noise levels in Egyptian streets are in



daily increase, reaching offensive limits locally and internationally.

A lot of residential compounds in Egypt were built too close to heavy traffic roadways due to both lack of land and its high cost. Sound barriers for such buildings became a must solution.

A second environmental problem in Egypt is getting rid of the used rubber tires. The developing of Egyptian vehicle industries and the tremendous rate of increase for imported cars caused to existence of number used tires that almost reached about 20 million tons of waste tires material per year. In Egypt most of the used rubber tires are burned as in expensive fuel for brick and pottery industries which produces a lot of toxic fumes that are environmental pollutant (J.M. Pastor *et al.*, 2014). Less amounts of used tires are used as children toys in play grounds and manufacturing of machine belts.

In the study (F. Asdrubali, and al., 2008) the researchers proved that sound insulating and absorbing materials could be manufactured using recycled tires granules, which can be used for buildings and road side barriers, producing rubber granules from used tires is a good alternative to used tires disposal into landfill. in the study (Ruben Maderuelo-Sanz, and al., 2012) proved that the use of material waste, Grounded end of life tires could produce a textile residue can be used in manufacturing of sound insulating products, helping to combat two different kind of problems, reducing used tires disposal waste material and noise control. A research paper done by (K.V. Horoshenkov, M.J. Swift, 2001) the researchers studied the effect of consolidation on the acoustic properties of loose rubber granulates. Based on a study of types of sound barriers using recycled tire rubber materials for its sound insulation characters as sound barriers in international applications. The research goals to study the most suitable application for recycled tire materials as elements for sound barriers in Egypt regarding to tires recycling technology in Egypt and its ease of application.

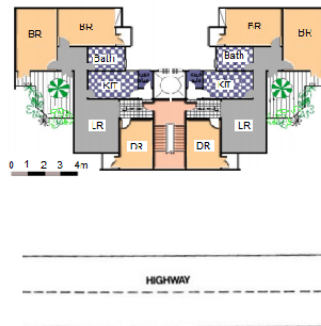


Figure-3. Room arrangement and balcony facing the road to reduce noise.

Source: the researchers

2.3 Acoustical construction

Walls, floors, windows, ceilings, and doors of a building can be intercepted noise as it passes through.

2. PHYSICAL TECHNIQUES TO REDUCE NOISE IMPACTS

There are many actions which can be taken to improve noise compatibility for any type of activity or land use. These are Site planning, Architectural design, Construction methods, and Barrier construction.

2.1 Acoustical site planning

Many site planning techniques can be employed to shield a residential development from noise. These can include, Figure-2.

- increasing the distance between the noise source and the receiver;
- placing nonresidential land uses such as parking lots, maintenance facilities, and utility areas between the source and the receiver;
- locating barrier-type buildings parallel to the noise source or the highway; and
- Orienting the residences away from the noise.

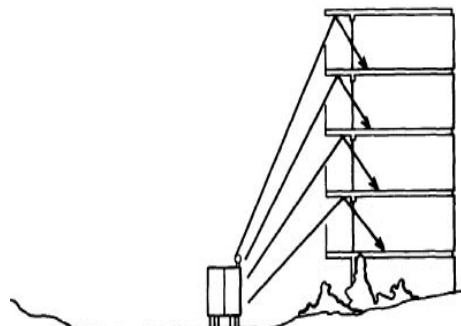


Figure-2. Parking garage, and open space to shield residential area (El Rehab City).

Source: <https://ambiances.revues.org/252>

2.2 Acoustical architectural design

Proper architectural design can control noise affecting the surrounding buildings. Acoustical considerations could be taken in account during planning of room arrangement, in addition to windows placement, building heights, balconies, and courtyards Figure-3.



Some examples of construction techniques noise reducing materials are shown in Figure-4:

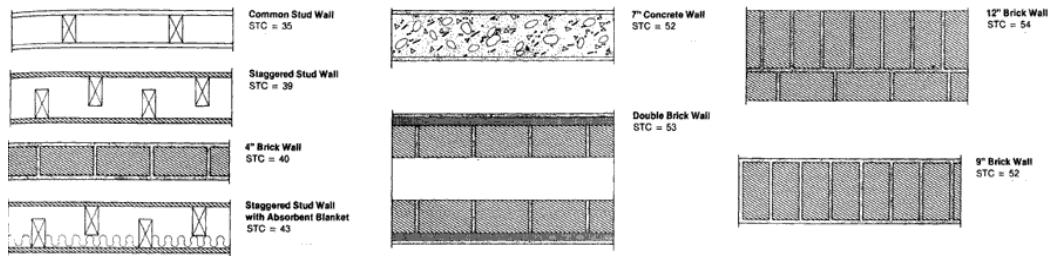


Figure-4. Wall types with sound transmission class (STC) Rating (is an integer rating of how well a building partition attenuates airborne sound.)

(Source: Environmental Protection Department, 2003)

2.4 Barriers

Noise barriers are solid obstructions located between noise sources. They are designed like interrupt system of acoustic energy flow between the noise source and receiver, Figure 5 & 6 air Pollution concentration levels close to roads can be reduced by the use of roadside noise barriers. Within 15-50 m from the roadside. Concentration levels of air pollution at the lee side of the noise barriers have the ability to reduce up to about 50% in comparison to values of open roads. Pollution plumes coming from the road are forced by noise barriers to move

up and over the barrier creating the effect of an elevated source in addition to enhancing plume vertical dispersion. Noise barrier decelerate and deflect the initial flow and force the plume to disperse horizontally.

There are three mechanisms which influence the acoustic performance of any noise barrier. Sound Diffraction, Sound transmission and Sound reflection/absorption (will be heavily influenced by the geometrical shape of the barrier), Figure-7. They can be made out of many different substances. Table-1 indicative comparison of various noise mitigative measures

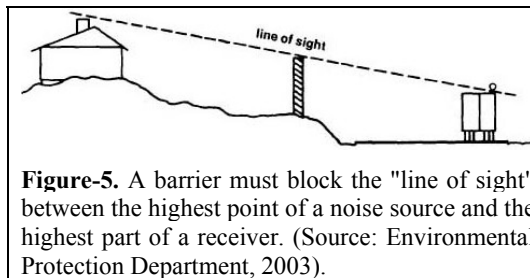


Figure-5. A barrier must block the "line of sight" between the highest point of a noise source and the highest part of a receiver. (Source: Environmental Protection Department, 2003).

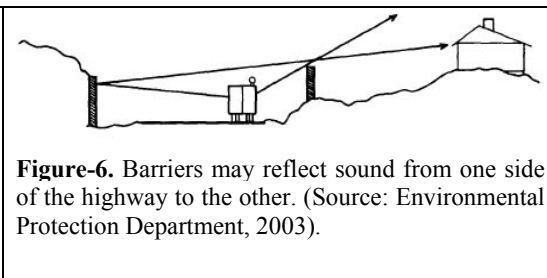


Figure-6. Barriers may reflect sound from one side of the highway to the other. (Source: Environmental Protection Department, 2003).

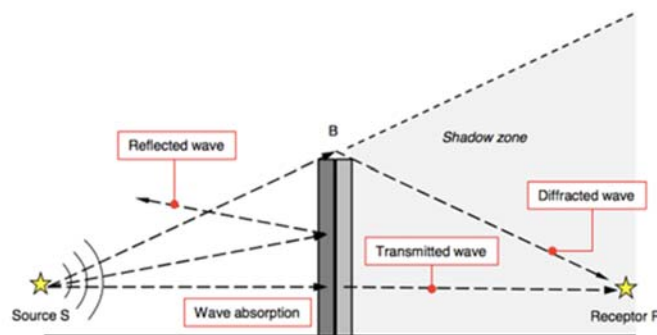


Figure-7. Mechanics affecting noise barrier performance.

(Source: Bowlby, W., and H. S. Knauer, 2012, P A Morgan, and al, 2015)

- a. Sloping mounds of earth (berms) reduce noise by approximately 3 dB greater than vertical walls of

the same height, in addition to having an attractive natural appearance, Figure-8.

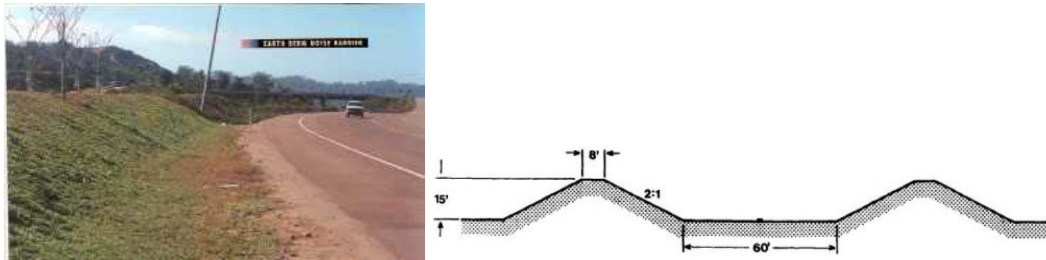


Figure-8. Sloping mounds of earth and Cross section of it
(Source: Environmental Protection Department, 2003)

- b. Fences and walls manufactured from various materials such as concrete, wood, metal, plastic, and stucco.
- c. Dense planted regions of shrubs and trees.
- d. Above techniques combined together.

Table-1. Indicative comparison of various noise mitigative measures.

<i>Measure</i>	<i>Effectiveness</i>	<i>Comparative costs</i>
Earth barrier	Same as that of other types of barriers needs more space	Very cheap when spare fill material is available on site.
Concrete, wood, metal or other barrier fences	Good; requires less space	10 to 100 times the cost of an earth barrier, but may save land cost
Underground road (cut and cover)	An extreme option for very heavy traffic; requires ventilation if over 300m long.	80 to 16,000 times the cost of an earth barrier
Double glazing of windows for facade insulation	Good but only when windows are closed; doesn't protect outside areas	5 to 60 times the cost of an earth barrier

(Source: Koji Tsunokawa, Christopher Hoban, 1997)

3. DESIGN CONSIDERATIONS OF NOISE BARRIERS

Detailed design of noise barriers has many factors that need to be considered. Barriers must be acoustically adequate. Acoustical design considerations include the material of the barrier (durability-cost), barrier dimensions and shapes, its locations, the desires of the public. However, proper design of noise barriers does not depend only on these requirements. Non-acoustical design considerations are equally important, such as Safety/Vehicle Impact, Fire Resistance and Emergency Access, Lighting Considerations, Maintenance Considerations, Installation. (Environmental Protection Department, 2003).

3.1 Acoustical design considerations.

Noise barriers material, shapes, location, and dimensions, can affect the total acoustical performance.

- Transmission loss of various barrier materials
- Reduction in noise barrier performance due to holes, slits or gaps

-Barrier shapes

-Material choice

-Barrier Materials (Concrete- Alternative Materials- Metal- Transparent Materials- Plastics- Recycled Materials- Sound Absorbent Materials), Table-2

-Earth Berms and Retaining Structures

-Non-Acoustical Considerations (Safety/Vehicle Impact- Fire Resistance and Emergency Access- Lighting Considerations- Maintenance Considerations- Installation)

3.2 Aesthetical aspect of noise barriers

-Architectural, the overall appearance of barriers could be articulated by applying architectural concepts such as rhythm, order, proportion, harmony and contrast

-Visual Impact - Compatibility with Local Features







-Coordination with Road Furniture - The Protected Side

-The Road Users' Side -The Impact of Tall Barriers

-Use of Transparent Barriers - Use of Color (Guidelines on Design of Noise Barriers, 2003)

-Use of Vegetation - Use of Transparent Barriers and Modifications to Barrier Designs

**Table-2.** Comparison between materials used as noise barriers:

<p style="text-align: center;">Concrete</p>  <p style="text-align: center;">Figure-9. Concrete noise wall.</p>	<ul style="list-style-type: none"> - Dry cast and wet cast. - The precast panel sizes approximately 4.5 m, The minimum thickness is 100 mm plus an additional 25 mm in total. -o The minimum wall thickness is approximately 150 - 200 mm. - Precast concrete walls can to relocate and used for building temporary walls and permanent installations. - Concrete products are suitable for any climate condition. <p>And exposed to freezing and thawing conditions.</p> <p>-Adequate cover to prevent or slow down salt laden moisture penetration rate and prevent it from reaching the steel reinforcing bars. Color consistency, a surface-applied used in the concrete mix, Figure-9.</p> <p>(Source: Federal Highway Administration U.S.- Department of Transportation)</p>
<p style="text-align: center;">Brick and masonry block</p>  <p style="text-align: center;">Figure-10. Brick noise barrier.</p>	<ul style="list-style-type: none"> - require a continuous concrete foundation. -must be anchored to the foundation with reinforcing bars. - The mortar used in barriers is part of wall structural strength which enables it to withstand the lateral forces falling against it. Figure-10.
<p style="text-align: center;">Metals</p>  <p style="text-align: center;">Figure-11. Metal barrier.</p>	<ul style="list-style-type: none"> -Rusting panels have the defect of staining adjacent concrete. -Sun-heated metal panels prevent Plants growth close to it. <p>Non-compatibility of Various Metal Combinations.</p> <ul style="list-style-type: none"> - Susceptible to glare from opposing light sources. -electrically conductive should be avoided near power lines. - Coating thickness must be verified to ensure durability. -Single, thin, flat sheets are not structurally rigid enough to resist wind loads. -Appropriate standard test method should be used to verify Brittleness, hardness, and tensile strength. Figure-11.
<p style="text-align: center;">wood</p>  <p style="text-align: center;">Figure-12. Wood barrier: tongue and groove planking.</p>	<ul style="list-style-type: none"> - Easily burned, generating ash, smoke and emissions that are toxic. -wooden barriers are not dimensionally stable as it tends to shrink & warp causing open cracks to form between joints if wood is not properly dried. - <i>decay</i> rapidly when in contact with moisture. Need To be treated with a chemical preservative. - Fasteners used can either be nuts and bolts, screws, staples or nails, lag bolts and carriage bolts. - Initial color is a problem with timber walls since it is usually governed by the type of preservative chosen. It fades to a weathered brown or gray color, Figure-12.
<p style="text-align: center;">Transparent panels</p>  <p style="text-align: center;">Figure-13. Transparent panel barrier: vandalism.</p>	<ul style="list-style-type: none"> - (Ex.: glass, acrylic, etc.). Transparency could be enhanced by using large pieces of material and limiting the number of supporting brackets. - Sensitive to ultraviolet light, sheeting haze and discolor occurs if not protected by proper UV stabilizer additives or coatings, leaving them in some cases translucent or even opaque. - Shatter resistant plastic products are mostly used, glass panels are not shatter resistant even by tempering or laminating its glass. - Glare happens from opposing light sources. - Depending on the size and type of material selected. Damaged panels cannot be repaired by patching, Figure-13.
<p style="text-align: center;">Plastics</p>  <p style="text-align: center;">Figure-14. Plastic noise barrier.</p>	<ul style="list-style-type: none"> - Plastic noise barriers are more flammable than other materials used in manufacturing barriers. Burning generates toxic smoke and emissions. <p>Shrinkage - Some plastic products may tend to shrink leaving open cracks between joints and deformation.</p> <ul style="list-style-type: none"> -Plastics are very sensitive to ultraviolet light which causes pigments rapid deterioration, change surface appearance, and lower material strength. - Shatter resistant deteriorate over time, causing it to be more brittle and also it may shatter by flying objects or vehicles impact. Figure-14.

**Recycled rubber****Figure-15.** Recycled rubber noise barrier.

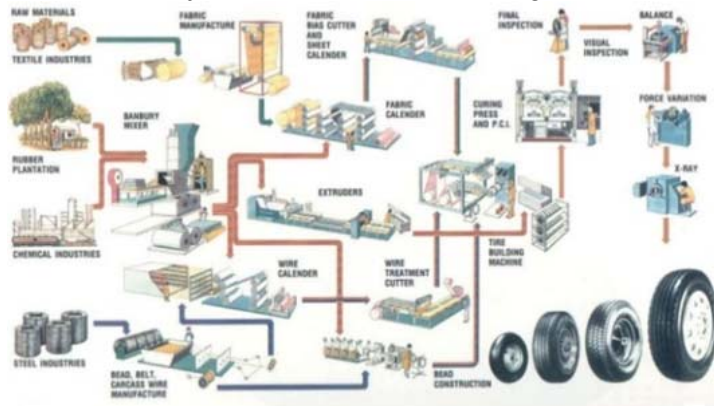
- High flammability producing the dense smoke when it burns.
- nontoxic under leachate testing. However, the mix additives to form and enhance the material might create toxicity problems.
- Recycled rubber noise barrier are not sufficiently rigid as a structural component for a noise barrier panel.
- oxidize over time when exposed to the elements.
- extensively perforated to promote bonding.
- adequate retardants are added to ensure that the minimum allowable rate of flame spread and smoke generated is not greater than the flame spread rate for a typical fence material, Figure-15.

Composites**Figure-16.** Composite noise barrier.

- Combination of basic materials to change the performance, durability, have a burning tendency or to be severely damaged. Burning generate toxic smoke, emissions, and ash.
- The shrinkage rate differ causing dimensional instability and may leave joints open cracks or promote warping, accelerated creep and delamination.
- very sensitive to ultraviolet light causing pigments rapid deterioration, change of surface appearance, and lowering material strength. (Deborah S. McAvoy, and al., 2014)
- **Composite noise barrier** does not have sufficient rigidity to be structural component for noise barrier panel.
- Primary materials nature or when combined with other materials may cause rendering of the final product and making it unsuitable for land fill sites future disposal. Figure-16.

4. RUBBER TIRES**Manufacturing rubber tire**

Relatively standardized processes and machinery are used in manufacturing Pneumatic tires, the tire industry is the major consumer of natural rubber, Figure-17.

**Figure-17.** Schematic of tire production process.

(Source :Salsons Impex Pvt. Ltd., <http://www.salsonsautomotivetyres.com>)

Composition &Source, Figure-18.

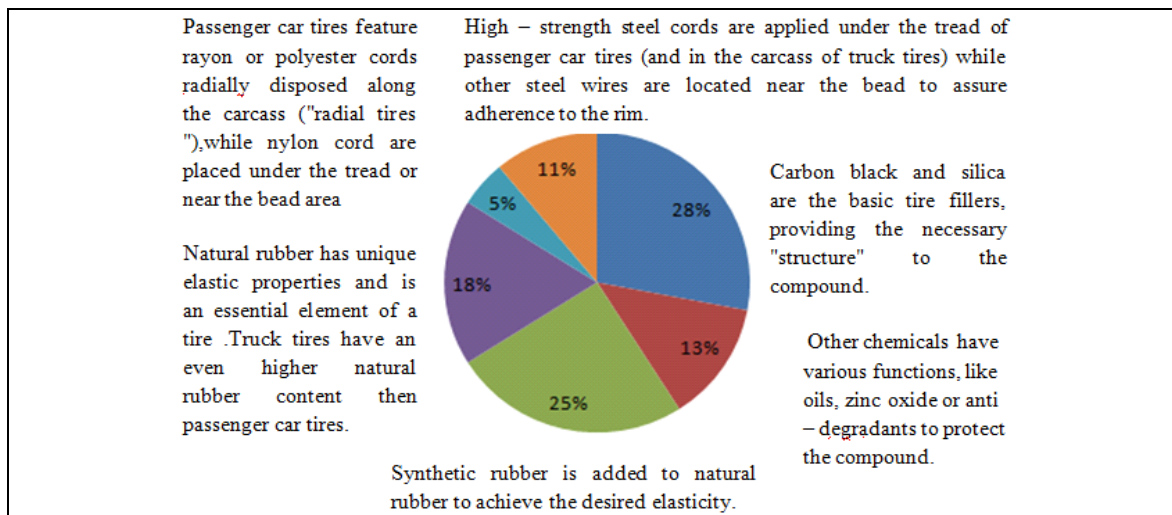


Figure-18. Composition & source. (Source: Managing End-of-Life Tires - World Business Council for Sustainable Development)

Environmental concerns

- (leaching) of toxins into the groundwater can affect sensitive organisms: Zinc, heavy metal, and rubber chemicals leach into water from used tires. The Shredded tire pieces leach much more, due to the increased surface area.
- considered the main sources of environmental polluting waste materials, due to the long time it takes to bio-degrade components they contain, (Ana Gheorghe, Anuța BORLEA (TIUC), 2012).

Advantages of recycling rubber for environment:

Recycling rubber conserves non- renewable petroleum resources; decrease the requirement for landscape maintenance by slowing the growth of weeds, reducing insects and rodents, decreasing soil compaction and refining drainage and save space of landfill and abolishing the destructive effects on humans, in addition to the environment.

Products of tire recycling, Fig.(19&20).

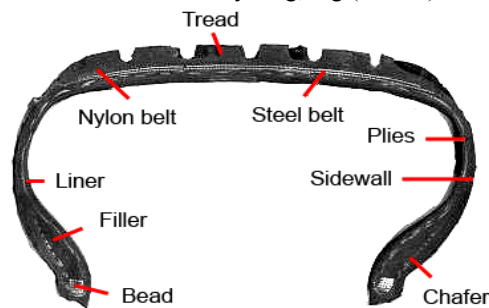


Figure-19. Products of tire recycling (Source: : Sadiktsis, Ioannis (2012). Automobile Tires-A potential source of highly carcinogenic dibenzopyrenes to the environment. Environmental Science & Technology.)

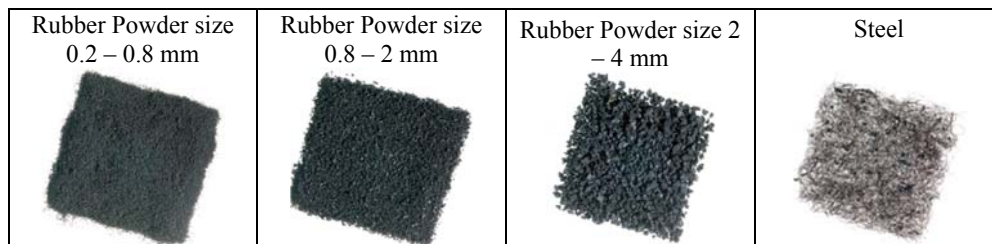


Figure-20. Products of tire recycling (Source : <http://www.naw-recycling.com/ct-menu-item-8/ct-menu-item-10>)

Uses of recycled rubber tire material

- Used widely in numerous outdoor and landscaping purposes (<http://www.naw-recycling.com/>)



- Used for bike and walking paths, agriculture pipes, fencing, roof tiles, pond liners, clothing accessories, Artificial reefs. Homes can be built with whole tires.
- Steel mills can use
- Can be used in steel mills as a carbon source, instead of coal in steel manufacturing.
- To increase its lifespan and durability, it is often mixed with asphalt, and to improve thermal and sound absorption properties, it is mixed with concrete.








5. NOISE BARRIERS WITH TIRES

Breakdown plants for scrap tires are being constructed in major urban areas. This is due to the need for scrap crumb rubber for products or simply to provide a mechanism to cut up or chip scrap tires for burning or disposal in landfills. As a result, various sizes of scrap rubber can be obtained at a reasonable cost. Uses for by-products of the breakdown process are needed to avoid

burning which is not considered desirable in many areas or disposition in landfills which is an unnecessary loss of a natural resource. There are many types of tire noise barrier, Table-3.

Noise at the Highway is considered normal when about 90 dBA and a neighborhood is quiet when at 45- 55 dBA. Table-4 illustrates that sound Barrier with Recycled tires is the best wall that makes the neighborhood quiet.

Table-3. Types of tires noise barriers.

types	Aestheti c			weight			space			time			used tires			Experie nce			finishing			cost			Size of used tires		
	G	M	B	L	M	S	L	M	S	L	M	S	L	M	S	L	M	S	G	M	B	L	M	S	L	M	S
	Blue					Red			Red		Green			Green		Blue			Blue			Blue				Green	
	Blue					Red			Red		Green			Green		Blue			Blue			Blue					Red
			Red	Blue			Blue				Red	Blue			Green				Red			Red		Blue			
		Green		Blue			Blue			Green		Blue				Red		Green			Red		Blue				
	Blue				Green			Green		Blue			Green		Blue			Blue				Green					Red
		Green		Blue			Blue			Green		Blue			Green			Green				Green		Blue			
	Blue				Green				Red		Red		Red		Green			Blue				Green			Green		

(Source: Felsburg Holt, and al., 2011 and Robert Otto Rasmussen and Richard C. Sohaney, 2012 and P A Morgan, and al, 2015)

**Table-4.** Shows decibel reduction comparison chart.

Decibel reduction comparison chart				
Material	STC Rating	Highway Noise Level	- STC Rating	= Noise Level After wall Installation
Recycled tires	37	90 dBA	- 37	= 53dBA
Concrete	28	90 dBA	- 28	= 62 dBA
metal	27	90 dBA	- 27	= 63 dBA
wood	26	90 dBA	- 26	= 64 dBA

Source: (<http://carsonite.com/pdf/AcoustaShield-reflective.pdf>)

Benefits and costs

- The scrap tire waste stream will be reduced substantially, whenever this noise barrier concept is constructed,
- A reduction in total overall energy use will result. Tires now placed in landfills must often be chipped or cut up with no productive use: of the rubber scrap. Also, when placed in dumps, this resource is lost forever. Using the scrap rubber will replace other natural materials and their production, such as steel, brick or wood. These are traditional materials used in noise wall construction and have high energy production costs.
- The scrap rubber will replace natural raw materials that are often non-renewable.
- Scrap tire rubber is considered a main problem in the waste stream as it is highly found everywhere; providing the encouragement for Egypt to benefit of a new product in addition to resolve a local environmental issue. Manufacturing locally the scrap tire filler for the core in the country as a cold process is environmentally sound.

The research paper takes three areas which are considered as the Egyptian crowded urban areas as a case study: Figures 21, 22, 23.

1. SakrKoraish - El Maadi area Cairo Egypt.

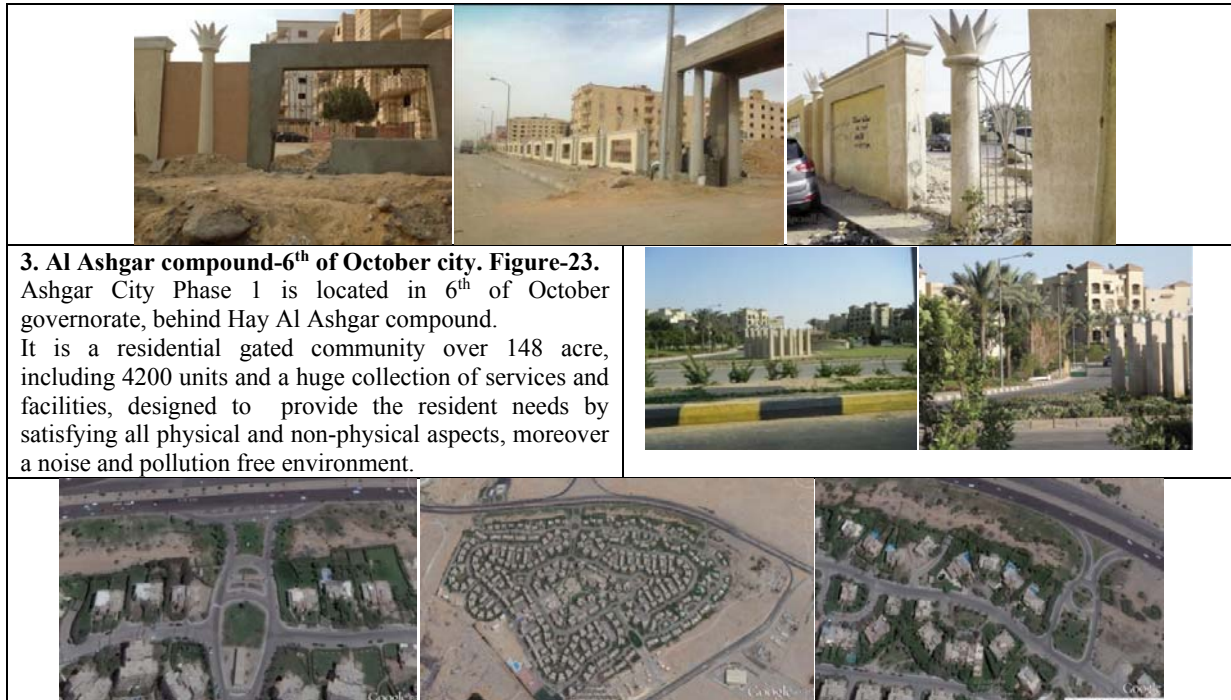
SakrKoraish is a complex of multi building blocks located on the side of one of the high traffic high ways that links Maadi district with Nasr City

Figure-21. SakrKorash - El Maadi area Cairo Egypt (source: researchers).

**2-Hadayek- Alahram. Figure-22.**

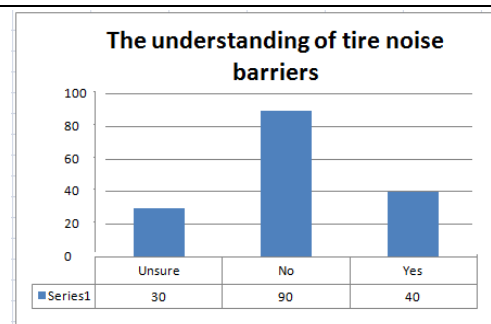
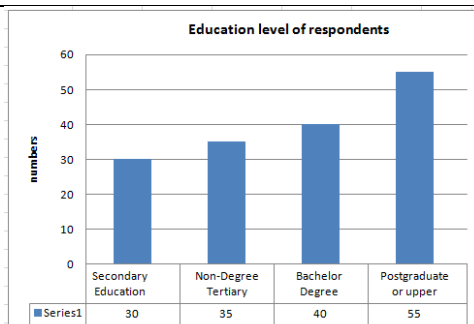
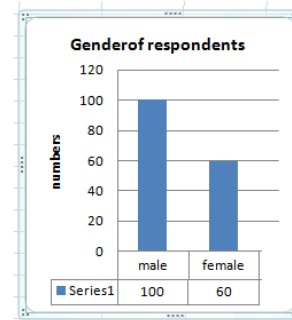
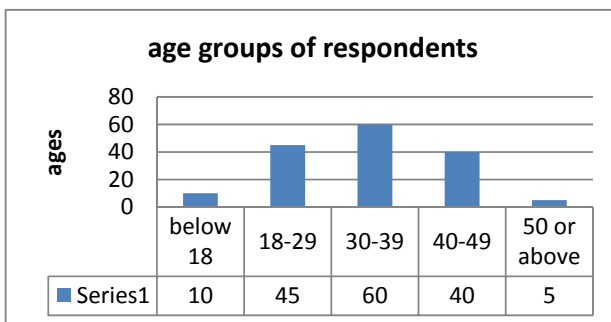
Hadayek- Alahram is a residential area located in the beginning of El- Fayoum Road, and on the right after crossing El- Remaya square.





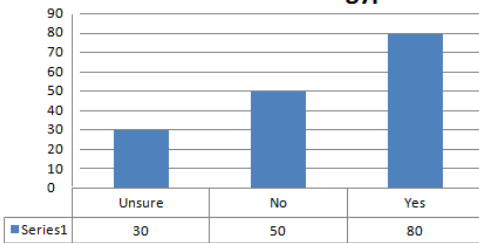
3. Al Ashgar compound-6th of October city. Figure-23.
Ashgar City Phase 1 is located in 6th of October governorate, behind Hay Al Ashgar compound. It is a residential gated community over 148 acre, including 4200 units and a huge collection of services and facilities, designed to provide the resident needs by satisfying all physical and non-physical aspects, moreover a noise and pollution free environment.

Questionnaires results

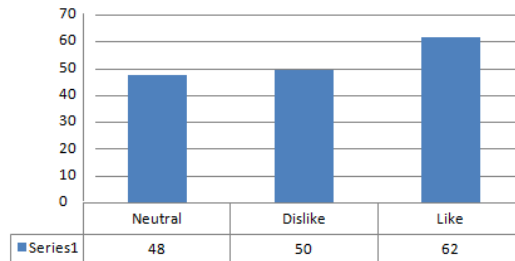




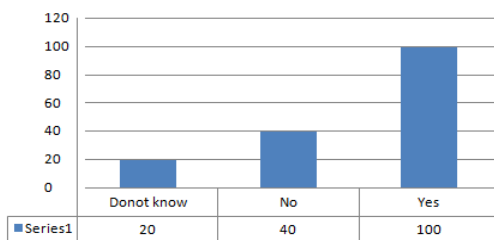
The understanding of any type of noise barriers in Egypt



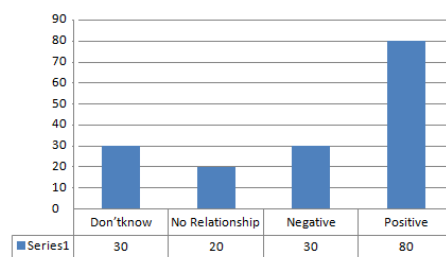
Preference of visual impact of tire noise barriers



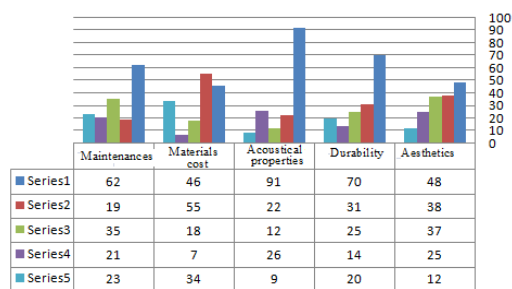
The perception of noise attenuation



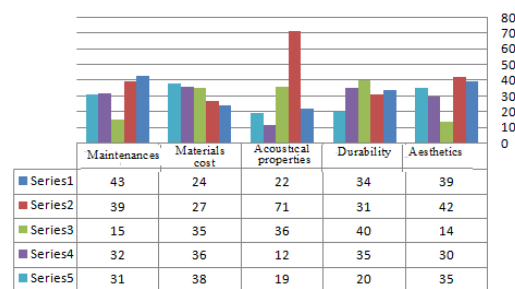
The thinking of tire noise barriers



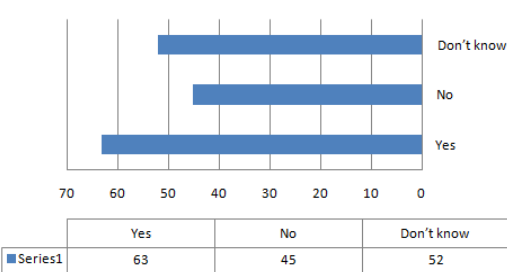
comparison of the most important and the least important criteria



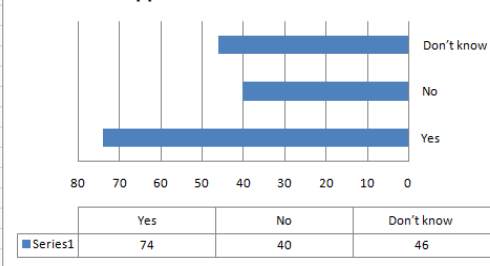
comparison of the most important and the least important features

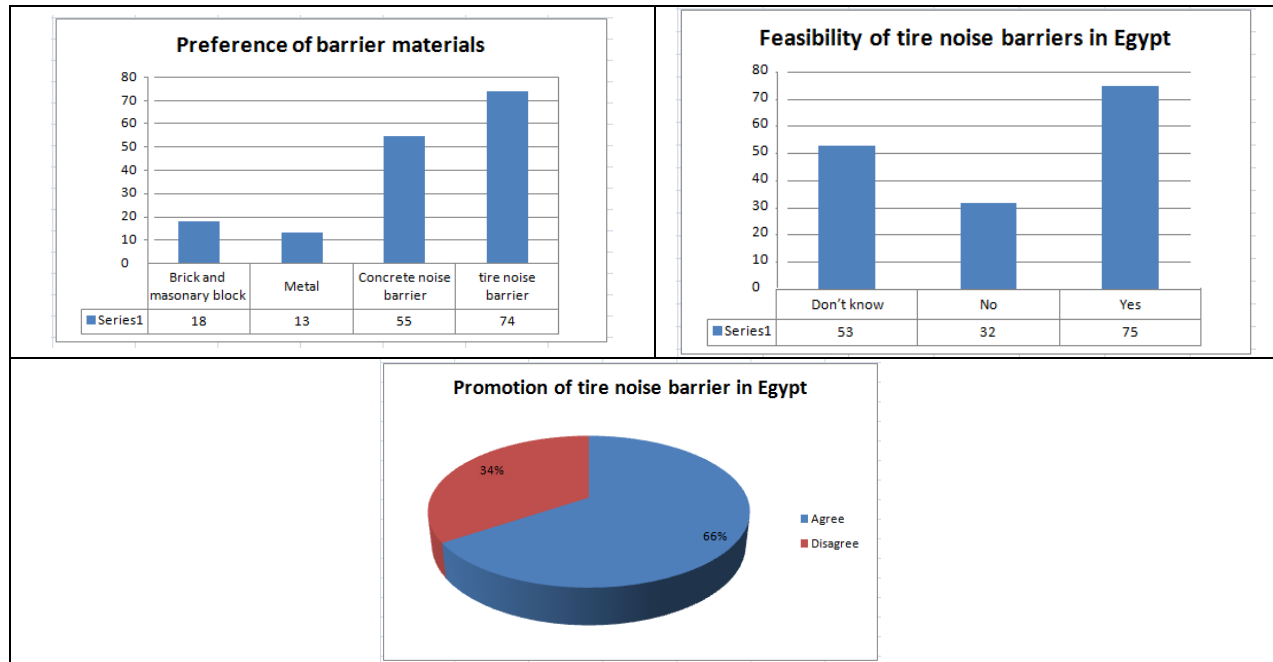


Reducing noise pollution by tire barriers



The application of tire noise barriers





RESULTS

The visual character of noise barriers:

- place a noise barrier four times its height from residences
- keep landscaping and planting close to the barrier to avoid visual dominance and to minimize graffiti and add visual quality
- Reflection of surroundings character
- Preserve aesthetic views and scenic vistas.
- Openings in noise barriers for intersecting streets or driveway connections demolish their efficiency.

Crumb rubber based specimen shows superiority in acoustical absorption.

Sound barrier walls differ in cost according to type and quality. Concrete is famous for its low cost. Reflective barriers could create noise for those across from the barrier, while absorptive barriers absorb and decrease the noise more effectually but cost more as they are commonly constructed and are combined of a diversity of materials that permit for absorption. Costs of berm Construction, excess soil should be available in the immediate area which could be used for its construction.

CONCLUSIONS

High noise levels for Egyptian building located close to heavy traffic roads and excess amounts of used rubber tires produced annually are two environmental problems.

The study showed that using recycled rubber tire products as a noise dumping element in fence sound barriers is one of successful rubber waste material utilizations. Site visits to tire recycling plants in Egypt showed that partially shredded tires are the most produced material from used tires as it is produced by simple

shredding machines available even in small sized factories.

Using partially shredded rubber tires in a structural container such as concrete blocks for the use in fence sound barriers is both economic and it overcomes fire risk of exposed rubber plaster material, oxidation of rubber, decoloring etc. Concrete block walls are widely used in Egypt for fences, adding partially shredded rubber pieces during building process will improve noise dumping capabilities of the fence wall, also staggering the blocks during the building process leads to un-even façade levels which improve noise dumping.

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APPENDIX B QUESTIONNAIRES

Feasibility study of tire noise barriers in Egypt

I am a researcher in National Research Center (Engineering Research Department) - Egypt. I am now working on a dissertation "Applicability of using recycled rubber tire materials as a noise dumper element for noise barriers in Egypt". The study investigates the potential of tire noise barriers and the perceptiveness of recycled rubber tire noise barriers in Egypt. This survey will be carried to gather a sample of Egyptian public opinions about noise barriers. It should only take about 10 minutes. The information you will provide is essential to the study and would be used exclusively for academic research purposes.



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1. What is your age group?

<input type="radio"/> Below 18	<input type="radio"/> 18-29	<input type="radio"/> 30-39	<input type="radio"/> 40-49	<input type="radio"/> 50or above
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2. What is your gender?

<input type="radio"/> Male	<input type="radio"/> Female
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3. What is your education level?

<input type="radio"/> Primary Education	<input type="radio"/> Secondary Education	<input type="radio"/> Non-Degree Tertiary	<input type="radio"/> Bachelor Degree	<input type="radio"/> Postgraduate or upper
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4. Do you know what tire noise barrier?

<input type="radio"/> Yes	<input type="radio"/> No	<input type="radio"/> Unsure
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5. Do you know any type of noise barriers used in Egypt?

<input type="radio"/> Yes, please give an example	<input type="radio"/> No
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6. The pictures illustrate rubber tire materials. What do you think about their visual impact?

<input type="radio"/> Like	<input type="radio"/> Dislike	<input type="radio"/> Neutral
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7. In your opinion, the vegetation on tire noise barriers can reduce noise pollution?

<input type="radio"/> Yes	<input type="radio"/> No	<input type="radio"/> Don't know
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8. Do you find the tire noise barrier is positive or negative on the environment?

<input type="radio"/> Positive	<input type="radio"/> Negative	<input type="radio"/> No Relationship	<input type="radio"/> Don'tknow
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9. The following is criteria for designing noise barriers. please evaluate their importance (Most important; 5- Least important)

<input type="radio"/> Aesthetics	<input type="radio"/> Durability
<input type="radio"/> Acoustical properties	<input type="radio"/> Materials and installation cost
<input type="radio"/> Maintenances issues	

10. The following is features of noise barriers. Please evaluate their order of preference (1- Most important; 5- Least important)

<input type="radio"/> Aesthetics	<input type="radio"/> Durability
<input type="radio"/> Acoustical properties	<input type="radio"/> Materials and installation cost
<input type="radio"/> Maintenances issues	







11. Do you think the tire noise barrier can eliminate traffic noise pollution?

<input type="radio"/> Yes	<input type="radio"/> No	<input type="radio"/> Don't know
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12. Do you think if the cost of the tire noise barrier is high, is it deserved and should be applied widely, in comparison to the traditional design?

<input type="radio"/> Yes	<input type="radio"/> No	<input type="radio"/> Don't know
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13. If you are going to choose a noise barrier, which of the materials design ideas illustrated below you will prefer?

 <p><input type="radio"/> tire noise barrier</p>	 <p><input type="radio"/> Concrete noise barrier</p>	 <p><input type="radio"/> Metal</p>	 <p><input type="radio"/> Brick and masonry block</p>
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14. Is it practical to use tire noise barriers in Egypt?

<input type="radio"/> Yes	<input type="radio"/> No	<input type="radio"/> Don't know
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15. Do you think tire noise barrier in Egypt is to be promoted in Egypt?

<input type="radio"/> Agree	<input type="radio"/> Disagree
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