March - April 2020
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Analytical Survey of Acoustical Material's VOC Emission and its Installation in Auditorium

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Abstract

Human being is a social animal and from the ancient times, gathering spaces are playing an important role in our society. Indoor and outdoor spaces were built for social gatherings like open air theatres, multipurpose halls, auditoriums, religious places like temples, Mosques, Churches etc.

Auditorium is a hall or large building used for stage performances, public assembly or speeches. In auditorium there is need to get acoustical treatment properly. Basic acoustic criteria for all types of auditoriums are the same. It should have low ambient noise level from internal & external source, appropriate reverberation time, Avoid echoes, flutter etc. To full fill these criteria appropriate acoustical material for floor, ceiling & wall is necessary. Contemporary acoustical materials, paints & adhesive use for auditorium emit some amount of VOCs (Volatile Organic Compounds). High VOC content materials decrease productivity of occupant and also cause illness. Exposure to VOCs in indoor environment can causes indoor air quality related problems. It is essential to study VOC emission of different contemporary materials and suggest appropriate materials for floor, ceiling and wall of auditorium. In this paper, Acoustical materials along with VOC emission, Absorption coefficient for different frequencies & installation techniques have studied & analyzed various types of materials and installation techniques can be used for floor, wall & ceiling of auditorium.

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Keywords; *Acoustical materials, VOC emission, Absorption coefficient, installation techniques*

I. INTRODUCTION

Good acoustical design is a necessity in today's architectural environment. An auditorium is an essential one for Drama, performances and music programs. Acoustic comfort is necessity of such a building. Absorption coefficient means the amount of any incident sound energy which is absorbed by the surface. Energy can neither be created nor destroyed, but it can be changed from one form to another is the law of conservation of energy. Absorption converts sound energy into heat energy. Sound level within rooms can be reduced but not between the rooms. When sound energy incident on any material some amount energy absorbed by the material. The measurement of absorbed energy is called the absorption coefficient. Ratio of absorbed energy to incident sound energy is the absorption coefficient. Ratio of reflect to incident sound energy is the reflection coefficient. A material with absorption coefficient zero reflects all sound incidents upon it. Absorption coefficient is one when material absorbs all sound energy incident upon it. All materials absorb some sound energy, so this is a theoretical limit '1'. Sound absorptive materials are widely used in a various of conditions. Sound absorptive materials exist in different forms. (Shiney A, March 2015)

The noise reduction coefficient (NRC) or sound absorption coefficient values are different for different materials.

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The ideal (RT) reverberation time of an auditorium is dependent on the use of auditorium. The reverberation time of an auditorium should be long enough which around 1.5 to 2.5 sec and this time should be longer for low frequency sound and shorter for high frequency sound. (Shiney A, March 2015)

Indoor air quality 'IAQ' is air quality within the building a term which relates to comfort and well-being of building occupants.

Volatile Organic Compounds 'VOCs' refer to organic chemical compounds which have significant vapor pressures, and that canbe harmful for human health and the environment.High VOC content materials cause health problems for occupant and affects their productivity. VOC is the name of a substance that contains carbon which evaporates at room temperature.

Sr.no	VOCs	HARMFUL EFFECTS
1	Benzene	Causes cancer
2	Toluene	Sore head and sensation of spinning around.
3	Xylene	Respiratory tract and eye touchiness, downer effect, sadness and death
4	Chloroform	Disturb central nervous system producing sensation of spinning around, depression, kidney and liver damages, skin disease
5	Ethylene, Styrene	ozone layer depletion of
6	Acetaldehyde, acetone	Breathing and eye annoyance
7	Phenol	Strong odour and poisonousness
8	Epoxides	Poisonous, Causes cancer
9	Ethers	Creating peroxides, upsetting the procreative system
10	Vinyl chloride, freon	Ozone layer depletion , greenhouse result, cancer-causing, poisonous, climate changes
11	Nitrogen holding compounds	foul odour, cancer-causing (disturbing urinary bladder)

Table 1 Some Volatile Organic Compounds And their Harmful side effect

(Evuti, 2013)

Find out the sound absorption coefficient and Noise reduction coefficient (NRC) values of different materials to provide a good acoustical environment & VOC contents of these materials using (MSDS) The Material Safety Data Sheet or Product Data Sheet, provided by supplier or manufacturer to estimate air emissions. Analysis to decide what type of materials can be used for floor, wall & ceiling of auditorium.

II. METHODOLOGY

- Case study of Auditorium to study the acoustical material used.
- Make a list of absorption coefficient & Noise Reduction Values of different contemporary materials.
- Collect information about VOC content in contemporary acoustical materials and its installation from manufacturer by Material Safety Data Sheet (MSDS) or Product Data Sheet, brochures
- Material study by market survey.
- Analytical conclusion will be based on data collection by case study method, Market survey & VOC emission & installation data collection.

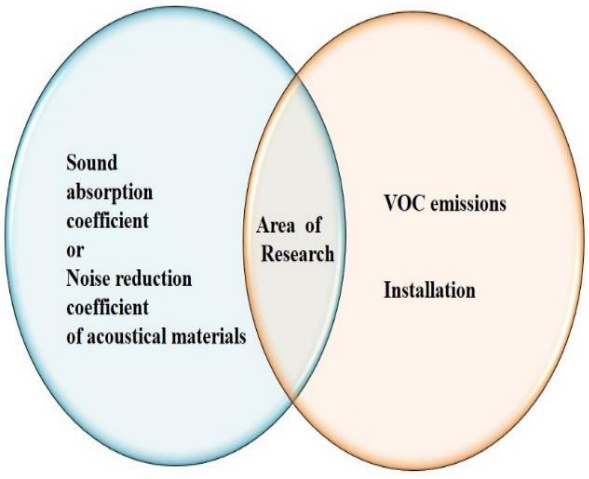

Figure 1-1

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March - April 2020
ISSN: 0193-4120 Page No. 9095 - 9102

III. LIVE CASE STUDIES

Case Study-1 MES (Management Education Society)

Auditorium, Balshikshan School Campus, Kothrud, Pune

Management Education Society Auditorium is one of the important auditorium in Kothrud suburb of Pune. Over the years the place has become cultural destination for Music, Concert and Drama. Number of programs has been held here like discussions, book release functions, gatherings, cultural meets etc.

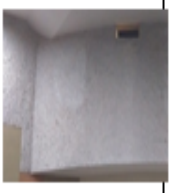
Material	Area	Size mm	Adhesive, sealants, Polish	Thickness mm	Images
Wood wool board with glass wool	wall	600 x 600	-	12	
Processed rubber wood	wall	2400 x 1200	maelamine polish	12	
Asona spray plaster on gypsum board	Wall	600 x 600	-	12	
carpet	Floor	-	Rubber based Fevicol SR-505	-	

Table 2 List of Materials and Adhesives used

Case Study-2 Keshavrao Bhosale Nattyagruh At Kolhapur

This is Maharashtra's oldest auditorium. The historic venue has been restored recently to its former glory by the Kolhapur Municipal Corporation.

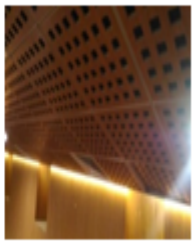
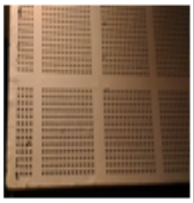
Material	Area	Adhesive, sealants, Polish	Size mm	Thickness mm	Images
Opta ceiling tiles	Ceiling	-	600 x 600	12	
Wood Work Ceiling Panels with maelamine polish	Ceiling	-	601 x 600	13	
Wood Work Wall Panels with maelamine polish	wall		602 x 600	14	
			2440X128	16	
Gyptone series fultone 50mm glass wool behind it	Wall		600 x 600	12.5	
Vinyl Floor	Floor	Arobond 44	-	-	

Table 3 List of Materials and Adhesives used

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March - April 2020
ISSN: 0193-4120 Page No. 9095 - 9102

IV. COMPARATIVE ANALYSIS

Case study	Case study 1	Case study 2
Material	**Carpet**	**Vinyl flooring**
area (Floor, ceiling, Wall)	Floor	Floor
VOC	Low or 0	≤ 10 µg/m3 (after 28 days)
Application techniques (sealants, adhesive etc.)	S-515, S-525, S-700, or S-751,Rubber based Fevicol SR 506	S-515, S-525, S-700, or S-750
NCR (Noise reduction coefficient)	0.59	0.05
Size	Roll	Roll

Table 4 Comparative Analysis of Flooring materials

Specifications	Application area	Type	VOC Content
S-525 Clear Thin Spread BioBased Tile Adhesive	Vinyl floor	Water-based/latex	**16.2 g/L (SCAQMD 1168)**
S-515 Clear Thin Spread Tile Adhesive	Carpet, Vinyl floor	Water-based/latex	**49 g/L (SCAQMD 1168)**
S-700 Thin Spread Floor Tile Adhesive	Carpet, Vinyl floor	Water-based/asphalt-rubber	**Zero g/L (SCAQMD 1168)**
S-750 Thin Spread Floor Tile Adhesive	Commercial Vinyl Primer for wood and concrete with self-adhering tile	Water-based/rubber resin	**5.9 g/L (SCAQMD 1168)**
S-288 Premium Vinyl Sheet Flooring Adhesive	• Fiberglass-Reinforced Sheet Flooring • Commercial Luxury Vinyl Tile Flooring	Water-based/rubber resin	**14 g/L (SCAQMD 1168)**
S-240 High Performance Epoxy Flooring Adhesive	• Vinyl Composition Tile	Two-part epoxy	**10g/L (SCAQMD 1168)**
Fevicol SR 505	Carpet, Vinyl floor, Glass Wool, Rock Wool	rubber resin	**5 gms / litre**

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March - April 2020
ISSN: 0193-4120 Page No. 9095 - 9102

Arobond 44	Vinyl floor	water based	**Zero g/L (SCAQMD 1168)**

Table 5 Adhesives used for Floor and Walls

		Case study 1		
Material		**Wood wool board**	**Asona acoustical plaster**	**Optra ceiling tiles**
area (Floor, ceiling, Wall)		Wall / ceiling	Wall	ceiling
VOC		24 µg/m³ (7 days)	-	0%
Plenum (Air Cavity)		-	-	-
Application techniques (sealants, adhesive etc.)		Framing, bolting	Spray gun / manually sprayed by troweling	Impaling clips (Adhesives), Z-Clips wall mount, Rotofast snap-on Anchor
Material use for application (sealants, adhesive etc.)		-	Spray gun / manually sprayed by troweling	-
Insulation		50 mm Glass wool	-	-
Absorption coefficient For Frequency	**125**	0.27	0.1	0.64
	250	0.56	0.35	1
	500	1	0.8	0.96
	1000	0.93	0.95	0.8
	2000	1	1	0.92
	4000	0.81	1	1
NCR (Noise reduction coefficient)		0.87	0.78	0.92
Analysis		it has low but some amount of VOC content Its absorption coefficient is less material is more reflective than absorptive. It can be installed by framing and bolting.	it has low but some amount of VOC content. They are applied by spray gun or manually sprayed by troweling by a skilled person. As thickness increases absorptivity increases particularly at low frequencies. it is absorptive.	it has 0% VOC content aesthetically it is attractive. Its absorption coefficient is more than 0.5 this material is absorptive. It can be installed by framing and bolting.

Table 6 Comparative Analysis part 1

Case study 2				
WoodWorks Ceiling panels	**WoodWorks Wall panels**	**Gyptone perforated pannels**		
ceiling	Wall	Wall/ Ceiling		
low	low	0%		
-	-	65mm	65mm	45mm
Framing, bolting	Framing, bolting	Framing		
-	-	-	-	-
-	-	without insulation	50mm **glass wool** 14 kg/m3	45 mm of underlaying **mineral wool**
0.56	0.35	0.2	0.4	0.35
0.64	0.76	0.35	0.65	0.65
0.43	0.48	0.55	0.8	0.85
0.19	0.5	0.75	0.7	0.85
0.1	0.5	0.6	0.65	0.75
0.04	0.57	0.4	0.55	0.75
0.34	0.56	0.56	0.70	0.78
it has low but some amount of VOC content aesthetically it is attractive. Its absorption coefficient is less than 0.7 this material is more reflective than absorptive. It can be installed by framing and bolting.		It has 0% VOC content aesthetically it is good. NRC typically ranges from 0 (total reflection) to 1.00 (total absorption). For perforated products, the NRC is dependent on the amount of open surface area, the type of acoustic fabric, the use of additional insulation material and the depth of the air cavity (plenum) behind the lining. It can be installed by framing and bolting.		

Table 7 Comparative Analysis part 2

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March - April 2020
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V. VARIOUS MOUNTING SYSTEMS

a) Impaling Clips

Decide the location of the panel where it will be mounted. Then mark outside edge of location for all side of panel. Use suitable fastener to mount clips to the wall. Clips should be set at least 6 inches from the outer edge. Apply sufficient adhesive to the back of the panel. Put the panel to the mark on the wall and then push it onto the clips to pin up the clip into the fibre glass core. Check panels are straight and exact at required position. These clips hold the panel in at the position while the adhesive sets (Ref: acoustical solutions broacher)

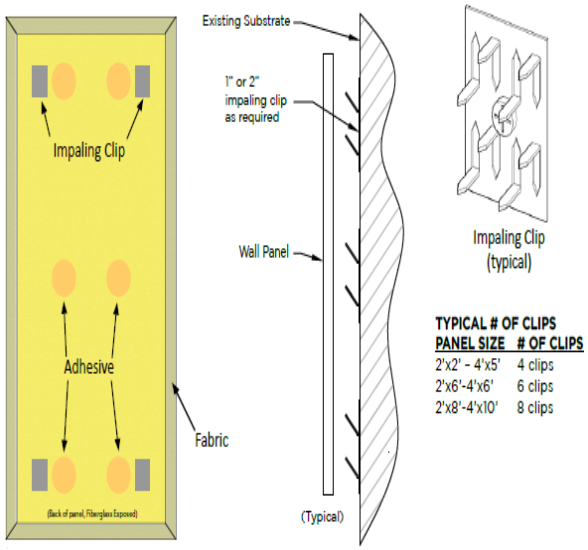

Figure 4-1

(Source: acoustical solutions broacher)

b) Z-Clips Wall Mount

These clips fasteners are in two parts used to mount panels. It use to the back of the panels. These wall clips are provide with the order. Decide the location of panels. Same mounting locations from panel onto the wall to line up with the clips on the back of the panels. Mark reference lines on the wall to confirm panel's position and level. Fit z-clips to the wall using suitable fasteners. Fasten panel z-clips onto wall z-clips. Same process for all panels

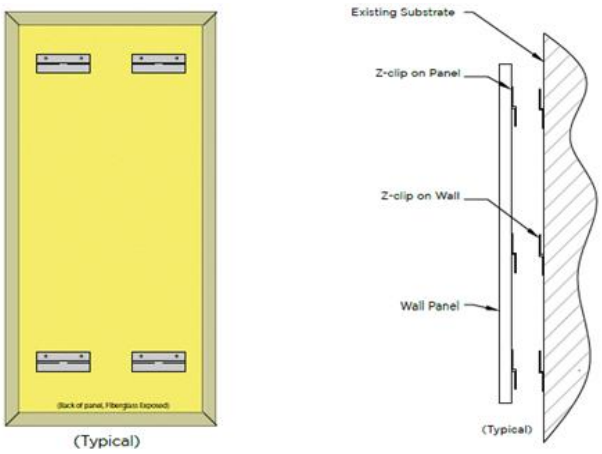

Figure 4-2

(Source: acoustical solutions broacher)

c) Rotofast Snap-On Anchor

Acoustical panels order with the right amount of Rotofast Snap-On Anchors and accessories required for the project. The anchors are pre-installed into the back of the panel. The suitable amount of marking plugs are used to ensure you have enough for the largest panel.

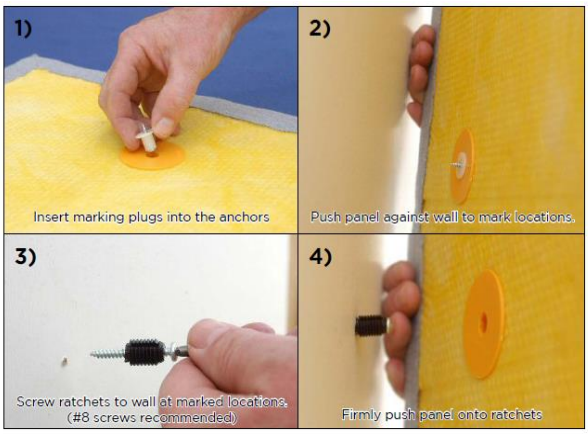

Figure 4-3

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(Source: acoustical solutions broacher)

VI. RECOMMENDATIONS& CONCLUSION

For auditorium not only low or zero voc emission materials are important but also its installation techniques, adhesive, paints, insulations and its voc emissions are important. For example Alphasorb Acoustic Panels has low VOC content and it has Various Mounting Systems like Impaling Clips, Z-Clips Wall Mount , Rotofast Snap-On Anchor (Ref: Figure , Figure , Figure). For Impaling Clips mounting system adhesive has used which emits some amount of VOCs. To avoid VOC emissions use Z-Clips Wall Mount or Rotofast Snap-On Anchor Mounting Systems.

Acoustical materials used for the auditorium are in large quantity so even if low voc materials are used its total voc emissions can be higher. Use a zero VOC materials avoid the use of adhesives and paints which emit VOCs, select appropriate installation techniques.

Acoustical materials for wall

Wood Works Wall panels has low but some amount of VOC content aesthetically it is attractive. Its absorption coefficient is less material is more reflective than absorptive. It can be installed by framing and bolting.

Asona acoustical plaster has low but some amount of VOC content aesthetically it is attractive. They are applied by spray gun or manually sprayed by troweling by a skilled person. As thickness increases absorptivity increases particularly at low frequencies. Asona acoustical plaster is absorptive.

Acoustical materials for Ceiling

Optra ceiling tiles has 0% VOC content aesthetically it is attractive. Its absorption coefficient is more than 0.5 this material is absorptive. It can be installed by framing and bolting.

Wood Works Ceiling panels has low but some amount of VOC content aesthetically it is attractive. Its absorption coefficient is less than 0.7 this material is more reflective than absorptive. It can be installed by framing and bolting.

Acoustical materials for Ceiling/Wall

Gyptone perforated panels has 0% VOC content aesthetically it is good. NRC ranges from zero (reflect all incident sound energy) to one (absorb all incident sound energy). For these types of panels NRC depends on extra insulation, air cavity, type of fabric used, exposed surface area. It can be installed by framing and bolting.

Wood wool board has 24 µg/m³ (7 days) VOC emissions. Wooden framing behind the panels with glass wool insulation, these panels are bolted to the wooden frame no adhesive and paint used.

Acoustical materials for Flooring

Vinyl flooringhas ≤10 µg/m3 (after 28 days) VOC emissions. Its absorption coefficient is low. It installs by using adhesives like S-515, S-525, S-700, or S-750.

Carpet has 0 or low VOC emissions. It is more absorptive than vinyl flooring. It installs by using adhesives.

Adhesives use for flooring some of them has low VOC or 0 VOC content. Avoid VOC Content Adhesives and use 0 VOC adhesives like **Arobond 44, S-700.**

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