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# JOURNAL OF SAFETY SCIENCE AND FIRE RESEARCH






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# JOURNAL OF SAFETY SCIENCE AND FIRE RESEARCH

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Trekking is a physical activity aiming at recreation, training, and physical fitness. Asa rule, people are engaged in this activity during vacations

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Air pollution is a significant environmental issue faced by the city of Patna, located in the state of Bihar in India. With a growing population and expanding industrial activities, the level of air pollution has increased significantly in recent years.

## Article 1

# Occupational Noise Assessment Through Frequency Analysis - A Case Study of Heating Ventilation Air Conditioning (HVAC) Systems in a Process Plant

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Key terms used:

Noise assessment, Octave band analysis, Occupational noise

**ABSTRACT**

Acoustic noise is a recognized occupational health hazard. Prolonged exposure to high noise level may cause hearing disability to the exposed personnel. Limiting exposure to noise within its occupational exposure limits (OEL), which is the maximum permissible total sound intensity, is adopted as one of the administrative control measures to prevent hearing impairment. In addition to the total sound intensity, the frequency of sound that lies in a wide range plays vital role in the noise induced harmful auditory and non-auditory effects.

However, the frequency specific assessment of occupational noise exposure is sparse. Here, we evaluated the noise generated from the various components of heating ventilation air conditioning (HVAC) system in a chemical process plant. Noise level was observed to be high in some locations, although the personnel exposure was within OEL. We analyzed the measured noise spectra using various assessment methods: A-weighted total sound pressure level, 1-octave band frequency analysis and Noise Rating (NR) analysis. It revealed that the major contributing frequency bands to the total noise intensity are different in different location. The frequency analysis suggested that the total noise intensity may not be the only indicator of the hazard; frequency has its role, too.

## 1. INTRODUCTION

Acoustic noise is a recognized occupational health hazard. Exposure to high noise level can cause auditory as well as non-auditory harmful effects on human health. The auditory effects are tinnitus, temporary shift of hearing threshold and even permanent hearing impairment; whereas, the non-auditory effects include annoyance, sleep disturbance, headache, lack of concentration, etc. [1-9]. The noise induced hearing loss (NIHL) is considered as one of the notifiable occupational diseases in India [10].

Acoustic noise can be defined as unwanted sound. Human ear can hear sound over a wide range of frequencies (20 - 20000 Hz). The health effects of noise following exposure depend on its intensity and duration of exposure. As the intensity of noise and duration of exposure increases the effects of noise also increases. In addition to the intensity of noise, the potential of auditory and non-auditory health effects of noise depends on its frequency, too [11]. The high frequency noise is more hazardous in damaging hearing ability. Hearing protectors, such as ear muffs and ear plugs that attenuate high noise level are used as personal protective equipment (PPE) to reduce exposure. The effectiveness of the hearing protectors also varies with frequency of sound. Alam et al [12] studied the noise attenuation offered by a number of ear muffs and ear plugs by real ear attenuation at threshold method, which revealed that the ear plugs offer more attenuation for low frequency (125 and 250 Hz) and high frequency (8 and 12 kHz) noise. In contrast, the ear muffs offer better attenuation at mid frequencies, (1, 2, and 4 kHz). Hence, the frequency specific evaluation of exposure to noise is important. Nevertheless, the frequency specific assessment of occupational noise is less. Recently, we studied [13] the frequency components of noise produced from machines in a mechanical workshop, which revealed that the major contributing frequency bands to the total noise intensity are different for different machine types.

In this study, we measured acoustic noise generated from various components of a heating ventilation air conditioning (HVAC) system in a chemical process plant. HVAC system is an integral part of any chemical process plant. It supplies fresh conditioned air to the various areas of the plant and exhausts the stale air containing hazardous contaminants. It also maintains the ambient temperature in the plant areas. Thus, the HVAC system helps to maintain a healthy occupational environment. We analyzed the frequency spectra of noise generated by the various components of the HVAC system using different assessment methods, namely, A-weighted total sound pressure level, 1-octave band frequency analysis and Noise Rating (NR) analysis. The results reflect the importance of frequency specific assessment of noise in work places.

## 2. MATERIALS AND METHODS

A class 1 sound level meter (Make: CASELLA) was used to record the sound pressure levels (SPL) and the frequency spectra of noise. The sound level meter was calibrated using 94 dB and 114 dB standard sounds of 1000 Hz. Frequencies of audible sound lie over a wide range. Therefore, specific frequency analysis bands have been standardized so that the measurements between different instruments can be compared. It has been agreed upon "preferred" frequency bands for sound measurement and analysis [14-15]. We recorded the SPL spectra in 1-octave bands. In 1-octave band, the lower frequency limit of the band is approximately half the upper limit. Each 1-octave band is described by its "centre frequency", which is the geometric mean of the lower and upper frequency limits.

SPL (noise) spectra were recorded at various locations of the HVAC system. We recorded SPL spectra in six locations: Supply Fan Area, Exhaust Blower Areas (three separate locations), Chiller Machine Area and inside a noise proof cabin (Operators' Cabin) installed in Chiller Machine Area. Noise was measured continuously for ~ 15 minutes during operation of the systems and the equivalent continuous SPL ($L_{eq}$) were recorded. $L_{eq}$ is the constant noise level (SPL) that would result in the same total sound energy being produced due to a time varying signal over a given period.

## 3. RESULTS AND DISCUSSION

### 3.1 A-WEIGHTED EQUIVALENT CONTINUOUS SOUND PRESSURE LEVELS

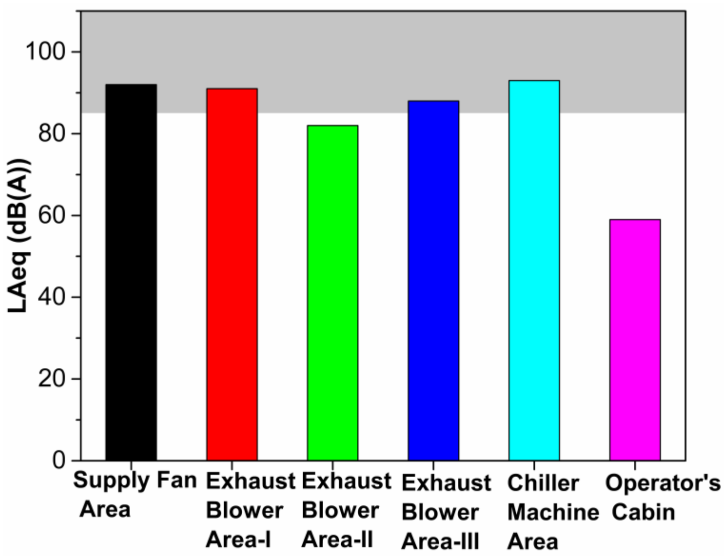
Human ear is not equally sensitive to sound in the entire audible frequency range. It is more sensitive to the higher frequency sound compared to the lower frequencies. Also, the high frequency sounds are more hazardous (causing hearing impairment). Therefore, in general, a weighting network is applied to the recorded SPL to simulate the response of human ear. The SPL values were measured using A-weighting network that mimic the frequency response of human ear to sound. Fig. 1 shows the total A-weighted equivalent continuous sound pressure level ($LA_{eq}$) at various measurement locations. One advantage of using $LA_{eq}$ values to compare the noise level of different locations is that it corresponds to the energy of sound wave over a certain time period. Moreover, the occupational exposure limits (OEL) of noise specified by the major regulatory agencies are expressed in $LA_{eq}$.

The American Conference of Governmental Industrial Hygienists (ACGIH) recommends the threshold limit values (TLV) for audible sound as given in Table 1.

| Exposure duration per day, in hours | Sound pressure level in dBA |
|---|---|
| 8 | 85 |
| 4 | 88 |
| 2 | 91 |
| 1 | 94 |
| 1/2 | 97 |
| 1/4 | 100 |

**Table 1 Threshold limit values (TLV) for audible sound [16]**

**Figure 1 A-weighted equivalent continuous sound pressure level ($LA_{eq}$) at different measurement location. The shaded part of the graph indicates $LA_{eq}$ of values greater than 85 dBA.**



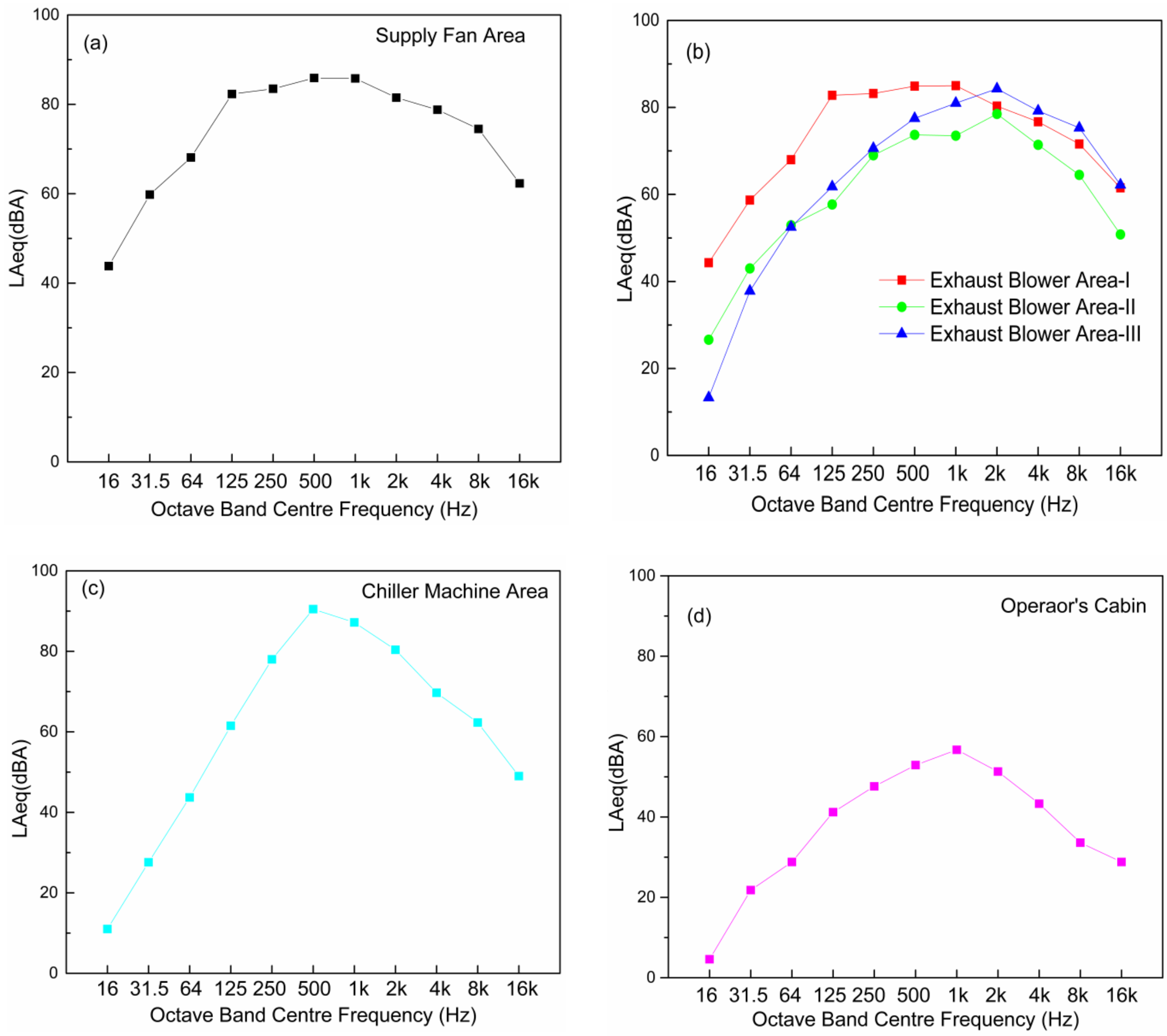

From Figure 1, it can be seen that the $LA_{eq}$ (8-hour time weighted average) of Supply Fan Area, Exhaust Blower Area I & III and Chiller Machine Area is greater than 85 dBA. It was learnt that these areas are not continuously occupied by the workers. The Supply Fan and Exhaust Blowers are generally operated from a control room located away from these areas. A noise insulated cabin (Operators' Cabin) is provided in the Chiller Machine Area for the operators of the machine. The $LA_{eq}$ of the Operators' Cabin is 59 dBA. Moreover, the operators use hearing protectors while visiting the high noisy areas. Therefore, the exposure of the workers to noise remains within the TLVs specified by ACGIH.

Total $LA_{eq}$ value is certainly an important parameter to assess occupational noise. It represents the total energy of the sound waves. However, it does not provide the noise intensity at different frequencies of sound. In fact, Yifan et al. [17] performed a pair-wise comparison experiment on subjective annoyance rating of noise samples, which indicated that the low frequency noise samples are more annoying than that of higher frequencies when their A-weighted SPL are same. The authors concluded that the A-weighted SPL cannot scientifically assess noise induced annoyance when the noise contains mostly low frequency components. The contribution of the various frequency components in the total SPL plays important role in noise assessment as well as its control measures. Therefore, we measured the SPL values at the centre frequencies of different 1-octave bands.

### 3.2. 1-octave Band Frequency Spectra of Noise Measured at Various Locations

Figure 2(a)-(d) shows the 1-octave band frequency spectra of measured noise at various locations. In all the locations, the frequency spectra follow a similar trend. $LA_{eq}$ increases with increasing frequency of sound, reaches a maximum and then decreases with further increasing of frequency. However, the frequency band at which the $LA_{eq}$ reaches maximum is not same for all the locations. Table 3 shows the 1-octave band centre frequency at which $LA_{eq}$ reaches its maximum. The noise spectra of Supply Fan Area and Chiller Machine Area reach maxima at 500 Hz. The noise spectra of Exhaust Blower Areas reach their maxima at 1000-2000 Hz. High frequency noise has higher potential for hearing impairment, whereas low frequency noise is more annoying. Persson et al. [18-19] suggested that A-weighted SPL underestimates the annoyance due to the low frequency noise below frequency about 200 Hz. Below 250 Hz band, the SPL of Supply Fan Area and Exhaust Blower Area-I are significantly higher than that of other locations. Therefore, noise of these two locations is expected to be more annoying than other locations.

**Figure 2 A-weighted equivalent continuous sound pressure level ($LA_{eq}$) at various octave band centre frequencies measured at different locations; (a) Supply Fan Area (b) Exhaust Blower Areas (c) Chiller Machine Area and (d) Operator's Cabin.**




Human ear is most sensitive to sound at 4000 Hz [20]. Similarly, the sound of 4000 Hz is believed to be the most hazardous for hearing damage [11]. In fact, the NIHL is reflected as a dip at 4000 Hz in the pure tone audiogram. The dip in the audiogram implies the maximum threshold of hearing. Therefore, the $LA_{eq}$ value at 4000 Hz octave band is an important parameter for noise exposure assessment. Table 2 shows the $LA_{eq}$ values at 4000 Hz band ($LA_{eq,\ 4\ kHz}$) of various locations. It is interesting to note that although the total $LA_{eq}$ of Chiller Machine Area is the maximum, the $LA_{eq,\ 4\ kHz}$ of Supply Fan Area and Exhaust Blower Areas are greater than that of the Chiller Machine Area. Even the $LA_{eq,\ 4\ kHz}$ of Exhaust Blower Area-II, of which the total $LA_{eq}$ is less than 85 dBA, is greater than that of the Chiller Machine Area. It suggests that although the total noise intensity ($LA_{eq}$; see Fig. 1) of Supply Fan and Exhaust Blower Areas are less than that of the Chiller Machine Area, their potential of causing hearing damage may be greater. These observations certainly indicate the importance of frequency specific noise measurement in the exposure assessment.

| Location | Octave Band Centre Frequency (Hz) at which LAeq (dBA) is maximum | LAeq (dBA) at 4000 Hz |
|---|---|---|
| Supply Fan Area | 500 | 78.8 |
| Exhaust Blower Area-I | 1000 | 76.7 |
| Exhaust Blower Area-II | 2000 | 71.4 |
| Exhaust Blower Area-III | 2000 | 79.2 |
| Chiller Machine Area | 500 | 69.7 |

**Table 2 Major contributing 1-octave bands to the total SPL at different locations**

### 3.3. NOISE RATING OF VARIOUS LOCATIONS

Apart from the protection of noise induced hearing impairment, the acceptability of the other non-auditory effects like annoyance and interference with speech communication are also important in workplaces. These non-auditory effects can make negative impact on the safety and productivity of the workers. Noise Rating (NR) curves developed by the International Organization for Standardization (ISO) is often used to assess the acceptable indoor environment for hearing preservation, speech communication and annoyance [21]. NR curve is used to specify the maximum acceptable noise level in each 1-octave band of a particular frequency spectrum. To determine the NR value of a noise spectrum, the SPL at each 1-octave band is compared to that in the corresponding standard NR curve. Fig 3 shows the typical NR curves (that are plotted as SPL vs octave band centre frequency) and noise spectra (unweighted in dB unit) of different locations. The NR curves were calculated using the equation 1 [22-23]. The SPL value at 1000 Hz band represents the number of the NR curve. The NR value of a particular noise spectrum corresponds to the first NR curve which just exceeds the noise spectrum at every 1-octave bands. For example, the NR value of the noise spectrum of the Exhaust Blower Area-II is 80 as shown in the Fig. 3. It means that the NR curve of NR 80 just exceeds the noise spectrum (Exhaust Blower Area-II) at every 1-octave bands.

$$\mathrm{SPL} = (\mathrm{NR_f} \times \mathrm{B_f}) + \mathrm{A_f}\ \mathrm{dB} \ldots\ldots\ldots (1)$$

Where, SPL is sound pressure level at frequency f and noise rating NR; $NR_f$ is noise rating at frequency f; $A_f$ and $B_f$ are physical constants.

**Figure 3 Noise Rating (NR) curves of NR 10 to NR 100 and SPL spectra of various locations.**

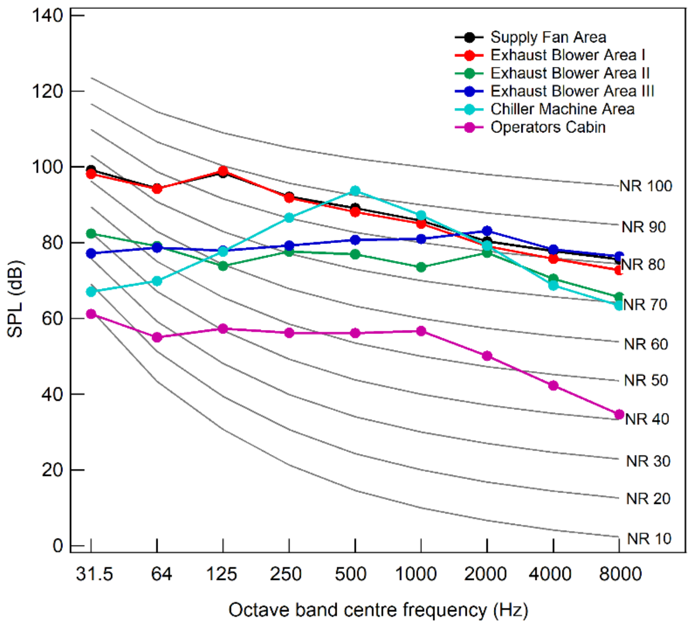



Table 3 shows the NR values of the noise spectra of each location. The maximum recommended NR values for typical applications are given in Table 4. Except Operators' Cabin, the NR values of other areas are high (NR: 80 - 91). Therefore, these areas should not be used or occupied for other activities. Installation of the sound proof cabin in Chiller Machine Area reduces the NR value to 57. The operators use this cabin as resting place or for other light engineering activities.

| Location | NR Values |
|---|---|
| Supply Fan Area | 88 |
| Exhaust Blower Area-I | 88 |
| Exhaust Blower Area-II | 80 |
| Exhaust Blower Area-III | 85 |
| Chiller Machine Area | 91 |
| Operator's Cabin | 57 |

**Table 3 Noise Rating (NR) values of the noise spectra of various locations**

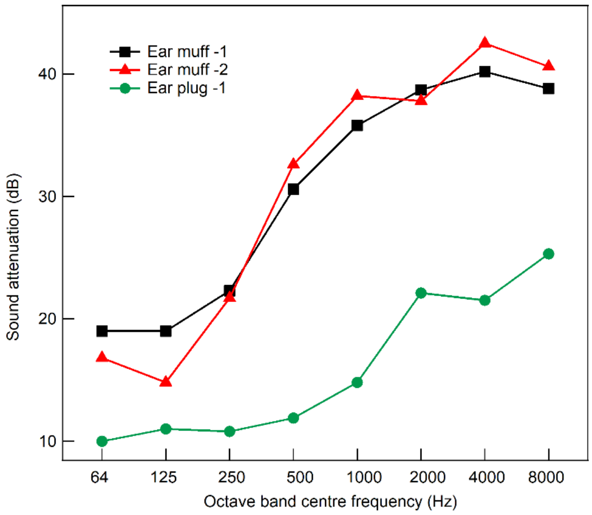
| NR curve | Application |
|---|---|
| NR 25 | Concert halls, broadcasting and recording studios, churches |
| NR 30 | Private dwellings, hospitals, theatres, cinemas, conference rooms |
| NR 35 | Libraries, museums, court rooms, schools, hospitals operating theatres and wards, flats, hotels, executive offices |
| NR 40 | Halls, corridors, cloakrooms, restaurants, night clubs, offices, shops |
| NR 45 | Department stores, supermarkets, canteens, general offices |
| NR 50 | Typing pools, offices with business machines |
| NR 60 | Light engineering works |
| NR 70 | Foundries and heavy engineering works |

**Table 4 Maximum recommended Noise Rating (NR) values for typical applications [21]**

## 3.4. SOUND ATTENUATION BY THE HEARING PROTECTORS

We investigated the sound attenuation offered by the hearing protectors (2 ear muffs and 1 ear plug) that are used by the workers. The sound attenuation data of the hearing protectors at different 1-octave band were obtained from the technical datasheet supplied by the manufacturers (see Fig 4). It can be seen that the ear muffs and ear plug are more effective in sound attenuation at higher frequencies. Nevertheless, the sound attenuation offered by the ear plug around 500 Hz is quite less. Therefore, the ear plug is less effective (compared to the ear muffs) in the locations such as Chiller Machine Area and Supply Fan Area where SPL near 500 Hz is maximum.

**Figure 4 Sound attenuation data of the hearing protectors as per technical datasheet.**



## 4. Conclusions

The frequency spectra of noise generated by various components of a HVAC system were measured in a chemical process plant. The measured noise spectra were analysed using various assessment methods, namely A-weighted total SPL, 1-octave band frequency analysis and Noise Rating method. The A-weighted total SPL of some locations is observed to be high, although the personnel exposure is within OEL. 1-octave band frequency analysis of the noise spectra revealed that the major contributing octave bands to the total noise intensity is not similar for all locations. Moreover, the frequency analysis suggested that only the total noise intensity may not entirely reflect the hazard potential of noise; the frequency of noise also plays important role. NR values of some locations are observed to be high. It is suggested that the frequency specific noise measurement should be included in hearing conservation program of occupational set-ups.

## 5.ACKNOWLEDGEMENT

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## Article 2

# Noise Pollution: A Reality in Public Places

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**ABSTRACT**

Noise being considered as one of the prominent factors for the pollution which affects the well-being of human beings, animals, and plants. It may stimulate the geological factors which may trigger catastrophes or disasters. The ecology can be impacted with the interference of noise. The effect as well as the consequence of the noise, which are generated from men-machinery effects. This is an effort to find out various pros and cons existing and passed in the area of noise pollution is tried to be brought out through this article.

Key terms used:

*Noise, disasters, ecology, urbanisation.*

## 1.INTRODUCTION

The high levels of noise and the implication of the noise levels on the environment is highly recommended to study (Nandi and Dhatrak 2008; Nelson et al. 2005; Rabinowitz 2000; Themanna and Masterson 2019; Ashly S and Anilkumar B 2016). Till date the research activities are focussing on a pre-set condition, which are inclusive of closed system such as factories, industrial clusters or even in an atmosphere of joyful moments which are in particular trigger during a football or cricket matches in a stadium full of crowd. No study or effects are not concentrated on the ill effects to the fellow viewers or even the inhabitants near to the perimeter of the stadium.

The concern is not only to be restricted to the football or cricket stadiums, as the festivals or processions (religious or political) or even the vehicular traffic and the subsequent noise generated may affect the well-being of the organisms. The earlier studies have identified that exposure to loud noise for more duration can damage the hair cells of the cochlear in the inner ear leading to irreversible sensorineural hearing loss (Azizi 2010; Basner et al. 2014; Hong et al. 2013; Nandi and Dhatrak 2008). There is need to study as well as to focus on the unforeseen or even unknown causes of the secondary health issues which might be the aftereffects of the unattended or unnoticed noise related scenarios. There are laws and guidelines which stipulates the limits or even exposure limits. The compliance is a questionable matter where the failure, if any can be compounding towards law makers. However, the responsibility of fellow citizens cannot be omitted. This study tries to bring out exposure limits as well as dose levels in public places and the chances of potential health hazards.

### 1.1 SOURCES OF NOISE

A major source of noise in the city is from traffic from the motors vehicles, horn (honking) processions related to political parties and festivals in religious institutions. Further to note, noise from the roadway is generated by commercial activity, construction. Noise levels and its threats may depend on the type of infrastructure, density of vehicles, climate variations. Further sources are stadiums, shopping malls, mobility hubs etc.

## 2.METHODOLOGY

The permissibility to the area for acceptance or limits can be done through noise assessment, which is the actual measurement of the noise levels. In consideration to the convenience, the Android supported Sound meter application released by Splend Apps is used for the study and the accuracy and authenticity is checked with the measurement taken with portable precision digital sound meter, model TSI QUEST SOUND DETECTOR SD-200 , manufactured by TSI Inc, USA, with measuring range 40-130dB with 0.1dB resolution. The sound level meter was calibrated before taking the measurements according to the user manual. Continuous sound level measurements during daytime (0800–2000 hrs.) was carried out in Ernakulam and Aluva city areas. The noise level in Ernakulam city and Aluva city were observed during different time intervals at different selected locations. The study locations were identified and measurements were taken at Commercial establishments and Educational and Hospitals were silent zones to be observed. The measurement areas include near to Metro Railway Station, Pulinchuvadu, Traffic Junctions including High Court, General Hospital Ernakulam, Bus Stand, Kaloor, Palarivattom round about, Edapally Junction, Cochin University Junction, Pump Junction, Aluva, Hotel in Pump Junction, Aluva Town Hall, Medical College Ernakulam.

Noise measurements using the application were taken using the prescribed procedure stipulated in the manual of the Sound Pressure Level meter. The results were noted in at the spot of measurement. The measured noise levels are compared with the limits as mentioned in the WHO standards / Central Pollution Control Boards. Industrial, commercial, shopping and traffic areas, indoors and outdoors (70 dB A - 110 dB A) for base 24 hour. Since the measured decibel using the application is 10 dB lower to the TSI QUEST sound detector, the measurements indicated in Table-1 is added with 10 dB(A) measurement to the actual readings.

| LOCATION | 8:00 AM – 12:00 PM | | | 12:00 PM-5:00 PM | | | 5:00 PM-8:00 PM | | |
|---|---|---|---|---|---|---|---|---|---|
| | Min | Avg. | Max | Min | Avg. | Max | Min | Avg. | Max |
| ERNAKULAM SOUTH | 51 | 80 | 105 | 59 | 89 | 113 | 63 | 89 | 115 |
| HIGHCOURT JUNCTION | 51 | 77 | 96 | 60 | 91 | 113 | 53 | 75 | 98 |
| GOVERNMENT HOSPITAL | 36 | 76 | 96 | 43 | 90 | 113 | 57 | 81 | 105 |
| CHILDRENS PARK | 52 | 78 | 96 | 61 | 92 | 113 | 61 | 92 | 113 |
| KALOOR BUS STAND | 66 | 97 | 115 | 60 | 89 | 105 | 69 | 101 | 119 |
| PALARIVATTOM CIRCLE | 63 | 96 | 110 | 62 | 84 | 99 | 71 | 105 | 121 |
| EDAPPALY JUNCTION | 67 | 96 | 113 | 65 | 89 | 101 | 65 | 92 | 109 |
| EVM SKODA CUSAT JUNCTION | 49 | 69 | 92 | 73 | 75 | 89 | 45 | 68 | 89 |
| PULINCHODU METRO STATION | 50 | 75 | 94 | 63 | 76 | 93 | 51 | 71 | 90 |
| ALUVA PUMP JUNCTION | 60 | 82 | 110 | 53 | 73 | 94 | 62 | 74 | 105 |
| ALUVA TOWN HALL | 55 | 77 | 98 | 49 | 72 | 90 | 51 | 75 | 91 |
| St. JOSEPH SCHOOL CHUNANGMVELY | 45 | 69 | 89 | 49 | 71 | 92 | 43 | 65 | 91 |
| ICRA MASJID MEDICAL COLLEGE EKM | 50 | 76 | 98 | 59 | 81 | 101 | 61 | 88 | 116 |

**Table 1 Mean value of digital sound level meter reading**

# 3.RESULTS AND DISCUSSIONS

## 3.1 RESULTS

It has been specified, during the surveys, that the noise levels detected in all the industries are much above the 80 dBA that is specified in the regulations. Almost all people in this area who commutes during these hours are disturbed due to the noise and the continuous impact of loud noise will wear down the hair cells inside the inner ear, which causes the change in the hearing capabilities. This is known as Temporary Threshold Shift, which may recover during the cause of time, with false impression that the impacted personals are all right.

If there are regular exposures to loud noise in the case of people who are working in the shops, hotels, learning institutes, the cleaning staffs near this area, this will destroy the hair cells or nerves in the ear which causes Permanent Threshold Shift (PTS) or permanent hearing loss. The people who are affected by these will not be able to realize that they are having hearing loss because this type of hear loss occurs gradually and the damage caused cannot be repaired or rectified.

The main findings of the study of noise in the above areas will produce health effects such as stress, frustration, sleep disturbance, difficult to concentrate in the daily activities, increasing the level of blood pressure and also the rhythm of heart beats which can lead to the cardiovascular diseases. As discussed above due to the prolonged noise which are well above the standards mentioned, can lead to temporary and permanent hearing losses. Some of the symptoms of these defect are mentioned below,

Primary symptoms, due to the noise in this area can be classified as

- Pain around or inside the ear
- Irritation or discomfort down the side of face, neck, or shoulder.
- Nausea or vomiting
- Unsteadiness

- Secondary symptoms, due to the noise in these areas include:
    - Headaches
    - Fatigue
    - Loss of balance due to problem in ear drum.
    - Nervousness.

## 3.2 DISCUSSION

The noise pollution will affect the people with exposure, would have symptoms like headache, nausea, etc which would aggravate the conditions of stress, temporary hear loss and cardio vascular system and reduction in hearing ability. The effect due to noise to be controlled by introducing sound barriers, forestation / planting trees, giving more importance to the usage of electric vehicles through legislation. The following control measures are mentioned below to consider the possibility of most effective mitigation measures.

- Examine, identify and eliminate the source of loud noise which the commuters and individuals working in this area are exposed as far as possible.
- If the above measure is not achievable, then the level of noise in this area who are exposed must be minimized by using engineering control measures, administrative control measure or by providing the personal hearing protectors.
- Noise barriers can be installed along the walls of hospitals, educational institution, which is best solution to reduce the sound pollution caused due to the vehicle movement.
- Legislative measures should be adopted along the sensitive zone like hospitals, high court by banning horns, limiting the number of vehicles etc.
- Plants and trees should be planted along the roads and highways which can reduce the noise pollution substantially.
- Efficient traffic management must be carried out.

- Reduce the speed of the vehicle in these areas can reduce the noise due to heavy breaking of buses, and heavy vehicles.

The entry of heavy vehicles including trucks during the working hours in the main part of cities may be restricted, which on the other way can lead to traffic congestion lead to higher noise level.

## 4. CONCLUSION

The noise assessment of the locations indicated that the noise levels in the area are progressing at a very fast rate with increasing population and heavy traffic. Noise levels obtained at different locations of the cities are appeared to be crossing the limits prescribed by the WHO.

The collected data and the results prove that on all assessed roads, junctions, commercial establishments, hospital zones, educational institutions are having higher noise limits than the permissible prescribed by CPCB /WHO. Even in the silent zones have exceeded the permissible norms of 50 dB (A).It was expected that the higher noise levels in the junctions / cities are due to fast and unsegregated urbanisation, which caused the more inflow of people from different regions. It is anticipated that the noise environment of the study area may cause great threat to the health of inhabitants in long term. Hence, a proper and strict law enforcement and thereby continual regulation is to be followed by the statutory bodies of the State.

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## Article 3

# Safety During Trekking in High Altitude Areas

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Key terms used:

Trekking, Uttarakhand, Weather, Safety Protocol, Himalaya, Evacuation.

**ABSTRACT**

Trekking is a physical activity aiming at recreation, training, and physical fitness. As a rule, people are engaged in this activity during vacations. However, very often, trekking is the main motive for travelling. This very fact allows us to refer to trekking as a distinct type of tourism, being the very reason to make a trip. The existing body of knowledge in tourism reveals that the trekking trails have global appeal and vast potentials to be established and developed as adventure tourism products destinations in world mountain regions. The adventure tourism is as one of the fastest growing sub-sectors of tourism.

This paper describes the challenges and hazards associated with the trekking Activity. It covers mainly the Avalanche accident scenario with the trekker and trekker team, what type of difficulty they faced during trekking in Uttarakhand High Altitude regions and also suggest some suggestion for safer Trekking. To ensure maximum possible safety on the treks, we have set up a protocol Himalayan High Maximum Safety Assurance Protocol. Proper Planning, proper communication with the local Authority, Weather Analysis and Time for Evacuation are the major key for Safer Trekking.

## 1.INTRODUCTION

There is no denying the fact that the hilly areas are full of scenic sights almost everywhere. Adding to that, the pleasant chilly atmosphere itself is enough motivationfor people to pack up and embark on a road trip to their neighboring hill stations. Venturing in the magical, mystical and heavenly beautiful High altitude remote and rough terrains of the Himalayas gives immense satisfaction to the anxiousness of thrill, the spirituals sense of the soul and curiosity itch of the human race. However, it's very easy to understand that it involves immense risks and might cause fatal consequences as well as on occasions.

Trekking – walking in nature – is a natural activity aiming at recreation, training, and physical fitness (Britannica, 2020). It often constitutes significant part of mountaineering and is a prerequisite for other activities such as backpack- camping, hunting, orienteering and other recreation activities in nature. Being capable for walking considerable distances without suffering from fatigue also encourages activities such as birdwatching, photography and cultural environment, etc. in Europe, Trekking is one of the most popular recreation and vacation activities (Lane, 1999). According to studies, in France and Italy, more than 1.000.000 trekkers engage in trekking, while, in the United Kingdom, they come to 1.000.000. InGermany, trekking is the third most popular recreation activity.

The research evidences for adventure tourism reveals that it has numerous trekking options and the significant proportions of new tourism attractions with access to the direct and authentic experience of nature and culture, the many of the global mountain trails are integrated with tourism on the forms a distinct trekking and adventure destinations. These tails attract millions of explorers, trekkers, mountaineers, and general-purpose visitors for the purpose of adventure tourism. As such there has been exponential growth in adventure tourism with tourists also visiting destinations previously undiscovered between 2010 and 2014; the adventure tourism industry grew by 195%. Adventure travel is rapidly becoming mainstream. The international adventure tourism market is likely to grow the compound annual growth rate of 45.99% during the period 2016-2020.

## 1.1 Himalayas short Description

**Location** : South and East Asia (Pakistan, India, Bhutan, Tibet and Nepal)

**Popular Tracks** : Great Himalaya Track -GHT (Ladakh – Markha Valley trek, Margalla Hills trek, Chomolhari trek, Kanchenjunga Basecamp Trail, Makalu Base Camp Trail, Annapurna Base camp Trail, Rara Khaptad Trekking Trail)

**Key Features** : Home to world's highest peaks including Mount Everest and K2

**Key Mountains range** : Over 4500 km of Great Himalaya ranges including Mt Everest, K2, Mt. Kanchenjunga, Mt. Makalu, Mt Cho you, Mt. Annapurna, Manaslu, Mt Dhaulagiri, etc.

**Ranges in Altitudes** : Up to 6000m

These Mountains are a valuable natural asset of which the tourism industry very often makes extensive use. The mountains as in table above are the flourishing ground for adventure tourism products cum destinations as these mountains with several lower and higher peaks of the globe posses enormous trekking trails. Such trails pass through lush green valleys, arid high plateaus and incredible landscapes. In this sense, Mountain tourism as an integral part of global tourism has developed as higher recreation and adventure for tourists who are fond of trekking. The last three decades have seen the deliberate creation of new trails for recreation and adventure tourism purposes (Hayes & MacLeod, 2008).

The Indian State of Uttrakhand, also called as Dev Bhoomi, meaning The Land Of Gods, has some of the finest trekking trails and mountaineering peaks in the Central Himalayas. The mighty river Ganga, also named as India's Lifeline emerges from innumerous stream and rivulets in these mountains. The Gangotri region and network of glaciers is one of the most scariest, yet beautiful zones in the Himalayas. Although the peaks here donot rise as tall as Mt. Everest, but Uttrakhand has some of the mostdifficult to climb mountains in the World. Nanda Devi, which was once considered the highest mountain in the World rises high in these lands. Uttrakhand offers the raw feeling of the Himalayas which is comparable tonone.

| What you get | What you fight |
|---|---|
| Ecstasy, Joy, Fulfillment, Accomplishment, fun, Enjoyment, Memories etc. | Dizziness, Headache, Stomach problems, Nausea, Loss of Appetite, HAPE, Cough, Confusion, Cold , Breathlessness, Fatigue , HACE , Death etc. |

**Table 1 High Altitude Seriousness**

## 2. MATERIALS AND METHODS

Mountains constitute 24 percent of the Earth's Surface (UNESCO 2014), Over the years, activities of mountaineering, skiing, via ferrata and hiking are becoming popular. all of which form the development of mountaineering tourism. In Nepal , trekking tours increased from 86,260 in 2011 to 105,000 in 2012 (Mnadhar 2013) and about 10 million people visited Austria's Alps every year (Austrian times 2008) and total of 6854 people have climbed Mount Everest successfully from the year 1956 to 2013 (Traveling Doctor 2014b).

In Uttarakhand, there are so many dangerous trekking spot like Kedartal Trek, Rupin Pass trek, Kedarkantha trek, Bali Pass trek, Har ki dun Trek, Satopanth Trek, Valley of Flower trek, Brahmatal Trek and Kalindi Khal Trek, Adi Kailash trek, Nanda devi east base camp, Mayali Pass trek and Kanari Khal trek etc. Participants in these activities should be aware of the hazards and risks and accept the risks and be responsible for their own actions. Mountaineering is characterized by the deliberate seeking of risks and the uncertainties of outcomes. It carries the risks - financial, physical (eg. Injury or death), social (e.g. Humiliation), Emotional (e.g. fear, anxiety) and also health.

Most severe hazards during Trekking are - Loose or Falling rocks, Falling ice, snowavalanches, heavy rain fall, extreme Height, Lack of oxygen, Bad weather and fall from snow and most important Landslide etc.

According to some experts, about 85 percent of avalanche victims trigger their own slide. The best thing to do to avoid an avalanche disaster is to steer clear of any snow- covered mountains since increased time in avalanche terrain equals more risk of involvement in an avalanche. Keep in mind that you must think ahead about what you would do in the event of an avalanche, try to move uphill and to the side, in order to avoid the pile-up. You will not be able to outrun it, so don't try. Just get to the side as quickly as you can to avoid the center, where the snow will be at its deepest. If you're getting closed in on, drop your equipment and move fast. If there are trees around, try to grab onto it. Avalanche hazard is not always obvious, but it isn't a mysterious phenomenon either. Avalanche education can help hikers make better decisions about safe snow travel and minimize risk. Fall Many tourists have died while posing for pictures by scrambling around or just walking too close to a canyon rim. Backcountry hikers have slipped or fallen descending friable rock and talus. Stay focused, use common sense, extreme care, and good shoes or don't do it. Step back or turn around and stay safe. There are various dangers related to being at high altitudes such as **altitude sickness** (associated with travel to elevations above 2000-2500m), heat and UV radiation conditions (such as heat exhaustion, heatstroke, sunburn, and snow blindness), and **cold-related conditions** (like hypothermia, frostbite, and immersion foot). Just know the dangers, be both physically and mentally prepared to face the challenges that await you at elevation, and you'll be fine. Head and spine injuries are potentially life-threatening. Such injuries are often caused by falling rock, ice, etc. If your route goes through avalanche and rockfall territory, travel at night or very early morning and move quickly. Watch for changing weather conditions and avoid these areas in heavy **rain**.

## 3.DISCUSSION

### 3.1 Killer October for UTTARAKHAND

According to Social activist Anoop Nautiyal who has been tracking major natural calamities and accidents in Uttarakhand, said ,October 2022 has indeed been a cruel and sad month for our state as 74 deaths occurred in four major disasters and accidents. The four hill districts of Uttarkashi, Pauri Garhwal, Rudraprayag and Chamoli witnessed these fatalities."

On October 4 , a team of 41 moutaineers, including 34 trainees and 7 instructors of Uttarkashi based Nehra Institute of moutaineering were hit by an Avalanche. The group had trekked to Mount Draupadi ka Danda- II as part of a high altitude "Navigation and height gain exercise". Thay reached the peak at around 4 am on Tuesday and were returning when they were swamped by an avalanche around 8:45 am.Twenty seven people were killed, Twelve escaped with injuries and two are still missing following the incidents.It was happened when the team were returning from Mount Draupadi ka Danda- 2 peak (5760 m). The executive director of Uttarakhand Disaster management Authority, said " The snout of the glacier si at around 3,700 m while the avalanche was reported somewhere around Mount Draupadi ka Danafterda 2 at an altitude of 5,670m. Fresh snow , massive crevasses and accessibility are major challenges."

Another Incident, a nine-members team, including three trekkers from West Bengal and six locals. They had left Liwadi village in Uttarkashi district for Khimloga- Chitkul trek on September 1. While trekking, the three trekkers fell in to the creviceof the glacier from a height of 5,600m after which one (Sujoy dubey) died, while two (Subrato and Narottam ) were seriously injured. After that 3 locals came down to inform Officers at an ITBP camp at chitkul about the incident. A case will be registered against all the three trekkers of West Bengal as they had left for the trek without taking the permission from the administration.

| Sl. No. | Major Causes for accidents | Suggestion to add safety for future |
|---|---|---|
| 1. | Lack of communication between Trekkersand Local Authority | Make Proper and easy process for trekkers for registration and provide all the guidelinesrelated to safety and safety equipment. |

| | | |
|---|---|---|
| | | (wireless sets, satellite phones) |
| 2. | Bad Weather forecasting | No trekkers should be allowed to trek in Bad.<br>weather condition. Make strict rules for violating the guidelines of local Authority. |
| 3. | Less Alert/ Prepared for Avalanche | Always prepared for everything like Avalanche and by proper planning of time forevacuation should be addressed by the Trainers and Local State authority. |
| 4. | Lack of planning for natural disaster towardstrekkers by the government | Extra helpers and assistant guide shall be provide for unplanned events during trekkingand Make the research about the trekking region related to find the best time period for trekking a particular Trek to avoid trekking<br>accidents by the local authority andGovernment. |

**Table 2 Causes for accidents and suggestions**

## 4.RESULTS

To ensure maximum possible safety on the treks, we have set up a protocol Himalayan High Maximum Safety Assurance Protocol. It starts with initial telephonic discussion to check physical fitness level and mental attitude required for trek. Before starting the trek every member of the team provides brief discussion on safety measures and emergency Evacuation plan and equipment to use. The following points are discussed as a result to enhance the safety for trekkers in future-(i) The guide to trekker ratio which we maintain is 1:6 for easier trek and 1:2 for all treks that go beyond 6000m.

(ii)The team will be taken for short acclimatization walks in the evening above 4000m.

(iii) Blood oxygen saturation will be checked every morning and evening above 3500m.

(iv) Mandatory exercise will be done prior to the trek start and cooling down session after reaching the campsite.

(v) Re-hydrating drinks and foods which issuitable for high altitudes to be served more like Dal, garlic soups, tang juices etc.

(vi)We would be providing safe boiled water for use.

(vii) Absolutely no Alcohol allowed during trekking.

(viii) High quality camping equipment, especially tents, High insulating mattresses and Subzero sleeping bags always carry.

(ix) Trek leaders will carry an emergency medicine kit and will contain all necessary high-altitude medicines in it.

(x)Team will be maintaining communication within team by a wireless set and use satellite phones to call office informed at base camp.

(xi) Extra Helpers or assistant guides will be taken in the team for handling unplanned return from the trek.

## 5.CONCLUSION

In this paper a brief review is made over about Safety during Trekking in high altitude areas. The growth of tourists and tourism is usually the main aim for all trail destinations in the world. Trekking is a recreation activity that involves covering any specified journey on foot. Good decision-making can help you avoid most of the hazards on the trail. It's important to do your research carefully and know what to expect from the environment you will be trekking in. Don't be ignorant, casual or complacent, and don't underestimate nature. Remember that underestimating nature and natural forces can not only be a costly mistake but your last one. "Pray for the best; prepare for the worst" as the old saying goes. It is your preparedness and quick reaction that might make the difference between life and death when you need to handle an emergency situation. So, be prepared. Best way to enhancement of safety during trekking are

(i) easy accessible communication between Trekker and local Authority.

(ii) Consideration of Weather and Nature Hazards

(iii) Time for Evacuation and follow all instruction and safety rules during trekking provided by the local authority. Enhancement of trekking trails to international standards that offer quality trail experiences, requires that trails are standardized, monitored and assessed by following a robust system of auditing. This is especially necessary to meet the expectations of the global hiking, walking and trekking tourists.

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## Article 4

# Vibration Control In Membrane Structures Using Fem For Structural Safety

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Key terms used:

*Vibration Control; Elastomer; DEA; ANSYS; Finite Element Analysis*

**ABSTRACT**

This paper deals with active vibration control on the space structures using FEM method for the structural safety. These are light & flexible type structures. They need effective vibration control methods. Various papers are published with respect to the active vibration control. This paper refers a particular study done by Hiruta *et al (2021)* in which the conclusion was to do the experiment in FEA and find out the optimal location for placement of those actuators considered. The actuators used are Dielectric Elastomer Actuator (DEA), these are most effective than Piezoelectric materials. The study includes software numerical analysis using ANSYS and do the finite element analysis on the particular material chosen in the paper by Hiruta *et al (2021),* compare the results and find

The experimental arrangement was reproduced in the numerical prediction being conducted in this paper. It was made possible by comparing the values of the modal analysis and vibration suppression values as referred in the Hiruta *et al.* paper. Thereafter, based on the transient analysis conducted in this report, the optimal location was studied. For this the various locations opted alternately and randomly were centre & diagonal, centre & horizontal and side centre other than the corner placed elastomer as referred in the Hiruta *et al.* paper. It was able to reduce the vibration on an average by 86%, 87% & 32%, respectively. Further it was made clear that Centre & Horizontally placed elastomer patch has much better vibration suppression, i.e, of 87%, with 50% more vibration suppression than when the elastomer patch is placed in corner location or side centre location.

# 1.INTRODUCTION

## 1.1 METHODS OF VIBRATION CONTROL

There are different vibration control methods for different machineries and systems & among the various types are the passive vibration control and active vibration control. Passive control involves use of dampeners, springs etc. by using their natural properties to reduce the effect of excitation to the structures/floors of concern. No external energy is input on to this system for any type of control. Dynamic characteristics remains unchanged in this type of control.

Active vibration control used to isolate dynamic excitations on the system. Once it senses the vibrations it will react accordingly to the mathematical model which has been embedded in it. Active vibration involves feedback and feed forward signals for proper working of the controls. Even though the cost is generally higher due to the use of actuators, these have become popular due to the effective suppression of vibrations and effectiveness in control. To avoid resonance the most effective method is the active vibration control compared that to the classic passive control method, in maintaining the level of vibration. For small machines and light weights, the Active Vibration Control is advantageous [1].

***Figure 1: Typical Passive Vibration Isolation System (Source: Vibration Engineering Consultants data book, 2019)***

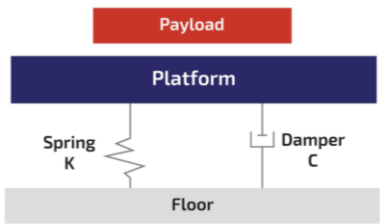
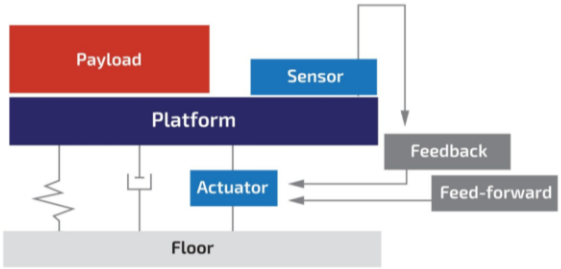


**Figure 2: Typical Active Vibration Isolation System (Source: Vibration Engineering Consultants data book, 2019)**




## 1.2 OBJECTIVES OF WORK

Nowadays as optimum control Active vibration is used for flexible structures. The challenge comes in the vibration control process because of complexity of the dynamic system. Some of the techniques used in the control of system vibrations include Piezoelectric materials and Dielectric Elastomers (DEAs). Presently, piezoelectric materials are used in the harvesting of mechanical energy because of its compatibility and compactness. However, its integral limits includes brittleness, aging and depolarization, these confines its development. Hence, DEAs potential in harvesting mechanical is being utilized more and more now. Larger and flexible space structures are made in this age of space technology with modal frequencies and damping ratios being relatively low. The precise requirement is to be met, thus application of active control for suppression of vibrations becomes more significant than ever before. Further Literature review was conducted to know the various studies on this Active Vibration Control behalf. The objective of the project is to perform Finite Element Analysis (FEA) of the experimental work carried out by Hiruta *et al.* (2021) for vibration control in membrane structures using dielectric elastomer actuators [3]. It is proposed to get the similar result using Finite Element Analysis using Ansys software for the experimental analysis done. The results to be obtained include to assess the Effectiveness of vibration control for a membrane structure using DEA in vacuum environments for structural safety and to determine optimal actuator placement effectively.

## 2. PRESENT INVESTIGATION

## 2.1 NUMERICAL PROCEDURE

The object is a membrane structure including a 0.05-mm-thick polyimide film (Du Pont-Toray, Kapton 200H) with weights & wires. Tension is applied on the corners of membrane

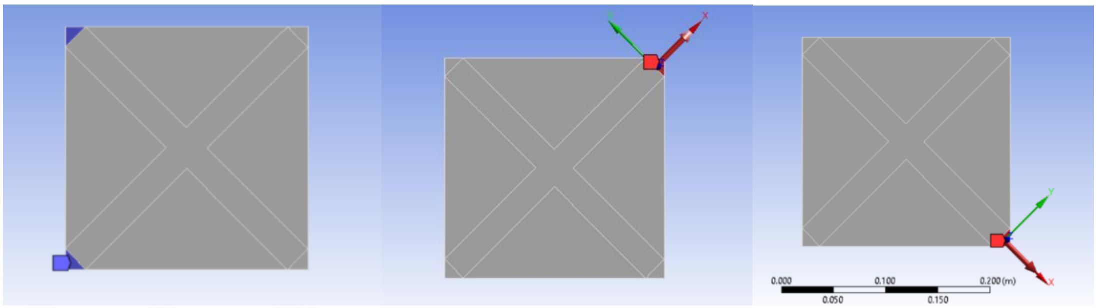
(200 mm × 200 mm) by using weights (each mass: 700 g) combined with wires. The properties of the Polyimide film is as tabulated below.

| Physical Property | Value |
|---|---|
| Young's modulus | 2.5 GPa |
| Mass density | 1.42 g/cc |
| Poisson ratio | 0.34 @ 23°C |
| Tensile strength | 231 MPa @ 23°C<br>139 MPa @ 200°C |

**Table 1 Physical Properties of Polyimide film (Source: Dupont Kapton Polyimide Film General Specifications, Bulletin GS-96-7". http://www.dupont.com/kapton/general/H-38479-4.pdf)**

In ANSYS geometry, tension forces was applied on the two adjacent corners of the film, i.e, of 13.734N each. The other two adjacent corners are made as fixed supports.

**Figure 3 Tension applied on the corners (image from ANSYS)**

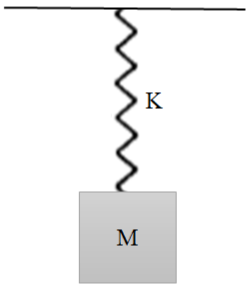



## 2.2 GOVERNING EQUATION

The governing equation considered is that of a simple Spring Mass System. Basic oscillatory system consists of a mass, massless spring and damper. A system with spring and a mass is capable of free vibrations and no external excitation needed. The parameters and equation are as follows.

Considering a spring mass system with mass ‘M’ and spring constant ‘K’.

**Figure 4: Simple Spring Mass System**




‘A’ is the amplitude at which system vibrates

Eigen value problem statement is as follows, in natural case *(taken from Mechanical Vibrations book by S. Graham Kelly);*

$([K] - \omega_i^2 * [M]) * A_i = 0$ ---------------------------------------------------------------------------(1)

Here,

$\omega_i^2$ is Eigen value

$A_i$ is the Eigen vector

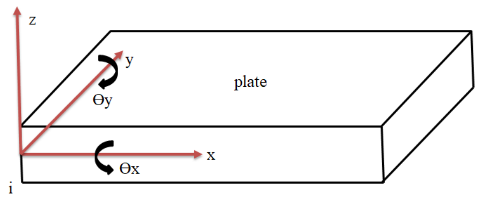
[M] – Mass matrix

[K] – Stiffness matrix

$\omega_i$ = angular frequency,

Natural frequency, $f = \omega_i/(2*\pi)$

**Figure 5 Degrees of freedom of Membrane**



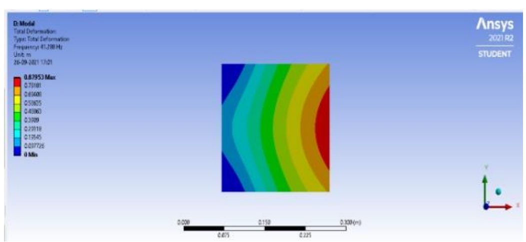
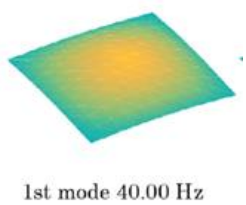

From the above indicative sketch it is clear that, Number of modes = Degrees of freedom = Size of matrix. Degrees of freedom in z direction and $\Theta_x$ & $\Theta_y$ rotations.

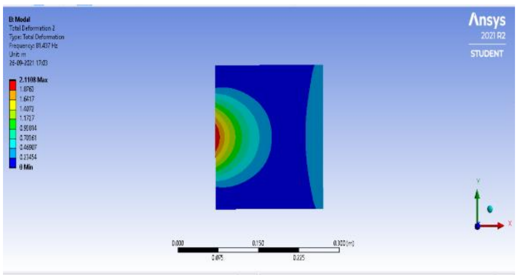
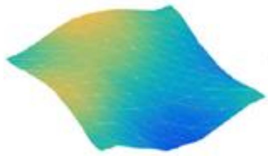
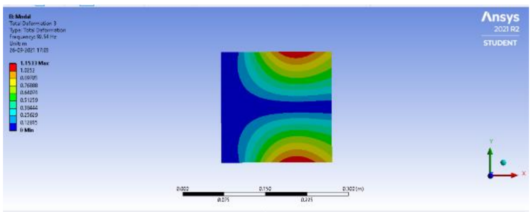
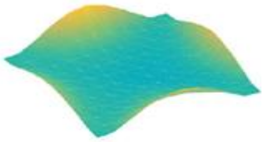
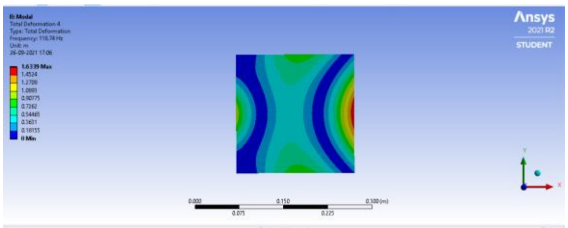
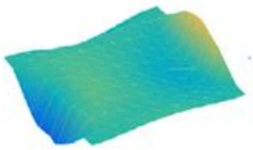
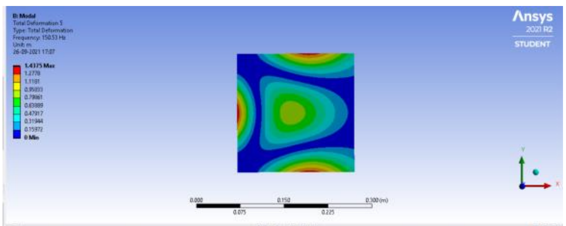
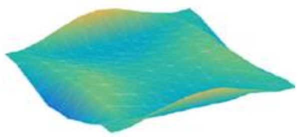
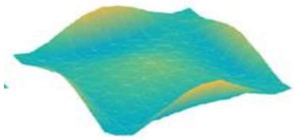
## 2.3 MODAL ANALYSIS

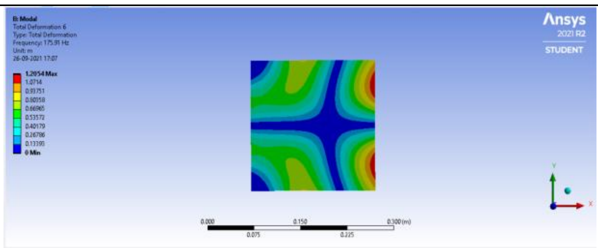
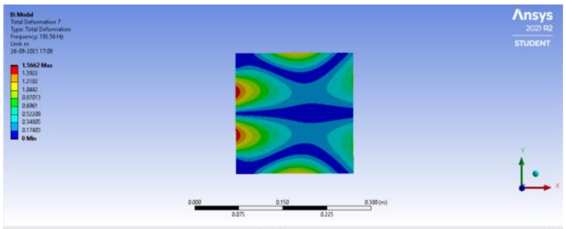
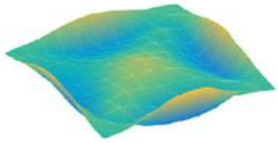
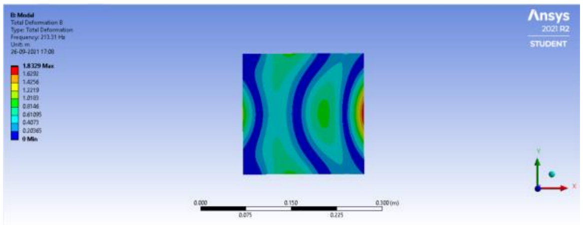
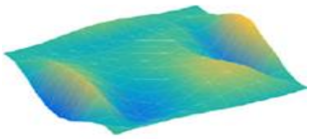
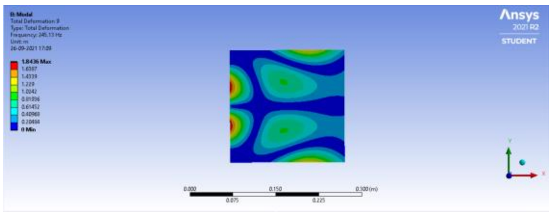
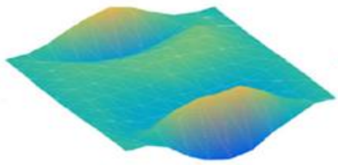
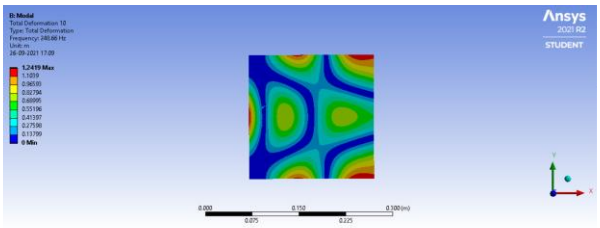
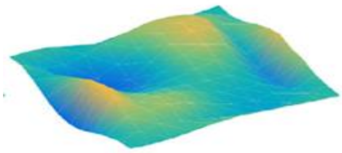
Further based on the geometry created, the modal analysis was done to get the required mode shapes and natural frequencies from the ANSYS software to compare with the experimental results obtained in the paper mentioned [3].

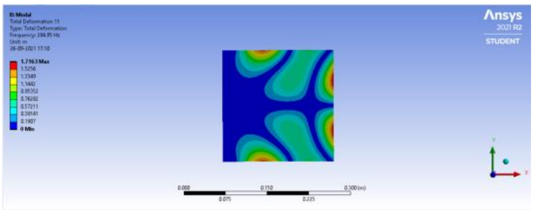
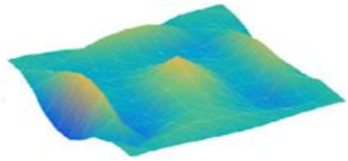
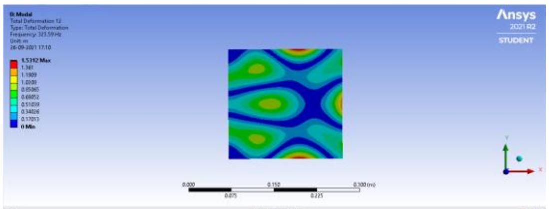
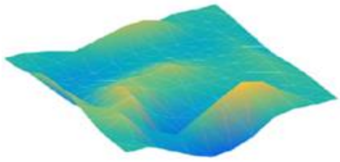
The solution as obtained is presented as below images of ANSYS. The results obtained shows the matching result of the first four modes of natural frequencies to that of the paper. The reasons for the difference in values of other modes may be due to the different restraints considered in the actual experiment considered which will have an impact on the natural modes of vibrations. Such considerations are also not clear in the paper presented by Hiruta *et al.*

**Figure 6: Different Modes (Sl. Nos. A to L) from ANSYS Modal Analysis and from referred paper [3]**

| S. No. | Different Modes from ANSYS Modal Analysis | Different Modes from referred paper [3] |
|---|---|---|
| A | Mode 1   |   |

| S. No. | Different Modes from ANSYS Modal Analysis | Different Modes from referred paper [3] |
|---|---|---|
| B | Mode 2   |  2nd mode 65.60 Hz |
| C | Mode 3   |  3rd mode 75.00 Hz |
| D | Mode 4   |  4th mode 83.13 Hz |
| E | Mode 5   |  5th mode 93.13 Hz |
| F | Mode 6 |  6th mode 99.38 Hz |

| S. No. | Different Modes from ANSYS Modal Analysis | Different Modes from referred paper [3] |
|---|---|---|
| |   | |
| G | Mode 7   |  7th mode 106.9 Hz |
| H | Mode 8   |  8th mode 116.9 Hz |
| I | Mode 9   |  9th mode 120.6 Hz |
| J | Mode 10   |  10th mode 128.1 Hz |

| S. No. | Different Modes from ANSYS Modal Analysis | Different Modes from referred paper [3] |
|---|---|---|
| K | Mode 11  |  11th mode 141.3 Hz |
| L | Mode 12  |  12th mode 143.8 Hz |

## 2.4 NUMERICAL PROCEDURE FOR VIBRATION CONTROL

An elastomer of acrylic based material is attached to the membrane structure as the Dielectric Actuator for the control/suppression of vibrations occurring on the membrane structure. The material used is of VHB series, 3M, Thickness: 0.5 mm.

| Physical Property | Value |
|---|---|
| Young's modulus | 3 MPa |
| Mass density (as per 3M VHB series product data sheet) | 0.710 g/cc |

**Table 2 Physical Properties of Acrylic material (Romasanta *et al.*, 2015)**

During ANSYS transient analysis, 0.650 N force is applied as laser on the central portion of the membrane. According to the report of Hiruta *et al.* (2021), around 37% reduction has happened in the present corner location of acrylic material. Thus the corresponding suppression force considered onto the elastomer patch attached to the membrane structure in the present numerical analysis study. Other than the corner location of elastomer patch, other 3 alternate locations were chosen and analysed for the percentage reduction in vibration. The various locations are as shown in below figures.

**Figure 7: Forces applied: Corner placed Elastomer patch**

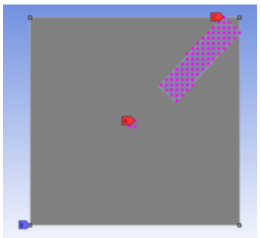


**Figure 8: Forces applied: Centre & Diagonally placed Elastomer patch**

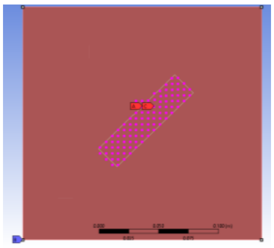


**Figure 9: Forces applied: Centre & Horizontally placed Elastomer patch**

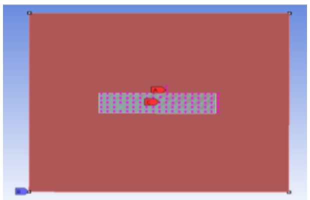
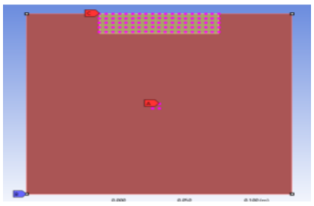


**Figure 10: Forces applied: Side centre placed Elastomer patch**



## 2.5 GOVERNING EQUATION FOR TRANSIENT ANALYSIS

With respect to the vibration control, a transient structural dynamic system was analyzed. Time dependent analysis is solved as per the below equation. If the mass M is subjected to a force F(t) acting in the positive x(t) direction as shown in figure below, then the equation of motion, becomes;

$$[M]x''(t) + [C]x'(t) + [k]x(t) = F(t) \text{ ----------------------------------------------------------(2)}$$

Here,

[M] – Mass matrix

[C] – Damping matrix

[k] – Stiffness matrix

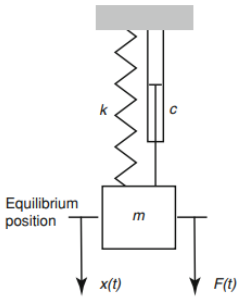
F(t) – Load

x"(t) – Nodal Acceleration

x′(t) – Nodal Speed

x(t) – Nodal Displacement

**Figure 11 Forced excitation system**




## 2.6 TRANSIENT ANALYSIS

Transient vibration is one that dies away with time due to energy dissipation. Usually, there is some initial disturbance and following this the system vibrates without any further input. The Finite Element Transient Analysis is done on the system without vibration control and with vibration control. The results of amplitude and deformation for various controls is as shown below.

**Figure 12: Amplitude & deformation without control**

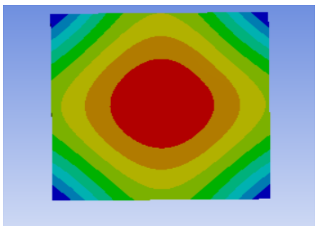


**Figure 13: Amplitude & deformation with control of corner placed elastomer patch**

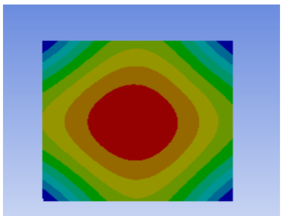
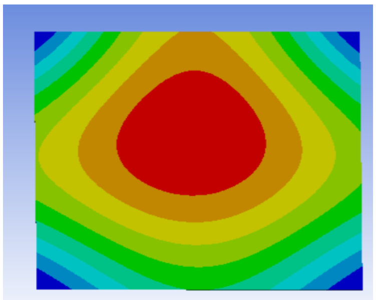


**Figure 14: Amplitude & deformation with**

**Figure 15: Amplitude & deformation with**

**control of centrally & diagonally placed elastomer patch**

**control of centrally & horizontally placed elastomer patch**



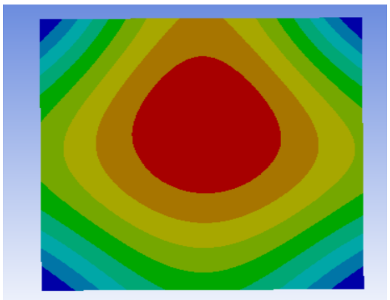
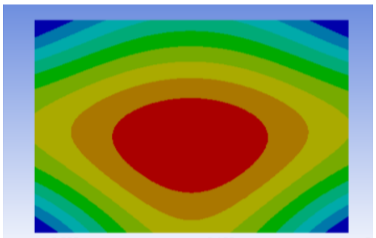


**Figure 16: Amplitude & deformation with control of side centre placed elastomer patch**



## 3. RESULTS AND DISCUSSION

Based on the available data from the journal paper presented by Hiruta *et al.* (2021), it was able to achieve nearby values for at least the first 4 modes of natural frequencies. The results so obtained from numerical analysis and value available in the paper is presented as below.

| Mode | Numerical Prediction | Experimental Values |
|---|---|---|
| 1 | 41.288 | 42.42 |
| 2 | 81.437 | 74.67 |
| 3 | 92.54 | 83.25 |
| 4 | 118.74 | 84.47 |

**Table 3 Comparison of the Natural Frequency**

Once the above tabulated result was obtained, further transient analysis was conducted in order to achieve/reproduce the vibration suppression so studied in the referred paper, i.e, with elastomer placed near to the corner of the membrane structure. Based on the transient analysis performed, it was able to reproduce the vibration suppression for corner placed elastomer patch as referred in the paper. The result of the amplitude from numerical prediction for with and without control for the corner placed elastomer patch is as tabulated below.

| Time (s) | Amplitude without control (cm) | Amplitude with control (cm) (As per paper) | Percentage suppression |
|---|---|---|---|
| 0.1 | 1.33 | 0.83 | 38% |
| 0.2 | 0.13 | 0.08 | 38% |
| 0.3 | 1.54 | 0.96 | 38% |
| 0.4 | 0.12 | 0.08 | 38% |
| 0.5 | 1.31 | 0.81 | 38% |
| 0.6 | 0.07 | 0.05 | 39% |
| 0.7 | 1.44 | 0.89 | 38% |
| 0.8 | 0.01 | 0.004 | 25% |
| 0.9 | 1.42 | 0.88 | 38% |
| 1 | 0.02 | 0.01 | 38% |
| 1.1 | 1.38 | 0.85 | 38% |
| 1.2 | 0.03 | 0.02 | 38% |

**Table 4 Amplitude from Numerical Prediction for with and without control (Corner placed elastomer patch)**

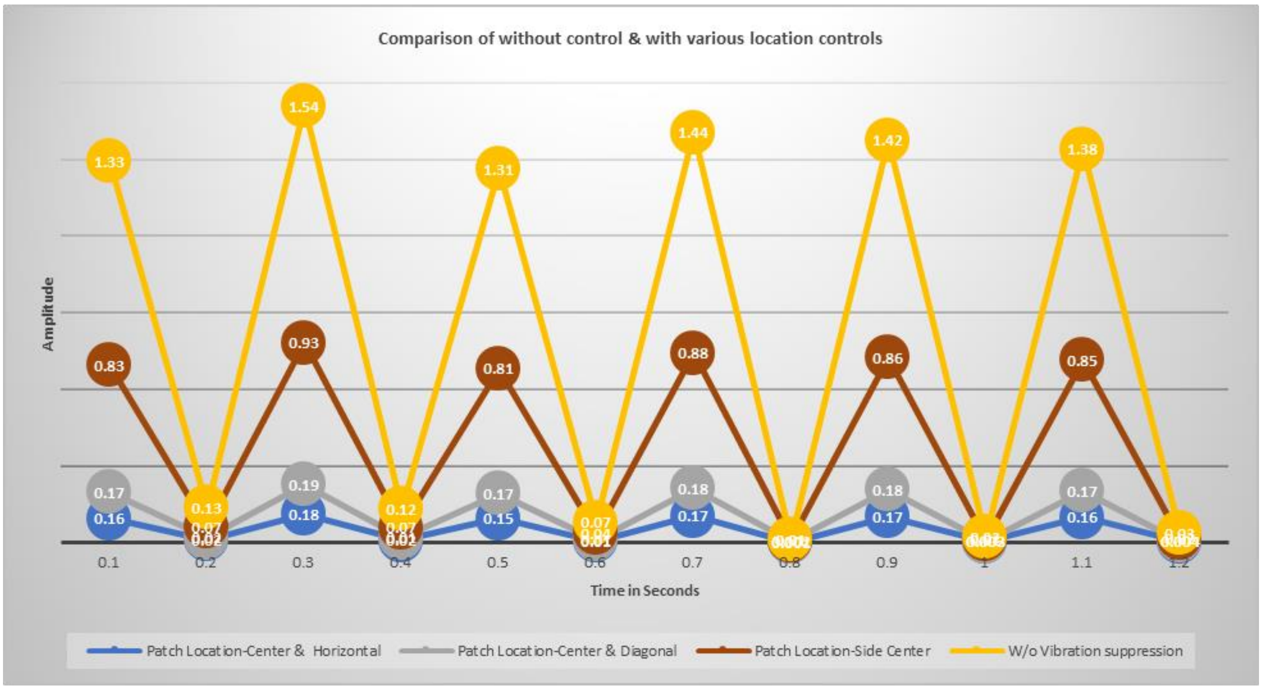
Now further to study the gap left out in the paper of Hiruta et al. by finding out the optimal location for vibration suppression in membrane structures for structural safety. The elastomer was alternately and randomly placed at various locations such as in central & diagonal, center & horizontal and also in side center locations. Thereafter the analysis was carried out with these arrangements. Hence it was able to reduce the vibration on an average by 86%, 87% & 32%, respectively. The tabulated amplitude values from numerical predictions for without and with control for various alternately placed elastomer patch locations is as below.

| Time (s) | W/o Vibration suppression | With Vibration Suppression | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Patch Location-Corner (As per paper) | Percentage suppression | Patch Location-Center & Diagonal | Percentage suppression | Patch Location-Center & Horizontal | Percentage suppression | Patch Location-Side Center | Percentage suppression |
| 0.1 | 1.33 | 0.83 | 38% | 0.17 | 87% | 0.16 | 88% | 0.83 | 38% |
| 0.2 | 0.13 | 0.08 | 38% | 0.02 | 88% | 0.02 | 87% | 0.07 | 45% |
| 0.3 | 1.54 | 0.96 | 38% | 0.19 | 88% | 0.18 | 88% | 0.93 | 40% |
| 0.4 | 0.12 | 0.08 | 38% | 0.01 | 89% | 0.02 | 88% | 0.07 | 45% |
| 0.5 | 1.31 | 0.81 | 38% | 0.17 | 87% | 0.15 | 88% | 0.81 | 38% |
| 0.6 | 0.07 | 0.05 | 39% | 0.01 | 87% | 0.01 | 88% | 0.04 | 46% |
| 0.7 | 1.44 | 0.89 | 38% | 0.18 | 87% | 0.17 | 88% | 0.88 | 39% |
| 0.8 | 0.01 | 0.004 | 25% | 0.002 | 70% | 0.001 | 79% | 0.01 | -76% |
| 0.9 | 1.42 | 0.88 | 38% | 0.18 | 88% | 0.17 | 88% | 0.86 | 39% |
| 1 | 0.02 | 0.01 | 38% | 0.002 | 90% | 0.003 | 85% | 0.01 | 47% |
| 1.1 | 1.38 | 0.85 | 38% | 0.17 | 87% | 0.16 | 88% | 0.85 | 38% |
| 1.2 | 0.03 | 0.02 | 38% | 0.004 | 88% | 0.004 | 87% | 0.02 | 47% |
| Average | | | 37% | | 86% | | 87% | | 32% |

**Table 5 Amplitude (in cm) from Numerical Prediction for without control and with control for various alternately placed elastomer patch locations**

The Graphical representation of the vibration suppression obtained for all alternate elastomer patch locations placed is as shown below. The graph explicitly shows the difference in the suppression of various patch locations.

**Figure 17 Graphical representation of comparison of without control & with various location controls**




## 4. CONCLUSIONS

The modal analysis results obtained from the modelled parameters of the controlled object in vacuum environment is compared with those values in the paper [3]. Based on the available data from the journal paper presented [3], it was able to achieve nearby values for at least the first 4 modes of natural frequencies. The reason for the major variation in the values that of the paper for the modelled geometry is found to be due to the various restrains considered in the actual experimental paper is not clearly indicated hence the difference. Now further transient analysis was conducted to get the active vibration control on the membrane structure to get the reduction/suppression in the vibrations as stipulated in the paper [3] for the structural safety. It was successful in achieving the required results after reproducing the present studied vibration suppression for corner placed elastomer patch as indicated on the paper being referred. The percentage in suppression occurred as per the Hiruta *et al.* paper is around 38% which is being similar to the results obtained from numerical analysis, thus arriving at the conclusion that the similar experimental arrangement has been made in the analysis performed. Based on the above method further numerical analysis was conducted by placing the elastomer patch at alternate locations such as on centre & diagonal, centre & horizontal and side centre.

As part of furtherance of the Hiruta *et al.* paper & based on the Finite Element transient Analysis, the optimal location of elastomer actuator was to be found. Therefore, in ANSYS model, elastomer was placed in central & diagonal, centre & horizontal and also in side centre locations and conducted the transient analysis. Thereafter it was able to reduce the vibration on an average by 86%, 87% & 32%, respectively. From all the alternate and randomly placed locations, it is clear that Centre & Horizontally placed elastomer patch has much better vibration suppression, i.e, of 87%. It is explicit from the findings that 50% more vibration suppression is occurring than when the elastomer patch is placed in corner location or side centre location. However there is only a slight change of approx. 1% in vibration suppression when placed either Centre & Diagonal or Centre & Horizontal. Hence the numerical analysis under this report is concluded by stating the fact that the closer to the disturbance or centred the elastomer is placed, more effective will be the vibration suppression to maintain the structural stability.

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# Article 5

## Air Pollution: A Real Case Scenario in Patna

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Key terms used:
Air Pollution,
Population,
Control

**ABSTRACT**

Air pollution is a significant environmental issue faced by the city of Patna, located in the state of Bihar in India. With a growing population and expanding industrial activities, the level of air pollution has increased significantly in recent years. This has led to severe health consequences for the citizens of Patna, including respiratory problems and increased mortality rates.

To address this issue, the government of Bihar has implemented various measures to control air pollution in the city. These include the installation of air quality monitoring systems, the promotion of public transportation and the use of cleaner fuels, and the imposition of stricter regulations on industries and construction sites.

Despite these efforts, the air quality in Patna remains a matter of concern, and there is a need for further action to reduce the level of pollutants in the atmosphere. This can be achieved through sustained efforts from the government, the industries, and the citizens of Patna, who need to work together to implement effective measures for air pollution control.

## 1. INTRODUCTION

The study on Air Pollution Control in Patna aims to address the issue of air pollution, which has become a significant environmental concern for the city. With a rapidly growing population and an expanding industrial base, the level of air pollution has increased considerably in recent years, causing severe health consequences for the citizens of Patna.

This study intends to identify the sources of air pollution in Patna, analyze the severity of the problem, and develop effective strategies and solutions to mitigate it. The Study team will collaborate with government agencies, NGOs, and other stakeholders to collect data and develop a comprehensive action plan for air pollution control.

The study will focus on various aspects of air pollution control, including the installation of air quality monitoring systems, the promotion of public transportation and the use of cleaner fuels, and the implementation of stricter regulations on industries and construction sites. The study will also seek to raise public awareness about the harmful effects of air pollution and encourage citizens to adopt sustainable practices that can contribute to reducing air pollution.

The ultimate goal of this study is to create a cleaner and healthier environment for the citizens of Patna by reducing the levels of air pollution in the city. By working together, we can ensure that Patna remains a sustainable and liveable city for future generations.

## 1.1 SOURCES OF AIR POLLUTION IN THE CITY

There are several sources of air pollution in Patna, which contribute to the poor air quality in the city. These sources can be broadly classified into two categories: anthropogenic (human-made) sources and natural sources.

## 1.2 ANTHROPOGENIC SOURCES OF AIR POLLUTION IN PATNA INCLUDE:

1. Transportation: Vehicular emissions from the large number of vehicles on the city's roads are a major contributor to air pollution. The use of outdated and poorly maintained vehicles, including diesel-powered trucks and buses, also exacerbates the problem.
2. Industrial Activities: Various industrial activities, such as power generation, construction, and manufacturing, contribute significantly to air pollution in Patna. The burning of coal, oil, and other fossil fuels releases a range of pollutants into the atmosphere.
3. Domestic Activities: Cooking and heating with solid fuels such as wood and coal in households also contribute to air pollution. The use of biomass fuels, such as cow dung cakes and agricultural waste, for cooking and heating is also prevalent in rural areas surrounding Patna.

## 1.3NATURAL SOURCES OF AIR POLLUTION IN PATNA INCLUDE:

1. Dust and Particles: Natural sources such as wind-blown dust and particles from construction sites, unpaved roads, and dry soil contribute to air pollution.
2. Weather conditions: Meteorological conditions such as high temperatures, low wind speeds, and atmospheric stability can cause air pollution to become trapped in the lower atmosphere, leading to a build-up of pollutants.

Identifying and addressing these sources of air pollution is essential to improving the air quality in Patna and protecting public health.

**Figure 1 Major Air Pollutants in Patna**

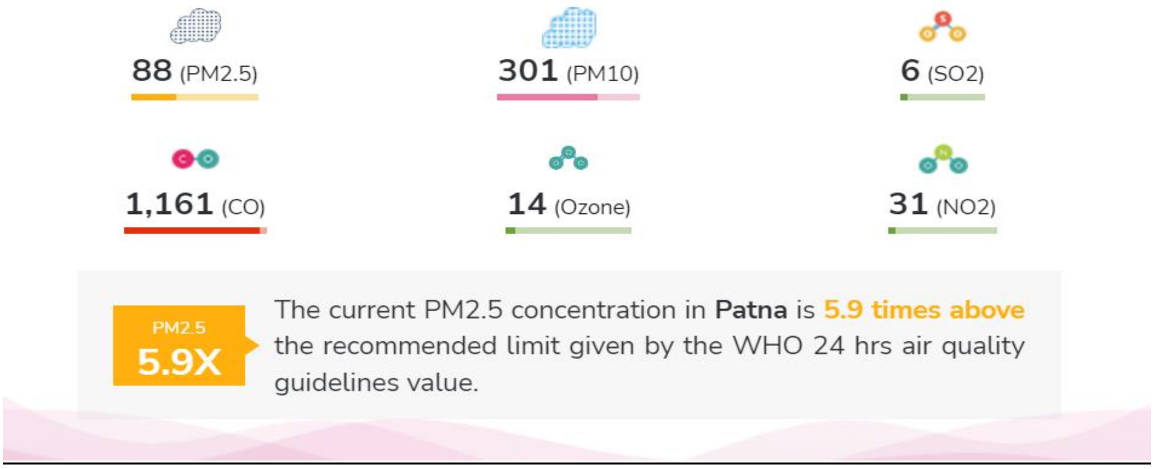



**Figure 2 Patna-Locations Air Pollution Level**

| LOCATIONS ↑↓ | Status ↑↓ | AQI-US ↑↓ | PM2.5 ↑↓ | PM10 ↑↓ | Temp ↑↓ | Humid ↑↓ |
|---|---|---|---|---|---|---|
| Igsc Planetarium Complex | POOR | 152 | 57 | 0 | 28 | 33 |
| Industrial Area | POOR | 178 | 63 | 309 | 28 | 33 |
| Mithapur | UNHEALTHY | 254 | 113 | 392 | 28 | 33 |
| Muradpur | UNHEALTHY | 253 | 133 | 391 | 28 | 33 |
| Rajbansi Nagar | POOR | 155 | 63 | 239 | 28 | 33 |
| Samanpura | HAZARDOUS | 441 | 143 | 545 | 28 | 33 |
| Shikarpur Govt High School | POOR | 142 | 51 | 237 | 28 | 33 |

Some of the locations in Patna with Poor to Hazardous status of Air Pollution. (Source:AQI) www.aqi.in

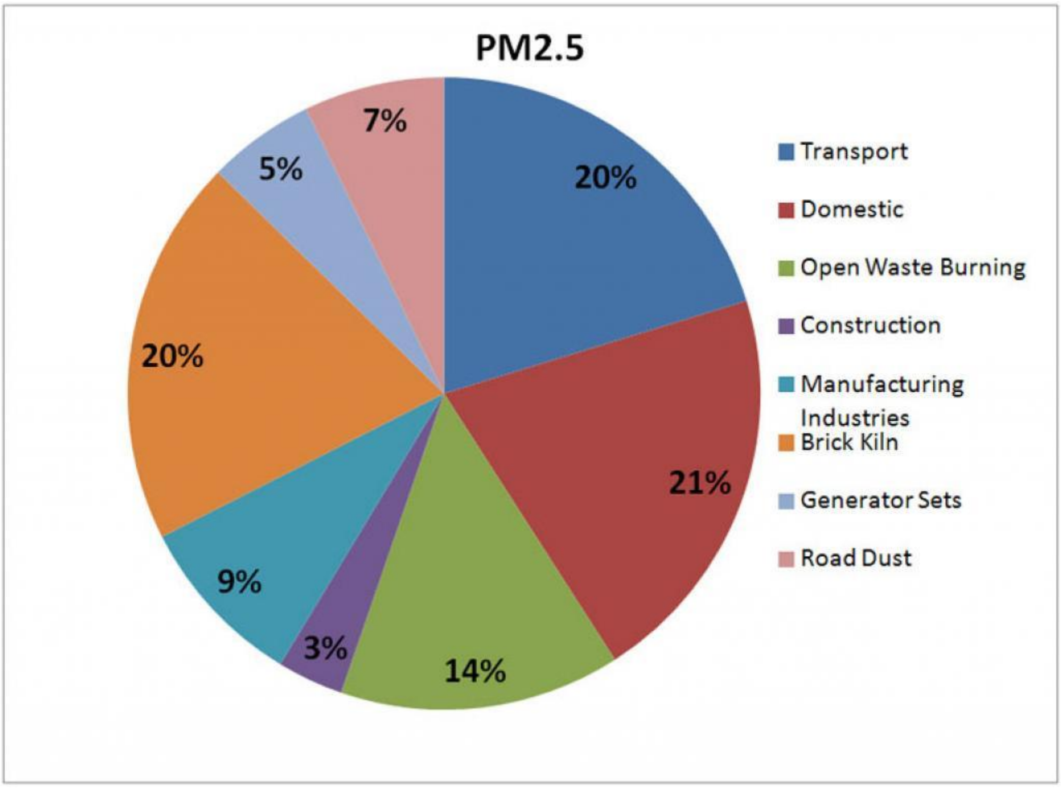
Figure 3 Average Air Quality Index (Source : Central Pollution Control Board)

**TOXIC BREATH**

Poor | Very Poor | Severe

| Date | Patna | Delhi | Muzaffarpur |
|---|---|---|---|
| Nov. 11 | 385 | 405 | 351 |
| Nov. 12 | 386 | 399 | 400 |
| Nov. 13 | 372 | 409 | 425 |
| Nov. 14 | 406 | 312 | 436 |
| Nov. 15 | 361 | 217 | 370 |

Figure 4 Particulate Matter (PM 2.5) percentage distribution



## 2.MATERIAL AND METHODS

To control air pollution in Patna, various materials and methods can be used. Installing air quality monitoring systems throughout the city can help identify areas with high levels of pollution, enabling authorities to target their control measures more effectively. Encouraging the use of public transportation can reduce the number of vehicles on the roads, thereby reducing vehicular emissions. Promoting the use of cleaner fuels like CNG and LPG can significantly reduce emissions from vehicles and industries.

Additionally, the government can impose stricter regulations on industries and construction sites to limit their emissions, such as mandating the use of pollution control equipment and enforcing stringent emission standards. Planting trees and creating green spaces in the city can help reduce air pollution by absorbing carbon dioxide and other pollutants from the atmosphere. Conducting public awareness programs about the harmful effects of air pollution and ways to reduce it can encourage citizens to adopt sustainable practices and contribute to pollution control efforts.

Implementing a combination of these materials and methods can significantly reduce the level of air pollution in Patna, creating a cleaner and healthier environment for the citizens of the city. It is crucial to identify and address the sources of air pollution to ensure that Patna remains a sustainable and liveable city for future generations.

To control air pollution in Patna, a range of materials and methods can be employed. Here are some examples:

1. Air Quality Monitoring Systems: Installing air quality monitoring systems across the city can help identify areas with high levels of pollution, enabling authorities to target their control measures more effectively.
2. Promotion of Public Transportation: Encouraging the use of public transportation can help reduce the number of vehicles on the roads, thereby reducing vehicular emissions. Promoting the use of electric vehicles and bicycles can also help reduce pollution levels.
3. Use of Cleaner Fuels: Switching to cleaner fuels such as compressed natural gas (CNG) and liquified petroleum gas (LPG) can significantly reduce emissions from vehicles and industries.
4. Stricter Regulations: The government can impose stricter regulations on industries and construction sites to limit their emissions. For example, mandating the use of pollution control equipment, and enforcing stringent emission standards for industries.

5. *Tree Plantation: Planting trees and creating green spaces in the city can help reduce air pollution by absorbing carbon dioxide and other pollutants from the atmosphere.*
6. *Awareness Programs: Conducting public awareness programs about the harmful effects of air pollution and ways to reduce it can encourage citizens to adopt sustainable practices and contribute to pollution control efforts.*
7. Implementing a combination of these materials and methods can significantly reduce the level of air pollution in Patna, creating a cleaner and healthier environment for the citizens of the city

## 3. RESULTS AND DISCUSSIONS

The implementation of various materials and methods to control air pollution in Patna has shown positive results in improving the city's air quality. The installation of air quality monitoring systems has helped identify areas with high levels of pollution, enabling authorities to target their control measures more effectively.

Encouraging the use of public transportation has led to a reduction in the number of vehicles on the roads, resulting in a decrease in vehicular emissions. The promotion of cleaner fuels like CNG and LPG has also contributed to a significant reduction in emissions from vehicles and industries.

The imposition of stricter regulations on industries and construction sites has led to better compliance with emission standards and the use of pollution control equipment. Planting trees and creating green spaces in the city has helped reduce air pollution by absorbing carbon dioxide and other pollutants from the atmosphere.

Public awareness programs about the harmful effects of air pollution and ways to reduce it have also played a significant role in encouraging citizens to adopt sustainable practices and contribute to pollution control efforts.

Overall, the combination of these materials and methods has resulted in a significant improvement in Patna's air quality, creating a cleaner and healthier environment for its citizens.

However, it is essential to continue implementing these measures and identifying new ways to control air pollution to ensure that the city remains sustainable and liveable for future generations.

## 4. CONCLUSION

In conclusion, air pollution is a severe problem in Patna that affects the health and well-being of its citizens. However, through the implementation of various materials and methods to control air pollution, the city has shown significant improvements in its air quality.

The installation of air quality monitoring systems, promotion of public transportation, use of cleaner fuels, imposition of stricter regulations on industries and construction sites, tree plantation, and awareness programs have all played a crucial role in reducing air pollution levels in Patna.

It is essential to continue implementing and strengthening these measures to ensure that the city remains sustainable and liveable for future generations. By working together to control air pollution, we can create a cleaner and healthier environment for ourselves and our community.

### Source

- The study is conducted on the basis of data collected from The Indira Gandhi Planetarium where concentration of pollutants in air is mentioned.
- Data Collected from Central Pollution Control Board

## 5. REFERENCE

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