Conference report Low Frequency 2008 Tokyo. 20 – 23 October 2008

This thirteenth International Conference on Low frequency Noise and Vibration and its Control, attracted 64 delegates from around the world. More than half were from Japan and seven from Korea and Taiwan. Twelve were from Europe, four from the USA, two from Australia – New Zealand and one from India. In all, fourteen countries were represented at the conference. This is an excellent and varied turn out in this specialist area. Once again, the international low frequency noise network met together, welcomed new members, and listened to 37 interesting papers on all areas of low frequency noise and vibration.

Shinji Yamada, Chairman of the Organising Committee opened the conference with a welcome to delegates, followed by **Geoff Leventhall**, who gave a review of **"Low Frequency Noise. What we know, what we do not know, and what we would like to know"** He reviewed the perception of low frequency noise (LFN) and the responses of people to LFN. Sometimes, when there are complaints of LFN and its effects, a specific noise cannot be measured. The possibilities were considered for development of enhanced sensitivity, for alternative (non-aural) receptors at very low frequencies and for false perceptions. The way in which we measure LFN may contribute to the problems.

Saiji Fukade described work on **Characteristics of infrasound radiated from the continuous short spans bridge due to running trucks.** Generally, running trucks in Japan have a tire spring vibration of 10-20Hz, which induces bending vibrations in continuous short span highway bridges. The radiated energy leads to rattle in nearby houses. It was shown that the mode of transmission was both ground vibration and infrasound. Reduction was obtained by extending the deck to move the expansion joint to the approach embankment, leading to up to 10dB reduction of the worst affected areas.

Tetsuya Myazaki considered the problems of **Low frequency noise caused by the self-excited combustion oscillation in the ground flare facility.** Self-excited oscillation in the ground flare facility is an example of low frequency noise (LFN) in industrial plants. It was shown to be caused by the feedback-loop developed between an acoustical system and a combustion system. A high level LFN of nearly 120dB at 8 Hz was observed close to the burner. This caused the rattling of house windows and doors in the area within a few kilometers. The 8Hz was removed by readjusting the burner and its settings.

Yoshiyuki Maruta described problems arising from **Low frequency air vibration at duct induced by forced draft fan in refuse incineration plant.** The problems arose when the forced draft fan was operating under conditions of low flow rate as controlled by the flow valve. The acoustic resonance in the air supply duct and the vibration resonance on the discharge silencer were excited by the low frequency pulsation of the discharge flow from the centrifugal fan. This was resolved by reinforcement of the

silencer and by returning by-pass duct from the delivery port to the suction side of the fan.

Raphaël Duee, in his paper **Absorbers on the rail to reduce pass-by noise of urban trains:** the specific case of a predominant lateral vibration of the rail dealt with the problem of by-pass noise of urban trains. A Track Wheel Interaction Noise Software Model, TWINS, has been used to estimate the proportion of wheel and track vibrations in the noise emission, showing that rolling noise is principally due to the track and especially to the rail. Reduction was achieved with absorbers on the rails. Modelling on TWINS led to a reduction of by-pass noise by 3dBA at 7.5m, whilst 4dBA was achieved on a test track

Cat Hope gave an interesting and illustrated talk on **The possibility of infrasonic music.** Low frequency sound on the cusp of the audible offers the possibility to redefine the way we think about listening to music. The extension of music into sound art means that more plastic art forms, such as installation, may involve music and allow vibration to manifest in objects other than musical instruments. As the perception of tonality is lost in very low frequency sound emissions, an opportunity arises for a different kind of music, and a different way of listening.

Hiroshi Sato solved some of the problems of on-site measurement of noise by using a wireless system, described in the paper. **Development of an on-site measurement system of low frequency noise and sufferer's responses.** The advantage of this system is that it can easily find the relationship between complainants' subjective responses to acoustical events in dwellings and the event's physical properties, such as time trend and frequency characteristics. Measurements were conducted in eight residential spaces and responses of complainants were also collected during measurements. These responses correlated well with the occurrence of the noise. Four analysis channels were used for interior noise measurement and one was for outdoor measurement.

Adam Smith also considered the detection problem in **Application of phased array technology for identification of low frequency noise sources,** which described some of NIOSH's work to identify and control dominant noise sources in a Continuous Mining Machine (CM). The impacts from the conveyor chain onto the tail roller, and the upper deck are the dominant noise sources at the tail-section of the CM. The objectives of the work presented in this paper were: 1) To rank the noise radiated by the different sections of the conveyor, and 2) to determine the effect of a urethane-coated tail roller on the noise radiated by the tail-section. This test was conducted using an 3.5-m diameter, 121-microphone phased array. The results show that a urethane-coated tail roller yields reductions in the tail-section of 2 to 8 dB in Sound Pressure Level in the frequency range of 1 kHz to 5 kHz. Additionally, a urethane-coated tail roller, in combination with a chain with urethane-coated flights, reduces the noise sources in the front and mid sections of the conveyor. The results show the applicability of phased array technology for low frequency noise source identification.

Masashi Hirai continued the problem of noise source identification with his paper **Source identification and countermeasures of low frequency noise in a factory in an industrial park.** In order to reduce the LFN, which was believed to come from a specific factory, noise measurements at each frequency of the LF pure tones are conducted at grids in the areas from inside the identified factory to a residence. A hand held FFT analyser is used so that identified sources in the specific factor affecting the residence can be identified.

Tokyo contrasts. Tea House on the lake, in a garden formerly used by the Emperor to entertain his guests. Now overshadowed by modern buildings

For LFN emission sources, not only sound pressure levels, but also vibration levels on external surface of the LFN source are measured. Countermeasures for identified emission sources are mainly to remove or stiffen vibrating parts in order to minimize amplification of the LFN.

Kim Nielsen dealt with measurement accuracy in his paper **Low frequency calibration of measurement microphones.** The calibration of measurement microphones below 100 Hz is not very well covered by the present IEC standards. The permitted uncertainty increases rapidly and for very low frequencies goes towards infinity. The paper approaches this issue and presents a unique way to verify and calibrate the low-frequency response of measurement microphones. Using a small isolated calibration volume and applying a constant force to a large piston inside this volume, gives a direct proportional relation between force and sound pressure, allowing calibration of measurement microphones down to 0.01Hz.

Ping-Chang Chen gave a paper on vibration control with **Robust control of active pneumatic vibration isolator with disturbance observer.** A robust controller is proposed, and is applied to obtain higher vibration isolation of the active pneumatic isolator. The active isolation system in the study is different from other control systems in that the disturbance from the floor can be measured directly using an accelerometer. The isolation control system is feed-forward for floor disturbance and feedback of payload

velocity. According to the robust controller design theory, the selection of appropriate weighting functions equips the isolation system with the desired specification and ability of disturbance rejection. The simulations and the experimental results show that the introduced robust control scheme improves the advantages of the passive pneumatic isolator.

Setyamartana Parman took us to the satellite region with the paper **Controlling attitude manoeuvres of a flexible satellite under low frequency vibration by using feed-forward constant-amplitude inputs.** The satellite consists of a rigid main body and two symmetrical flexible solar panels. Under constant-amplitude thrust, large low frequency oscillations may occur after the manoeuvre, so disturbing its orientation to earth. In order to reduce residual attitude angle oscillations, an input shaping method is used. This method determines the number and time locations of input pulses to be used on the satellite with regard to the system's flexibility. As the result, the input consists of a sequence of constant pulses in suitable directions and time switching locations. Then, attitude manoeuvres of the satellite are simulated numerically. By shaping the inputs, the residual oscillation of attitude angles of the satellite can be suppressed successfully into an expected level.

Emiliano Boniotto considered problems of human vibration in **Uncertainty in the experimental evaluation of occupational exposure to hand-arm vibration.** This research takes into account the importance of risk measurement and the importance of a correct evaluation of uncertainty linked to the metrological methods. Uncertainties associated with field assessments of daily exposure to hand-arm vibration (HAV) have been investigated in three categories of power tools in different working conditions and for different hand arm measure adapters (direct, flat base and shaped base). The HAV exposures were measured in different working conditions for over 100 individual vibrations. The methods used in the study to calculate measurement uncertainties are in accordance with the ISO publication "Guide to the Expression of Uncertainty in Measurement". The study made it possible to isolate major sources of uncertainty in field assessment of daily exposures to HAV. The investigation revealed that, in all the field conditions, differences in the characteristics of the measurement adapter and/or the working conditions were the most relevant uncertainty components.

Masashi Uchikune dealt with physiological and psychological effects of vibration in **Study on the effects of the backrest contact-transmitted whole-body vibration.** Seated drivers experience health effects, developing over time, and the experimental conditions used included horizontal acceleration of 0.42m/s^2 to 0.816m/s^2 and from 0.42Hz to 0.55Hz over 30 minute periods. Physiological effects were examined by investigating the effects on the cardiovascular system, the blood flow system, the respiratory movement and salivation, to confirm the effects on the autonomic nervous system and on postural sways in the normal Romberg position. Additionally, psychological responses of unpleasant and comfortable were obtained from the subjects. Unpleasant sensation developed above about 0.36m/s^2. Proposals are made for clarification of the standard, ISO 2631.

Yeu-Jong Huang turned to laboratory standards in his paper **Evaluation for a new low frequency primary vibration calibration system in NML.** A vibration shaker (APS-500) and a laser interferometer are mounted on a new seismic block. This new iron block has a mass of about 4000 kg and dimensions of 2000 mm×600 mm×700 mm. Investigation of the block's dynamic characteristic gave a first mode of 314 Hz. It is greater than the maximum calibration working frequency of 70 Hz. Accelerometer calibration voltage sensitivity value difference is less than 0.3% and error normalization value is less than 0.8 between the new and present primary vibration calibration system. From the results, there is a consistency between these two systems. NML will continue to evaluate the new primary vibration calibration system and conduct intercomparisons with other countries in the near future. When national measurement standards are in consensus with the international standards, then the new primary vibration calibration system will replace the present system.

Sunao Kunimatsu dealt with theoretical developments in the **Study on the effect of sound barriers by using the infinite element method.** Sound barriers have a complicated effect on the acoustical propagation in the atmosphere. In the case that a number of barriers are present, the geometrical theory of diffraction is difficult in predicting the sound pressure at the points of interest. The paper tackles this problem in an unbounded domain by using the infinite element method through directly solving the Helmholtz equation, assuming a fixed source location, rigid barriers and low frequencies. Effects of barriers on the sound pressure field are investigated by changing the barrier height, thickness and distance from the source. Satisfactory agreement is shown with the analytic solution. The application and extension of this method to more complicated problems, such as those with multiple barriers located obliquely are straightforward.

Ravindra Ingle described on board problems in **A theoretical investigation on natural frequencies of vibration and noise due to engine and propeller system of Ultra Large Crude Carrier (ULCC)** An analytical approach has been adopted for determination of frequency and noise. The effect of LBP[1] and Dwt[2] of ULCC on the power requirement and service speed has been studied. The analysis has been carried out for the propeller diameter, propeller pitch and selection of number of blades to reduce vibration and noise. The effect of service speed of all the ULCCs on the fuel consumption per day has also been studied and presented. The paper concludes with the comparison of natural frequencies obtained by analytical approach with determinations by FEM.

In a second paper, **Ravindra Ingle** described **An investigation on natural frequencies of hull due to periodic vibrations from engine and propeller system of container ships** The increase in service speed of a ship directly affects the frictional resistance in the sea and requires more power to overcome that resistance. An analysis has been made, selecting the number of propeller blades with suitable diameter of the propeller in order to reduce the vibration due to cavitation. Vibration due to natural frequencies of the hull can also be reduced further by increasing the Dwt capacity and LBP of the ship and by running the engine at low speeds. The comparison of natural frequencies of the hull by analytical method with FEM using Ansys 9.0 has been made .

Christian Sejer Pedersen discussed environmental problems in the paper **Low-frequency-noise complaints: an investigation of twenty-one cases**. From 203 cases of low-frequency complaints a random selection of twenty-one cases was used in order to answer the question whether

[1]LBP = length between parallels, which is the length of the ship at the water level

[2]Dwt = dead weight, which is the maximum weight of cargo, fuel etc that a ship can carry

the annoyance is caused by an external physical sound or by a physically non-existing sound, i.e. low-frequency tinnitus. Noise recordings were made in the homes of the complainants, and the complainants were exposed to these in blind test listening experiments. The low-frequency hearing of the complainants was investigated, and characteristics of the annoying sound were matched. The results showed that some of the complainants are annoyed by a physical sound (20-180 Hz), while others suffer from low-frequency tinnitus (perceived frequency 40-100 Hz). Physical sound at frequencies below 20 Hz (infrasound) is not responsible for the annoyance – or at all audible – in any of the investigated cases, and none of the complainants has extraordinary hearing sensitivity at low frequencies. It is anticipated that physical sound is responsible in a substantial part of the cases, while low-frequency tinnitus is responsible in another substantial part of the cases.

Frits van den Berg continued the complaint theme with **Low frequency noise can be a phantom sound.** Suffering from almost continuous and steady low pitched sounds at home can be a serious threat to one's well-being. Often the sound source is not obvious or cannot be found. In many cases there is no clear evidence from the analysis of the ambient sound of what the disturbing sound could be. Thus Low Frequency Noise (LFN) has become an ominous concept, a confrontation between sufferers asking for understanding and a solution and often helpless acoustic experts. From reported measurements one must conclude that, at least in some cases, it is improbable or even impossible that LFN is actually present at a relevant level, in which case it has to be concluded that the sound originates within the person. When brought into a very quiet environment, normally hearing people do hear low pitched and other sounds. A hypothesis is that LFN sufferers do hear low pitched sounds, as other people would in a dead quiet place, but do not recognize it as such.

Marianna Mirowska considered the problem of long term exposure in her **Subjective assessment of low frequency noise from building service equipment and its long lasting effects on inhabitants' health** Questionnaire investigations were made among inhabitants complaining about noise coming from building appliances such as fans, pumps, transformers, freezers (as tested group) and among their neighbours living in the same block, in dwellings without equipment noise (as control group).Through inquiry forms and interviews, subjective assessments were analysed of annoyance and long term effects of low frequency noise in the dwellings on health of exposed people were assessed. The investigation results indicate that unacceptable noise persistently appearing in dwellings, even at very low levels, is recognised as annoying or very annoying and it is a potential health risk for inhabitants.

Ken Okada covered a difficult area in **How to perceive ILFS & LFN radiating machineries and relationship between the perception mechanism and human responses in physiology.** Perception mechanisms were discussed via effects on the auditory and vestibular systems. Mechanisms for vestibular detection are shown as follows 1) The perception mechanism will differ from that of audible LFN perceived by the cochlear system. 2) The sound wave goes through the endolymph filled scala media to the vestibular labyrinth. 3) The hair cells and stereocilia of Utricle, Saccule and three semicircular ducts perceive ILFS. These hair cell systems are available for lower frequency signals, such as ILFS, than that of the organ of Corti. 4) The physiological symptoms found between the vestibular symptoms and the symptoms of human response under relative low sound levels are, in certain respects, similar. 5) The human response due to ILFS may be only the response of the vestibular system as a warning signal, but this is extremely unpleasant for the sufferer.

Jongkwan Ryu described work on **Hearing thresholds of low frequency complex tones with a center frequency of 60 Hz.** Hearing thresholds of low frequency complex tones were measured using the bracketing method. The complex tones consisted of two tones which were geometrically centred at 60 Hz and had frequency differences of 30, 60, 90, or 120 Hz. The sound pressure levels of two tones were set to an equal intensity or to an equal sensation level for each individual subject. An additional threshold measurement was conducted for complexes, which comprised two to six tones within 25 to 145 Hz range. Results showed that a complex signal with multiple tones could be detected even if the level of its individual components was below threshold. However, the improvement in complex signal detection depended on the frequency difference (bandwidth) as well as on the level difference between tones. Effects of bandwidth and the number of tones on the detection of complex tones, and sound detection models in low frequency region are discussed.

Toshio Watanabe considered **Simultaneous masking and temporal masking of low frequency sound.** Simultaneous masking and temporal masking of low frequency sound by band noise were measured. The masker of simultaneous masking is a band noise whose centre frequency is 20Hz. The level of the masker is 70dB. Measurement signals are pure tones and the frequencies are from 8Hz to 50Hz by ⅓ oct steps. Sixteen subjects participated. The masking of forty subjects had already been measured in the same conditions. The masking characteristics differed with the individual and the frequency characteristics were divided into three patterns. This result was in agreement with the conclusion, which was drawn before. Forward and backward temporal masking was measured in some subjects. Measurement signals are pure tones of 25Hz and 50Hz. The masker is band noise that is the same one in the measurement of simultaneous masking. The masking characteristics were very different from those at audio frequency. It was difficult to explain why the temporal masking characteristic of low frequency sound is different from that of audible frequency range. The clear relation between the forward masking and the simultaneous masking were not observed. The clue to find the masking characteristic of low frequency sound may be obtained.

Steve Benton described work on **Personal and proactive: cognitive behavioural therapy (CBT): a Method for coping with low frequency noise annoyance.** Health care systems around the world, not withstanding significant differences between industrialised and developing nations, are facing the prospect of nearly 40% of their population being over 65 by 2051. This population dynamic may represent an important influencing variable for care agencies responsible for solving LFN problems, and related annoyance, as the largest population of LFN sufferers is in the 50+ age group. This paper considers recent research findings into the effectiveness of cognitive and behavioural techniques for LFN sufferers and explores the potential for technological systems to help provide citizens with flexible access to high quality and pro-active health care.

Yukio Takahashi described **Vibratory sensation induced by low-frequency noise – the threshold for the perception of vibration in the head.** In previous studies, the threshold was measured for sound pressure levels for perceiving vibratory sensation induced

by low-frequency noise within the 20-50 Hz range. The threshold levels for perceiving vibratory sensation were higher than the hearing threshold levels. Almost all of the subjects reported that they felt vibration in the head, which suggested that the head was the most sensitive part of the body to vibratory sensation. A distinct dip appeared at 40 Hz in the threshold level contour for perceiving the vibratory sensation. In the present study, as a first step for investigating the body part dependence in the perception of vibration in persons exposed to low-frequency noise, the authors measured the threshold sound pressure levels for perceiving "vibration in the head" in a wider frequency range (16-80 Hz). For comparison, the threshold sound pressure levels for perceiving "vibration in the chest" were also measured. As a result, the threshold levels for perceiving "vibration in the head" were found to be lower than those for perceiving "vibration in the chest", which supported the idea that the perceptual characteristics of the vibratory sensation induced by low-frequency noise were dependent on parts of the body and suggested that the head played an important role in perceiving the vibratory sensation.

Tommaso Meloni described **New Swiss regulation to protect persons from vibrations and structure-borne noise.** An ordinance has been drafted which protects persons in buildings against the harmful effects or nuisance of vibration and structure-borne noise such as, for example, from railways. The ordinance will enter into force soon. The regulation is based on the classical principle of an evaluative determination with subsequent rating on the basis of exposure limits. The vibration exposure limits are orientated on the perception threshold. For structure-borne noise exposure limits are described by energy-equivalent units and they are stipulated in an audible range distinctly above threshold. Additionally, maximum levels are also applied at night. This is intended to take into account sleep disturbance. Aspects such as proportionality and stipulated remediation deadlines enable the legislation to be implemented. However, remediation is problematic in relation to rail transport facilities in particular. This is due to the high complexity of implementation measures and the related costs. The technical developments demanded in the ordinance should make a beneficial contribution to realising the long-term goals.

Hung-Liang Kuo spoke on **The development of low frequency noise standards in Taiwan.** Although a Noise Control Standard has been in use since 1992, there are increasing noise complaints. In 2003, the Environmental Protection Administration (EPA) tried to mitigate the situation, by focussing on the 30,000 noise complaint cases which were not yet settled, some of which did not exceed the Noise Control Standards, but still annoyed the complainants. These had main low frequency noise components. One hundred complaint sites have been measured inside houses to study the spectrum distribution. The sources of noise were cooling towers, air conditioners etc. The low frequency noise standards for entertainment and business premises have been completed and amended in Noise Control Standard articles in 2005. Following that, the low frequency noise standard for factory plants or sites and construction projects or facilities were studied and amended in 2006 and 2008. This paper describes the development and content of the low frequency noise control standards in Taiwan.

Satoshi Shindo introduced the **Activity report of "Working group on evaluation of habitability to low frequency noise and vibration", Architectural Institute of Japan.**

In 2006 the committee on environmental vibration of the Architectural Institute of Japan, established the working group on evaluation of habitability for low frequency noise and vibration, to correspond to the low frequency noise and vibration problem in buildings, which has occurred in urban areas in recent years. The WG members consists of a variety of specialists, such as not only in the architectural field, but also ergonomics, mechanical engineering, civil engineering, acoustics, etc. The WG is functioning as a place of information exchange with other academic societies. In this paper, the activity reports from 2006 to 2007 and the main activities in the 2008 fiscal year on the collection of case studies for building design and the outline of an installation manual for home equipments, namely outdoor units of room air-conditioning equipment etc. are described.

Hiroaki Ochiai described determination of the **Threshold sound pressure level of rattling of fittings due to low frequency sound.** Rattling of fittings by low frequency sound is a serious problem in Japan. A number of experiments have been carried out by several research institutes, but the numbers of test samples was not enough, so general conclusions have not yet been given. New work has been laboratory experiments on the minimum sound pressure level for rattling of 63 kinds of fittings due to low frequency sound. An evaluation method for rattling has also been considered. The minimum sound pressure levels of rattling of 63 fittings in the experiment are distributed over a very wide range of sound pressure levels in each frequency. Finally, an evaluation proposal, *L*rat,ave-SD, as the new evaluation value. *L*rat,ave-SD showed a good correlation with complaints about structural effects of low frequency sound.

Masayuki Shimura described the problems from wind on microphones at low frequencies in his paper **Wind effect for low frequency sound pressure measurement.** There are two aspects of wind effects on field measurement of low frequency sound. One is the distortion by wind on long distance propagation and the other is the degradation of measurement quality due to wind induced noise. Focusing on the latter problem, a wind tunnel test was conducted using the low frequency sound pressure meter under several cases of wind velocity and wind turbulence. Sound pressure and wind turbulence are simultaneously measured and can be obtained separately. In the present paper, the experimental results are discussed. It is pointed out that most influential physical parameter is the intensity of turbulence in wind field.

Delegates listen attentively to a presentation

Hiroyuki Imaizumi described **Low-frequency wind noise reduction by microphone – enclosed type windscreen for outdoor noise measurements.** Outdoor noise propagation is influenced by meteorological conditions. Noise measurement at a receiver is also affected by wind noise and has to be suspended under strong wind condition. The authors have developed a windscreen framed with thin iron and covered with porous polyester urethane foams, in which a foam spherical windscreen with a 90mm in diameter is set up. Acoustical characteristics of several kinds of urethane foams have been examined and the performance on wind noise reduction by each foam has been studied, mainly through outdoor measurements. 20dB attenuation or more of the wind noise at frequencies from 3Hz to around 10Hz has been observed by using this type of windscreen. Application of a small version of the windscreen to field measurements of artillery noise after long-range propagation over a hilly region is described.

Hideaki SUETSUNA described a **Study of aerodynamic noise predictions on several trailing edge shapes for wind turbine blade.** The purpose of this work is to reduce the trailing edge noise of wind turbine blades. Varying the thickness of the trailing edge makes the edge sharp or blunt. Compressible Large-Eddy Simulation is used to simulate the flow field and acoustic field directly in the near field of the NACA0012 blade, while the far field aerodynamic noise is predicted using acoustic analogy methods. The prediction of aerodynamic noise emitted from a NACA0012 blade requires the analysis of vortex structures and pressure fluctuations and their interaction with the trailing edge. Brooks et al. showed that untripped laminar boundary layer and tripped turbulent boundary layer have different peak level of the blade surface pressure spectrum, which means good prediction of acoustic field around a blade requires good prediction of turbulent boundary layer. The pressure fluctuation spectrum near the blunt trailing edge indicates high levels for a specific frequency range, which shows similar trend compared with the experiment.

Helge Aagaard Madsen dealt with **Low frequency noise from wind turbines – mechanisms of generation and its modelling.** The paper presents an overview of LFN characteristics of modern turbines based on numerical simulations. Typical sizes of modern turbines are from 1-3 MW nominal generator power and a rotor diameter ranging from 80-100 m but larger prototypes up to 5 MW and with a rotor diameter of 126 m have now been installed. The simulation package comprises an aeroelastic time simulation code HAWC2 and an acoustic low frequency noise (LFN) prediction model. Computed time traces of rotor thrust and rotor torque from the aeroelastic model are input to the acoustic model, which computes the sound pressure level (SPL) at a specified distance from the turbine. The influence on LFN on a number of turbine design parameters are investigated and the position of the rotor relative to the tower (upwind or downwind rotor) is found to be the most important design parameter. For an upwind rotor the LFN levels are so low that it should not cause annoyance to neighbouring people. Important turbine design parameters with strong influence on LFN are the blade tip speed and the distance between rotor and tower.

Bo Søndergaard described further work on wind turbines in **Low frequency noise from wind turbines – methods for prediction and assessment of the noise levels and the audibility of low frequency noise.** Noise is one of the determining factors when planning new sites for wind farms or single wind turbines. Especially, low frequency noise and infrasound have been brought up during recent years. Lack of knowledge has made it difficult for planners and authorities to include this in the planning and decision process. As part of an investigation of low frequency noise from large wind turbines methods for prediction of the low frequency noise outdoor and indoor are suggested. Conclusions on the audibility of the low frequency noise in the literature are often made from psycho-acoustic inadequate procedures and methods. A procedure for calculating the audibility of low frequency sound (and infrasound) has been defined. Results from noise measurements are presented to show the development of the low frequency noise with wind turbine size.

Katsuhiro Kikuchi dealt with **Continuous pressure waves generated by a train running in a tunnel.** Some characteristics of tunnel continuous waves are one of low-frequency sounds radiated from a railway tunnel portal. Theoretical results and measurement data obtained from a field test are given. A method of separating an incident wave from pressure data measured in a tunnel is given and applied to data obtained from a field test, enabling the incident wave to be separated from pressure data measured in the tunnel .

Shigetaka Takata decribed **A study of low frequency noise control of blast in tunnel construction.** The blasting low frequency noise at the time of tunnelling work is a very loud sound, leading to complaints of low frequency noise, especially as some blasting is at times when people are sleeping. In order to remove the complaint, it is necessary to attenuate the sound pressure of the blasting low frequency noise. Installation of a removable screen at the tunnel entrance is a way of attenuating the sound pressure of the blasting low frequency noise.

The conference included discussions led by Ben Sharp on a new Wyle Labs – NASA project on subjective effects of high level infrasound and low frequency noise. This work is related to the development of large rotorcrafts.

MORE INFORMATION

Many of the papers have multiple authors, but only the presenting author is given above. Full details and papers are given in the conference Proceedings CD which can be obtained from the conference organiser, **Shinji Yamada. E-mail: yamada@ms.yamanashi.ac.jp**

ANSWERING BACK

An attacker who knifed two men in a pub after being asked to keep his voice down has been jailed for six-and-a-half years. Brian Lunan, 31, of Alexandria, Dunbartonshire, struck in the town's Station Bar on 6 October, 2003. The High Court in Edinburgh heard Lunan left the pub after being jokingly warned about the noise and went home, changed into camouflage gear and a balaclava, and returned with knives. In September 2004, he admitted the assaults at Dumbarton Sheriff Court but fled Scotland. He returned last month and gave himself up.

ROUGH RESPONSE TO CIVIL REQUEST

A 70-year-old Northampton pensioner was assaulted by two men when he asked them to stop talking loudly outside his home. The two men were talking in Farmbrook Court, Thorplands, between 9.30pm and 9.50pm November 24th when the pensioner asked them to keep the noise down. One of the men then punched through a glass panel in the front door, smashing it, and when the victim went outside to speak to the offender he was assaulted by both men.