NOISE PREDICTION AND MEASUREMENT FROM CONSTRUCTION SITES

NADIRAH BINTI DARUS

UNIVERSITI TEKNOLOGI MALAYSIA

NOISE PREDICTION AND MEASUREMENT FROM
CONSTRUCTION SITES

NADIRAH BINTI DARUS

A project report submitted in partial fulfillment of the
requirements for the award of the degree of
Master of Science (Construction Management)

Faculty of Civil Engineering
Universiti Teknologi Malaysia

JANUARY 2014

To my beloved parents, Darus bin Dir and Haslina binti Zakaria and siblings, Nadia, Nadimi, Nabilah, Nabihah, Muhammad Nadhir Adha, Muhammad Naim, Najwa Dayana, Najla Dania, Muhammad Nasif and Najat Damia.

ACKNOWLEDGEMENT

First and foremost, I would like to thank Allah S.W.T the Almighty for giving me the strength and ability to complete my project report successfully. Apart from that, I am also would like to express my sincere appreciation to all parties whose have help me in completing this project report.

Special thanks to my expert supervisor, Dr. Zaiton Haron for her impressive ideas, knowledge, patience and understanding that she has contributed throughout the whole completion of this project report. Deep gratitude also goes to her for correcting various related documents with attention and care.

Thanks and appreciations to Mr. Izzudin (Project Manager), Mr. Aizam (Project Executive) and Miss Fiza (Clerk of Work) from IOI Properties for their helps, permission and support. My great gratitude also goes to Mr. Tan (Project Director) and Mr. Rahman (Site Manager) from Profit Composite Sdn Bhd.

Thousand thanks to all my postgraduate friends, Zanariah, Siti Nadia, Noradawiah and Dahlia who have helped and supported me in completing my project report. Finally, I would like to express unending thanks and gratitude to my beloved parents and family members for their encouragements, helps and supports.

ABSTRACT

Construction industry is one of the contributors to economic growth and it has the highest tendency to generate noise. Construction noise becomes one of the main sources of noise pollution which affect the public and construction workers. Construction noise prediction at planning stage must be carried out and prepared through Environmental Impact Assessment (EIA). There are various methods of construction noise prediction that have been practiced by the respected parties. The British Standards Institution (BSI) and the Department of Environment (DOE) have published BS 5228 – Part 1: 2009 – Code of Practice for Noise and Vibration Control on Construction and Open Sites and The Planning Guidelines for Environmental Noise Limits and Control respectively. These standards and guidelines were usually be used by the respected parties since currently, there are no specific established noise prediction method. However, previous researches were claimed BS 5228 – Part 1: 2009 procedures as inaccurate due to several factors. Thus, this study was carried out to evaluate the disparity of results between construction noise predictions using BS 5228 – Part 1: 2009 procedures and real on-site noise measurements. The objectives of this study are to obtain noise levels from construction sites, to predict noise levels from construction sites and to evaluate the disparity between these two results. The real on-site noise measurements were conducted at three selected construction sites with different stages of construction. Meanwhile, construction noise predictions were calculated using BS 5228 – Part 1: 2009 procedures. The disparity of the results was evaluated using statistical test in Statistical Package for Social Sciences (SPSS) software. The results of one sample T-test show the significant differences between these two results. The disparity might due to several affecting factors such as atmospheric and geometrical factors, operation conditions, periods and powers and work schedules of construction activities.

ABSTRAK

Industri pembinaan merupakan salah satu penyumbang kepada pertumbuhan ekonomi dan ianya mempunyai kecenderungan besar untuk menghasilkan bunyi bising. Bunyi bising pembinaan menjadi salah satu punca utama yang memberi kesan kepada orang awam dan pekerja pembinaan. Ramalan bunyi bising pembinaan pada peringkat perancangan mestilah dilakukan dan disediakan menerusi *Environmental Impact Assessment (EIA)*. Terdapat pelbagai kaedah ramalan bunyi bising yang telah diamalkan pihak berkenaan. *British Standards Institution (BSI)* dan Jabatan Alam Sekitar (JAS) masing-masing telah menerbitkan *BS 5228 – Part 1: 2009 – Code of Practice for Noise and Vibration Control on Construction and Open Sites* dan *The Planning Guidelines for Environmental Noise Limits and Control*. Lazimnya, piawaian dan panduan ini digunakan pihak berkenaan kerana tiada kaedah ramalan bunyi bising yang khusus diterbitkan pada masa ini. Namun begitu, kajian terdahulu mendakwa kaedah *BS 5228 – Part 1: 2009* adalah tidak tepat disebabkan beberapa faktor. Oleh itu, kajian ini dilaksanakan untuk menilai ketidaksamaan antara keputusan ramalan bunyi bising menggunakan kaedah *BS 5228 – Part 1: 2009* dengan keputusan ukuran sebenar di tapak pembinaan. Objektif kajian ini adalah untuk memperolehi serta meramal tahap bunyi bising dari tapak pembinaan dan menilai ketidaksamaan antara dua keputusan yang diperolehi. Ukuran sebenar telah dilakukan di tiga tapak pembinaan terpilih yang mempunyai peringkat pembinaan berbeza. Manakala, ramalan bunyi bising telah dikira menggunakan kaedah *BS 5228 – Part 1: 2009*. Ketidaksamaan keputusan telah dinilai menggunakan ujian statistik dalam perisian *Statistical Package for Social Sciences (SPSS)*. Keputusan T-test satu sampel menunjukkan perbezaan antara dua keputusan ini. Ketidaksamaan keputusan mungkin disebabkan beberapa faktor seperti faktor keudaraan dan geometri, keadaan, tempoh dan kuasa operasi dan jadual kerja aktiviti pembinaan.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

dB	-	Decibel
dB (A)	-	Decibel A-weighted
Hz	-	Hertz
L_{Aeq}	-	Equivalent continuous sound pressure level
L_{max}	-	Maximum sound level
L_N	-	Percentile levels
L_p	-	Sound pressure level
L_r	-	Rating sound level
L_w	-	Sound power level
L_{10}	-	Percentile levels with values exceeding 10 % of elapsed time
L_{50}	-	Percentile levels with values exceeding 50 % of elapsed time
L_{90}	-	Percentile levels with values exceeding 90 % of elapsed time

LIST OF ABBREVIATIONS

BSI	-	British Standard Institutions
DOE	-	Department of Environment
DOSM	-	Department of Statistics, Malaysia
EIA	-	Environmental Impact Assessment
FHWA	-	Federal Highway Administration
SLM	-	Sound Level Meter

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Introduction

Construction industry as second large contributor has contributed 17.1% to growth of Gross Fixed Capital Formation (GFCF) of the country in 2012 (DOSM, 2013). All developing countries including Malaysia have a great development in construction industry where it grows along with economic growth of the country. There are various initiatives taken to reduce the environmental impacts of construction processes, however, construction is still the main contributor to environmental impacts and pollutions (Fuertes *et al.*, 2013).

Various associated factors which include environmental factors must be considered for any project development and construction in order to avoid adverse environmental impacts. These environmental impacts are categorized into three main category including ecosystems, natural resources and human health (Li *et al.*, 2010). Construction noise can be categorized under human health impacts and it is commonly categorized as local issues. According to Zolfagharian *et al.* (2012), identification of major environmental impacts of construction processes can helps to improve effectiveness of Environmental Management System (EMS).

Noise can be defined as unwanted or undesired sounds (Edworthy, 1997; Muzet, 2007; Hamoda, 2008; Fernandez *et al.*, 2009). The main sources of noise are including traffic noise (road and air traffic), industries, construction and public works and the neighbors. There are various different sources of construction noise pollution at construction sites including the use of heavy plants and machineries and noisy tools and equipment where it has widely spread and caused serious social problems (Manatakis *et al.*, 2002). These construction noises must be properly predicted and controlled in order to avoid excessive noise exposure that may affect the public committee as well as the construction workers.

Therefore, assessment and prediction of construction noise at planning stage is very crucial and it can improve the environmental performance of construction processes and activities. According to DOE (2007), noise is one of the important elements which are subjected to EIA. Practically, construction noise prediction will be included in EIA report and it is being prepared by EIA consultants. In Malaysia, DOE has suggested that BS 5228 – Part 1: 2009 procedures, a deterministic approach to be used as noise prediction method. However, the methods of construction noise prediction vary among different consultants since there is no established method to be adopted.

Based on BS 5228 – Part 1: 2009 procedures, there are three methods have been suggested to predict the noise (BSI, 2009). The first method (the most accurate prediction) is carrying out noise measurements of a similar construction plant and equipment, the same operation mode and power over a time period with sufficient operation cycles. Generally it is measured at appropriate distance of ten meter or other distances with correction to ten meter. The second method is using the sound power levels, L_w and values of activity L_{Aeq} as provided in the standard. The third method is obtaining the maximum permitted L_w of the construction plant, adjusting the L_w based on the variation and applying correction for distance ratio.

1.2 Problem Statement

Construction activities or processes cannot be hindered from creating noises. These noises have affected many people including the public as well as the constructions workers. Due to this situation, complaints related to this problem are continuously increased and reported all over the time by the affected parties especially the public committee or local residents. As reported in NST (2012), the local residents of Persiaran Halia, George Town, were affected by air and noise pollutions of the nearby building construction. These pollutions were arising from rock blasting at the nearby construction site and have affected the local residents in term of health aspects and daily life.

The Star (2012a) also reported similar case where the residents of Taman Yarl, Kuala Lumpur were disturbed by the noise from tractors due to the sewerage construction works beyond the permitted working hours. Other than that, the public who are local residents of Taman Nusa Indah, Kiara Hill in Johor Bahru were troubled by noise from construction sites. They were sleepless during night due to 24 hours construction and blasting works of water tower nearby their houses (The Star, 2012b). Any construction projects or activities must consider the impacts on environment and the public in order to avoid excessive environmental impacts, noise exposures and complaints from the public committee.

The most important element to control this problem is by having an effective noise management. Prediction of construction noise at planning stage is very essential to ensure the construction noise levels expose to the public and construction workers are within the limit. There are various methods of noise prediction that have been adopted by the EIA consultants in predicting noise prior to construction of a project. However, currently, there is no specific established method to predict construction noise. Basically, there are two main types of construction noise prediction method such as deterministic (e.g.: BS 5228 – Part 1: 2009 procedures) and stochastic (e.g.: Monte Carlo Analysis) approaches.

One of the methods to predict the noise is noise modeling. Modeling can be considered as a good tool in assessing environmental impact of noise but noise predicting models are limited due to various types of construction sites, complex interaction between noise levels, distance from the noise source, project size, type of construction equipment used and construction stages. Other than that, BS 5228 – Part 1: 2009 – Code of Practice for Noise and Vibration Control on Construction and Open Sites and The Planning Guidelines for Environmental Noise Limits and Control also can be used as reference for noise prediction. However, different methods of noise prediction vary among different consultants.

Based on previous researches, Carpenter (1997) was claimed BS 5228 – Part 1: 2009 procedures for construction noise prediction (L_{Aeq} prediction) as inaccurate (Haron *et al.*, 2008). This is due to fluctuation of noise from construction sites where it involves different sources of noise, possibility of simultaneous operations, different acoustical characteristics, different conditions and locations. According to Haron *et al.* (2009), noise levels generated from construction sites are vary with time where it is due to different conditions and variations. Thus, this study was carried out to evaluate the disparity of results between predictions using BS 5228 – Part 1: 2009 procedures and real on-site noise measurements.

1.3 Aim and Objectives of the Study

The aim of this study is to compare the prediction and real on-site measurement of construction noise emission levels produced from construction sites. The objectives of this study are as follows:

a) To obtain noise levels from construction sites.

b) To predict noise levels from construction sites.

c) To evaluate the disparity between results obtained in a) and b).

1.4 Scopes of the Study

The scopes of this study are as follows:

a) This study focused on different stages of construction including earthworks, substructures (piling works) and superstructure works.

b) The prediction and on-site measurement of construction noise were focused on equivalent continuous sound pressure level, L_{Aeq}.

c) The real on-site measurements of construction noise were carried at construction sites which are located at Kempas and Skudai, Johor.

d) The predictions of construction noise were done using BS 5228 – Part 1: 2009 procedures.

1.5 Significances of the Study

The significances of this study are as follows:

a) The measured sound power level, L_w of construction plants and machineries at construction sites can be reference to the related parties in predicting construction noise.

b) The disparity between predicted and measured results can be used as proves to encourage related parties to use stochastic approach instead of deterministic approach in predicting noise from construction sites.

1.6 Limitations of the Study

The limitations of this study are as follows:

a) The study only focused on deterministic approach (BS 5228 – Part 1: 2009 procedures) in predicting noise from construction sites where stochastic approach (e.g.: Monte Carlo Analysis) was not included.

b) The different stages of construction were taken from several construction sites instead from the same site due to time constraint and on-site construction work progress.

c) The period of on-site measurements is one hour only instead of eight hours (full working hours per day) due to time constraint and limited usage of required instruments where the usage must be properly managed.

REFERENCES

Ballesteros, M. J., Fernandez, M. D., Quintana, S., Ballesteros, J. A. and Gonzalez, I. (2010). Noise Emission Evolution on Construction Sites - Measurement For Controlling and Assessing Its Impact on the People and on the Environment. *Building and Environment*. 45, 711-717.

Bell, J. (1993). *How to Complete Your Research Project Successfully (A Guide for First – Time Researchers)*. London: UBS Publisher' Distributors Ltd.

Berglund, B., Lindvall, T. and Schwela, D. H. (Eds.) (1999). *Guidelines for Community Noise*. London: World Health Organization (WHO).

British Standards Institution (BSI) (2009). *BS 5228 – Part 1: 2009 Code of Practice for Noise and Vibration Control on Construction and Open Sites*. The United Kingdom: BSI Group Headquarters.

Burge, P. L. and Thalheimer, E. (2012). Five Myths of Construction Noise. *Sound and Vibration*. 46(12), 15-17.

Cozby, P. C. (2005). *Methods in Behavioral Research*. (9^{th} ed.) New York: McGraw-Hill.

Department of Environment (DOE) (2007). *The Planning Guidelines for Environmental Noise Limits and Control*. (2^{nd} ed.) Malaysia: Department of Environment.

Department of Statistics, Malaysia (DOSM) (2013). *Press Release Gross Fixed Capital Formation (GFCF) 2005-2012*. Malaysia.

Duerden, C. (1970). *Noise Abatement*. London: Butterworth & Co. (Publishers) Ltd.

Edworthy, J. (1997). Noise and Its Effect on People: An Overview. *International Journal of Environmental Studies*. 51, 335-344.

Fernandez, M. D., Quintana, S., Chavarria, N. and Ballesteros, J. A. (2009). Noise Exposure of Workers of Construction Sector. *Applied Acoustics*. 70, 753-760.

Field, H. L. and Solie, J. B. (2007). *Introduction to Agriculture Engineering Technology – A Problem Solving Approach*. (3rd ed.) New York: Springer Science + Business Media, LLC.

Fisher, C. (2004). *Researching and Writing a Dissertation for Business Students*. England: Pearson Education Limited.

Fuertes, A., Casals, M., Gangolells, M., Forcada, N., Macarulla, M. and Roca, X. (2013). An Environmental Impact Causal Model for Improving Environmental Performance of Construction Processes. *Journal of Cleaner Production*. 52, 425-437.

Gannoruwa, A. and Ruwanpura, J. Y. (2007). Construction Noise Prediction and Barrier Optimization Using Special Purpose Simulation. *Simulation Conference*, *2007 Winter*. 9-12 December. Washington, DC, 2073-2081.

Gibson, G. E., Wang, Y. R., Cho, C. S. and Pappas, M. P. (2006). What is Preproject Planning, Anyway? *Journal of Management in Engineering*. 22, 35-42.

Glatthorn, A. A. (1998). *Writing the Winning Dissertation a Step-by-Step Guide*. The United States of America: Corwin Press, Inc.

Hamoda, M. F. (2008). Modeling of Construction Noise for Environmental Impact Assessment. *Journal of Construction in Developing Countries*. 13(1), 79-89.

Haron, Z., Oldham, D., Yahya, K. and Zakaria, R. (2008). A Probabilistic Approach for Modeling of Noise from Construction Site for Sustainable Environment. *Malaysian Journal of Civil Engineering*. 20(1), 58-72.

Haron, Z. and Yahya, K. (2009). Monte Carlo Analysis for Prediction of Noise from a Construction Sites. *Journal of Construction in Developing Countries*. 14(1), 1-14.

Haron, Z., Mohd Noh, H., Yahya, K., Omar, W. and Abd Majid, Z. (2012). Assessing Noise Emission Levels from Earthwork Construction Equipment. *Malaysian Journal of Civil Engineering*. 24(1), 13-28.

Hickling, R. (2006). Decibels and Octaves, Who Needs Them? *Journal of Sound and Vibration*. 291, 1202-1207.

Huizingh, E. (2007). *Applied Statistics with SPSS*. London: SAGE Publications Ltd.

IBM Corporation. (2012). *IBM Software Business Analytics*. The United States of America: IBM Corporation Software Group.

Kerr, A. W., Hall, H. K. and Kozub, S. A. (2002). *Doing Statistics with SPSS*. London: SAGE Publications Ltd.

Leary, M. R. (2004). *Introduction to Behavioral Research Methods*. (4th ed.) The United States of America: Pearson Education, Inc.

Leica Geosystems AG, Heerbrugg. (2011). *Leica DISTO™ D5*. Switzerland: Leica Geosystems.

Leica Geosystems (2013). *Leica DISTO D5*. Retrieved from http://www.laser-measure.co.uk/leica-disto/leica-disto-d5.html on 9th July 2013.

Li, X., Zhu, Y. and Zhang, Z. (2010). An LCA-Based Environmental Impact Assessment Model for Construction Process. *Built and Environment*. 45, 766-775.

Luxon, L. M. and Prasher, D. (Eds.) (2006). *Noise and Its Effects.* England: Whurr Publishers Limited.

Manatakis, E. and Skarlatos, D. (2002). A Statistical Model for Evaluation and Prediction of the Noise Exposure in a Construction Equipment Area. *Applied Acoustics*. 63, 759-773.

Muzet, A. (2007). Environmental Noise, Sleep and Health. *Sleep Medicine Reviews*. 11, 135-142.

Naoum, S. G. (2007). *Dissertation Research and Writing for Construction Students.* (6thed.) The United States of America: Elsevier Ltd.

Naravane, S. (2007). *Effect of Industrial Noise on Occupational Skill Performance Capability*. Masters: Mumbai University.

New Straits Times (NST) (2012). *Sleepless Nights Due to Construction*. Retrieved from www.nst.com.my/streets/northern/sleepless-nights-due-to-construction-1.46668 on 7th July 2013.

Occupational Health and Safety Division. (2012). *System Solution Pocket Guide for Occupational and Environmental Health Professionals*. The United States of America: 3M Company.

Pulsar Instruments Plc. (2013a). *Model 33 Real Time Analyzer with 1:1 & 1:3 Octave Band Filters & Sound Level Meter One Instrument – 'A World of Solutions'*. The United Kingdom: Pulsar Instruments Plc.

Pulsar Instruments Plc. (2013b). *Model 105 & 106 Acoustic Calibrators*. The United Kingdom: Pulsar Instruments Plc.

Saran, S. (2006). *Analysis and Design of Substructures – Limit State Design*. (2nd ed.) The Netherlands: Taylor & Francis/Balkema.

Stangor, C. (2007). *Research Methods for the Behavioral Sciences*. (3rd ed.) The United States of America: Charles Hartford.

Suter, A. H. (2002). Construction Noise: Exposure, Effects and the Potential for Remediation; A Review and Analysis. *American Industrial Hygiene Association*. 63, 768-789.

Syal, M. G., Grobler, F., Willenbrock, J. H. and Parfitt, M. K. (1992). Construction Project Planning Process Model for Small-Medium Builders. *Journal of Construction Engineering and Management*. 118, 651-666.

The Star (2012a). *Construction Works Beyond Permitted Hours Irks Resident*. Retrieved from www.thestar.com.my on 6th July 2013.

The Star (2012b). *Kiara Hill Residents are Troubled by Noise from Construction Site*. Retrieved from www.thestar.com.my on 6th July 2013.

U.S Department of Transportation. (2011). *Federal Highway Administration (FHWA) – Special Report.* Retrieved from http://www.fhwa.dot.gov/ environment/noise/ construction_noise/special_report/hcn03.cfm on 22nd July 2013.

Vaucher de la Croix, D. and Freneat, C. (2013). Permanent Vibration and Noise Monitoring as a Valuable Tool to the Construction Industry. *Acoustical Society of America*. 19, 1-5.

White, D., Finlay, T., Bonton, M. and Bearss, G. (2002). Press-In Piling: Ground Vibration and Noise During Pile Installation. *Deep Foundations*. 363-371.

Xianren, Z. and Yanyan, Z. (2013). Noise Radiation Measure – Sound Power and Its Test Methods. *Research Journal of Applied Sciences, Engineering and Technology*. 6(1), 57-62.

Zhou, J., Li, Y. and Ma, H. (2012). Study on Prediction and Assessment of Noise Environment Impact during the Construction Period. *International Journal of Advancements in Computing Technology (IJACT)*. 4(6), 1-9.

Zolfagharian, S., Nourbakhsh, M., Irizarry, J., Ressang, A. and Gheisari, M. (2012). Environmental Impact Assessment on Construction Sites. *Construction Research Congress 2012*. 1750-1759.