sciendo

ERGONOMIC DIAGNOSIS OF CONCRETE MIXER WORKPLACE. CASE STUDY

doi:10.2478/mape-2018-0095

Date of submission of the article to the Editor: 04/2018
Date of acceptance of the article by the Editor: 07/2018

MAPE 2018, volume 1, issue 1, pp. 751-758

Dr Iwona Żabińska
Dr Artur Kuboszek
Silesian University of Technology, **Poland**

Abstract: The article shows the results of ergonomics diagnosis at the concrete mixer workplace. Above mentioned results constitute only a part of a widespread project which aims at integrated ergonomic diagnosis of workplace environment considering improving both technical conditioning and psycho-social conditioning. Foregoing researches were conducted in several companies in Silesian Voivodeship with regard to different work positions. The ergonomic diagnosis was done with the usage of tools as: Ergonomic Control Test CET II and Dortumd's list. The remarks allowed to evaluate worker's awareness of ergonomics, and to identify problems in this field.

Keywords: ergonomics, diagnosis, workplace, concrete mixer

INTRODUCTION

Ergonomics as theoretical and applied science consist in adapting machines, tools, devices and material work environment to the psychophysical possibilities of man in order to eliminate threats to human health and life, optimize the biological cost of work, ensure adequate efficiency and comfort during work and job satisfaction (Rozdz. II §11; Górska, 2015). The basis of this science is a man, his work comfort, safety during its performance, and not the economic effect. However, it should be emphasized that the ergonomic organization of work has a positive impact on the well–being and health of employees which promotes greater efficiency of work. Currently both employers and the scientific community are paying increasing attention to work ergonomics in different in various work environments (Bartnicka et al., 2017; Bartnicka et al., 2018; Koszembar–Wiklik et al., 2015; Krystosik–Gromadzińska, 2015; Mleczko, 2016; Winnicka–Jasłowska, et al. 2017; Zaborowski et al. 2015). The main reasons for the growing importance of ergonomics are, among others: longer people's lifetime, longer professional activity, increase in employment of disabled people.

1. METHODOLOGY OF RESEARCH

In order to compile the results, an in–depth interview was conducted with employees using job questionnaire form created for this purpose. It contained questions being an extension of the questions from the CET II general list (Ergonomic Taxonomy Cel II) (Burger and Boer, 1968). Employees were questioned in a friendly atmosphere thanks to which the answers characterizing their workplace were obtained. During the free conversation, employees were offered a range of interest in ergonomics and attention was paid to the elements of the work environment that may affect their physical and psychological burdens resulting from the place and method of work. The information obtained allowed to concretize the scope of the ergonomic diagnosis. Detailed diagnosis was made by completing the answers to all questions from the Dortmund's list (LD). Both documents were analysed what allowed to draw conclusions and propose improvements for the analysed workplace. Due to the possibility of taking a series of photos, 3DSSPP software was used to analyse the physical load of

musculoskeletal system for selected positions during work performance (3D Static Strength Prediction Program™).

2. CHARACTERISTIC OF THE WORKPLACE

Basic tasks performed by a concrete mixer on the production site is the service of the concrete mixer, filling the form with concrete, imprint them on the pallet and moving the concrete elements to the dryer. The scope of duties depends also on the air temperature. During winter, when the low temperature does not allow to perform even basic jobs, employees perform different jobs on the company's premises, particularly cleaning jobs. The company doesn't use any chemical antifreeze admixtures in order to provide identical physical and mechanical properties of the produced elements. Working on this position requires considerable physical effort. Factors that may affect the musculoskeletal system load were analysed as a part of the ergonomic diagnosis of the workplace.

3. ERGONOMIC DIAGNOSIS OF THE WORKPLACE

3.1. Assesement of the level of comfort/discomfort in connection with the equipment at the workplace

The work station at the vibrating table which is used for concentrating the concrete and at the concrete mixer is spacious enough, and the arrangement of work items and equipment enables a correct working position. The arrangement of these elements enables working only in standing position. There are no chairs at the workplace to prevent standing. The height of the plane on which work operations are carried out is adopted to the position at work and distance from the eyes. The arrangement of work items, including control devises, enables its proper control by hands and does not cause any static tension. Control devices (vibrating table switch–keys and concrete mixer switch–keys) are within reach of the upper limbs. Pedal control is neither necessary nor desirable. At the workplace hand tools are used, such as: a shovel, a float for mashing. This work requires using personal protective equipment (clothing, shoes, gloves). Personal protective equipment does not affect the proper reception of the information and does not hinder movements or performing work.

The work does not require intensive involvement of the sight organ or acoustic organ. There are no special requirements in terms of lighting and colour perception at this workplace. During performing work communication by speech is not necessary. However normal communication is hampered by the noise emitted by the machines. Work at this position is adopted to the capabilities of elderly people in terms of: pace, visual requirements, short–term (transient) memory. Data required to perform the work are obvious, unambiguous and appropriate. The amount of information does not exceed the mental capacity of the employee and does not overload him/her. There is no long–term tension of attention. All the information needed to make a decision are given in the right time and in the right order.

3.2. The level of phisical load due to the used working method

The performed work is related to physical load. Large and small muscle groups are loaded. The work is done in standing position, requires walking and also bending. The work requires raising and lifting elements weighing up to 60kg. weights must be lifted from the position of the vibrating table and it is possible to lift them in the right position. Transport routes are from obstacles. As a part of the diagnosis three positions held by employee at work were analysed and they are marked as: position 1, position 2, position 3 (Figure 1, Figure 3, Figure 5). Computer analysis with the use of 3DSSPP programme allowed to determine the level of the threats and burdens of the musculoskeletal system for the activities performed. In the position number 1, the employee is slightly inclined in the torso – by 8 degrees form the vertical position, stands at a straddle (about 44 degrees) – see Figure 1. His hands lift the load with the handles.

In this position, due to the weight being transferred and the way balancing forces to keep the balance, there is no visible load on the joints or musculoskeletal system (painted red movements nodes).

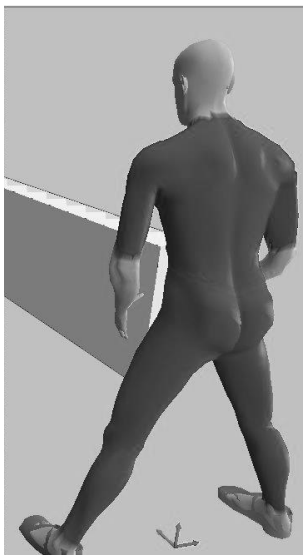

Fig. 1. Position 1. Phantom view. Moving a longitudinal element of a concreto fence structure

Only on the basis of the report of a collective computer analysis (Figure 2) it can be concluded that the load of the radial–wrist joint exceeds the limit value.

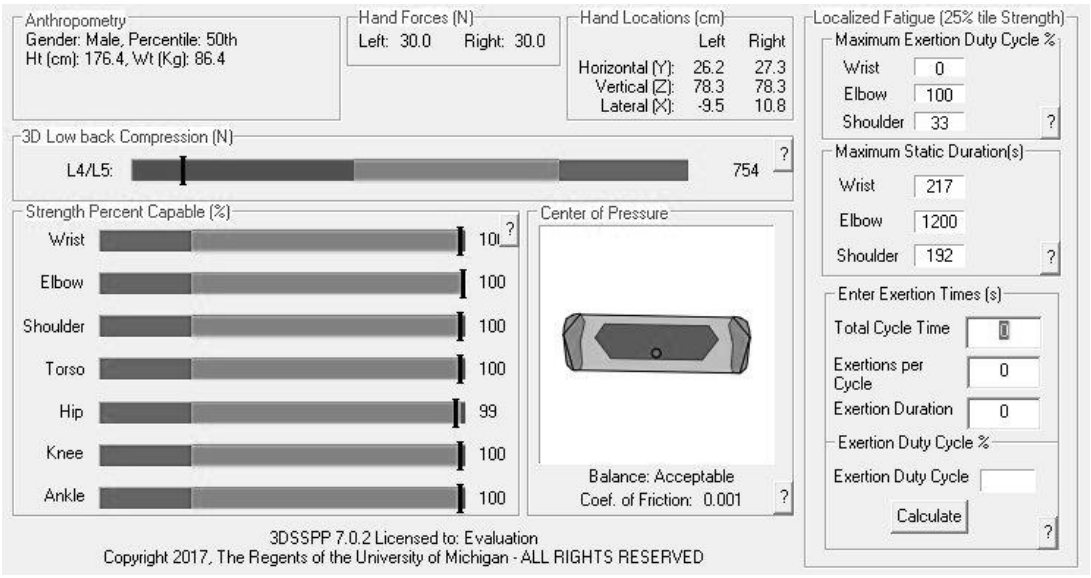

Fig. 2. Collective report for the position numer 1

In the position number 2, the employee is strongly inclined in the torso – by 60 degrees from the vertical position. The head also has an incline (12 degrees), stands at a straddle (about 25 degrees) – see Figure 3. In this position the hip and knee joints are exposed to significant loads.

Fig. 3. Position 2. Phantom view. Lifting of an element of a concreto fence structure

On the basis of the collective computer analysis (Figure 4) it can be concluded that overall loads of the musculoskeletal system are in the permissible low ranges (yellow field). Based on the computer analysis and performed snapshot observation it can be stated that the performed activity is burdensome for the radial–wrist joint and shoulder joint. Only 5% of the population with these anthropometric parameters is able to do this work at such a wrist position, 21% with such a shoulder joint load. It can cause fatigue of these elements of the musculoskeletal system, especially if this action happens repeatedly and when the employee remains longer in this position.

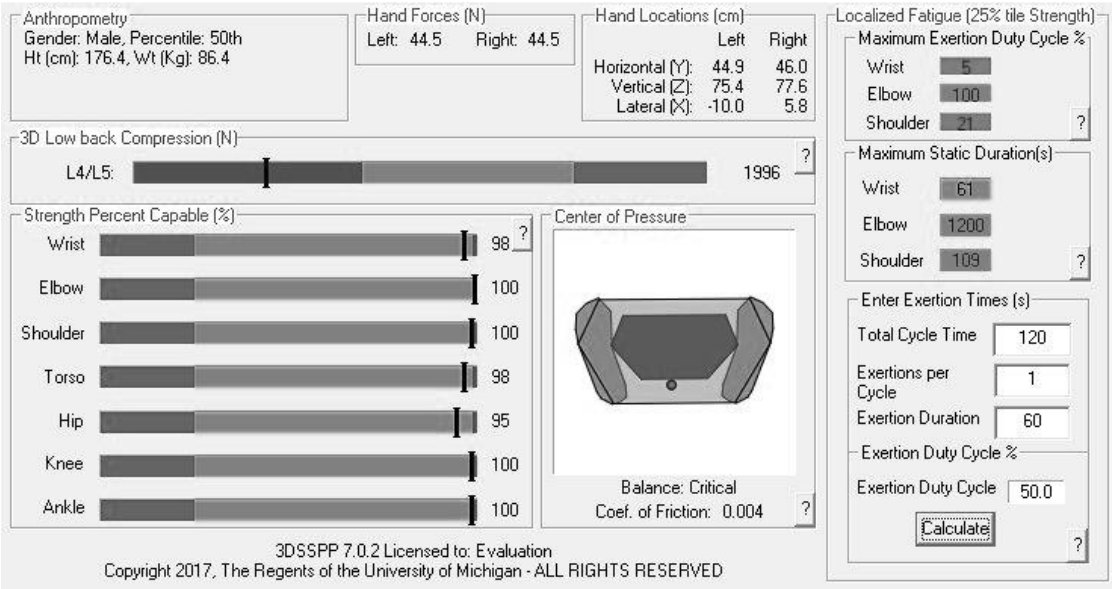

Fig. 4. Collective report for position 2

In the position number 3, the employee is inclined in the torso by 15 degrees from the vertical position. Due to the need of moving sideways he is turned left in the spine by 11 degrees and lent to the right (in the direction of his movement – by 3 degrees) – see Figure 5. In this position, due to the weight being handled and the way of balancing forces to keep the balance, the ankle joints are the most exposed to overload (Figure 6).

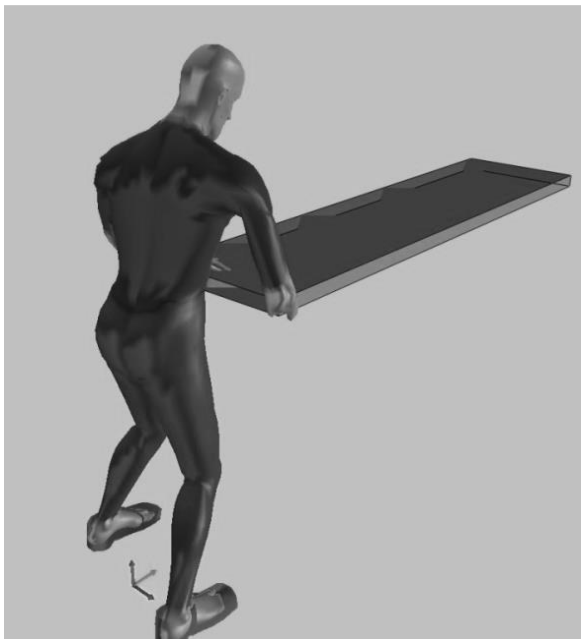

Fig. 5. Position 3. Phantom view. Position adopted over the shaker table when the block is handled

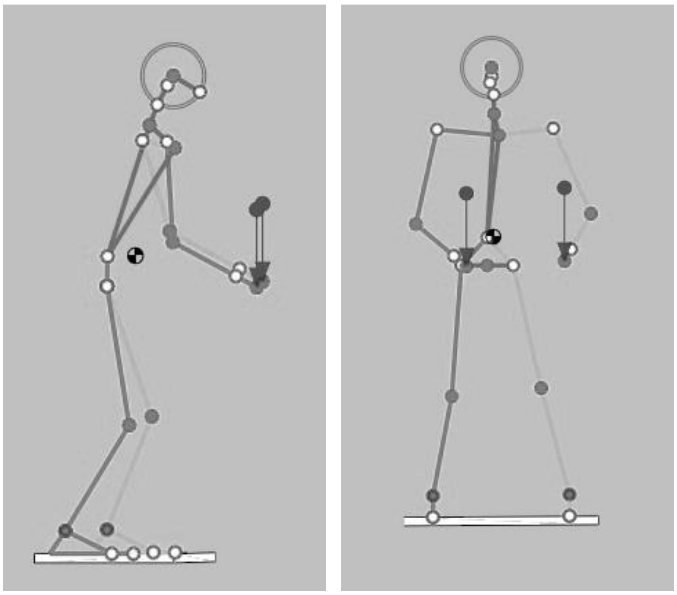

Fig. 6. Position 3. Position adopted when moving a concreto block. Egde views from the side and front

On the basis of computer analysis collective report (Figure 7) it can be stated that as expected the loads are not extremely high. The loads on the ankle and hip joints are within the permissible low ranges. However, there were local overloads for the arms, elbow joints and radial–wrist joint. It can cause fatigue of these elements of the musculoskeletal system. Body balance is defined as critical.

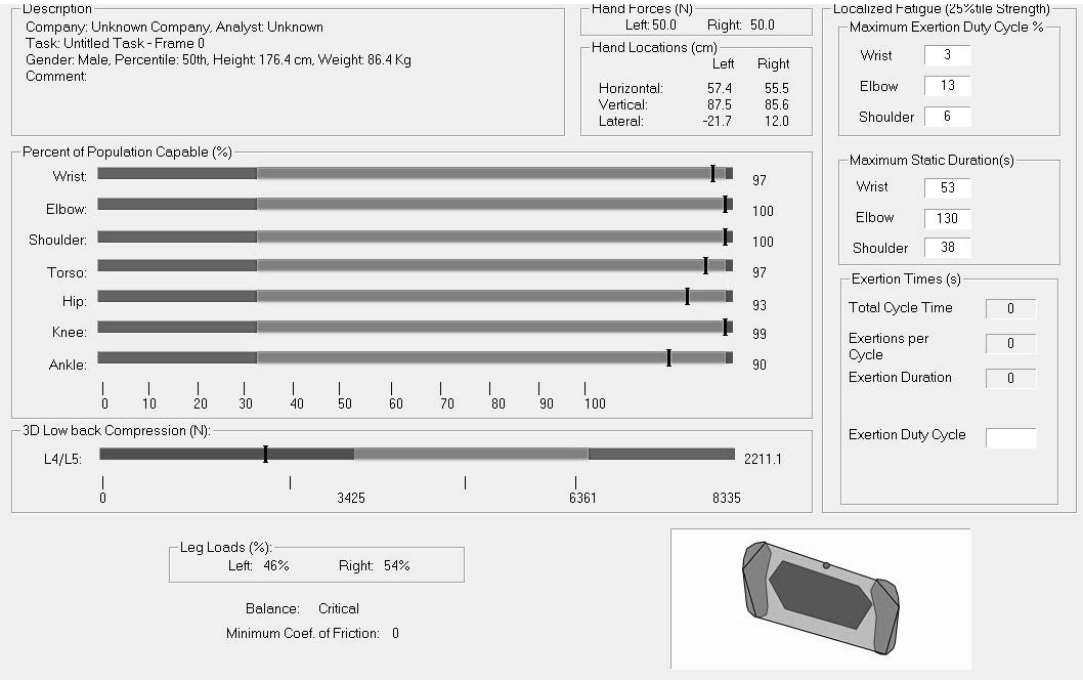

Fig. 7. Position 3. Collective report on the loads for the modeled position. Assessement of the impact of workplace equipment in controlling devices on the level of mental load

3.3. Enviromental loads

The work does not take place in thermal comfort conditions because the workstation is located in an open air space. In case of bad weather conditions (i.e. low temperature, rain, heat) almost all employees feel uncomfortable. Exposing to insolation can be the cause of unpleasant overheating of employee. But it should to be noted that most of the outside workplace is roofed. In the work environment there is a noise coming from working machines (vibration table, concrete mixer). Therefore, there is a risk of hearing damage by noise. At the workplace it is not possible to apply technical and organizational solutions to reduce the noise level. Therefore, employees are provided with individual hearing protective measures.

Workers are exposed to vibrations produced by the vibrating table. In addition, the chemical compounds contained in the mixtures may contribute to allergic reactions like: eyes redness, corneal damage, redness or burning of the skin). The workplace is also dusty and irritating to the respiratory tract. Fly ash contained in some mixtures contains silicone, clay and iron oxides.

3.4. Comfort/discomfort level due to work organising

The performing worki s not a shift work. Normal work time is 8 hours per day and 40 hours weekly. On the analysed workplace the overtime is very rare. The pace of work is not directly forced by the employer or the machines, but it is forced by the payment system which is taskwork system. Employees decide about the time and duration of brakes on their own.

4. DISCUSSION

According to the workers, working at the position of the concrete mixer requires vigilance and concentration. Due to those, it exposes the workers to little stress. A stressful element may also be the fact that the work is performed in taskwork system and that the jobs are carried out in pairs. Employees, however, think that the pace of work and factors related to the implementation of tasks are comfortable, and interpersonal relations and the psychological climate – beneficial. It can be concluded that there is relative comfort associated with the organization of work at the examined position.

In the opinion of all employees, except one, it is desirable to replace some of the activities performed by them manually with using machines. An employee who was of the opposite opinion, equated all facilities with the risk of reducing the workplace.
An interview with employees showed that the concept of ergonomics was known by 1/3 of employees, while all of them claimed that the employer did not organise any trainings in this area. The majority of respondents declared their willingness to expand knowledge in the field of ergonomics, and thus to improve the quality of their work. The most direct impact on the work of a concrete mixer has working environment, i.e.: low temperature, rain, heat, noise, vibrations, dust and volatile chemicals. During the observation it was noted that the employees did not use the available protective measures.

CONCLUSION

Carried out research allowed to gain knowledge about the working conditions and ergonomic awareness of the concrete's physical worker.
As a result of the ergonomic diagnosis, it was stated that employees should be provided with the information about:

- Correct position at work and energy expenditure,
- Preventing noise and the proper use of protective measures in this area, as well as the effects of prolonged exposure to noise,
- Counteracting the effects of vibrations
- Counteracting chemical compounds contained in concrete mixes,
- Counteracting dust and volatile compounds that may be present in concrete mixes.

In addition, it was found that it is advisable o measure the quantities characterizing noise in the work environment and compare the results with the thresholds of operation and NDN.
As a result of the diagnosis, the following preventive actions were determined:

- Due to the work in an open air, employees should have an access to a room providing protection from the solar radiation and the possibility of warming up during winter,
- In autumn and winter, employees should be provided with hot and cold drinks and prophylactic meals,
- Workers should have working clothing designed for outdoor work and suitable for the season,
- Workers should be provided with a dust mask, safety goggles and gloves when handling with bulk material,
- Workers should be provided with protective measures against the noise,
- When working at the vibration table, workers should be wearing antivibration protective gloves.

On the basis of the employee awareness results, it can be postulated, during periodic health and safety trainings, to present not only what the right work position should look like, or how a work station should be organized properly, but also situations and activities typical for the job position of the person being trained should be overtrained.

ACKNOWLEDGEMENTS

The paper is the result of statutory research carried out at the Institute of Production Engineering at the Faculty of Organization and Management of the Silesian University of Technology as part of a project number 13/030/BK_18/0039 called "Development of intelligent production methods as well as work and life environments in the context of production engineering challenges".

REFERENCES

3D Static Strength Prediction Program™ Version 7.0.4. Available at: https://c4e.engin.umich.edu/tools–services/3dsspp–software/ [Accessed 15 May 2018].

Bartnicka,J., Piedrabuena, A., Portilla, R., Mleczko, K., Moyano-Cuevas, J. L., Pagador, J. B., Sanchez-Margallo, F. M., Peter, A. and Tokarczyk, J. (2017). Ergonomics education in orthopedic surgery. LIFE: International Journal of Health and Life-Sciences. Vol. 3 iss. 2, s. 194-215.

Bartnicka,J., Piedrabuena, A., Portilla, R., Moyano-Cuevas, J. L., Pagador, J. B., Sanchez-Margallo, F. M., Augut, P., Michalak, D. and Tokarczyk, J. (2018). Train4OrthoMIS online course as a manner of improving ergonomics in orthopaedic surgery. In: Advances in human factors and ergonomics in healthcare and medical devices. Proceedings of the AHFE 2017 International Conferences on Human Factors and Ergonomics in Healthcare and Medical Devices, July 17-21, 2017, Los Angeles, California, USA. V. Duffy, N. Lightner. Eds. Berlin: Springer, 2018, pp. 149-158,

Burger, G. C. E. and Boer, K. (1968): CET II Ergonomic Task Analysis. Amsterdam.

Górska, E. (2015). Ergonomia, projektowanie, diagnoza, eksperymenty, Warszawa: Oficyna Wydawnicza Politechniki Warszawskiej.

Koszembar-Wiklik, M., Kucerka, D. and Hrmo, R. (2015). Ergonomics of integrated didactic workplaces. Applied natural sciences 2015. 5th International Scientific Conference, Jasna, Low Tatras, September 30 - October 2, 2015. Ed. P. Nemecek. Trnava : Faculty of Natural Sciences University of SS. Cyril and Methodius, 2015, s. 174-180

Krystosik–Gromadzińska, A. (2015). Bezpieczeństwo i ergonomia pracy na statku. Logistyka 5/2015, s. 1035–1041.

Mleczko, K. (2016). Wymiana wiedzy, jako czynnik wspomagający proces projektowania ergonomicznych narzędzi medycznych. Systemy Wspomagania w Inżynierii Produkcji z. 2, s. 240–248.

PTErg. (1983). Statut Polskiego Towarzystwa Ergonomicznego. (Rozdz. II §11).

Teymourian, K, Seneviratne, D. and Galar, D. (2017). Ergonomics contribution in maintainability. Management Systems in Production Management. Vol. 25, issue 3, 31.

Winnicka-Jasłowska, D., Jastrzębska, M. and Tymkiewicz, J. (2017). Ergonomics of laboratory rooms - case studies based on the geotechnical laboratories at the Silesian University of Technology. - ACEE Archit. Civ. Eng. Environ. 2017 vol. 10 nr 2, pp. 35-41,

Zaborowski, M., Kopański, Z. and Leszczyński, P. (2015). Ergonomics at work in the ambulance – the opinion of paramedics. Journal Of Public Health, Nursing And Medical Rescue. No. 3/2015 s. 27–32.