112 - ERGONOMIC ANALYSIS IN A CONSTRUCTION SITE

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1. INTRODUCTION

Ergonomics as a science had its origins in World War II, when relations between man and machine have become central to the arms race and the technological advances in warfare, although in unfavorable situations, such as the battlefield, those tasks requiring precision and workers' skills. Considering mishaps as critical in these situations, there was an increase in research to adapt the instruments for the characteristics and skills of the operator, which starts the modeling principle of ergonomics as we know it today (PINHEIRO and FRANÇA, 2006).

Despite initial attempts, ergonomics stabilized only with the support of the U.S. government, along with the military period, investing in research in universities and institutions. Later, these skills were also used in industries other than the warlike sector after the war, spreading throughout the world. However, the definition of ergonomics has developed over the years and is more comprehensive, aiming not only to adapt man to the machines, such as providing security, comfort and well-being in performing their tasks. Currently ergonomics can be defined as the study of man's adaptation to work, and we can use the resources of other sciences as support (DO RIO and PIRES, 2001). One technique of ergonomics application is the rectification, and according to Iida (2005) the work ergonomic analysis is one of them in order to analyze, diagnose, and fix real work situations.

Included in the concepts of ergonomics there is occupational biomechanics, which studies the interactions between man and the physical work, analyzing the postures, the application of forces and the consequences generated (IIDA, 2005). According to Pinheiro and França (2006), many jobs, products and machinery are not suitable to humans and can cause stress, fatigue and muscle aches.

The construction industry represents one of the most primitive areas of work and less ergonomic approach today. According to Iida (2005) this is the fact d eve of the activities are dispersed and little power of organization among the workers. These are likely to the performance of grueling manual labor, and often without the use of protecting equipment. Given an account of low wages and education levels, and long hours make workers more susceptible to risks due to physical and mental work.

Another significant reason, according to Ribeiro et al. (2005 apud Mansilla 2010) is that workers often underestimate the risks they are exposed to. Essentially this becomes the backbone by those responsible through training and explanations, to prevent accidents. These factors show the need for awareness and application of ergonomics in order to minimize occupational hazards in construction.

Given this context, the study sought to apply the concepts and ideas of ergonomics, conducting an ergonomic analysis (biomechanics and environmental factors) of working in a construction site. From this point forward, analyzing the results with the available standards and bibliographies, identifying likewise they are within the ranges set forth in order to suggest feasible improvements to provide greater security and comfort to the workers.

2. METHODOLOGY

The study was conducted in June 2011 in a construction site, located in Curitiba, Parana. To perform the analysis we selected three jobs: a circular saw, a marble saw and a cement mixer operator, which were considered visually more harmful to workers. The environmental factors were analyzed (noise, brightness, temperature and ventilation) and occupational biomechanics with the ergonomic use of a questionnaire.

When making measurements of environmental factors (brightness, noise, ventilation and temperature) in the workplace the employee worked normally, that is, in real conditions of exposure. For each environmental factor measured 10 measurements were made and values to be presented are the respective means.

For measuring the noise was used a sound pressure level meter with an attenuator of wind, that is, a decibel Instrutherm brand, model RS 232 / Datalloger, DEC - 5010, adjusted in the curve "A" and "slow" mode. The same was placed near the ear of the worker and the values obtained were compared with the Regulatory Standard NR-15 (BRAZIL, 2011a).

The temperature and wind speed were measured with an anemometer ICEL brand, model AN-20. The results were compared with the NR-15 (BRAZIL, 2011a) and NR-17 (BRAZIL, 2011b). A light meter Instrutherm brand, model LDR-380 was used to measure the brightness.

3. ANALYSIS AND DISCUSSION OF RESULTS

In regard to the biomechanics, it's presented that the activities with a marble saw and circular saw were a static, because it requires some workers muscles to remain contracted to keep working (IIDA, 2005).At work there are static periods of breaks to switch between muscle contraction and relaxation (Do Rio and Pires, 2001). This condition requires the recovery interval longer than the dynamic work leads to greater energy consumption and heart rate and also the build-up of lactic acid that leads to muscle pain and fatigue (COUTO, 1996).

The activities done in the cement mixers were noticed dynamic, as well as the worker who performed such activity, he moved like lifting and transporting materials, alternation between muscle contractions and expansions (IIDA, 2005).

The marble saw weighed about three pounds and in addition, the worker had no support for the arm in horizontal reach. The worker said he felt pain in the wrist when the workload was so intense. In that position, the height of the working surface was very low compared to the worker, which resulted in poor posture, can cause pain in the spine and shoulder girdle

(IIDA, 2005).It could also trigger back problems the worker had in the past and even bring about new injuries. While in the circular saw area the bench height was adequate to the job, which generated the same good posture.

In addition to these unfavorable factors to workers' health, there was the discomfort caused by environmental exposure to weather. The marble-saw operator worked outside, subject to weather elements such as cold and excessive heat that can cause physical stress (Do Rio and Pires 2001). In the other two working areas was a cover for workers, but there was no side windbreak.

In all working areas, the workers maintain a stand-up position that may cause pain in the feet and legs (varicose veins) and can be highly stressful in the marble and circular saw working areas where besides keeping a standing-up position was also static, resulting in a more difficult for the heart to pump blood to the extremities of the body.

In the cement mixer job area, the lifting and carrying loads should be done with the spine in a vertical direction using the muscles of the legs, and with the load as close to the body, according to Pinheiro and França's (2006) assumptions. If the job is not done right, there is risk of pain and deformation of the spine between work related injuries and other injuries, according to The River and Pires (2001), one of the most common causes of accident leave is due to abnormalities and injuries related to the spine. The employee of this job area did not use gloves, PPE required for this type of work and it's extremely important, because it avoids contact with materials such as cement, which can cause illness and allergies. The Direct skin contact with this material may cause various skin diseases due to their chemical properties, being the most frequent, the irritant contact dermatitis (ALI, 2009). It is emphasized that in the circular-saw working area the use of gloves was implemented, however PPE does not require them because the gloves may get tangled, which could cause serious accidents.

In relation to environmental factors data were collected which then were plotted on bar charts for comparison with current standards.

With the average obtained from data collected in the measurement of noise, we put together the graph in Figure 1.

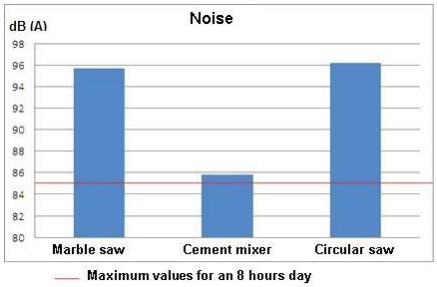

Figure 1 - Noise values obtained for the three positions analyzed compared with the limit of the standard NR-15 for unsanitary 85dB (A).

Analyzing Figure 1 shows that all jobs (marble saw, concrete mixer and circular saw) reached values above the average noise set by the NR-15 (BRAZIL, 2011a).This provides for a day of 8 hours the worker is exposed to a noise of up to 85 dB(A). Taking into account the average value of each job, hours recommended by the standard are: marble saw (1 hour and 45 minutes), cement mixer (7 hours) and circular saw (1 hour and 45 minutes). However, there was the use of PPE for all employees headset, which allows them to work continuously for an 8 hour work without injuries to their health since these devices attenuate the required amount of decibels for each case. It is emphasized that the noise values obtained are much higher than the comfort limits stipulated by the NR-17 which is 65 dB (A) on average.

With the average obtained from data collected in the measurement of brightness, we put together the graph in Figure 2. The values obtained were compared with the limits of the NBR 5413 (ABNT, 1992). Therefore, according to the existing limits of comfort in this standard, we analyzed the work situation and admitted the following characteristics: the visual work is critical, productivity, speed and accuracy are of great importance, the observer's visual ability is below average. Then, we select the value of 1000 lux minimum required for each job, the highest among the three specified in the class B "Tasks with normal visual requirements, average working machinery, offices," as the minimum necessary to carry out activities in the workplace.

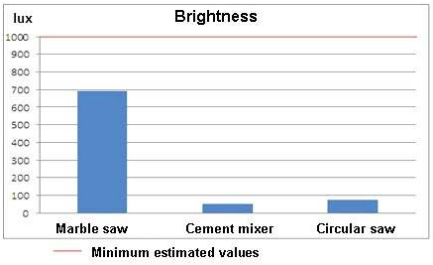

Figure 2 - Brightness values obtained for the three working areas analyzed.

In Figure 2 we can observe that none of the jobs have adequate conditions of brightness. We should take into account that the values obtained are influenced by natural light by being in the open, therefore, the figures may be reduced due to the fact that the measurements on the sky being cloudy, that is, low solar incidence.

As for ventilation, average values are shown in Figure 3. Average values were compared with the ceiling provided by NR-17 (BRAZIL, 2011), which is 0.75 m / s.

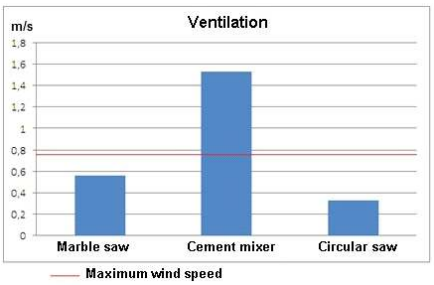

Figure 3 - Wind speeds obtained for the three working areas analyzed.

It is observed from the graph in Figure 3 that only the cement mixer exceeded the maximum. But it is important to clarify that by being in the open the values varied greatly during the measurements, therefore, although the average found in marble and circular saw areas are within the limit, there were times when the wind speed was higher than the maximum stipulated by the standard. It is emphasized that the cement mixer had the highest values due to the fact of being located next to a corridor where air flows.

With the values obtained in the measurement of temperature, we put together the graph in Figure 4. These were compared with the range considered ideal for thermal comfort provided by NR-17 (BRAZIL, 2011), which is 20 to 23°C.

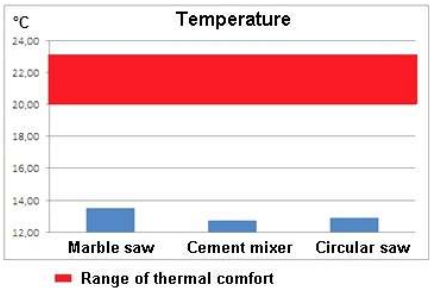

Figure 4 - Temperature obtained in the three working areas analyzed.

It was observed that the temperatures were low, this can be explained by the fact that the jobs are in an open environment. These figures are disturbing, because low temperatures can lead to increased accidents due to loss of manual dexterity.

4. CONCLUSIONS

Before starting the workday would be important for workers to stretch out, according to Iida (2005), prevent pulled muscles and increase blood flow. So the workers begin a more wary workday, reducing the risk of accidents.

Jobs in the circular and marble saw areas were static and standing, and highly stressful. Fatigue could be reduced with periodic short breaks throughout the workday. The regular breaks would also reduce muscular work, the discomfort and stress, which can generate accidents. Although these working areas, employees should make use of face mask (covers nose and mouth) to prevent allergies and respiratory diseases.

The horizontal surface of the marble saw working area was inadequate to the worker's height. It should be implemented a table according to the anthropometric dimensions of the worker and armrests. Thus, muscle aches, strains in the column and injuries would be prevented and existing injuries would not be bothered. Moreover, such a job would have to receive coverage to avoid exposure to weather elements and temperature. These environmental factors can cause discomfort, negligence, and stress can result in illnesses and work injuries.

The operator in the cement mixer would have to use gloves to avoid health related problems to the skin that can be caused by materials such as cement and quicklime.

In the workplace of the operator of the circular saw had materials scattered on the ground, a factor that could cause accidents if the employee tripped, for example. The materials should be stockpiled. Also to prevent accidents, the employee should not wear gloves.

The main change to be made is the increase in the layout of the area covered in order to reallocate the marble saw working area, as well as the workplace of the circular saw, which was also in misplaced, near the edge of the cover.

In relation to noise it was suggested that it is possible to reduce it in the cement mixer area, through the lining of the tub with acoustic insulating material.

The use of PPE noise-protection headphones in all workers was checked but as the equipment exceed the noise limit established by the NR-15, it is important to emphasize its use, because that way, the 8-hour work will not be harmful to the worker.

Concerning the brightness, it was observed that the circular saw and mixer working areas there were light bulbs, but were turned off. Anyway the solution would be insufficient to the problem of illumination, since the results for this factor were very low. The proposed solution would be to increase lighting by increasing the number of lamps, preferably fluorescent. Besides changing the overall lighting would be ideal to mix it with the existing one, mainly in the saws' positions which are the most in need of enlightenment, due to the accuracy that workers require when operating them, both the circular saw as well as the marble one.

For ventilation and temperature issues, the same solution is suggested: the use of barriers (fences, screens, among others) around the casing to prevent drafts and become weather proof .These barriers do not completely cover the sides, leaving upper and lower gaps, allowing the output of suspended particles and air circulation. So the wind speed would be reduced and the temperature would become more pleasant in the workplace and can reach the values required by NR-17.

The fences can also be used to separate the workplaces of the saw from the cement mixer area, since the saw employees use masks to avoid inhalation of harmful particles (detached from the sawn materials), and on the cement area, that does not happen, therefore the use of PPE is not necessary.

REFERENCES

ALI, Salim Amed. **Occupational Dermatoses.** – 2nd ed. - London: Fundacentro, 2009. 412 p.

BRAZILIAN ASSOCIATION OF TECHNICAL STANDARDS. NBR 5413. Interior Brightness - Procedure. Rio de Janeiro: ABNT, 1992.

BRAZIL, **Ministry of Labour and Employment. NR-15 - Unhealthy Activities and Operations.** Legislation Atlas Manual, 68th Edition, Sao Paulo: Atlas, 2011a.

BRAZIL, **Ministry of Labour and Employment. NR-17 - Ergonomics.** Legislation Atlas Manual, 68th Edition, Sao Paulo: Atlas, 2011b.

COUTO, H. A. **Ergonomics applied to work: technical manual of the human machine.** Belo Horizonte: ERGO Press, 1995. Vol 2.

IIDA, I.. **Ergonomics: Design and Production**. Sao Paulo: Edgard Blücher, 2005.

MANSILLA, G. **Analysis of the ergonomic risks of the activity frame in civil construction at construction sites**

of Tres Lagoas / MS. Cuiaba: UFMT, 2010.

PINHEIRO, A. K. S.; FRANÇA M. B. A. **Ergonomics applied to the anatomy and physiology of the worker**. Goiania: AB, 2006.

RIO, R. P.; PIRES L. **Ergonomics: fundamentals of ergonomic practice.** 3rd Edition. Sao Paulo: LTR, 2001.

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ERGONOMIC ANALYSIS IN A CONSTRUCTION SITE

ABSTRACT

Ergonomics has been increasingly applied in a vast number of industries but very little in construction. Thus, this research presents an ergonomic analysis in certain jobs within the construction site of a large building in the city of Curitiba to see what the actual working situation of those who work in such. To achieve this, it was necessary to use as a research tool questionnaire to identify biomechanical problems and measuring equipment (sound level meter, anemometer, thermometer and light meter) to evaluate the environmental factors (noise, ventilation, temperature and brightness) of the 03 jobs analyzed. We analyzed the jobs of circular saw operators, marble saw and cement mixer. The results showed the presence of biomechanics at construction sites, predominantly static that can generate faster fatigue as far as the environmental factors are concerned, which has problems of noise levels, brightness, temperature and ventilation at the sites. Thus, it can be concluded that the building site analysis requires a comprehensive ergonomic study to match the existing ergonomic standards, both with regard to biomechanical problems like the environment, which appeared outside the tolerance limits.

KEY WORDS: Biomechanics; Ergonomic Analysis, Health, Construction.

ANALYSE ERGONIMIQUE DANS UN CHANTIER DE CONSTRUCTION

RESUME

L'ergonomie est chache fois plus appliquée en plusieurs secteurs de l'industrie. Par contre, elle n'est pas beaucoup appliqué à la construction civile. De cette manière, cette recherche montre une analyse ergonomique en certaines postes de travail dans un chantier de construction d'une grande entreprise de construction de Curitiba-PR, au Brésil. L'objectif de l'étude est de vérifier quelle est la réel situation de travail des personnes liées à la construction des chantiers. Pour le développement de ce travail, il a été nécessaire brancher sur un questionaire de recherche pour identifier les problèmes biomécanique et sur des équipements de mesure, comme : un decibelimètre, pour évaluer le niveau de bruit ; un anémomètre, pour l'analyse de la ventilation ; un système de mesure de l'éclairement lumineux et un thermonètre. On a analysé trois postes de travail : le poste des operateurs d'une scie circulaire, d'une scie marbre et d'une bétonnière. Selon la biomécanique, les résultats montrent qu'il y a de travail statique en prédominance dans les chantier de construction. Ces travails peuvent générer de la fatigue et les facteurs environnementaux présent des problèmes de niveau de bruit, d'éclairement, de temperature et ventilation dans les chantiers de construction. De cette manière, on peut concluir que le chantier des constructions analysé a besoin d'un grand étude ergonomique pour s'adapter aux normes ergonomiques existants, soit pour les probèmes biomécanique ou soit pour l'environnement hors du limite de tolérance.

MOT CLÉS: Biomécanique; Analyse Ergonomique; Santé; Construction Civile.

ANALISIS ERGONOMICO EN UNA OBRA

RESUMEN

La ergonomía se ha aplicado cada vez más en las diversas ramas de la industria, pero poco en la construcción. Así, este estudio presenta un análisis ergonómico en determinados puestos de trabajo en el sitio de la construcción de un gran edificio en la ciudad de Curitiba para ver cuál es la situación de trabajo real de los individuos. Con este fin, fue necesario el uso de un cuestionario instrumento de investigación para identificar problemas biomecánicos y equipos de medición (medidor de sonido, anemómetro, medidor de luz y termómetro) para evaluar los factores ambientales (ruido, ventilación, temperatura e iluminación) de los 03 puestos de trabajo analizados. Se analizaron los puestos de trabajo de los operadores de sierra circular, sierra de mármol y un mezclador. Los resultados mostraron que hay alrededor de la biomecánica en los sitios de las obras de construcción predominantemente estáticas que pueden generar más rápidamente la fatiga y cómo los factores ambientales, que tiene problemas en la obra y los niveles de ruido, iluminación, temperatura y ventilación. Por lo tanto, se puede concluir que el análisis de lugar de trabajo requiere un estudio exhaustivo ergonómico para que coincida con las normas ergonómicas existentes, tanto en lo referente a problemas biomecánicos, como el medio ambiente, que se presenta fuera de los límites de la tolerância.

PALABRAS CLAVE: Biomecánica, Análisis ergonómico, Salud, Construcción.

ANÁLISE ERGONÔMICA DENTRO DE UM CANTEIRO DE OBRAS

RESUMO

A ergonomia vem sendo cada vez mais aplicada em diversos ramos da indústria porém muito pouco na construção civil. Desta forma, esta pesquisa apresenta uma análise ergonômica em determinados postos de trabalho dentro de um canteiro de obras de uma construtora de grande porte da cidade de Curitiba para verificar qual a real situação de trabalho dos indivíduos. Para tal, foi necessário utilizar como instrumento de pesquisa um questionário para identificar os problemas biomecânicos e equipamentos de medição (decibelímetro, anemômetro, luxímetro e termômetro) para avaliar os fatores ambientais (ruído, ventilação, iluminância e temperatura) dos 03 postos de trabalho analisados. Foram analisados os postos de trabalho dos operadores de serra circular, serra mármore e da betoneira. Os resultados mostraram quanto a biomecânica que existem nos canteiros de obras trabalhos predominantemente estáticos que podem gerar mais rapidamente a fadiga e quanto aos fatores ambientais, que tem-se problemas no canteiro de obras quanto aos níveis de ruído, iluminância, temperatura e ventilação. Assim, pode-se concluir que o canteiro de obras analisado requer um amplo estudo ergonômico para se adequar as normas ergonômicas existentes, tanto no que tange aos problemas biomecânicos como nos ambientais, que se apresentaram fora dos limites de tolerância.

PALAVRAS CHAVES: Biomecânica; Análise Ergonômica; Saúde; Construção Civil.