77 - HUMAN FACTORS AND ERGONOMICS ASSESSMENT OF MORTAR PREPARATION USING MIXERS

GUSTAVO HENRIQUE STALL;
RODRIGO EDUARDO CATAI;
ROSEMARA SANTOS DENIZ AMARILLA;
KIRILL ALEKSEEV
FederalTechnological University of Paraná (UTFPR)
Curitiba - Parana - Brazil
gustavostall@hotmail.com

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1. INTRODUCTION

Construction industry involves many stakeholders and serves for further development of economy, by improvements in infrastructure, which are necessary for industry in general(NORDIN et al., 2011; POTTS e ANKRAH, 2013).Construction always involved big masses of people, majority of which is inexperienced, which led to injuries and traumas (IIDA, 2005; NUNES, 2014).

According to Ray and Tiezer (2012), activity of construction workers sometimes provokes torsion deformity of body joints such as back, shoulders and knees. Therefore, such a body positions may cause stretching of muscles and dislocation of joints, which leads to more serious health problems. In general, construction workers face higher rates of musculoskeletal disorders related to work, about 16% more than workers in other industries (BOSCHMAN et al., 2015). The author Nunes (2014) presents case of construction workers, saying that they face relatively high risks. That is why process of work should be organized and adopted in appropriate way to norms and rules of work safety (MITROPOULOS e CUPIDO, 2009).

Terms of comfortable conditions at the work place are described in Regulatory Norms NR17. These norms and rules supposed to be followed by both managers and workers for welfare, security and productivity improvement (NUNES, 2014). In the meantime, ergonomics work with different methods which all together provide results for implementation (IIDA, 2005; NUNES, 2014). In addition to established parameters, NR17 provides employers with ergonomic work analysis (AET) to adopt appropriate working conditions (NUNES, 2014).

On the basis of background mentioned above, the following article is aimed to analyze working conditions that builders face during filling mortar into mixers, using NR17. In order to provide more exact data RULA (Rapid Upper Limb Assessment) and REBA (Rapid Entire Body Assessment) techniques were used.

2. REVIEW OF LITERATURE

To meet Regulatory Standard NR 17, the ergonomic work analysis should include descriptions of the characteristics of the jobs related to furniture, utensils, tools, physical space for the work execution and positioning conditions and movement of body segments, which is one of the minimum recommendations of NR17 (BRAZIL, 2015). To improve the postural assessment of individuals apply methods developed for this purpose, such as Rapid Upper Limb Assessment (RULA) and Rapid Entire Body Assessment (REBA).

Developed by McAtamney and Nigel Corlett (1993), the RULA method allows to perform analysis of the upper limbs (neck, trunk, shoulders, arms and wrists). According to Pavani (2007), this method is referred to as an agile technique that allows assessing of biomechanical overload of the neck and upper limbs in performing a task. To perform ergonomic analysis posture diagrams using human body and three tables that provide the assessment of exposure to risk factors, they consider the number of movements, static muscle work force, working posture determined by the equipment and the time work without pause. Through RULA method presented score is indicating that there is need for changes in the workplace. Therefore, Table 1 made for the interpretation of the results.

Table 1- Results of RULA method

RULA SCORE	ACTION LEVEL	ACTION
1 or 2	1	Indicates that posture is acceptable if it is not maintained or repeated for long periods.
3 or 4	2	Indicates that further investigation is needed and changes may be required.
5 or 6	3	Indicates that investigation and changes are required soon.
7	4	Indicates that investigation and changes are required immediately.

Source: Implemented by McAtamney and Corlett (1993).

REBA technique is similar to RULA analysis. Developed by Hignett and McAtamney (2000), REBA method estimates the risk of bodily disorders which workers are exposed from an assessment of the unpredictable positions. This method consists of six steps (i) observation of the task; (ii) selection of the positions to be analyzed; (iii) score of postures; (iv) preparation of the treatment of the postures; (v) establish the final score; (vi) confirm the level of action and urgency of the respective measures.

Monteiro (2013) pointed out in his research that the selection criteria of the postures can be based on the frequency of the adopted positions, the duration of time the position maintained in the activity and muscle strength required in addition to the identification of certain postures that cause discomfort. The evaluator supposed to choose different body parts for ergonomic analysis and for initiating corrective actions on particular posture using the information given by the REBA method, as shown in Table 2.

Table 2 - Results of REBA method

RULA SCORE	ACTION LEVEL	ACTION
1	Negligible	None necessary.
2 - 3	Low	May be necessary.
4 - 7	Medium	Necessary
8 – 10	High	Necessary soon.
11 - 15	Very high	Necessary NOW.

Source: Implemented by Hignett and McAtamney (2000).

3. METHODOLOGY

In this research has been applied the study of multiple cases as main technique, which made it possible to collect a larger amount of information with less errors in the survey, due to the fact that the investigated sector consists of more than one company (GIL, 2009). Data were collected in six mid-size residential constructions, which are located in the city of Curitiba, State of Parana. It was counted on the participation of eight workers, who act as servants of masons.

For ergonomic diagnosis the following sources were used: direct observation, photographic records and interviews with questioning, both for the workers' personal data (age, gender, occupation, amount of working hours) and also to find out which equipment is used and what is opinion of workers about the height of it. The questions were formulated as "how" and "why", in order to receive opinion of workers and subsequently raise more relevant data on the parts of working process, such as body aches and case clearances, as well as information about the daily life in work and the use of equipment.

In order to enrich the analysis the Ergolandia 5.0 software was used, which has 20 different tools for ergonomic analysis. In this research the RULA and REBA tools were chosen. From a methodological point of view these techniques contributed the recommendations that can be taken to solve the problem diagnosed during the execution of tasks. Models of mixers which are supplied by the workers at construction sites are the batch mixers, continuous mixers.

4. DISCUSSION AND RESULTS

On the basis of research's results, several ergonomic recommendations were proposed to solve the problems reported by workers. Figure 1 shows the opinion of workers interviewed regarding height of the mixer. Note that this variable was identified by respondents as unanimity, which is high or very high, 75% of employees consider the height of the mixers as high and 25% consider too high. The opinion of respondents is explained by the fact that the mixers have between 1.25 meters and 1.60 meters high, it means that this height must be overcome by the workers to supply equipment using 50 kilos industrialized mortar bags.

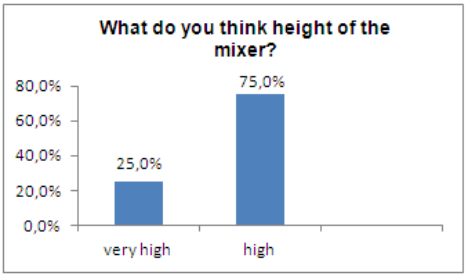

Figure 1 - Results of mixer height survey

In Figure 2 well seen how workers try to decrease the height of mixers for filling process. Note that the "steps" created by employees are pallets and wooden benches made in the work place to overcome the height of the mixer. While the workers make attempts to facilitate the working process and improve the position for loading the equipment using these objects, the numerous repetitions of the up and down movements during the workday causes fatigue of the lower limbs.



Figure 2 - In-site made “steps” for working process improvement

In Figure 3, it is observed that 75% of respondents use pallets and 25% prefer to work with wooden benches to facilitate the services. The pallets had a higher percentage for the reason that they are easily found in the working area. The bagged mortar is delivered on pallets, so after discharging a mortar pallet worker uses it as a platform in front of the mixer. Some respondents reported that they used mortar bags themselves in other works as "step" until it was possible to use pallet for this purpose.

To solve this problem it is recommended to decrease the difference in height between ground level and the upper surface of the equipment. During the interview it became clear that in all cases the workers somehow used up objects to create a "step" and improved equipment. The difference in height can cause fatigue due to the manipulations outside the normal work style.

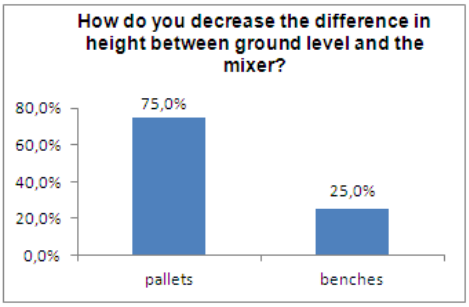

Figure 3 - Results on ways of equipment adaptation with pallets and mortar bags

Figure 4 shows the interview results with respect to fatigue and body aches. 75% of respondents feel some sort of fatigue in the body while using mixers, 62.50% feel pain in the spinal column, 25% have pain in the lower limbs and 37.50% have pain in the upper limbs. Only 25% of respondents said they did not feel any pains at the end of the working day.

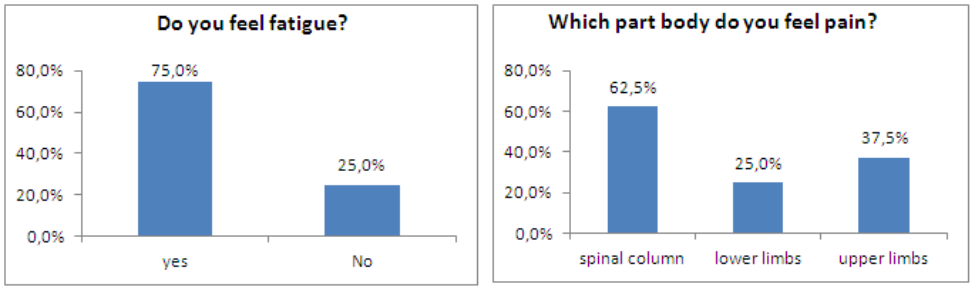

Figure 4 - Results of survey about pain in different body parts

The reported pain is explained by the fact that worker actually exert great strength to carry equipment due to the high altitude. The highest percentage of pains is in lower back, which is caused by the fact that the extension of the lumbar occurs at the time the employee is about to unload the mortar bag on the mixer. There have been reports showing that at the beginning of working processes using continuous mixers nothing was created to reduce the difference in height between the floor and the top of the equipment, but the employees felt severe pain in the lower back and instinctively brought the pallets close to equipment to facilitate the working process and to avoid pain and therefore possible dismissals. Even they were using pallets to perform such postures to supply equipment.

Figure 5A illustrates the occurrence of the extension of the lumbar. It is noted that the extension of the lumbar occurs at the time that the worker needs to reach a little higher to discharge the mortar bag. Certainly that position was attenuated with the aid of pallets, but did not eliminate the problem completely. Figure 5B shows that due to height it is impossible to avoid lifting of arms above the shoulders. In some cases it was reported that initially the employees felt pain in the arms and also in the lower back, but they said the "body got used". Pains in the upper limbs are explained by the occurrence of elevated shoulders to supply the equipment.

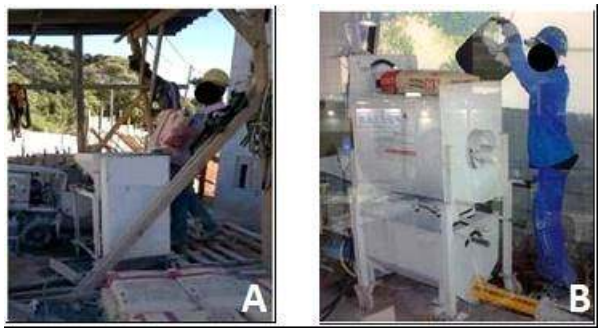

Figure 5 – A) Detailed image of lumbar extension; B) Moment in which arms are lifted above shoulders

It is recommended to use ramp to avoid both the elevation of the shoulders as the extension of the lumbar while supplying mixers at a height that is deemed appropriate and avoid ergonomic risks. Besides being safe, ramp will eliminate the height difference that supposed to be responsible for reporting 25% of pain in the lower limbs. The worker goes up and down the stairs several times during the working day and thus begins to require more strength in the legs and knees.

At the end of the interview it became clear that to solve the problems we have to work with a ramp to provide access to equipment without forcing worker to load parts of the body as diagnosed during this study. By the fact that workers have organized on their own a way to facilitate the work and try to avoid body aches, none of them ever removed that “step” back. After the interviews postures adopted by servants were simulated using an ergonomic software, "Ergolandia 5.0" developed by FBF systems in order to assist professionals in the field of Occupational Health. Figure 6 illustrates the configurations used in the method RULA.

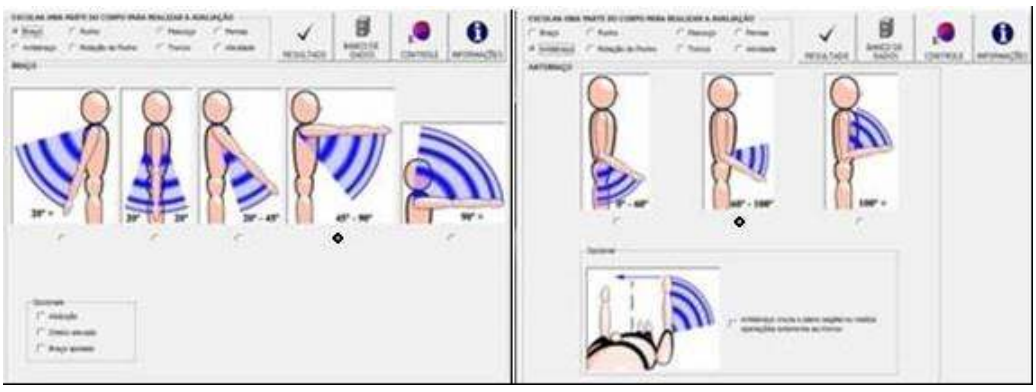

Figure 6 - Data analysis with RULA software

With RULA method the position of the arms was considered between 45° and 90°, the forearm between 60° and 100°. Wrist, neck, trunk and legs were considered without rotation and erect, which is the most appropriate position for the activity. It was found that the mixing was accomplished with loading bagged mortar or cement bag, which weight was 50 kilograms, the

sand and water addition, the load considered in the software was more than 10 kilograms and repetitive. Figure 7 shows the results of posture evaluation made with the RULA method. The software gave the score "5 or 6", which means that one must conduct an investigation and make changes.



Figure 7 - Final result of RULA method valuation

In cases when elevation of the shoulders and arms were more than 90°, the RULA method showed the score "7". In this case the intervention must be immediate to make some changes. Using the method RULA some positions in arms and forearms were simulated so that it was possible to see what changes would reduce ergonomic problems. It was considered for the method, the arms between - 20° and + 20 ° and forearms between 60° and 100°, coming to a lower score. The software resulted in the score "3 or 4", which means that may need changes.

In this case it is clear that the problem became softer, because altered the time the employee must win to supply equipment for avoiding awkward postures. It was applied also by means of REBA diagnostic method. Figure 8 shows the result of posture valuation made by the method.



Figure 8 - Results of REBA method

The REBA method showed a score between "4 and 7". Due to that fact it can be considered that there is medium risk with regard to the positions of the servants and intervention is necessary, not only in the workplace but also in the organization of working process.

5. CONCLUSION

It is concluded that as the criteria established by Norm NR17, the ergonomic analysis applied in this research made it possible to discover the working conditions that the workers of masons were exposed during filling mortar mixers. It was found that the equipment must be suitable for the psycho-physiological characteristics of workers, so that it is preserved to occupational health and physical integrity of the servants.

Therefore, after data collection and application of ergonomic analysis with the support of RULA and REBA methods, it was noticed that the mortar mixers expose the workers with ergonomic inappropriate conditions such as awkward postures, use of muscle power and lifting the arms above the shoulders. Therefore the results presented in this study revealed the variables that cause pain in the upper limbs, lower limbs, pain in the lower back and muscle fatigue. It was noted that the equipment analyzed were not adapted to man and working process, and it is emphasized that these case studies are the reverse of what is recommended by the literature concerning ergonomics.

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Rodrigo Eduardo Catai- R: Deputado Heitor de Alencar Furtado, 4900 Bairro: Ecoville - CEP 81280-340 - Curitiba - PR

HUMAN FACTORS AND ERGONOMICS ASSESSMENT OF MORTAR PREPARATION USING MIXERS

ABSTRACT

This article aimed to analyze working conditions that builders face during filling mortar into mixers, using NR17. In order to provide more exact data RULA (Rapid Upper Limb Assessment) and REBA (Rapid Entire Body Assessment) techniques were used. In this research has been applied the study of multiple cases as main technique. Data were collected in six mid-size residential constructions, which are located in the city of Curitiba, State of Parana. It was counted on the participation of eight workers, who act as servants of masons. In this research the RULA and REBA tools were chosen. From a methodological point of view these techniques contributed the recommendations that can be taken to solve the problem diagnosed during the execution of tasks. Therefore, after data collection and application of ergonomic analysis with the support of RULA and REBA methods, it was noticed that the mortar mixers expose the workers with ergonomic inappropriate conditions such as awkward postures, use of muscle power and lifting the arms above the shoulders. Therefore, it is concluded that the analyzed construction sites need to adapt their equipment and workplace as recommended by Norm NR17, to prevent ergonomic problems, either removal of the workers.

KEYWORDS: Ergonomics. Workplace safety. Mortar mixers.

ÉVALUATION ERGONOMIQUE DANS LE MORTIER PRÉPARATION À L'AIDE BLENDERS

RÉSUMÉ

Cet article vise à analyser les conditions de travail que les constructeurs sont confrontés pendant le remplissage mortier dans des mélangeurs, en utilisant NR17. Afin de fournir plus exacte RULA de données (Rapid Upper Limb évaluation) et LCI techniques (entières évaluation rapide du corps) ont été utilisés. Dans cette recherche a été appliquée l'étude de plusieurs cas comme principale technique. Les données ont été recueillies dans six de taille moyenne constructions résidentielles, qui sont situés dans la ville de Curitiba, État de Paraná. Il a été compté sur la participation de huit travailleurs, qui agissent comme des serviteurs de maçons. Dans cette recherche, les outils et Réba RULA ont été choisis. D'un point de vue méthodologique ces techniques ont contribué les recommandations qui peuvent être prises pour résoudre le problème diagnostiqué pendant l'exécution des tâches. Sur la base des résultats de recherche, plusieurs recommandations ergonomiques ont été proposées pour résoudre les problèmes signalés par les travailleurs.. Par conséquent, après la collecte des données et l'application de l'analyse ergonomique avec l'appui de méthodes RULA et Réba, il a été remarqué que les mélangeurs de mortier exposent les travailleurs à des conditions inappropriées ergonomiques tels que des postures inconfortables, l'utilisation de la force musculaire et la levée des bras au-dessus des épaules. Par conséquent, il est conclu que les chantiers de construction analysés doivent adapter leur équipement et lieu de travail tel que recommandé par Norm NR17, pour prévenir les problèmes ergonomiques, soit l'enlèvement des travailleurs.

MOTS-CLÉS: Ergonomie. La sécurité au travail. Mélangeurs de mortier.

EVALUACIÓN ERGONÓMICA EN LA PREPARACIÓN DE MORTEROS UTILIZANDO MEZCLADORES

RESUMEN

Este estudio tiene lo objectivo de analizarlas condiciones de trabajo que los sirvientes de albañiles están expuestos durante el llenado con mezcladores de mortero, según lo dispuesto en la Regla Relulamentadora NR17. Para tal, se realizó visitas en seis sitios de construcción de tamaño medio en la ciudad de Curitiba, Estado de Paraná. Para la recolección de datos se utilizó las siguientes fuentes de evidencia: la observación directa, registros fotográficos y entrevistas. A fin de enriquecer la análisis ergonómico se aplicó las técnicas de RULA y REBA, para la análisis postural de los sirvientes. Los resultados mostraron que existe la necesidad de intervención de mejoras en las condiciones de trabajo para evitar un mayor daño a la salud de los trabajadores, como ocurrió problemas posturales para el abastecimiento de mezcladores, como levantar los brazos encima de los hombros y la extensión de la lumbar. Por lo tanto, se concluye que los sitios de construcción analizados necesitan adaptar su equipo y el lugar de trabajo como se recomienda la NR17, para evitar problemas ergonómicos y la retirada de los trabajadores.

PALABRAS CLAVE: Ergonomía. Seguridad del trabajo. Mezcladores mortero.

AVALIAÇÃO ERGONÔMICA NA PREPARAÇÃO DE ARGAMASSAS UTILIZANDO MISTURADORES

RESUMO

Este estudo tem como objetivo principal analisar as condições de trabalho que os serventes de pedreiros estão expostos durante o abastecimento de misturadores com argamassa, conforme estabelecido na Norma Regulamentadora NR17. Para tanto, realizou-se visitas em seis canteiros de obras de médio porte, na cidade de Curitiba, Paraná. Para o levantamento de dados utilizou-se as seguintes fontes de evidência: observações diretas, registros fotográficos e entrevistas. A fim de enriquecer a análise ergonômica aplicou-se as técnicas de RULA e REBA, para análise postural dos serventes. Os resultados mostraram que há necessidade de intervenção de melhorias nas condições de trabalho para evitar futuros danos à saúde dos trabalhadores, pois ocorreram problemas posturais durante o abastecimento dos misturadores, tais como elevação dos braços acima dos ombros e extensão da lombar. Portanto, conclui-se que os canteiros de obras analisados precisam adequar seus equipamentos e posto de trabalho conforme as recomendações da Norma Regulamentadora NR17, de modo a evitar problemas ergonômicos, tampouco afastamento dos trabalhadores.

PALAVRAS-CHAVE: Ergonomia. Segurança do Trabalho. Misturadores de argamassa.