SYSTEMS & MANAGEMENT
Electronic magazine

# ERGONOMIC RISK ANALYSIS BETWEEN SERVANTS DURING THE EXECUTION OF FOUNDATIONS

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## ABSTRACT

This research has the objective of evaluating the ergonomic risks to which the servants are exposed during the execution of foundations, in a construction site. It is characterized as an exploratory-descriptive and quantitative study. The results allowed verifying the precariousness of technologies directed to the work activities performed by the servants. It is suggested, therefore, that construction companies adopt economically viable measures to minimize the ergonomic risks to which these professionals are exposed, contributing to the improvement of the quality of life at work as well as the increase of organizational productivity.

**Keywords:** Ergonomic Risk; Laborer; OWAS; Foundations.

PROPPI / LATEC
DOI: 10.20985/1980-5160.2018.v13n1.1128

**Electronic Journal of Management & System**
Volume 12, Number 1, 2018, pp. 36-44
DOI: 10.20985/1980-5160.2018.v13n1.1128

## 1. INTRODUCTION

In the scenario of the Brazilian economy, the construction sector stands out for its relevance in the area of employability. According to the *Instituto Brasileiro de Geografia e Estatística* (IBGE - Brazilian Institute of Geography and Statistics, 2011), this sector is responsible for employing a progressive number of workers when compared to previous years. In 2011, approximately 2.7 million workers were employed, which means that more than 2.5 and 1.6 million employees in the same sector in 2010 and 2007, respectively.

However, based on the *Serviço Social da Indústria* (SESI - Social Service of Industry, 2008), it is verified that the activity developed by this sector is considered dangerous and exposes the workers to various occupational hazards, with specifics and intensities that depend on the type of construction analyzed, the stage of the work and the way of conducting the programs and actions of safety and health at work.

Occupational hazards are defined as those arising from the organization, procedures, equipment or machines, processes, environments and work relationships, which may compromise the safety and health of workers, depending on their nature, concentration, intensity and time exposure. They are classified into five categories: physical, chemical, biological, ergonomic, and accident (SESI, 2008).

For the purpose of this study ergonomic risks were addressed, since it is one of the most frequent occupational hazards in construction sites and, besides reaching practically all construction workers, affects mainly the laborers, subjects of this research (Araújo *et* Meira, 1996).

In addition, in the context of foundation works, it is verified that such activities are classified as a maximum risk degree in the health and safety of the worker, as indicated in Annex I of the Regulatory Norm that deals with the Specialized Services in Safety Engineering and in Occupational Medicine (NR-4) (Brasil, 2011).

In this perspective, the objective of this article is to analyze the ergonomic risks to which the workers are exposed during the execution of excavated and block pile foundations, since, among the workers in the civil construction sector, they are the most exposed workers to the risks of injuries of this nature. Therefore, we analyzed in detail all the postures assumed by them in previously defined activities inherent to the stage of foundation.

This research was carried out at a construction site located in the city of Montes Claros, located in the northern state of Minas Gerais, Brazil. It is important to point out that Montes Claros is the only average city in the north of Minas Gerais and it is characterized as a polo city when it performs functions around services, commerce and industry (França et al., 2009). And according to data from the IBGE (2010), it has a population of 361,971 inhabitants.

In this context, this city is part of the Southeast region, which is precisely the holder of leadership in terms of employed personnel and value of the incorporations, works or services of the sector, according to the Annual Survey of the Construction Industry (IBGE, 2011). Thus, this study justifies its locality in the Southeast region and defines the city of Montes Claros/MG as a research scenario.

Therefore, it is possible to verify the pertinence of the present study, since, through this, it will be possible to know the real ergonomic conditions to which the laborers are exposed during the execution of activities pertinent to the stage of foundation, as well as to seek solutions that aim to minimize such risks and thus guarantee quality of life at work and increase organizational productivity.

## 2. THEORETICAL FRAMEWORK

### 2.1. Ergonomics: history and concept

According to Iida (2005), ergonomics emerged after World War II, from an interdisciplinary work carried out by several professionals, such as engineers, physiologists and psychologists. Unlike other sciences, it is evident that ergonomics has an "official" date of birth: July 12, 1949. This day marks the first meeting, in England, of a group composed of scientists and researchers interested in the discussion and formalization of the existence of this new branch of interdisciplinary application of science.

However, although there is a precise date for the official emergence of ergonomics, it is said that it was preceded by a long period of gestation, which goes back to prehistory. It probably started with the first prehistoric man in choosing a stone whose shape best suited the shape and movement of his hands so as to use it as a weapon. In this way, the tools developed provided power and facilitated tasks, such as hunting, cutting and crushing. It is explained that the ergonomics consists of a study that aims to adapt the work to the man, in order to adjust the work to men's capacities and limitations (Iida, 2005).

According to Martins et al. (2017: 271), ergonomics is defined as a "science that aims to modify work systems to match existing activities with the characteristics, skills and limitations of workers in order to provide efficient, comfortable and safe performance".

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The regulation regulating ergonomics (NR-17) states that it aims to provide comfort, safety and the good performance of workers through the adoption of parameters that allow their adaptation of working conditions to psychophysiological characteristics (Brasil, 2011).

It is pointed out that the productive performance of an organization depends on the ergonomic conditions, since they aim to promote safety, health and employee satisfaction in order to reduce fatigue, errors, stress and accidents. Therefore, in addition to providing a better quality of life at work, the application of ergonomic methods is essential, because by the reduced rate of absenteeism, increased productivity and product quality, the organization will grow, thus becoming competitive and achieving success in the market (Marques *et al.*, 2010).

From this, it is evident that the ergonomic action in any company has as its function to understand and to delineate the productive system in order to provide to the workers the accomplishment of their tasks in a safe and competent way, with respect to their mental and physical capacities (Rodrigues *et al.*, 2013; Gomes *et al.*, 2017).

### 2.2. Civil construction: foundations

According to Peinado et al. (2013), the increase in population and growth in Brazilian cities triggered a growing demand for housing, which led to a greater incentive to build large buildings, culminating in the heating of the construction sector, responsible for the generation of thousands of jobs in Brazil.

Still with the current actions and mitigating measures adopted by the government and employers, there is a considerable incidence of occupational accidents and occupational diseases, representing a significant number in the scope of the national civil construction (Medeiros, 2016).

In the context of the construction industry, it should be emphasized that it requires its employees to carry out rather arduous tasks, in addition to other factors peculiar to the sector, such as the low level of training of workers, low level of education, utilization of the outsourced employability system, the low remunerations and the lack of programming of the tools to carry out the activities. In this way, it is perceived that ergonomics is extremely necessary for the minimization of occupational risks as well as the maintenance of the physical and mental integrity of these collaborators (Saad *et al.*, 2006).

In the case of buildings, it is verified that, during the construction process, there is a continuous change in activities, the environment and workers, since the services inherent to each stage are carried out by different contractors. Among the stages of such production, stand out: foundation, structure/masonry and finish (SESI, 2008).

In order to carry out the present work, it was necessary to approach the foundation stage, since it is a fundamental part of the building works and is characterized by supporting all the weight of the building and resting on the solid part of the ground. In view of this, it is evident that the characteristics of the project and the terrain are of fundamental importance for determining the type of foundation to be adopted (SESI, 2008).

To that end, it is pointed out the existence of Annex I of the NR, which deals with the Specialized Services in Safety Engineering and Occupational Medicine, which considers foundation works, according to the National Classification of Economic Activities (43.91-6) , as risk degree four, that is, the highest degree of risk in the area of safety (Brasil, 2011). This classification is justified by the great complexity of carrying out an adequate analysis of the possible measures and implementation of the accident prevention plans in the activities carried out at this stage, given that, according to the type of foundation executed, work in confined spaces in the service of extension of the bases of the pipes, for example, present high indices of risks of industrial accidents (Peinado *et al.*, 2013).

### 2.3. Occupational diseases

The physical constitution of the human being responds differently to the physical stimuli according to the place where the activity is being performed. This leads to the conclusion that the lack of comfort in the work environment can cause, besides discomfort, several types of occupational diseases, jeopardizing the worker's safety and quality of life (Paiva *et* Santos, 2012).

According to Saad (2008) and Bezerra (2015), the development of activities at the construction site constantly demands the execution of repetitive movements and the handling of loads, characterizing heavy work, which causes the excessive use of the musculature and consequent occurrence of occupational diseases. In this context, musculoskeletal disorders that are closely related to fractional, repetitive, unqualified, and inappropriate or improper activities in human working conditions stand out. Linked to the objective of greater productivity, the workers are required to accelerate during the execution of the tasks, being devoid of a dialogue or questioning between the workers and the organization, also characterizing an oppressive management (Martins Junior *et* Saldanha, 2009).

In this way, it is verified that the incompatibility between the physical capacities of the employee and the demands

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of the work performed are responsible for the occurrence of muscular traumas. Therefore, such traumas are caused basically by the impact and excessive effort during the accomplishment of the task (Iida, 2005).

According to Iida (2005), impact trauma occurs in a specific region of the body, which is affected by a sudden force in a short period of time, and can cause bruising and serious trauma, exemplified by bone fractures and tissue lacerations. The trauma related to excessive stress, in turn, occurs in the physical performance of the task, when excessive force and inadequate body movements are required.

In view of the foregoing, this study adopts as an area of coverage the trauma related to excessive effort, since it is the main cause of employee leave, as a result of musculoskeletal injuries and diseases. This type of trauma causes different lesions, such as nerve compression, lumbar disorders, tendonitis and tenosynovitis (Iida, 2005). Also included in this classification are lesions promoted by repetitive traumas, such as (Iida, 2005, p. 164): work-related musculoskeletal disorders (WMSDs); cumulative trauma injuries (CTIs); and repetitive strain injuries (RSI).

The acronym WMSDs is more comprehensive and includes the CTI and RSI.

It is pointed out that occupational injuries affect the physical and mental health of the worker, reducing their functional capacity, directly interfering in the worker's productivity and quality of life (Saad, 2008).

## 3. MATERIALS AND METHODS

This research consisted of an exploratory-descriptive study, using a quantitative approach, carried out with laborers directly involved in the works dedicated to the execution of foundations, of the pile-and-block type, at a construction site in the city of Montes Claros, located in the north of the state of Minas Gerais, Brazil.

In order to carry out this research, the project was submitted to the Research Ethics Committee of the Faculdades Unidas do Norte Minas (FUNORTE) and was approved in March of 2014, by Opinion No. 567367.

It should be emphasized that, because it is a research involving human beings, it is in compliance with Resolution No. 466 of December 12, 2012, of the National Health Council, which prescribes respect for bioethics, principles of autonomy, non-maleficence, beneficence and justice of human beings (Brasil, 2012).

Thus, all the laborers (100%) received the informed consent form for the participation of the research, agreed to participate in it and answered the questionnaire proposed (April/2014).

The data collection instrument was applied to 100% of the research subjects. It is a questionnaire consisting of seven objective questions that characterized the profile of the subjects in this study. In addition, observations were made, including photos and filming of the laborers during the execution of foundations, in order to detail and enumerate precisely the tasks performed by the universe researched and the main postures assumed by the research subjects during the realization of those tasks.

The data collected were analyzed in May 2014, when they were coded, tabulated and statistically calculated and presented in graph form, analyzing the content of the questionnaires applied as well as the results obtained through the Ergolândia software (Version 5.0) by the Ovako Working method Posture Analysin System (OWAS).

According to Iida (2005), the OWAS method was created to obtain information to improve working methods by identifying inappropriate body postures adopted by workers. Thus, for this method, observations were made where, for each step identified, the postures related to the back, arms and legs, the use of force or load and the phase of the activity analyzed were considered. It is verified that this method is used to record the postures and each posture is described by a four-digit code, as represented in Figure 1.


**Figure 1**. Posture code - *OWAS* method
Source: Research Data (2014)

Thus, the database of the software Ergolândia Version 5.0 was filled in the OWAS module according to the positions identified in each step and the result was the action

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category of each step, which identifies whether preventive measures are necessary or not, as exemplified by Figure 2.

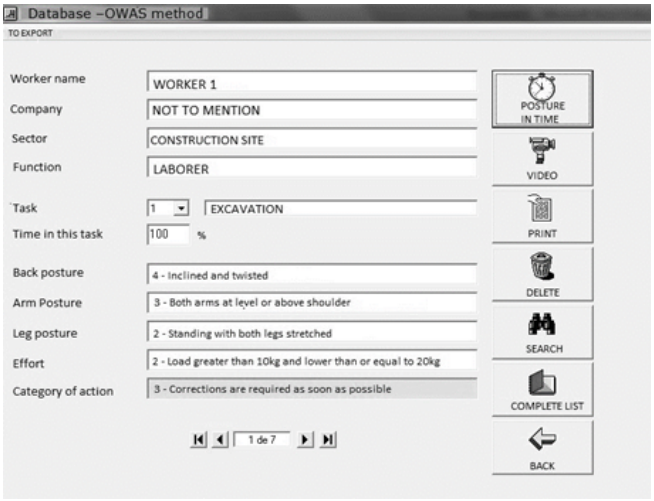


**Figure 2.** Database –*OWAS* method
Source: Research Data (2014)

It is observed that such categories to be found are classified by codes by which their respective levels of action are identified, as described in Table 1, below.

**Table 1.** Description of Action Categories - *OWAS* Method.

| Action category | Action |
|---|---|
| 1 | No corrective action is required |
| 2 | Corrections are required in the near future |
| 3 | Corrections are required as soon as possible |
| 4 | Immediate corrections are required |

Source: Research Data (2014)

## 4. RESULTS

### 4.1. General profile of workers

Initially a research was carried out to verify the general profile of the workers studied through applied questionnaires and direct observations performed at the studied site. In this way, it was verified that the construction site has 110 employees distributed in the functions of in charge, laborer, mason, hydraulic fireman and electrician, and they carry out their working day from 7:00 am to 12:00 pm and 1:00 pm at 5:00 pm.

The questionnaire applied to the laborers aimed to characterize the subjects of the research and to identify the main complaints of the servants regarding the ergonomic risks found in the execution of their activities and the measures adopted by the company in that context.

In summary, according to Figure 3, the results of the research show that the majority of workers analyzed are young and of average age, with few workers over 50 years old. This fact suggests that the activity is an attraction to the young people that start in the labor market and that allows the stay of workers, although small, of professionals with older age.

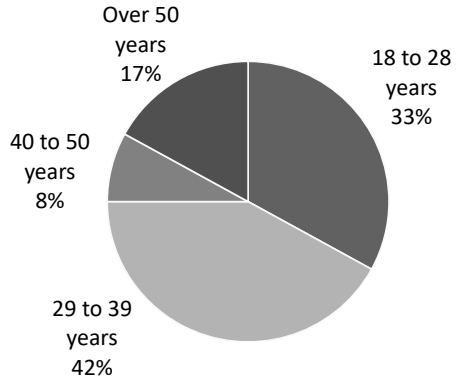


**Figure 3.** Age group
Source: The authors themselves

Another relevant point is that there is a balance in relation to the time of experience in the function, since half the number of workers studied has less than two years in the function and the other half is more than two years, emphasizing the previous affirmation, of attractiveness to the young people and older professionals. All workers are male and have a low level of education, since they are illiterate or have a maximum of two years of secondary education.

### 4.2. Biomechanical analysis

#### *4.2.1. Ergonomic problems and measures adopted*

It was observed that the majority of workers complains about the use of intense physical effort, lifting and manual transportation of loads, demands of inappropriate postures and repetitiveness in the execution of their activities. Thus, it is evident the characterization of the work carried out in the civil construction emphasized in the present article, since it involves arduous tasks and it expends great physical effort of the collaborator.

Moreover, it was found that 92% of the workers indicated the manual lifting and transportation of weight as a risk identified in their activities, in addition to the intense physical effort and inadequate posture requirements cited by 67% and 58% of the workers, respectively. Added to these identified risks, the rigid productivity control, the imposi-

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tion of excessive rhythms, monotony and repetitiveness, as shown in Figure 4, were also cited by a smaller number of workers.

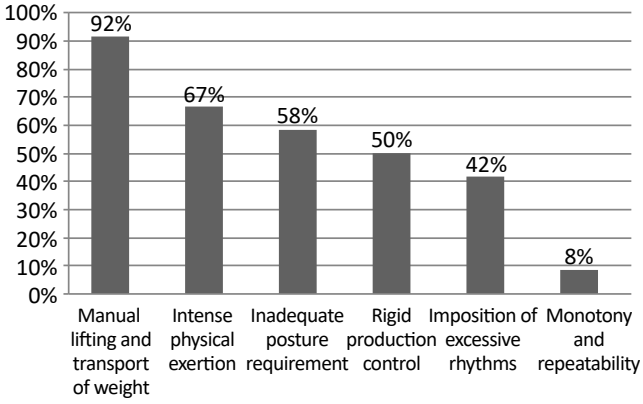


Figure 4. Risks identified by Laborers
Source: The authors themselves

*4.2.2. Results of the OWAS method*

According to Iida (2005), the analysis of the category of action occurs due to the combination of four variables. In order to do so, in order to launch data in Ergolândia software, it was necessary to describe the sequential steps in the execution process of the analyzed foundations (Figures 5) and, therefore, the identification of the adopted postures and load manipulated by the laborers in the respective stage, from the photos and filming made at the construction site. In this way, the codes of the postures identified in each activity were assigned, according to Table 2.

**Figure 5.1.** Excavation of blocks

**Figure 5.2.** Pipe cleaning

**Figure 5.3.** basic regularization

**Figure 5.4.** Concrete blocks

**Figure 5.5.** Cargo transportation - excavation

**Figure 5.6.** Cargo transportation - pipe cleaning

**Figure 5.7.** Cargo transportation – basic regularization
**Figure 5.** Stages identified in the execution of the analyzed foundation
Source: The authors themselves (2014)

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**Table 2**. Positions code according to the OWAS method

| Action category | Action |
|---|---|
| 1 | No corrective action is required |
| 2 | Corrections are required in the near future |
| 3 | Corrections are required as soon as possible |
| 4 | Immediate corrections are required |

Source: The authors themselves (2014)

It is evidenced that in each stage four digits were assigned according to the posture adopted to carry out the activities. The digits follow the sequence: back posture, arms posture, leg posture and required effort. Thus, with the combination of the four codes of each activity inserted in the action table, the action categories were obtained for each step described in Table 3.

**Table 3.** Category of action according to the postures – OWAS

| ACTIVITY | Level | Action |
|---|---|---|
| Excavation of blocks | 3 | Corrections are required as soon as possible |
| Pipe cleaning | 4 | Immediate corrections are required |
| Basic regularization | 3 | Corrections are required as soon as possible |
| Blocks concreting | 2 | Corrections are required in the near future |
| Cargo transportation - excavation | 3 | Corrections are required as soon as possible |
| Cargo transportation - pipe cleaning | 3 | Corrections are required as soon as possible |
| Cargo transportation - basic regularization | 4 | Immediate corrections are required |

Source: The authors themselves (2014)

From the above table, it is noted that of the seven work steps identified, the cleaning of pipes and the transport of loads for base regularization fall within the maximum category of action, accompanied by four other activities classified in the category. Thus, it is necessary to adopt measures in order to correct them immediately or in the near future, respectively.

## 5. DISCUSSION

In the case of the profile of the workers studied, it was confirmed through the questionnaire applied that the majority of workers are young and middle-aged, characterizing this type of activity as an attraction for the young and that there are a small number of workers above 50 years of age. In this study, predominance in relation to the time of experience in this function was identified: less than two years for half of the workers.

It was also evidenced that all the respondents are male with low level of education, illiterate or, at most, high school. These characteristics are in agreement with the one exposed in the context of the construction industry, in which workers with a low training index and low level of schooling are identified. This scenario is also characterized by low wages and lack of programming with the work tools, causing occupational hazards. Therefore, it requires the development of ergonomics in order to minimize these risks and, consequently, to maintain the physical and mental integrity of the worker, as approached by Saad et al. (2006).

It was also possible to evaluate the workers' complaints, especially in relation to the intense physical efforts applied in manual transport and lifting of loads, with inadequate and repetitive postures. These activities, as stated by Saad (2008), require repetitive efforts and the handling of loads that lead to excessive muscular effort, causing occupational diseases, especially musculoskeletal disorders.

Reaffirming the above, it was evaluated that 92% of the workers pointed out lifting and manual weight transport activities as the greatest aggravating factors in their activities, followed by excessive efforts with 67% and inadequate postures, with 58%. It is highlighted as another aggravating factor the rigid productivity control, identified by 50% of the laborers. According to Martins Júnior et Saldanha (2009), when higher productivity is desired, the workers are required to accelerate during the execution of activities, which characterizes an oppressive management, since there is no questioning or dialogue between the laborer and the company. Another result was the presence of imposition of excessive rhythms, such as monotony and repetitiveness, identified by 8% of the study participants, considered the smallest because of the small number of employees.

The action categories, defined from the column positions, arms and legs assumed concurrently with the loads during transport and manipulation were recognized as results of the software analysis. The action categories were as follows: "corrections are required as soon as possible", "corrections are needed in the near future" and "immediate corrections are required", the latter being the most severe. In the execution process, whose stages were divided between block excavation, pipe cleaning, basal regularization, block concreting and cargo transport, there is a prominence in the cleaning of the pipes and the transport of loads during the regularization of the base, since they are the most harmful steps to the ergonomics of the employees, needing to be corrected immediately. Thus, as Iida (2005) points out, the OWAS method made it possible to identify body postures that were proven to be inadequate for workers, requiring correction.

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## 6. CONCLUSION

This research proved that the activities carried out by the laborers at the construction site during foundation services, as well as the occupational hazards that affect them, according to the action categories resulting from the Ergolândia software (OWAS) analysis, are arduous. From the obtained results, it was verified the necessity of implantation of improvements as result of the observation of the gravity of the postures assumed.

It is pertinent to emphasize that this research is restricted only to the studied worksite whose foundation stage, definition of its type and execution depends on several factors, such as soil, technical specifications, logistics, costs, besides sporadic and unpredictable factors characteristic of this stage. Each company adopts different measures regarding the treatment and concern with its employees; therefore, the results only apply to the scenario of the study, since it did not cover the security measures adopted here for all construction sites in the city of Montes Claros – MG.

In view of the situation studied, it was verified the precariousness of technologies directed to the work activities performed by the servants, since almost all the services performed by them are of a manual form, leading to the growing appearance of musculoskeletal disorders.

With the presence of a technology directed to this class it would be possible, directly and indirectly, to avoid several other aggravating factors. At first an income would be noticeable during the activities, since the workers would render less efforts during the activities, having a greater productivity. This would lead to a decrease in sick leave due to occupational diseases, reducing the costs of medical treatments and non-productive labor.

In the social area, the efficiency of technologies would have a reflection on health services, since the number of hospitalizations and queues for care would also be reduced, minimizing state expenditures and professional, psychological and physical wear and tear on the part of workers. Improving the quality of life of the class would be the best strategy for society, since both the company, as well as the servant, the health system and the whole society would receive the benefits.

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**Received:** Jan 06, 2016

**Approved:** Jan 18, 2018

**DOI:** 10.20985/1980-5160.2018.v13n1.1128

**How to cite:** Oliveira, F. S., Viana, E. S., Oliveira, F. S. et al. (2018), "Ergonomic risk analysis between servants during the execution of foundations", Sistemas & Gestão, Vol. 13, No. 1, pp. 36-44, available from: http://www.revistasg.uff.br/index.php/sg/article/view/1128 (access day month year).