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# HSE Management for a Sound Work Environment: Strategies for Improving Health Safety and Environmental Indicators Through Ergonomic Design Thinking

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Additional information is available at the end of the chapter

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## Abstract

Ergonomic Design Thinking (EDT) is a project management methodology that takes advantage of two important concepts or themes in carrying out project actions. The first is Design Thinking itself, a project management approach originally proposed by Tim Brown, who knew beforehand the full potential of design tools, techniques and maybe we should add idiosyncrasies. Designers have “their own way” of following through and carrying out issues such as deadlines and sequences, for example. This logic is similar to another important theme: ergonomics. The main objective of ergonomics is adapting work systems to workers themselves. By doing so, its professionals dig deep into the social technical fabric of a workplace and use recurrent and iterative strategies in order to search for a perfect fit for a given workstation. EDT as a modeling guide for workspace projects have been used in Brazil for quite some time. This text outlines an interesting experience in which EDT was used as a conception tool in building a new health safety and environmental (HSE) management system model for construction sites. A real case—an ongoing construction work—was used to contextualize the experiment and better define the various instruments of this HSE model. Due to the work environment and predominant job characteristics available, the EDT approach did quite well in terms of serving its project management purpose, as it was confirmed when the new system became fully functional.

**Keywords:** ergonomics, health, safety and environmental, management systems

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## 1. Introduction

Ergonomic Design Thinking (EDT) was originally conceived as a project management model used for both organizational design and project management. Thus, it must be understood as an effective tool for project management optimization in general applications, not only design projects. The main idea is the general concept that makes possible the application of creative reasoning and intensive end-user participation in the course of project management just like designers do when solving problems in their during the creative work process. Conventional planning and decision making methods flow in a linear manner, way different from creative thinking. “HSE,” short for health safety and environmental management is a fairly new—and crucial—area in operations management [1], especially for those organizations that fall in the category of complex systems, which require a 360° approach to operations management. HSE decision analysis in such environments is definitely a challenge, since prioritizing becomes difficult due to multiple criteria to assess, risks to ponder and level of severity in terms of collective impact and workstation evaluation.

This chapter outlines the general model for carrying out HSE project management approaches in the workplace. In practical terms, it adds up to existing management systems that are designed to comply with industry and government standards. In order to contextualize the theoretical framework, a case study is employed as a guide for the implementation of a specific HSE Management system for the construction industry. In order to achieve that, the work team used a set of strategies set forth by the EDT modeling, as proposed by Santos and Soares [2]. The choice of this industry segment is due to the fact this particular sector is known by the lack of qualification of its workers. As a consequence, it is acknowledged worldwide as a low performance sector in terms of controlling its operational and environmental risks and hazards.

The EDT approach used in the course of the process being described in here was carried out to help the consolidation of a HSE management system for building construction sites. Thus, the complex nature of the work process is dictated not by its operational characteristics or the usual determinants of larger complex systems (i.e., oil refineries, nuclear power plants, medical emergency rooms, construction sites), but because of the difficulties posed by management issues, such as control and enforcement of safety and health practices in this type of work. The building and construction industry struggles to set up and maintain effective action plans and indicators when it comes to health safety and environmental processes, commonly referred to as HSE. In fact, its workers ranks the second most exposed to work accidents of all industrial segments in Brazil [3], just behind the transportation sector.

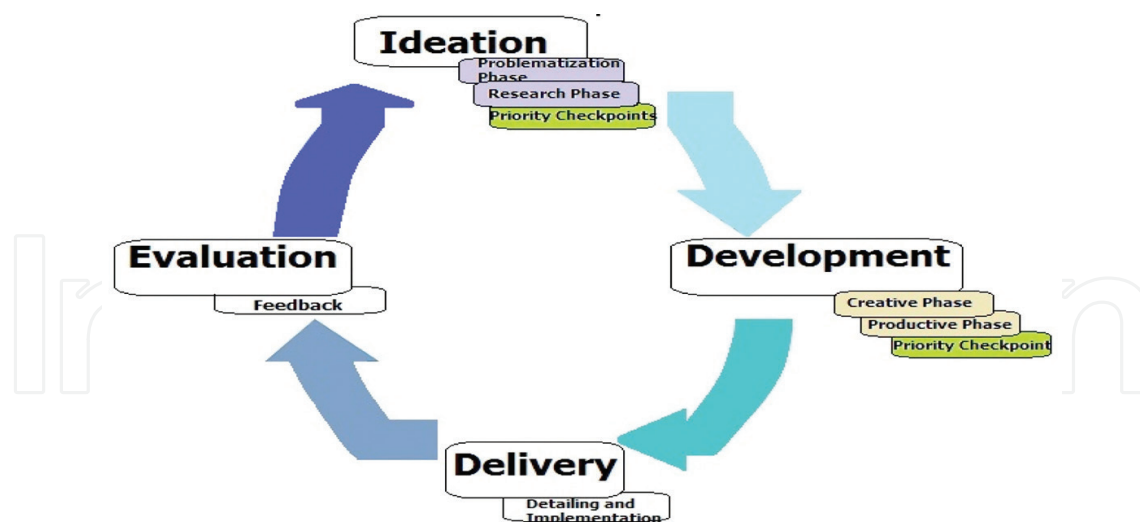
The consequence of poor control and management of HSE in construction sites leads to a series of problems ranging from plain inconvenience of mishandling or misinterpretation of data to more serious ones such as poor HSE plans and management systems. The end result of this is converted into an unpleasant workplace, health and safety issues and all sorts of environmental problems. Without the continuous optimization of HSE processes, it becomes virtually impossible to positively improve the work conditions for the workers and all those directly or indirectly affected by the outcomes of bad planning, poor management and actual

operational actions. The EDT methodology provides the “real work element” for such continuous improvement since it is more palatable and credible for containing and merging the expectations of the workers with the needs of the productive process.

## 2. Theoretical framework

The concept of EDT derives from the general Design Thinking concept, originally proposed by Brown [4], who defined it as “a discipline that uses the designer’s sensibility and methods to match people’s needs with what is technologically feasible and what a viable business strategy can convert into customer value and market opportunity.” However, the concept has proven to adhere well beyond the design and marketing spectrum. Likewise, ergonomics is not only a tool for improving work conditions but also an effective way for a better design of products and for bringing productivity, therefore economic advantage, for the organizations [5, 6].

The idea behind Design Thinking has been the appropriation of creative thinking and intuitive response actions involved in the design process in a wider range of situations, outside the Design field. With that in mind, Santos and Soares [2], proposed a combination of the Design Thinking “creative based process management” and Ergonomics for Project Management processes in which the interaction between users and those in charge of designing work environments or systems is key to an overall conformity to job design principles and user needs, as well as to the compliance to normative standards and labor legislation (Figure 1).



**Figure 1.** General EDT model.

The concept of Ergonomic Design Thinking, hereafter called by its acronym EDT, adheres to the notion of employing formal creative thinking built from within the spectrum of real work actors. Santos et al. [7] points out that nobody knows better about the job than workers

themselves. Therefore, it would seem counterproductive not to take in consideration their insights when trying to improve their work conditions, workstations or work systems. Thus, Ergonomic Design Thinking must be seen as a general model for participatory actions in the workplace, which in turns make areas such as Ergonomic Design, product development and, definitely, job design all possible terrain for its dissemination.

All those actions demand sequential steps somewhat flexible to allow creative thinking to flourish. In fact, the model started to be used in setting up HSE management systems in a variety of organizations. Health, safety and even environmental processes are all connected to an important participatory demarche in operational work activities. They should not be dealt with in an insulated manner, without proper integration. Our lives and our health can be affected by poor design choices [8]. By inference, this is true for HSE interventions. Regardless all constraints that may arise in workplace, engineers are mostly responsible for all work environment inadequacies. It is fair to say that companies intuitively use Design Thinking to an extent, even without realizing it. However, organizations resist in taking a human-centered approach because they cannot grasp at the perspective of trying something entirely new. Something that arises out of their control, in the midst of a balance of users' needs, technology and organizational constraints.

The building construction industry is characterized by particularities not present in any other industry. First off, it is entirely a project driven industry, no "final product" is ever alike, due to geographic and geological variations and differences in systems and components (building materials and techniques). Contrary to regular transformation industry, storage and logistics is not a major direct problem, but quality control is as important as in regular manufacturing. Then, we have the construction site issue. It functions as a temporary factory, one in which often times workers share not only tasks but also sleeping rooms with fellow workers. Yet, there is no true attachment to the workplace. It will be used and discharged at the end of every project.

Likewise, teams are not permanent, rarely replicated in the next construction projects. For instance, if a work activity is identified as critical under HSE standpoint, a training program is immediately implemented. However, those trainees will hardly experiment the same constraints in their next construction project. In fact, sometimes they may be even out of the industry all together, since the Building Construction Industry (BCI) is also characterized as a temporary job for many people, employing large amounts of unskilled workers. In order to be successful, a HSE qualification program must take in consideration all of these issues and address them properly. HSE plans and systems need to be pragmatic, safety driven and easily assimilated by everyone. Although every construction site has its own characteristics, it is possible to establish a replicable model that could pass on the essence of prevalent work characteristics that are present in such work environments.

Brazilian Standard NBR 12284 [9] defines a construction site as "a set of areas destined to the execution and support of construction industry Works, divided in operational and living areas." In other words, it is the entire portion of land in which a construction plan will be materialized, plus the storage areas, equipment and machines (concrete mixers, cutters,



welding pits, etc.) and also sleeping barracks, restrooms and lunchrooms for the workers. They are inherently hazardous places to work and to “live” and often times workers have no choice but to stay overnight since construction works and construction sites may be located in remote areas.

The risk of developing musculoskeletal disorders is very high because in most cases there is no possibility of mechanical material handling. Besides heavy lifting, workers are often exposed to awkward postures, making the BCI the leading industry in ergonomics-related risks and impacts [10]. This is all aggravated by heat stress (especially in some states) and other environmental hazards. Making matters worse, the exposure to job design constraints, issues such as lack of job security and crew rotation, increases the chances of accidents and infirmities [11].

In places with a strong public welfare system, occupational data and epidemiological statistics are usually more precise and credible than in wealthier nations in where private modalities of welfare are more common. In Brazil, the National Institute for Social Security needs a robust database to be able to control multiple benefits it manages, from retirement pensions to temporary disability payments, including indemnity for work accidents and work-related illnesses and disorders. The system operates in an intricate network of information, trying to avoid errors and frauds by individuals and companies, since resources are becoming gradually scarce as population grows older and people live longer.

The cost of liability insurance for example is not a flat rate for generic or specific business categories. It is based on each tax identification number, so that companies with poor occupational health and safety indicators will pay gradually more if they keep neglecting this particular issue. In fact, there is a curiosity that comes from epidemiological data in places with more harsh labor and welfare legislation. More precise data in occupational health and safety data lead to a false perception of low standards. Because it tends to increase reporting of the negative outcomes of HSE management systems, it ends up making them look ineffective when compared to other countries. Often times, countries that are known for having poor health and safety standards may look better in some of those standards. It happens because reporting of occupational health and work accidents in those countries are also very poor.

**Table 1** contains data extracted and combined from various Brazilian government agencies [12, 13], and illustrates epidemiology severity data for the BCI, in terms of frequency.

According to the social security annual statistics report [13], the impact in terms of occupational health and safety figures is exponentially more relevant once the data are further detailed. Out of more than 700.000 work-related accidents, about 121.000 of those involved victims under 29 years old and the building and construction industry is responsible by nearly one third of those figures. Soares [14] sums up the economic impact of work accidents saying that social security agencies alone spends around US\$ 1 billion in wages, benefits and other expenditures, whereas the private sector spends another US\$ four to five billion due to poor work conditions.

Number of work related accidents in Brazil			
Year	Accidents	Illnesses	Deaths
2000	363.868	19.605	3.094
2005	499.680	33.096	2.766
2010	709.474	17.177	2.753
2011	720.629	16.839	2.038
2012	705.239	14.955	2.731

**Table 1.** Number of work related accidents in Brazil.

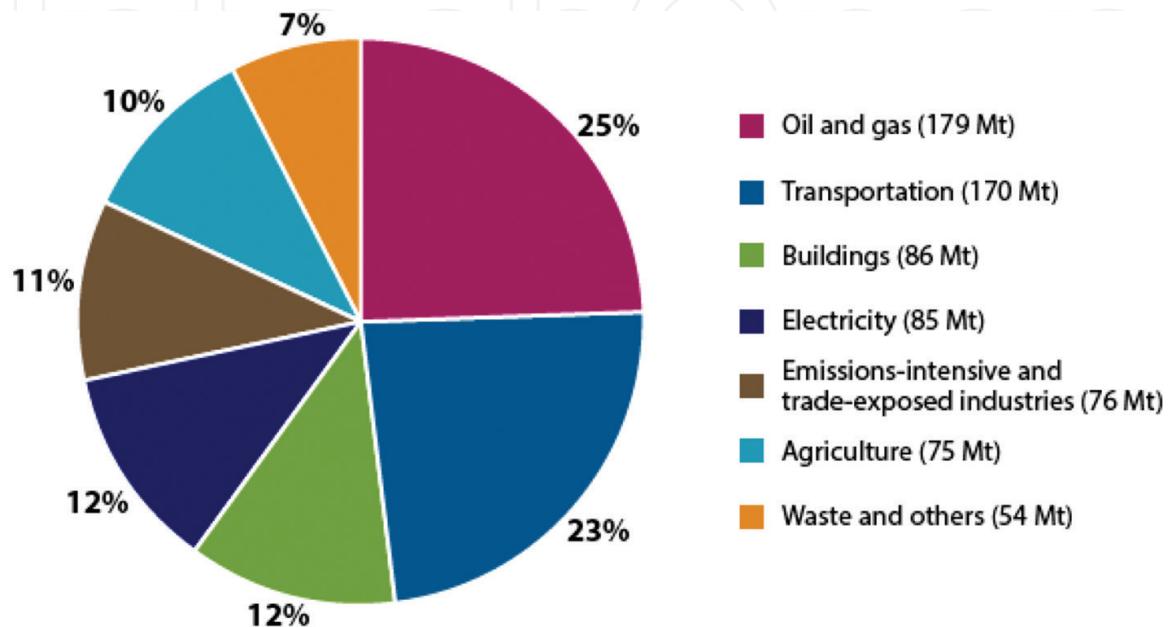
By looking at the data in **Table 1**, it is tempting to infer that the decrease in the number of fatalities and illnesses—despite an increase in number of accidents—is due to the improvement of work conditions and incentives in preventive measures, such as the use of personal protective equipment (PPE) and collective protective systems. However, it is fair to say there has been an overall raise in awareness by workers and consciousness by organizations to employ systematic measures for the improvement of work conditions as a whole, which includes some human factors and ergonomics actions. Another Brazilian government-funded agency, SESI [15], points out a list of prevailing occupational illnesses and injuries in the building construction industry. **Table 2** lists the main causes and preventive measures for each one of those work hazards.

Main occupational illnesses in the building construction industry		
Occupational illnesses	Causes	Preventive measures
Hearing loss	Long exposure to noise above 85 dB	PPE usage, collective acoustic protection
RSI/WMD	Repetitive tasks for long periods of time	Adequate use of rest, work breaks, warm up and stretching exercises
Silicosis and asbestosis	Inhalation of fine particles from asbestos and ceramic like materials	Use of appropriate PPE (masks)
Air embolism	Underwater work or incorrect use of equipment	Compliance with norms and decompression procedures
Low back pain	Inadequate material handling/load lifting	Avoidance of heavy lifting/use proper mechanical aid
Heat stress	Long exposure to ultraviolet sun rays	Proper hydration and avoiding excessive sun exposure
Contact dermatitis	Contact with cement, chemicals or even certain types of PPE	Use PPE appropriately, clothing, gloves and so on

**Table 2.** Prevailing occupational illnesses in the BCI.

The last letter in the HSE acronym represents the environmental aspects of the workplace, its aspects and impacts for the people and surroundings. The BCI is by large the biggest generator of solid urban waste. Considering the entire production chain, the environmental impact

varies according to the construction system (steel, wood, concrete and combinations) but it is always high nonetheless. The graph on **Figure 2** shows the distribution of greenhouse gas emissions in Canada per each type of economic sector, placing the BCI, negatively, as a major contributor for another important environmental indicator. The full report makes considerations on the data gathering methodology that raises the numbers for the construction sector even more by adding indirect impact of the entire production chain [16].



**Figure 2.** Distribution of greenhouse gas emissions in Canada.

The BCI's overall environmental impact has to do with processes such as mining (for sand and aggregates), which accounts for great levels of energy consumption, transportation (mostly by diesel trucks) and last, but not least, generation and inadequate disposal of debris and unused materials. In fact, a great deal of the problem is created by the lack of understanding and acknowledgment on the part of authorities and society in general regarding the negative impacts of clandestine disposal and the benefits of solid urban waste disposal. Usually, BCI solid waste is considered a minor environmental hazard, which impact is basically due to the volume generated. However, this misconception hides some by-products of those residues, such as the proliferation of undesirable species as rats, cockroaches and insects that may act as vectors for various diseases [17].

### 3. Developments and building of the model

Every management system model is embedded with particularities and peculiarities related to whatever industry it will be applied in. As obvious as it sounds, it is not rare to find various management systems that are built with generic mechanisms and inferences that will not adhere to specific industry processes. HSE management systems for transformation industries, for example, follow certain criteria based on the nature of their operations. If it involves



air pollution, preventive actions related to chimneys are necessary to be considered in maintenance plans. Likewise, occupational health issues will vary immensely, depending on the presence of certain risk factors, prevalent climate and atmosphere, geographical and geological conditions and other aspects. Using EDT methodology, the team involved in a consulting project in charge of carrying out an analysis for setting up a new HSE program in a construction site, decided to start with a brainstorm activity with all key actors in a construction site. The resulting master plan for the program establishment and project implementation was defined according to an operational sequence based on **Table 3**.

<b>Analysis phase</b>	<ul style="list-style-type: none"><li>- Observational analysis—during this step the consulting project team performs workstation and activity analysis to assess program guidelines and best practices opportunities</li><li>- Tool applications—methodological tools are applied to facilitate the process and maximize results</li><li>- Project reporting—it represents the communication of the results to the various agents (managers, engineers and workers)</li></ul>
<b>Validation phase</b>	<ul style="list-style-type: none"><li>- Project validation—the analysis report needs to be verified and validated by all stakeholders, in search of errors and misinterpretations</li><li>- Complementation—as a consequence of the validation, new analysis, as well as the application of different tools, as required to assess different issues regarding environmental impacts, health and safety hazards</li><li>- Final check—before implementation the report is consolidated and a master action plan for the implementation is set forth. Elements for the banner launch are discussed and a schedule is set for that and other implementation actions</li></ul>
<b>Implementation phase</b>	<ul style="list-style-type: none"><li>- Capacitation training sessions—as part of the HSE management system, workers and other people involved in the various construction site processes need to be informed about and qualified to deal with risks hazards and to adhere to best practices related to health safety and environmental issues</li><li>- Banner launch—it is a symbolic event in which a banner illustrating best practices for HSE in construction sites is presented to workers and all the people using this workspace. The banner is displayed in conspicuous places inside the area, such as the lunchroom</li></ul>

**Table 3.** Construction site HSE management system model.

**4. Case study**

In order to contextualize the proposed HSE management model, it is necessary to apply the various mechanisms embedded in that model in a real scenario. Thus, resourcing to a case study strategy will not only allow linking theoretical aspects to real life issues but also facilitate the understanding of the model outreach. A construction site in a city in the State of Rio de Janeiro, Brazil, was sorted out in this particular case, for better illustrating the application of the HSE management model being described herein. Starting from a general plan outlined in **Table 1**, each step will be now described in their most relevant aspects.

#### 4.1. Analysis phase

An essential tool for the alignment of different perceptions and to establish, by consensus or inferences, guidelines for an appropriate diagnostic of a work process is the brainstorming tool. It is a group creativity technique that tries to lock up on conclusions for a specific problem by gathering ideas spontaneously, as they are verbalized by its members. It was extremely useful for the definition of the various analysis instruments, methods and techniques that were eventually implemented to carry out the work process analysis in the construction site. The methodology for the analysis phase follows this sequence:

- (a) Global analysis: It starts with a walkthrough, a broad analysis that consists in screening both organizational and operational aspects that may influence or be influenced by the work environment. General characteristics of the enterprise need to be assessed and reported during this phase.
- (b) Observational analysis: The observational analysis is concurrent to steps c and d. It displays the characterization of a given work activity or workstation with a short description of aspects and impacts, as well as images of eventual improvements derived from the action. Some activities were contextualized through a technique called “Animated Simulation” [18], in which workers simulate through role playing the real activity that takes place.
- (c) OIT check list: It is dynamic questionnaire (excel spreadsheet) based on the most relevant aspects of the ergonomics check list from the International Labor Organization (OIT in Portuguese). It is built in a way that automatically displays essential information on the task and serves for prioritizing the HSE action plan.
- (d) Conversational analysis: During the process of applying the HSE check list, the analysts use a technique called “Conversational Action” [19], which helps to “extract” important information more naturally from the workers.
- (e) Tallying and validation of data: The results of all different actions, especially the application of action tools, must be tallied and validated.
- (f) Reporting (communication) of findings: The last phase in the HSE management system methodology is reporting and communication. In ergonomic actions, there is a preliminary report, called hot report that is elaborated during the process in order not to miss important information that might be otherwise lost if left out for the end of the field work.

In order to stay focused on the main aspects of the analytical phase, a detailed explanation of all the different steps of the entire methodology could be counterproductive and cause some misconceptions. Therefore, only essential operational actions will be detailed, in other words, further description is concentrated only on those actions that were performed by the HSE analysis team in the course of the field work, prior to diagnostics itself.

#### 4.1.1. Observational analysis

In order to better illustrate the context in which the observational analysis is carried out, an excerpt of the HSE appreciation report is needed. The selected operation consists of a concrete pouring process, for building foundation.

##### Foundation concrete : works

**Workstation:** bricklayers and helpers

**Situation:** The activity consists the pouring of concrete into wooden forms that were previously built and laid in each appropriate frame mold (**Figure 3**). The concrete is pumped up into the forms by a flexible pipe that connects to a special concrete truck, which has a rotating mixing barrel to maintain concrete's chemical characteristics and pumping equipment (**Figure 4**). It may be performed under any climatic and atmospheric condition, except in case of heavy, persistent rain.



Figure 3. Foundation pouring.



Figure 4. Vibration of concrete mix.

**Visible impacts:** Awkward postures of workers, unsafe and unstable surfaces used as base for the activity, evidence of poor planning of activities and lack of operational and safety



training, harsh environmental conditions without proper protection, no incentives for hydration, soil contamination, and improper solid waste disposal.

**Checklist application:** According to the HSE checklist, the activity stands in 53% of adequacy, which is considered acceptable by HSE standards. However, there are several small interventions that may raise current levels to a “good” mark, which will be listed in the following section.

**Improvement opportunities:** (a) adding collective protection equipment (CPE) in the workplace, (b) specific training designed to fit the nature of each task, (c) adding schedule pauses for certain activities, (d) potable water available next to the operations, (e) improving signage and notes in conspicuous places, (f) allocate appropriate areas for solid waste disposal, avoiding soil contamination, and (g) ladders and scaffoldings should be used as standard equipment.

**Environmental aspects:** During preparation and pouring of concrete at least 5% of material was lost (**Figure 5**), either by poor connection between hose joints, spills from truck equipment or by lack of care of workers as pumping is carried out. A lot of the concrete mix flows over the wooden forms or under them straight to the ground (**Figure 6**). In this particular case, not only the mix cannot be re inserted into the frames but also part of mix percolates through the soil.



Figure 5. Concrete waste.



Figure 6. Wood waste.

After hardening, the left overs could be reused as aggregates. However, the chosen destination for discharge in our context was a rented dumpster.

**Regulatory and legal framework:** (a) **Environmental**—according to environmental regulations (CONAMA 307 Resolution, Art. 3rd) concrete and wood are class A materials, which mean they should be fully recycled. Therefore, it is not legal to discharge them as trash. If they are not used in the site, they must be taken to special facilities for future reuse; (b) **health**—in terms of occupational health, this work activity does not comply to several aspects of labor regulations, especially offending Articles in NR 15 (safety risks), NR 17 (ergonomics) and NR 24 (cleaning and conservation. Occupational hygiene standards are also disrespected, especially those related to temperature and weather exposure; (c) **safety**—there are some issues with regard to PPE and Collective Protective Equipment (CPE) during operations, as established by NR 6, NR 7 and NR 9, as well as Brazilian Technical Standards (ABNT/ISO).

#### 4.1.2. OIT check list

According to the check list, which is a quite simple excel spreadsheet that runs in a tablet device, the particular activity shown in here stands in 53% of adequacy. This is considered acceptable by HSE standards. The filling of the check list is pretty much a straightforward operation. The analysts basically use their fingers to a scroll down list with two possibilities: yes and no/not applicable. The annotations in red are “manually” registered by the analysts and contain important notes for diagnostics and the establishment of “HSE Program Improvement Opportunities,” which is incorporated in the resulting Program’s Best Practices Banner (Figure 7).

SMS		PROGRAMA DE GESTÃO DE SMS	
SMS		Análise de SMS do Trabalho - Setor ou Função: Diversos	

Lista de verificação para mapeamento de Ergonomia, Segurança, Saúde e Sustentabilidade  
Situação : CONCRETAGEM DA FUNDAÇÃO

Questões Ergonomia e Segurança do Trabalho:		Questões Associadas a Saúde, Eficácia e Sustentabilidade:			
1	Esforço muscular estático?	NÃO	21	Água potável indisponível ou quantidade insuficiente?	SIM
2	Repetitividade notória na atividade?	NÃO	22	Deslocamentos são frequentes ao longo do dia?	NÃO
3	Reporte espontâneo de sobreesforço?	NÃO	23	O trabalho ocorre em turnos?	NÃO
4	Situações envolvendo torção ou flexão de tronco?	SIM	24	Existe trabalho externo com temperaturas acima de 36°?	SIM
5	Situações envolvendo torção ou flexão de cabeça?	SIM	25	Existe trabalho externo com temperaturas abaixo de 10°?	NÃO
6	Situações envolvendo extensão de tronco ou cabeça?	SIM	26	Legibilidade de documentos/avisos/sinalização insatisfatória?	SIM
7	Adução ou abdução de membros inferiores?	NÃO	27	Iluminação é incompatível com a natureza da atividade?	NÃO
8	Adução ou Abdução de membros superiores?	SIM	28	A temperatura é inadequada para realização normal da atividade?	NÃO
9	Bancadas de trabalho com altura incompatível?	NA/NO	29	O nível sonoro encontra-se fora dos limites de tolerância?	NÃO
10	Utilizam-se ferramentas perfuro-cortantes?	NÃO	30	Falta proteção contra intempéries no local de trabalho?	SIM
11	Utilizam-se ferramentas vibratórias?	SIM	31	Falta treinamento específico para a natureza dos serviços?	SIM
12	Pouco espaço de trabalho ou mobilidade insuficiente?	SIM	32	Falta liberdade ou autonomia na realização das tarefas?	NÃO
13	Faltam proteções ou barreiras contra incidentes e acidentes no local de trabalho?	SIM	33	Sudorese excessiva ou aparentemente deficitária?	NÃO
14	Comunicação com colegas insatisfatória ou insuficiente?	NÃO	34	Urina muito clara ou muito escura?	NA/NO
15	EPI's incompatíveis com a natureza do trabalho?	NÃO	35	Faltam orientações básicas operacionais <i>por escrito</i> para novos colaboradores?	SIM
16	As pausas pré-programadas são inexistentes ou reduzidas?	SIM	36	Descarte de materiais e lixo não atende princípios ambientais (seleção e reaproveitamento)?	SIM
17	Existe movimentação de carga acima de 23 KG?	NÃO	37	A escolha dos insumos segue apenas o critério econômico-financeiro?	SIM
18	Espaço de guardar de ferramentas de trabalho inadequado?	NA/NO	38	As técnicas construtivas são ecologicamente eficazes?	SIM
19	Falta monitoramento dos operários?	NÃO	39	O esgoto de alojamentos/cantina/escritório de obra despeja direto na rede ou fossa?	SIM
20	Existe movimentação manual de carga de grandes dimensões?	NÃO	40	A etapa da obra gera poluição ambiental (gases, fumos, poeiras em quantidade)?	SIM

91 a 100% = Excelente	Computar somente itens aplicáveis e percentual proporcional.	Quantidade de itens favoráveis:	Total de respostas:	53%
71 a 90% = Boa		Percentual de itens favoráveis:	Percentual	
51 a 70% = Aceitável		Condição Ergonômica:		
31 a 50% = Moderada				
Menos de 31% = Necessita intervenção Imediata				

Observações: (em vermelho são exemplos de regi)

Foi dada orientação postural e de ajustes em equipamentos/dispositivos de trabalho.

Recomendada modificação de procedimento

Recomendada pausas sem obrigatoriedade de intervalos determinados.

Recomendada modificação de procedimento

Recomendada alteração/adocção de EPI (botas, luvas, capacete, calça e camisa).

Recomendado redireção de funções.

Figure 7. Tube underpinnings concrete pouring checklist.

#### 4.1.3. Tallying and validation of data

The assessment of HSE conditions report (A-HSE report) is the final product of the analytical process. It is submitted to the scrutiny of all participants in the process during the validation phase that follows. The data submitted are organized according to relevance and synthesized in tables and diagrams, a selection of which is presented as follows. Some data come from images; therefore, they were not translated into English.

- (a) Severity table for each analyzed work activity: It presents the full list of work processes according to the degree of adequacy in terms of HSE standards (**Table 4**). The lowest levels are color coded in red, moderate levels in orange and the highest ones in yellow.

Work Activities	Occupational Severity Levels
Pipe foundation excavation	15
Rebar positioning	40
Formwork (floors)	45
Columns spacing bars	45
Foundation Rebars	48
Concrete work (floors)	50
Formwork (Pilars and Beams)	50
Rebar work (Pillars and Beams)	50
Walls elevation	53
Foundation Concrete Work	53
General formwork	55
Plastering	55
Painting	55
Flooring	60

**Table 4.** Occupational severity levels.

- (b) SIC diagram: SIC stands for sum of critical indices (**Table 5**). It is elaborated using an excel spreadsheet with embedded logic formulas and simple macros. It produces a clear picture of the overall work system and allows prioritizing of an eventual HSE action plan according to the risks and severity aspects and impacts present in each activity, following gravity, trend and urgency of action. Its color coding allows instant visualization for

CL OIT	G	U	T	E N	SIC	
73%	3	3	3	5	185	
Resultado da Adequação do Posto Administrativo - Canteiro de Obras REDUC					Legenda	
91 a 100% = Excelente				73%	<100	
71 a 90% = Boa					100,1-150	
51 a 70% = Aceitável					150,1-275	
31 a 50% = Moderada					>275,1	
Menos de 31% = Necessita Intervenção Imediata						

**Table 5.** Sum of critical index for one particular workstation.



sorting out those work activities that require urgent or immediate action (red and purple, respectively). The percentage result indicates solely the severity level, therefore, it is possible for an operation (or workstation) to have high adequacy to HSE standards but require special attention, just like in the example provided as follows.

- (c) Final overall portrait of the work system (RFO): As the name indicates, it is a final picture of the entire operation, as assessed by the analysis team. As in every HSE management system context, the picture is a representation of a current situation and it may be modified by several work environment circumstances and, of course, improved by appropriate HSE actions (Figure 8).

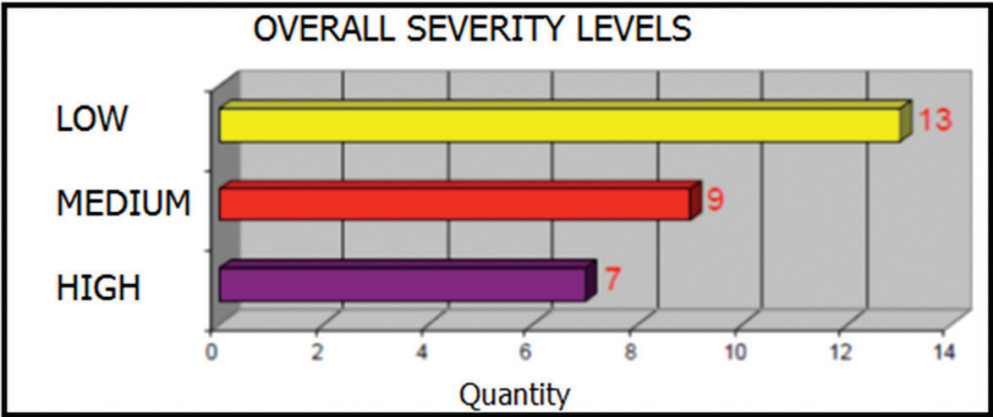


Figure 8. Overall severity levels for the work environment.

4.2. Validation phase

A final and validated A-HSE report version, along with the HSE best practices banner is a combined final product of the validation process. They are both now ready to be implemented, along with its subsequent HSE program guidelines, which become part of a broader HSE management system or policy. The HSE program will be consolidated during the implementation phase that follows.

4.3. Implementation phase

Possibly, the best illustration of what Ergonomic Design Thinking can produce to the work systems is the final result generated in the process of application of our proposed HSE management system model. The PROSMS (HSE program) best practices banner is a quite symbolic representation of a collective interaction of people and disciplines to contribute towards a better, safe and sound work environment (Figure 9). It is “launched” in an event that combines training and social gathering. The banner is displayed in a conspicuous place inside the construction site, usually the lunchroom.

## PROGRAMA DE MELHORIA DAS CONDIÇÕES DE SMS (PROSMS)

### EMPRESA XYZ ENGENHARIA

#### O QUE É SMS

O termo SMS é um acrônimo que remete a Gestão de SMS, ou seja, os processos de controle e ações preventivas em Saúde, Meio Ambiente e Segurança do Trabalho. A Gestão de SMS é um Sistema de Gestão Integrado, o que significa que cada um dos aspectos de Saúde, Meio Ambiente e Segurança recebem tratamento combinado, de forma a garantir a plena satisfação das condicionantes ligadas a cada um dos aspectos individuais. Isso visa a prevenção dos riscos ocupacionais de modo geral, garantindo-se a preservação do meio ambiente. Para tal, é importante que existam mecanismos e indicadores que permitam o monitoramento e adequação dos eventuais problemas identificados durante a apreciação das condições de trabalho.

Um Sistema de Gestão Integrada em SMS pode ser definido como um conjunto de processos, procedimentos e práticas utilizados em uma organização para implementar suas políticas de saúde, segurança e proteção ambiental, o que tende a ser mais eficiente na consecução dos objetivos oriundos de cada uma delas, já que existem "interesses" distintos se sobrepondo (DE CICCIO, 2004). Um Sistema Integrado de SMS, portanto, visa unir o atendimento às normas de forma simultânea para os pontos comuns em processos fins e processos meio. Por exemplo, no processo de aquisição, que não é um processo fim associado ao plano operacional, deve ser verificada, além das especificações técnicas – atribuição da função qualidade – os elementos de conformidade ambiental, saúde e de segurança no trabalho envolvido em cada produto ou serviço.

Dentre os fatores ou critérios considerados mais importantes na avaliação de um posto ou atividade de trabalho, podem-se citar: **ERGONOMIA** - É aplicação de conhecimentos relacionados a fisiologia, psicologia, sociologia biomecânica e outros aspectos da natureza humana de forma a adequar os meios e os sistemas de trabalho às características psico-fisiológicas dos trabalhadores. Do ponto de vista normativo, a Ergonomia está associada a diversas normas regulamentadoras, em especial a NR-17, específica para Ergonomia, além Normas Técnicas, Legislação Trabalhista (CLT) e Dispositivos legais, como a NBR 9050 de acessibilidade.

**SEGURANÇA DO TRABALHO** - No Brasil engloba aspectos de Higiene Ocupacional - que lida com as medições associadas aos diferentes riscos do ambiente de trabalho (temperatura, ruído, iluminação, etc.) - e procedimentos e normas para realização das atividades de trabalho seguro, ou seja, aquele que garanta ao trabalhador a prevenção de acidentes e a sua integridade física.

**MEIO AMBIENTE** - Os aspectos ambientais são tratados de forma qualitativa pela Gestão de SMS, já que os dados quantitativos são atribuições próprias dos processos de controle ambiental, da mesma forma que na dimensão saúde não são coletados dados de epidemiologia. Busca-se principalmente a identificação de possíveis riscos ambientais decorrentes do processo de trabalho.

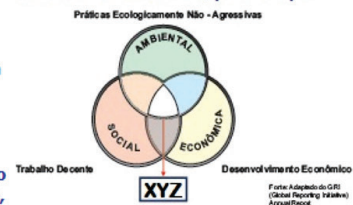
#### PROSMS

Um Programa de SMS (PROSMS) pode ser definido como um instrumento de ação continuada que permite a perenização das mudanças propostas durante o diagnóstico das condições de SMS em atividades e postos de trabalho. A incorporação dessas modificações por meio de orientações e recursos visuais auxilia a absorção natural das boas práticas. Assim, folders, cartazes e banners devem ser distribuídos em locais de grande trânsito de pessoas, de forma a garantir o alcance do maior número de colaboradores, amplificando o potencial de melhoria das condições de trabalho. Deve-se enfatizar que a efetivação das diferentes propostas está diretamente ligada a participação voluntária e de forma colaborativa de toda a força de trabalho, os maiores beneficiários de uma mudança positiva no local de trabalho. Dentre as formas de participação possíveis temos: o reporte e registro de desvios; identificação de riscos possíveis à saúde (repetitividade, sobrecarga física, etc.) e ao meio ambiente.

Para poder exercer bem seu papel de observador atuante, o trabalhador precisa receber dados essenciais do meio ambiente de trabalho, que incluem acesso às normas e procedimentos e orientações quanto ao reconhecimento de riscos e leitura dos indicadores de SMS e outros.

#### PROSMS NA XYZ

Na XYZ Engenharia o PROSMS faz parte de sua Política de Gestão Integrada em Qualidade, Segurança, Meio Ambiente e Saúde. A política, condizente com o tripé da Sustentabilidade (Figura abaixo) visa a melhoria contínua dos processos de trabalho, garantido ao mesmo tempo condições satisfatórias em termos de produtividade, a partir de estratégias de motivação e satisfação para a força de trabalho. Nesse sentido, coaduna-se com os princípios elementares dos processos globais de certificação corporativa, como a ISO 9000 e ISO 14000, por exemplo.



#### As Recomendações da Apreciação

Toda Apreciação das Condições de SMS de um local deve gerar um Quadro de Riscos e Oportunidades, conforme modelo abaixo. Nesse quadro devem constar os aspectos e impactos associados às atividades e postos de trabalho, normas, leis e instruções técnicas específicas para realização das tarefas e os riscos prevalentes para cada situação de trabalho. A partir desse conjunto de informações, são elencadas também as recomendações essenciais para operacionalização das diferentes atividades. Esse quadro é elaborado a partir do Diagnóstico das Condições de SMS e levam em conta o potencial de risco e outros dados relevantes, indicados pela aplicação das diferentes técnicas e ferramentas, como a Matriz de Priorização SIC. A Matriz de Priorização SIC estabelece uma ordem de prioridade de acordo com os riscos ocupacionais e ambientais de um posto ou atividade de trabalho.

Perfilado ou Função	Risco Associado	Impacto Associado	Enquadramento Normativo	Postura Forçada	Repetitividade	Esforço Muscular/Exercício	Risco de Morte ou Lesões	Trabalho Estático	Stress por calor ou frio	Recomendações
1. Trabalho estático (sentado), movimentos repetitivos de membros superiores e inferiores, uso de ferramentas manuais, levantamento e deslocamento de cargas pesadas, digitação de documentos.	Lesões e Doenças Ocupacionais (DOO) e Lesões por Esforço Repetitivo (LER)	NR 17.3 e subitens NR 17.4 e subitens NR 17.5.1.2; NR 17.5.2; NR 17.5.3.1; NR 17.5.3.2; NR 17.5.3.3								Introdução de pausas frequentes e rotinas alongadas possíveis; treinamento de mão-de-obra.
2. Trabalho estático em pé, levantamento e deslocamento de cargas pesadas, perda de visão e impacto cognitivo.	Doenças Ocupacionais (DOO)	NR 17.2 e subitens NR 17.3.1 e subitens NR 17.3.2								Introdução de pausas para recuperação de fadiga.
3. Trabalho de força física, levantamento e deslocamento de cargas pesadas, uso de ferramentas manuais, levantamento e deslocamento de cargas pesadas, uso de ferramentas manuais.	Lesões musculares agudas e DOO	NR 17.2 e subitens NR 17.3.1 e subitens NR 17.3.2; NR 17.3.3; NR 17.3.4; NR 17.3.5								Redução da carga de trabalho; pausas para recuperação de fadiga; exercícios de alongamento para evitar dor muscular.
4. Trabalho com calor e vapores tóxicos, ruído e altas temperaturas.	Doenças ocupacionais, Lesões por Esforço Repetitivo (LER) e DOO	NR 17.2 e subitens NR 17.3.1 e subitens NR 17.3.2; NR 17.3.3; NR 17.3.4; NR 17.3.5								Adotar medidas e ações para controle de temperatura e umidade; uso de roupas leves e protetores solares; uso de protetores auriculares e protetores faciais; uso de protetores de calor.
5. Trabalho Estático, Ruído e Altas Temperaturas, Contato com partes e vapores tóxicos.	Doenças ocupacionais, Lesões por Esforço Repetitivo (LER) e DOO	NR 17.2 e subitens NR 17.3.1 e subitens NR 17.3.2; NR 17.3.3; NR 17.3.4; NR 17.3.5								Química de alongamento para evitar problemas na coluna; manter tempo em locais de circulação e armazenagem em de materiais.

Figure 9. HSE best practices banner.

## 5. Final considerations

The health safety and environmental management system model shown in this chapter resulted from the application of a methodology called Ergonomic Design Thinking. It is based in two equivalent project management approaches easily found in design and ergonomics projects. Preliminary experiences had already shown that the Design Thinking approach proved itself effective not only for design project actions [20]. Using the general concept derived by Tim Brown's original approach, EDT adds the basic principle of ergonomics: No one knows better the work performed than workers themselves. And this is particularly true for ergonomics projects, since ergonomists and human factors professionals know exactly what is necessary to allow a perfect synchronicity between their logic and knowledge and the correct listening and interpretation of what some have been calling "the voices of the shop floor" [21].

Naturally, much more real-world experiences are needed to master the technique and to affirm without shadow of a doubt that this model is more effective and others. It is definitely better than the ones the authors have previously utilized. Hopefully, the publication of this text will provide an opportunity to disseminate the method and its tools to a more broad and global audience. To wrap up the discussion, a list of important issues that should be addressed before employing any participatory action method is presented down below.

1. Know who the end users are (and involve them),
2. Employ one methodology (not "the" methodology),
3. Emphasize iterativeness (not only interactivity),
4. Break the linear ruling (but don't run in circles),
5. Don't ever give up (make lemonades with sour lemons),
6. Be trustworthy (never hide flaws and mistakes),
7. Communication is key, fear control is out (stimulate reports),
8. Simulate real job situations (don't guess what you don't see),
9. Never fear opposition (get opposition closer),
10. Present well viewpoints (perception is more important than reality).

One last issue is important to address. The best thing about both EDT methodology and our proposed HSE management system model is that they do not employ intricate, complex tools or instruments. It is completely "open source", so there is no proprietary software to buy, copyrighted materials or any similar exclusivity resource. Even some known and common tools used during ergonomic assessments, like the Corlett Diagram and the NIOSH equation for horizontal load handling, for example, are not under any trademark imposition. It was designed as a collective experiment in which all free men is more than welcome to join in.



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## References

- [1] Kleindorfer, P. R., Singhal, K., Van Wassenhove, L. N., (2015). Sustainable Operations Management. *Production and Operations Management*. 2005; 14: 482–492. doi:10.1111/j.1937-5956.2005.tb00235.x
- [2] Santos, M., Soares, M., (2016). Ergonomic Design Thinking – A Project Management model for Workplace Design, In: *Ergonomics in Design: Methods and Techniques*, Soares, Marcelo & Rebelo, Francisco (Eds.), Boca Raton: CRC Press.
- [3] Ministry of Labor and Employment (MTE), (2015). National Strategy for the Reduction of Work Accidents 2015–2016, Brasília – Brasil.
- [4] Brown, T., (2008). Design Thinking, *Harvard Business Review*, 86: 84–92.
- [5] Jonh R. W., (2014). Fundamentals of systems ergonomics/human factors. *Applied Ergonomics*. 2014; 45(1): 5–13. DOI: 10.1016/j.apergo.2013.03.021
- [6] Hendrick, H. & Kleiner, B. (Eds.), (2016). *Macroergonomics: Theory, Methods, and Applications*, Boca Raton: CRC Press.
- [7] Santos, M. et al., (2009). Can We Really Opt in Terms of Ergonomic Methodologies and/or Approaches? In: *Annals of XVII IEA Congress*, Beijing.
- [8] Santos, M., (2012). The PhOCoe Model – Ergonomic pattern mapping in participatory design processes. *Work* (Reading, MA). 2012; 41: 2643–2650.
- [9] Brazilian Association of Technical Standards, (1991). Areas of experience in construction sites - ABNT / NBR 12284, 1991.
- [10] Haslam, R. A. et al., (2005). Contributing Factors in Construction Accidents. *Applied Ergonomics*. 2005; 36(4): 401–415. doi:10.1016/j.apergo.2004.12.002

- [11] Couto, H., (1995). *Ergonomics Applied to Work: Technical Manual of the Human Machine*, Vol I and II, Belo Horizonte: ERGO.
- [12] Fundacentro[CS627], (2012). Jorge Duprat Figueiredo Foundation for Safety and Work Medicine. 2012. Annual Report on Safety and Prevention at Work (in Portuguese), available at <http://www.fundacentro.gov.br/> 05/23/2016.
- [13] INSS, National Institute of Social Security (Brazil), (2013). Statistical Data Annual Report, available at <http://tabnet.datasus.gov.br/tabdata/cadernos/cadernosmap.htm> 05/27/2016
- [14] Soares, L., (2008). The financial impacts of labor accidents on the Brazilian budget: A political and pedagogical alternative to reduce expenses, Dissertation ISC, Brasília, 2008.
- [15] SESI - Social Services Industry, Safety and Health in the Construction Industry in Brazil - Diagnosis and Recommendations for the Prevention of Accidents at Work, SESI Annual Report (in Portuguese), 2015, available at [http://arquivos.portaldaindustria.com.br/app/conteudo\\_18/2014/07/28/6973/ESTUDODESST2015.pdf? R = 0.625125239368](http://arquivos.portaldaindustria.com.br/app/conteudo_18/2014/07/28/6973/ESTUDODESST2015.pdf?R=0.625125239368) 05/27/2016
- [16] Environmental Canada, (2013). Canada's Emissions Trends Report, available at [https://www.ec.gc.ca/ges-ghg/985F05FB-4744-4269-8C1A-D443F8A86814/1001-Canada's%20Emissions%20Trends%202013\\_e.pdf](https://www.ec.gc.ca/ges-ghg/985F05FB-4744-4269-8C1A-D443F8A86814/1001-Canada's%20Emissions%20Trends%202013_e.pdf)
- [17] Karpinsk, L.A. et al., (2009). *Differentiated Management of Civil Construction Waste: An Environmental Approach*. Porto Alegre: Edipucrs, 2009.
- [18] Santos, M., Vidal, M., (1999). The Use of Live Animated Simulations for Malfunction Prevention in Facilities, In: *Proceedings of the I Latin American Ergonomics Conference*", Salvador, Brazil, September, 1999.
- [19] Bonfatti, R. J., Vidal, M. C., (2003). Conversational Action – An Ergonomics Approach to Interaction[I8], In: *Rethinking Communicative Interaction*, Grant, P., (Ed.), John Benjamin Publishing Company, Philadelphia, US ,pp. 108–120.
- [20] Siqueira, O. A. G., Cunha, L. S., Pena, R. D. S. F., Corrêa, B. S., Amorim, M. E., (2013). Project Methodology for Design, Ergonomic Methodology and Design Thinking: Convergence in Developing Solutions in Design. In: *Cadernos Unifoa Especial Design - Centro Universitário de Volta Redonda Fundação Oswaldo Aranha*, Vol. 1, December, pp. 49-66.
- [21] Santos, M., Vidal, M., (2008). Success or Failure, What a difference a good plan makes: A Benchmarking Case Study of Robotics Implementation in Two Public Pharmacy Facilities. In: *ICIEOM (International Congress on Industrial Engineering and Operation Management)*, Rio de Janeiro.