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MEASURES OF COLLECTIVE PROTECTION FOR THE CONSTRUCTION OF BUILDINGS IN METALLIC STRUCTURES: A NEW APPROACHING

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Proposal: The use of metallic structures in the construction of vertical buildings, still in small scale, starts to spread out in the northeast of Brazil due to its diverse advantages such as: properties of high tensile strength and compresssion, homogeneity of the material, reduced time of execution due to the industrialization process, possibility of reusing materials amongst other characteristics. However the processes of manufacture and assembly of metallic structures are characterized by the raised potential of serious accidents risks. Since the assembly is faster than the other stages of the construction, it is very common to still find buildings in metallic skeleton, and the laborers working in unsafe conditions. In this context, it is realized that the incorporation of this new constructive method requires some cares specially in relation to measures of collective protection of the workers, because the structures are ample and it is not possible the mere adaptation of measures for protection normally used in workmanships of armed concrete frames. The sector lacks of information techniques that make possible the application of the relative requirements to the system of protection in compliance with the effective norms of Safety at Work. The objective of this work is to consider measures of collective protection of safety for the workers, in the phases of manufacture and assembly of constructions in metallic structures. Method of research/Approaching: Survey of the technical estate and current law on measures of security in metallic workmanships, followed by a diagnosis and qualitative evaluation of the measures used in two worksites in the State of Pernambuco, through the accompaniment of the constructive process, interviews and documentary analysis. Results:

The measures of collective protection proposals are adapted for the specificities of the sector and based in the requirements of the NR-18 in order to minimize the risks of accidents and to improve the workers' quality of life.

Palavras-chaves: Management of safety in construction; Safety at work; Metallic structure.

Seção 1.01

1. Introduction

Currently in Brazil, due to increasing value of steel, the trend would be an effect of restraining in the investments of the metallurgic sector. However, this economic branch is in ascension, nevertheless with one still discrete parcel in the northeast region of Brazil. In 2002, a great company of steel production introduced in Brazil the production of plated profiles. Called as structural profiles, it represented the ascent of another important step in the technological advance of the construction in steel segment. An aspect which unites to this situation is the fact that the Brazilian market has tried a gradual growth in the offer of complementary products, as panels of internal and external closing, flagstone of the most varied types, finishing, paintings and coverings, allowing flexibility in the projects and the execution of any type of workmanships in metallic structure (IIDONY, 2004b). For this reunion of factors, one considers that the market of construction in steel has been remained reasonably warm. In civil construction, the participation of the metallic structure, still relatively small, has displayed a good performance and a constant and consistent growth in the last years.
Properties of high tensile strength steel and compression, homogeneity of the material, reduced time of execution due to the industrialization process, possibility of reusing the materials, amongst others, define the main advantages of the using of steel in civil construction (IIDONY, 2004a).

However an important consideration that must be made is that the processes of manufacture and assembly of metallic structures are characterized as of great potential of risks of serious accidents. The activities not only demand refined technical knowledge and good physical preparation for the heavy work, but mainly sensitivity with safety during the innumerable phases of the work, that go from the simple preparation of the seedbed, to the final assemblies of great structures. According to Barkokébas Jr et al (2004), the accident is an outcome of the combination of a series of factors and it hardly occurs in consequence of one only cause. Another aggravation, more specifically to the northeast region of Brazil, is the lack of technical knowledge in what refers to the methods of safety, caused by the simple factor that construction in metallic structure is a technological innovation in the sector.

The item related to metallic structures was introduced in the NR18 - Regulatory Norms of Safety and Medicine at Work, because of the great diffusion of this method in Civil Construction (SAMPAIO, 1998). Its use, in the distinct phases of manufacture and assembly, possess risks that require concrete actions in the prevention matter. Considering that the assembly is faster than the remaining portion of the construction, it is very common to still find buildings in metallic skeleton, and the laborers working in quite dangerous conditions.

The great challenge, in virtue of the pioneering of some constructors in the branch, is to control the protection of employees used to work in buildings of armed concrete in civil construction, whom now, would be working in an area of exposition to activities of metallurgic principles, never seen by them before. Many times, by the lack of experience of the worksites administrators, these risks are only perceived after the beginnings of the work in the worksites, verified by the lack of orientation and training of the employees which takes them to extreme exposition to the risks of accidents at work. One knows that many times the

employees are recruited in the locality of the deriving workmanships or of other worksites where the safety aspect is little or never observed.

Work in high places, heavy equipment, transportation of great dimension profiles, welds, cuts, esmerilhamento, amongst other activities, display new risks to the acquired conditioning of these workers, throughout their personal experiences in civil construction. For this reason, the workmanship managers need to be well guided, to plan the workmanship since the election and training of the teams, even before the beginning of the works in the worksites.

2. Theoretical referencial

In accordance with Pinho (2005), the metallic structures are constituted by a group of parts that after being joined will form a steady set that will support the building. For manufacture of the parts, it must have an industrial unit (it can be the worksite itself), where the means of production will be centered the means of production such as machines and equipment, laborers and administration, raw materials, etc. According to the author, the manufacture process can be understood as the transformation of the materials in parts through the basic operations of cutting, folding, piercing, and welding, among others.

In the construction in steel each part possesses its specific place in the structure and performs a role in the constitution of the workmanship. The act of joining the parts in the worksite to form the set of the structure assembly is called mounting (PINE, 2005).

In all the academic works that make use of Safety and Health at Work (SST) in metallic structure, are unanimous in relation to the importance that must be given firstly to the phase of planning the workmanship. A detailed study of the constructive stages, endorsed to the obligator normative disposals on what refers to the SST, it will supply subsidy to the efficient adoption of writs of collective prevention and individual safety. Iidony (2004a) states that the assembly plan when studied well will provide works in loco in accordance with safety limits.

Considering this premise, the following aspects of SST to be studied in the phases of manufacture and assembly of metallic structures will be analyzed.

2.1 Measures of security in the process of manufacture

Sampaio (1998) states that with the material being in the entrance of the workmanship, the normal sequence of the manufacture procedure is: a) Discharge; b) Classification and storage; c) Sizing and cutting; d) Esmerilhamento; e) Piling up of elements for storage. In all these sub-stages, each part of the structure will be manipulated and carried from one side to another, being deposited in a place, and later to be dislocated again. When the equipment of cutting and piercing, welding or painting are fixed, the parts will have to be moved from one place to another until being concluded. Therefore, the part is constantly hoisted, dislocated and stored in repeated operations. Because of this it is essential, at the beginning, to study the best equipment and process of transportation to be adopted in the worksite.

The most used equipments for hoisting of metallic profiles are the cranes and derricks. These means of survey of parts possess limits of load capacity, which cause limitations to the weight of the parts. It is important that each part has visible indication of its weight, in order not to submit to the machine to efforts above the established one. According to NR18, item 18.10.6, the pre-manufactured structural parts must have compatible weights and dimensions with the

carrying and hoisting equipment.

Beside these, in accordance with Pine (2005), the following factors can be displayed as limitations for the dimensions, weights and volumes of the parts - either in set, or individually: Relative problems to the path of transportation, as limitations related to the allowed width, height and maximum weights; Limits imposed by the process of assembly or the availability of space in the worksites; Relative limitations to the stability of the parts during the assembly process, either of one have asked for individually during the hoisting, or after occupy its place in the structure; Dimensions of the commercialized profiles, among others.

By these reasons or other derivatives of these, the parts must be conceived in the phase of the project and be prepared for transport, in order not to cause problems in the stages of transportation and assembly.

Another important issue to be analyzed is the procedure of storage of the metallic profiles in the workmanship. The profiles must be the nearest possible to the hoisting equipment, carried in a rational way, in order to prevent to the maximum its displacement (SAMPAIO, 1998). This measure by itself, has the power to reduce sufficiently the probability of industrial accidents risks proceeding from falling materials.

In the sequence, We consider the activities of oxyacetylene cut (intermittent in the manufacture process), which offer physical and chemical risks to the health of the workers, because of this it is needed to take preventive measures of safety with the use of individual protection equipment..

Another phase of the manufacturing metallic structures, which in particular is responsible for a great deal of accidents, is the operation of esmerilhamento, provoked by the particle projection against the eyes of the laborers or for rupture of abrasive records. For its prevention, Sampaio (1998) considers prevention measures of safety the use of fixed esmerilhadeiras, always when it's possible, the use of records or adequate abrasive rocks and maintenance of machines and records in perfect state of use. After executing the cut of the profile, in accordance with item 18.10.7 of the NR18, the barbs must be all removed in order to prevent the people being hooked or cut.

Finally, the process of common welding not only in the process of manufacture, but also in the process of assembly, deserves special attention due to the risks of electric shocks. The activities of welding by electric arc, also offer risks of poisoning by nitrogen oxide and metallic smokes, proceeding from the vaporization of the metal that is being welded and the used electrode. For this reason, activities of welding in open environments outdoors are recommended.

2.2 Measures of security in the process assembly

In the beginning, the assembly of metallic structures is relatively simple; since each one of the parts was conceived and manufactured for one determined position, and it is enough just to place them in their right place. However, either for the dimensions of the part and the workmanship, or by the necessary ways to make it fit with its position in the structure, the assembling displays sufficiently peculiar difficulties

It is important that in the definition of the stages of assembling the metallic structure, it is always important to make a parallel with the relative questions to the SST. As the assembly is faster than the remaining portion of the construction, Sampaio (1998) quotes that it is very common to still find buildings in metallic skeleton and the laborers working in quite dangerous conditions. Therefore it is basic to program the work in such a way that, when it is finished the ranking of metallic beams, one proceeds to the construction of the permanent floor, so that the ranking of the following beams is made in firm and safe basis. Similar to the manufacture process, in the assembly process the probability of the occurrence of industrial accidents is bigger specifically in the activity of hoisting the profiles. For this reason, to reduce to the minimum the risk of accidents in the transportation phase, it is convenient to also reduce the work of union of parts in high places, accomplishing the biggest number of them before the hoisting.

Based in these statements, before the transportation to the workmanship, the most complex structures as stairs and treliças, must be mounted preferentially out of the worksite (in a unit of manufacture), with the purpose of avoiding extreme works in the worksite, with high levels of complexity. Thus facilitating the checking up of measures and accomplishing of necessary adjustments, in addition to prevent the transference of problems at the safety at work levels to the worksite in the assembly phase.

According to Sampaio (1998), it is more and more frequent the overlapping of activities of diverse companies in civil construction. Therefore, the risk of falling objects on one team located below must be prevented. The author advises to interpose a barrier of one or more concrete flagstone between an activity and other to minimize the risks. During the hoisting of the parts of the structure, all the teams must be moved away from the area of possible falling objects, until the part is on one or more flagstone of protection. However, beyond the risks of projection of materials, there is also the risk of falling over the scaffold.

The measures of collective protection become therefore, an important weapon against accidents proceeding from falling of high places, this when well studied and implemented in the worksite. For instance, in a study of case in a company of metallic structure in Montenegro (RS), the constructor displayed a plain standard of assembling metallic structures in the worksite. Besides fixing hooks in the pillars and beams, one decided to leave punctures in the pillars for the passage of guiding-cables for the setting of security belts (SAURIN, 2004). This measure by itself does not guarantee the security against fall of height in the activities of assembling; however it becomes an important preventive instrument together with installations of provisory floor and body keeper which are obligatory items of the NR-18.

3. Methodology of research

First, a bibliographical survey for acquisition of knowledge on procedures of safety in workmanships of metallic structure had been accomplished, withholding to the phases of manufacture and assembly.

After that, information of two workmanships in constructed metallic structure in the State of Pernambuco had been collected, through interviews and analysis of documentations. The studied workmanships had been called by "workmanship A" and "workmanship B" and had respectively used 300 tons of steel and 130 tons of steel. The workmanship A comprises 2

floors and workmanship B 4 floors, which constructive process is characterized by superstructures in profiles plated in steel, with vertical walls of pierced ceramic bricks and horizontal floors in massive flagstone of armed concrete

After the data collection, it was made a qualitative evaluation of the adopted measures of safety in these worksites. Finally, on the basis of the bibliographical references and in the studies of the adopted measures of safety in these worksites, it had been elaborated proposals of measures for collective protection in the manufacture phases and assembly, adapted for the specificities of the sector and based in the requirements of the NR-18.

4. Results

When interviewing the administrators of the workmanships in study, the necessity to precede a minute study of the manufacture processes and assembly was unanimous, after establishing the delimitations of these areas in the worksite, besides choosing the equipment of hoisting in function of the executive safety and operational capacity. In the two workmanships, there had been concern about the study of the layout so that the area of storage of materials was leased strategically in order to diminish to the maximum the transports of metallic profiles, diminishing for consequence the risks of accidents.

With relation to the qualification of the workers, in the two workmanships they were concerned about the administrators in the selection of the employees who would participate of the teams of manufacture and assembly, considering that the activities would require not only technical quality but also, discernment for identification of the safety risks to which one would be exposed. In workmanship B, the employees still had been submitted to the qualification, being informed and instructed of the measures of safety that would be adopted in the worksite. They had received training from a team of the body of firemen for works in height and how to act in fire event. This had made easier the inspection by the safety team in elapsing of the workmanship regarding the employees' awareness of the risks to which they had been exposed, and the respective measures of safety that would have to be followed.

It is worth to remember that the following safety procedures proposed were evaluated not only theoretically, but mainly in practical with the employees in the worksite itself, and also analyzing later the effectiveness of the training. In case one verified imperfections in the agreement of the measures of control by the workers, the training would be revised and repassed until guaranteeing that such measures had met the effect expected.

4.1 Plan of jib

One of the great challenges in the assembly phase is undoubtedly the protection of the employees used to works in the civil construction, who start working in an area with exposition to activities of metallurgic principles. Work in high places, heavy equipment, transport of profiles of great dimensions, welds, sanders, amongst others, displayed new risks to the acquired conditioning of these workers, throughout their personal experiences in civil construction.

Aiming at the protection of the workers with concerning the risk of materials projection, one becomes necessary to adopt safety measures that prevent the transportation of structural profiles over workers. In accordance with the NR-18, item 18.14.5, in the transportation and

structural discharge of the profiles, beams and elements, measures of prevention must be adopted according to the signaling and isolation of the area

In order to attend this legislation, the "workmanship A" adopted measures of isolation of the area through the instruction and inspection of the team for safety of the workmanship itself. In the transport or assembly of a metallic profile, the security technician requested that everybody should withdraw until the operation was completed, and would not offer more risks to the worker, then the activities were released. Whilst in "workmanship B", a more organized procedure, through sonorous alert was adopted, indicating that the employees would have to withdraw of the risk area.

After that, a sufficiently simple procedure and efficient safety is presented, for isolation of area, called here as "Plan of Jib". It is a procedure sufficiently used in companies of iron assembly line, that easily can be applied in the phase of assembly of profiles.

The jib plan is a measure of collective protection, whose procedure is based on defining security areas, which does not display the employees the risks of falling materials, here more specifically the metallic profiles. When the plan comes into action, the employees must be alert to withdraw themselves for the security areas.

Initially, it must be chosen at least 2 (two) areas of safety delimited for protection keep-body, strategically chosen each one in an extreme limit of the land of the workmanship, with the premise of the guarantee of the inexistence of risks of projecting materials. These areas must have capacity to hold the amount of people who certainly will have to withdraw of the risk areas. For this, it will have to be everything minutely dimensioned. For better agreement, assuming the definition of two areas of called jib area "X" and area "Y", each one of these areas will be responsible for the jib of half of the worksite, that can be delimited by the central axis of the workmanship.

The reasoning is simple: Assuming that in area "X" the hoisting of a metallic pillar will be made, in a luminous viewfinder located in the middle of the worksite, that must be visible for all, it will ring a sonorous alert of 5 seconds with a luminous alert indicative of area "X", having to be vacated immediately. In the respective area, it will only be allowed the circulation of the specific assembly team of this front of service. In the case of the two areas are exposed to risk, in the luminous picture are indicated the lights of the areas "X" and "Y", having this being vacated simultaneously.

In all the procedures of dangerous transportation of parts which displacement displays risks of accidents of projecting materials, the crane operator himself must set in motion the safety system. This system could be set in motion by a buttonhole, having to be next to his area of performance.

The operations considered as dangerous, must be defined by the technical team of the workmanship and be repassed through training to the crane operator , preventing unnecessary stops to drive the plan of jib into action without necessity. Some examples of dangerous operations can be characterized as the transportation of parts above 6m of independent length of the height of displacement (figure 1) or the hoisting of pillars and the assembly of the beams incased between the borders in the superior face of the pillars.

(a) (b)

Figure 1 - Displacement of heavy profiles (a) and Assembly of metallic beam (b)

After executing the risk procedure, the signal lings in the viewfinder are extinguished, indicating that the employees can return normally to their activities.

For the good functioning of this "Plan of Jib", the following precautions must be taken: To train the crane operator where, when, and in which conditions the plan of jib comes into action, acquiring knowledge that this operation is strictly necessary to the conditions of risk to the security of the workers, preventing losses in the production of the employees with unnecessary stops; all the employees must be trained with practical simulation in the worksite; in the dangerous operations, only the strictly necessary employees defined by the resident engineer must participate directly of the operation, having all others to withdraw; the buttonhole of driving the alarm must be located always next to the work field of the crane operator, optimizing the running times, etc.

4.2 Projects of access

The construction of accesses (platforms, scaffolds, stairs, etc) in a construction of metallic structure, the principle, seems to be sufficiently easy, but there are the risks of inherent accidents to the function, it becomes a little complex when these accesses must be in accordance with the SST norms. Either in the "workmanship A" or in "workmanship B", analyzing its photographic registers, one verified that before being manufactured the definitive metallic stairs of the workmanship, tubular scaffolds with marine type stairs had been adapted making possible practical access between the floors. In accordance with the NR-18, these procedures are not acceptable, once the hand stairs must have its restricted use only for provisory accesses and services of small transport. It was also verified in the two workmanships, the use of tubular scaffolds without the right anchorage, braking, keep-body protection, wooden floors, thus offering risk of accident to the workers.

By means of these identified imperfections, the stairs of collective use for the circulation of people and materials must be projected in solid construction and endowed with railing and baseboard. Therefore, one recommends that the provisory accesses are projected, when possible, in the stairs of definitive access of the construction. This because the metallic stairs

can be pre-manufactured and easily mounted in loco, with the definitive railings already, preventing inadequate arrangements. With intention to avoid scaffolds with raised heights, and vertical overlapping of works, it is important to adopt the programming of works of concreting of flagstone before the assembly of the metallic beams of the immediately superior floor. Of this form, all the scaffolds had started to be supported in firm floor, also making possible the periphery keep-body installation.

4.3 Measures of protection against height falls

This point with certainty is what worries most the responsible ones for safety of the workers in workmanships of Metallic Structure. Due to wide personal experience that many workers of the assembly team have, they start to find that the risk is under control jeopardizing the possibility of the occurrence of an accident.

We can also detect, that the reason of this displeasure is fruit of the conditioning that the assembly teams are exposed to: "production" for mounted ton of steel. For being a selective team, and the proper metallic solution to only be viable due to the decrease of the factor "time of workmanship" for the costs still are high, normally there is an amount of money for gratuity of the income of these teams. Conclusion: "Who produces more, earns more".

In this context, the measures of protection against height falls become one of the most pillars important in the guarantee of safety of the worker to be adopted in the worksite.

Even if the process of assembly of the metallic structure is made simultaneously to the concreting of the flagstone, always there is the risk of fall for the employees who execute the assembly and weld of the profiles in the immediately superior floor, mainly in the periphery beams. In this in case, since the keep-bodies use is not possible due to the ample structure, the alternative that has been being used in the practical one to prevent the risks of fall of workers is the use of steel handles as measure of collective security.

This measure was used in the two workmanships in study, and particularly in the "workmanship A" it was also adopted periphery keep-body, guaranteeing effectiveness in the measure of protection against falls of the workers. In the other hand, in "workmanship B" the steel handles installed in the extremity of the construction had been removed only after beginning of the masonry of external prohibition, not being installed in no moment the periphery keep-body, being in disagreement with the NR-18. In accordance with the norm, it is obligatory in the periphery of the construction, the installation of protection against fall of workers and projection of materials from the beginning of the necessary services to the concreting of the first flagstone.

In the particularity of the activity of assembling of the metallic profiles of the immediately superior floor to the existing floor, one becomes necessary before the concreting of the flagstone the complete weld of the profiles, not being possible the installation of the guard periphery body. It is accurately this activity that only the steel handles can be adopted as measured efficient in the guarantee of the protection against fall of the workers, since the structure is ample not allowing the keep-body installation. In this case that, the steel handles can be passed in metal accessories welded in the proper pillars as adopted in “workmanship B" shown in fig. 2, or simply passing for punctures executed in the related pillar. For bigger

security, the use of stretchers becomes necessary to leave the handles well tensioned guaranteeing its efficiency. However, for the safe use of the steel handles as measure of collective protection against falls of height in workmanships of metallic structure, future studies are suggested so that this alternative can guarantee the fulfillment of all the requirements to the relative norm for safety and health at work.

Figure 2 - Steel handles settled in accessories welded in the pillar

Right after the assembling of the metallic beams, the steel handles of the periphery immediately were removed and installed rigid bulkheads, in system of keep-body and baseboard. Making a particularity to the workmanship of metallic structure, the keep-body also can be manufactured in tubular profiles in steel, being able to be reused in scale in diverse workmanships. An example of model suggested in this work is presented in Fig. 3.

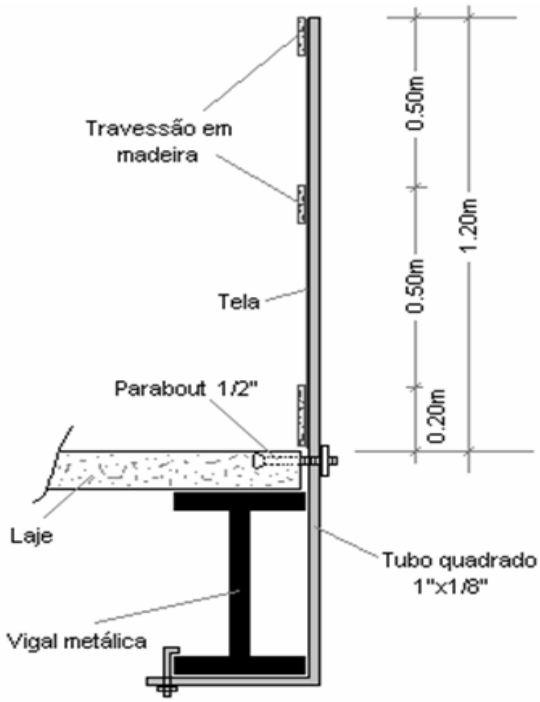

Figure 3 – Keep-body of adjustable periphery

This suggested model must be developed in compatibility with the safety norms, attending to the following requirements: Constructed with height of 1,20m for the superior dash and 0,70m (seventy centimeters) for the intermediate dash; Baseboard with height of 0,20cm and vain between crosspieces filled with screen or another device that guarantees the safe closing of the opening.

This solution of keep-body, that at the beginning can be considered onerous, is not. Because it can be used innumerable times and for some types of different beers of profiles (being adjustable), it becomes an ideal solution for safety and economy for constructors who want to invest in the branch of assemblies of Metallic Structures. It is important that all the computing of these structures, even if they are only keep-body function, is accomplished by specialized professionals in the area of structural calculation.

According to NR18.13.6, in all perimeter of buildings construction with more than 4 (four) floors or height equivalent, it is obligatory the installation of a main platform of protection in the height of the first flagstone that is, at the very least, a right-foot above of the level of the land. This platform must have, at the very least, 2,50m of horizontal projection from the external face of the construction and complement of 0,80m of extension, with inclination of 45º from its extremity. Similar to the keep-body, despite the workmanships in study having in the maximum 4 (four) floors, figure 4 illustrates suggestion proposal in this work for project of main platform of the workmanship protection.

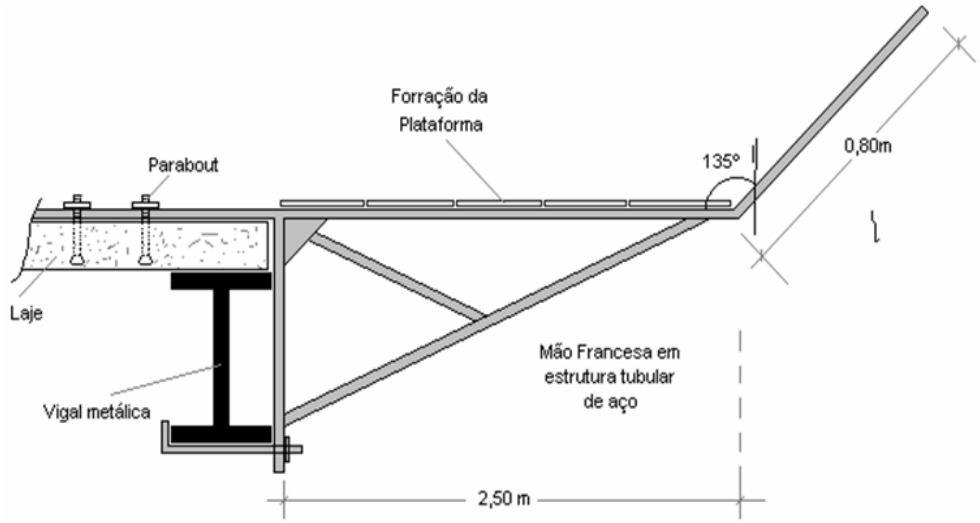

Figure 4 - Main platform of protection

Above and from the main platform protection, there must be installed, also, secondary platforms of protection, in rocking, of 3 in 3 flagstone. These platforms must have, at the very least, 1,40m of rocking and a complement of 0,80m of extension, with inclination of 45º from its extremity as demanded by the NR18. Once again, it is important to be aware that a platform project as this above, it is indispensable the sizing of the parts, by means of the requests to each they will be submitted. Only specialized professionals in the area of structural computing can define such specifications.

5. Conclusions

Each workmanship in steel is the result of a succession of decisions taken since the conception of the structure until the assembly of last part. It is important that each professional is aware of the possible repercussions of each phase on the others. The planning phase must deserve careful and detailed preparation, in order to become really safe, efficient and economic, to facilitate to the maximum the works in field, inside of the safety limits. Therefore, all the decisions must be endorsed to the obligator normative disposals in what refers to health and safety of the worker. From the agreement of this premise, the history of success of the workmanship starts to be written.

An important result of this work is the agreement of the necessity of the programming of the assembly work, in such way that finished the rank of the metallic beams, one proceeds to the construction of the permanent floor so that the following rank of the pillars is made in firm and safe basis. Since the assembly is faster than the remaining portion of the construction, it is very common to still find buildings in metallic skeleton and the laborers working in quite dangerous conditions. This measure would currently eliminate part of the risks of existing accidents in these worksites.

It is clearly, that the solutions displayed in this article are the consequence of the beginning of the concern with this new metallic structural conception in our region, knowing therefore that there is the necessity of new studies on the subject, having still to evolve a lot.

Finally, the work of the involved professionals with the conception and the construction of the structure will be realized by the common user from his concrete results: a pretty and useful durable and safe workmanship. However, to the professionals, the success of the workmanship will not be limited to the perception of the good acceptance from society or only in the economic results for the enterprise; it will depend mainly on the guarantee of the physical integrity of the workers, the greatest patrimony of the company.

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