



Geometric documentation of mining industrial historical heritage: application to a metallic headframe from the ancient mining district in Linares-La Carolina (Jaen)

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Abstract

The different types of headframes, located in the old mining district of Linares-La Carolina (Jaén), represent a magnificent example of industrial mining heritage, specifically related to the mineral extraction phase.

However, while being aware of its importance, the absence of the graphical information along with the lack of protection, it brings about a progressive deterioration in addition to the numerous cases of looting which are suffering.

Therefore, this communication is intended to rescue from oblivion these morphologies performing geometric documentation thereof. For this purpose, this study bases on in the engineering graphic understood as a fundamental tool for the comprehensive study and subsequent dissemination of that heritage. Only from a reliable three-dimensional model and the obtained detailed drawings, it can make a detailed functional analysis by techniques of Computer Aided Engineering which will identify the points where the stresses are highest and therefore know their structural behavior.

In particular, it has obtained the three-dimensional model of the headframe of the well No. 1 reef 'El Cobre' in the town of Bailen (Jaen), through the use of direct methods of capturing geometry measure and finally, by the use of AutoCAD software.

In turn, the three-dimensional model and plans obtained may be used for the dissemination of that heritage through an appropriate tourism promotion and a possible implementation techniques of virtual and augmented reality.

1 Introduction

The Mining Industrial Historical Heritage (MIHH) is one of the most outstanding examples of cultural heritage increasingly being studied from some viewpoints.

On the other hand, not many years ago there has been a growing awareness of the heritage related to mining and industrial activities and, the result of this, it was been worded the Charter of El Bierzo for industrial mining heritage in Spain (approved by the Heritage Council in June 2008) [1]. It has also developed numerous parks, museums and interpretation centers in various areas where there has been the decline of mining from the indoor cultural tourism initiatives. It has been called mining tourism, industrial tourism and even tech-tourism.

The manifestation of MIHH is wide, due to it depends on the specific activity, but could be classified in [2]:

1. Linked to extraction. There are examples as dumps, quarries and tips (Opencast), shafts and mining gallery (underground mining) and headframes, metallic derricks, masonry derricks, mining houses, hoppers, elevators, pumping powerhouse, boiler houses, smokestacks, compressors, storages or electric substation (support facilities for extraction).
2. Linked to the processing of the mineral. There are examples as washing, sorting and processing zones (washing and compaction) or power plants and smelters (transformation).

3. Linked to maritime and river transport or land. Some samples are the railways, railway stations and loading platforms.
4. Linked to social and administrative uses. There are examples as neighborhoods, headquarters, workers' housing, management house and technical home (accommodation) or schools, chapels, stores, hospitals, offices, casinos and sports facilities (equipments).

The present communication has focused on an MIHH example of mineral extraction phase, particularly in metallic headframe, with a support structure of the pulleys guiding the cages or elevators along the main shaft in a mining operation. The cages have the mission of communicating the inside with the outside of the mine, inserting and / or removing material, at the same time serve for the transport of the operators.

2 The metallic headframe

The use of metallic headframe applied to metal ore extraction process, started from this activity is known by humans [3].

It is an articulated support which has the direction of the resultant force between the weight of the material and the force exerted to raise, usually surmounted by a metal structure called headframe, with two pulleys which are wound cables extraction. In this way, it makes easy the ascent or descent of the cages.

In particular, in the old mining district of Linares-La Carolina, there was a boom in the mining of lead (from

galena or lead sulfide), driven by the technological advances of the Industrial Revolution. Not surprisingly, the mining landscape of Linares-La Carolina is one of 100 outstanding examples of industrial heritage by TICCIH (The International Committee for the Conservation of Industrial Heritage) [4].

In the above mining district has been numerous cases of metal and masonry headframe. Unfortunately, of which only some are due to the exploitation suffered for years.

Thus, this communication is to shed light on these ingenious for which hardly exists technical or graphic information.

2.1 Historical evolution

The historical evolution of the headframe is perfectly explained in an article by Menéndez Suárez [5], which is used to make this historical approach.

The use of 'lathe hand machine', perhaps used in pre-Roman mining, lasted almost until the end of the nineteenth century and it was used shallow wells with low volumes of extraction and also in interior short wells (fig. 1). From this book is possible get more data related to the historical evolution.

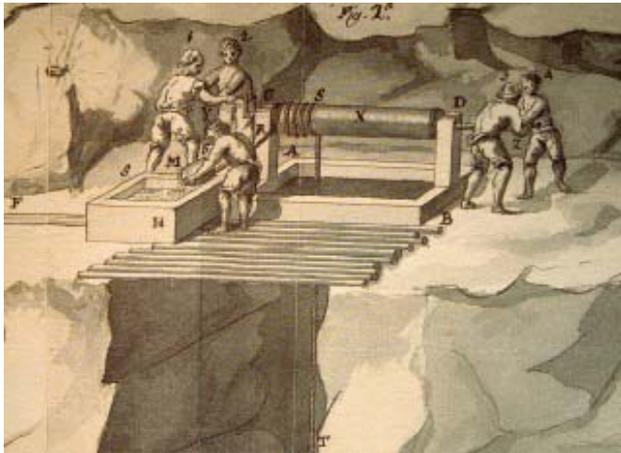


Fig. 1 Lathe hand machine (Illustration from the book 'Memoria de las Reales Minas de Almadén' by Bethancourt on 1783).

Afterwards, it was employed the lathe mechanic machine, where the movement is transmitted to the crank shaft through gears driven from humans, this allocation allows raising greater loads.

The subsequent to this was the 'blood engine' by humans. For this, the horse was used to transmit motion through gears and a lever.

Later 'capstan' or 'baritel' also appeared which was driven by force animal (fig. 2).

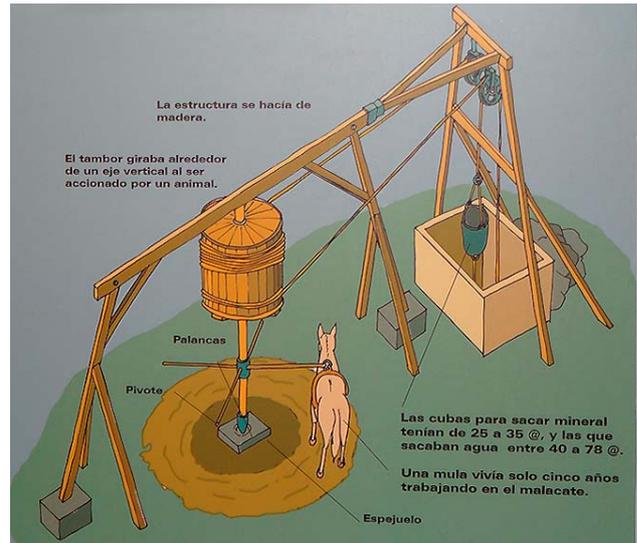


Fig. 2 Capstan (picture taken in the Interpretation Centre of mining landscape in Linares (Jaén)).

It is a wooden structure with a shaft or axle that in its upper part has a drum where two wires are wound, driving two pulleys. As a result, there is the ascending or descending of the extraction vessels.

This structure was kept during the sixteenth and seventeenth centuries, but with the arrival of the Industrial Revolution and, basically, the emergence of the steam, it was developed new devices such as the steam engine of a vertical cylinder for extraction purpose, mine drainage, among other uses.

In the early nineteenth century, it appeared the metal cable that is powered by the first steam engine of cylinder horizontal.

In the last quarter century, new devices are developed such as the friction Koepe monocable pulleys and then the Koepe multicable pulleys.

Finally, in the twentieth century, the steam was replaced by the electricity as an energy source, but the headframes are already abundant in the major extraction wells of mining sites.

2.2 Typologies

Essentially and under the structural point of view, the simplest headframes are composed of two uprights and, usually, a pair of struts braced together and also connected to the whole. From this basic structure triangulated innumerable variations can occur [5].

This author provides a rough classification that provides twelve types throughout the Spanish territory, taking into account the kind of materials they are constructed and the machines are located in the floor or suspended on headframes, whether they are flat cable coils, cylindrical drums, conical, bi-cylindrical-conical or friction system types of one Koepe cable or multi-cable for round cables.

But also, as indicated above, it can be classified according to the material they are constructed [6], remaining between these four types: wood, metal (pure or mixed with iron wood), concrete (reinforced or mass) and masonry, brick or mixed (masonry-brick or masonry-iron).

3 Methodology

In this section will describe the steps taken to obtain the geometric documentation of a metallic headframe

under study. It is located in the well number 1 of the property 'El Cobre' on the place 'Matacabras' of the town of Bailen (Jaen). It has been chosen for its excellent state of preservation and belonging to the type of metal headframe type 7 by the rough classification by Méndez Suárez [5].

Specifically, it has obtained its 3D model based on the use of empirical techniques whose input data were collected from a depth fieldwork, which has led to a series of dimensional drawings and an extensive photographic report. Thus, it was considered a valid methodology given the accuracy required by the work object.

3.1 Input data: Fieldwork

In the absence of detailed mapping to allow laboratory work to understand its geometry and dimensions, it was necessary to perform a series of tasks to collect such information as an extensive photographic report made with a digital camera model Canon Ixus 12 megapixel resolution.



Fig. 3. General view picture of the metallic headframe.

Figure 3 shows a general view of the headframe and in figure 4 it can be seen a detailed view of the pulley wheel.



Fig. 4 Detailed picture of pulley wheel.

Subsequent to photographic report were a series of dimensional drawings of all functional elements that make up the headframe, thus obtaining its geometry and dimensions. Thus, Figure 5 shows the dimensioned drawing the general outline of the tower.

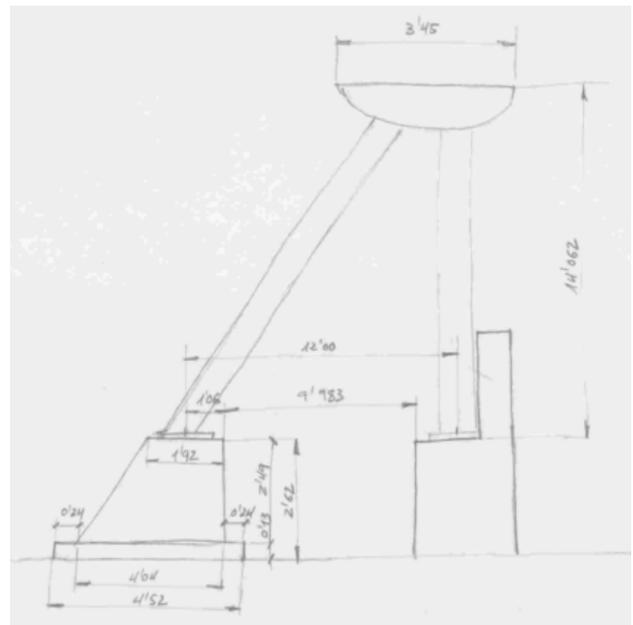


Fig. 5 Dimensioned drawing of general sketch.

The measurement in situ of the different elements of the set was complicated, because not all of them were accessible due to the large size of this one. Some dimensions were deduced by dimensional analysis and compared to other accessible elements.

The measuring instruments used were a flexible tape of 10 meters long with a Leica laser distance model: Disto D8. Presenting this great difficulty in taking measures that could exceed 5 meters; to determine the measure was necessary to set the laser pointer on the precise location for a few seconds for readability.

3.2 Geometric documentation

From the point of view of engineering, reliably dimensional modeling is an optimal tool as it allows the precise study of each model elements and providing an overview of how they are integrated between them.

Thus, based on the dimension drawings is performed laboratory work in order to obtain their three-dimensional solid modeling.

The software used was Autodesk AutoCAD 2012 [7]. Although this software is not parametric, which is recommended in design processes which will redefine the geometry of the object as a result of successive evaluations about this, the use of this program is justified for two reasons: first, for standardization, since the generated file (.dwg or .dxf file in its neutral variant exchange), no exchange problems if the generated model is then used in another application where you can add textures, lights, animations computer simulations or CAE applications for dynamic analysis of model behavior, and secondly, because of their ease of use, since not 3D solid modeling requires the use of too many commands.

4 Results

Following, it is shown the results of three-dimensional modeling of each element, confirming the whole set metallic headframe.

4.1 Support cross sections and foundations

They consist of two uprights and two struts. There is symmetry between them but there are not parallelisms between each pair of structural elements, making an angle between them of about 20° . Also, each element is formed by four angle sections 75 mm (fig. 6).

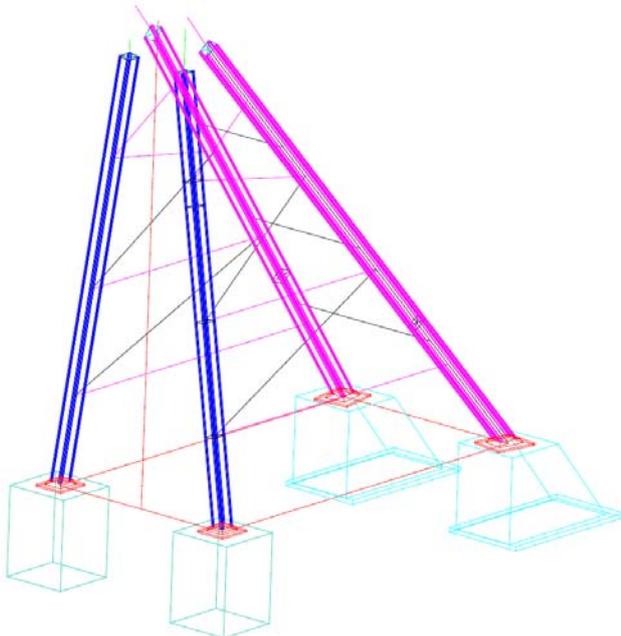


Fig. 6 Support cross sections and foundations.

4.2 Anchor plate and gusset plate on supports

These are going to serve for attachment of the lateral tie beams, connecting the upright with the strut, providing lateral rigidity to the structure. Its thickness is 7mm (fig. 7).

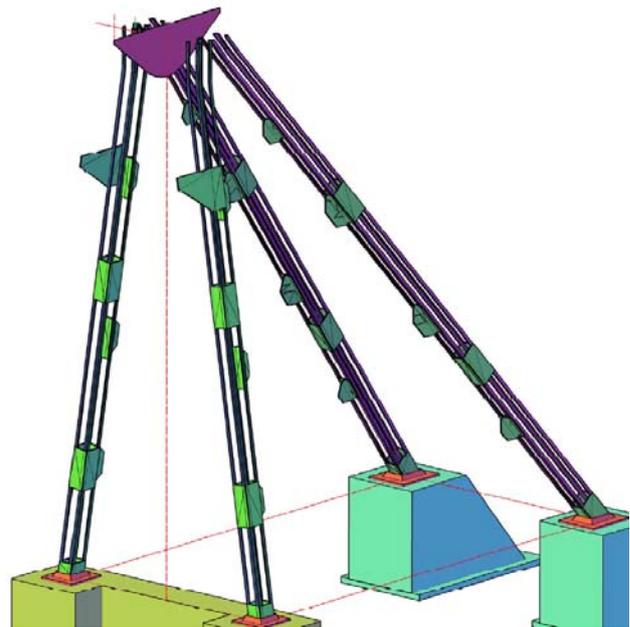


Fig. 7 Anchor plates and gusset plate on supports.

4.3 Clip of the support beams

They are prismatic plates 7 mm thickness which are located on the four sides of the pillars on the outside, being joined by rivets. Its mission is to form a composite profile so as to increase the rigidity of the support (fig. 8).

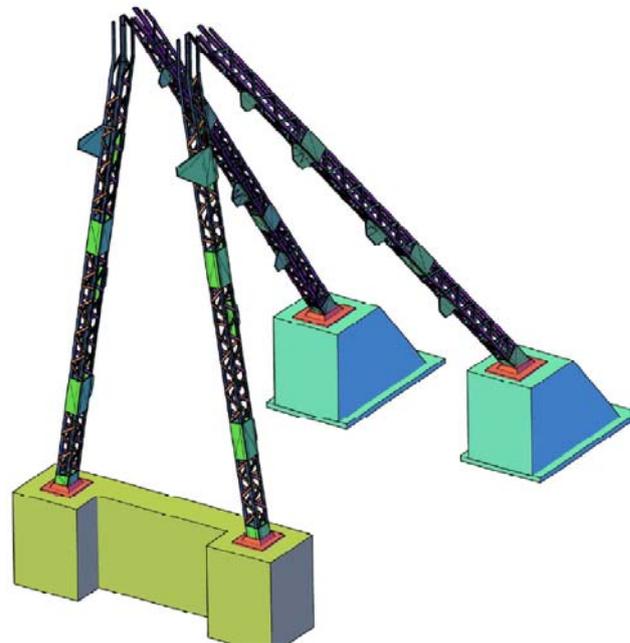


Fig. 8 Clip of the support beams.

4.4 Lateral tie beams

Its mission is to provide rigidity to the structure. Connecting the upright and the strut of each structural element and are joined with rivets on the anchor plates and gussets plates placed in the supports. The IPN profile is located 220 (figure 9).

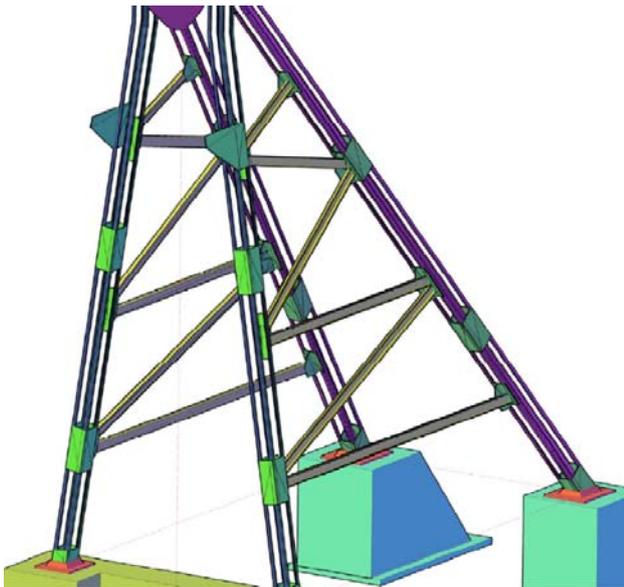


Fig. 9 Lateral tie beams.

4.5 Transversal tie beams

Its function is to provide rigidity to the structure. They are placed together so that the struts on both sides. The IPN 220 profile is located (figure 10).

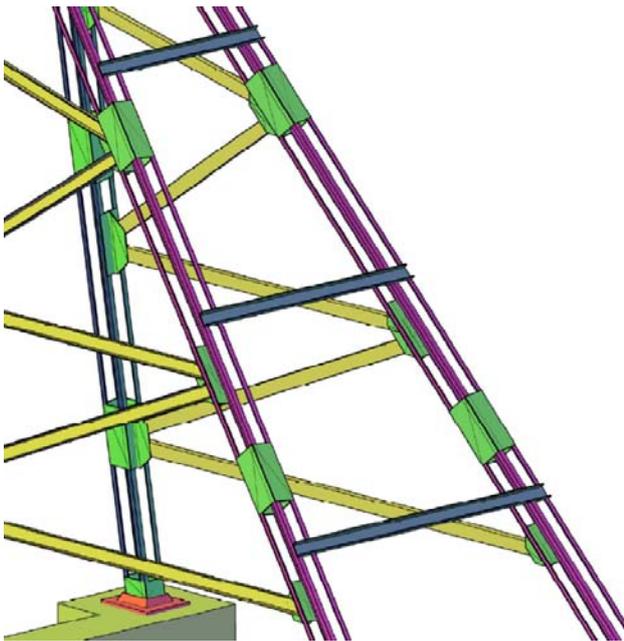


Fig. 10 Transversal tie beams.

4.6 Rivets of the joints

This type of joint is used to connect all elements of the structure. The rivets used are of spherical cap on both sides of 30 mm diameter with an intermediate cylindrical shaft (fig. 11).

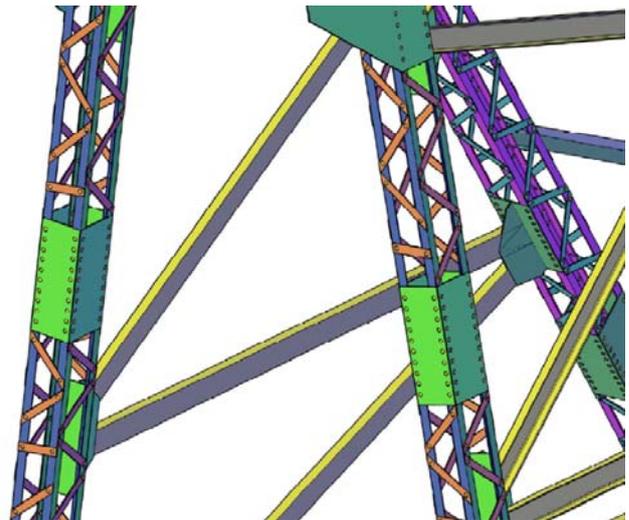


Fig. 11 Rivets of the joints.

4.7 Gusset plates between supports

Its mission is to provide rigidity to each pair of support, being located in the upper part of this piece next to the base. Are symmetrical trapezoidal plates with intermediate bonding a plate, the thickness of 10 mm (fig. 12).

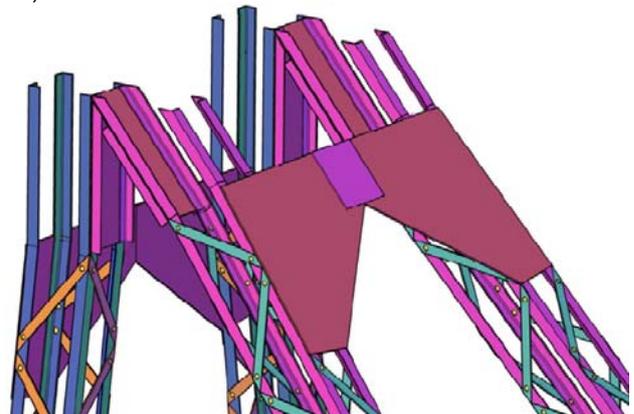


Fig. 12 Gusset plates between supports.

4.8 Base piece for attach elements

Structurally it is the most important part of the headframe and its function is to attach all elements of the structure, including the concurring on four supports, pulley bearings and roof structure.

It consists of parallel plates forming the bottom 'boxes' holes for the embedment of the supports, being joints made with double plates.

In the upper two cavities are formed to allow passage of the pulley wheels and the plate thickness is 10 mm (fig. 13).

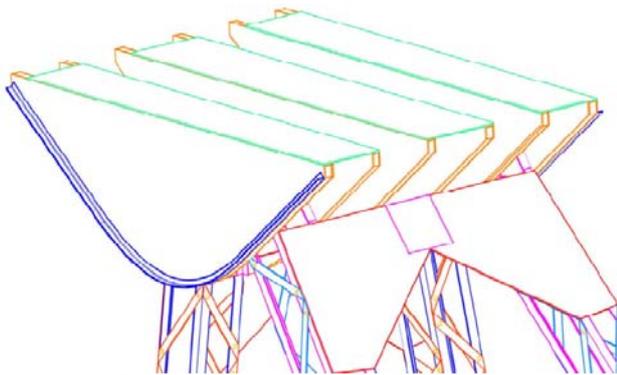


Fig. 13 Base piece for attach elements.

4.9 Pulley wheels

Its function is to support and guide the cables that permit the passage and movement of the cages.

They consist of several components, each having twelve spokes and an intermediate drum with a diameter of 2.80 m.

They are supported in two bearings and, in turn, these are supported on the floor of the base part (fig. 14).

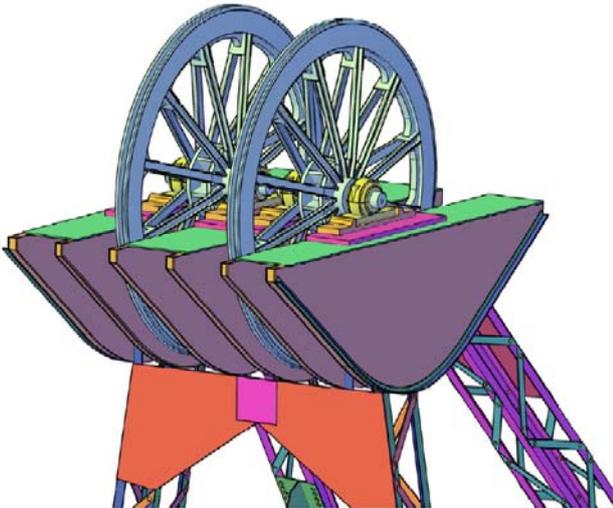


Fig. 14 Pulley wheels.

4.10 Bearings

These are the parts which hold the pulley wheels and contact the wheel axle on either side of it, allowing its rotation.

Internally usually have bearings to reduce friction between moving parts and the least resistance.

It is a double piece that allows insert the wheel axle at its upper parts and joint of the two parts is made with screws.

They are supported on plates that provide stability and rigidity to the assembly (fig. 15).

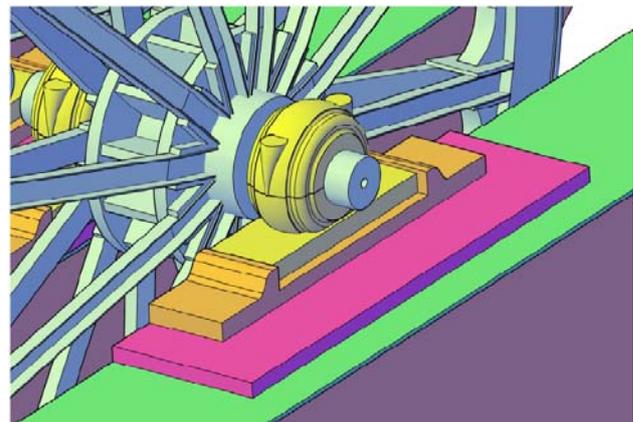


Fig. 15 Bearings.

4.11 Roof structure

Its function is to protect the pulleys from the weather.

It comprises a metal framework formed by U-profiles and angles, being the crossings reinforced with gussets plates that provide rigidity.

In the upper part plates are placed to cover the support, provided with longitudinal straps for supporting and fixing the cover plate (fig. 16).

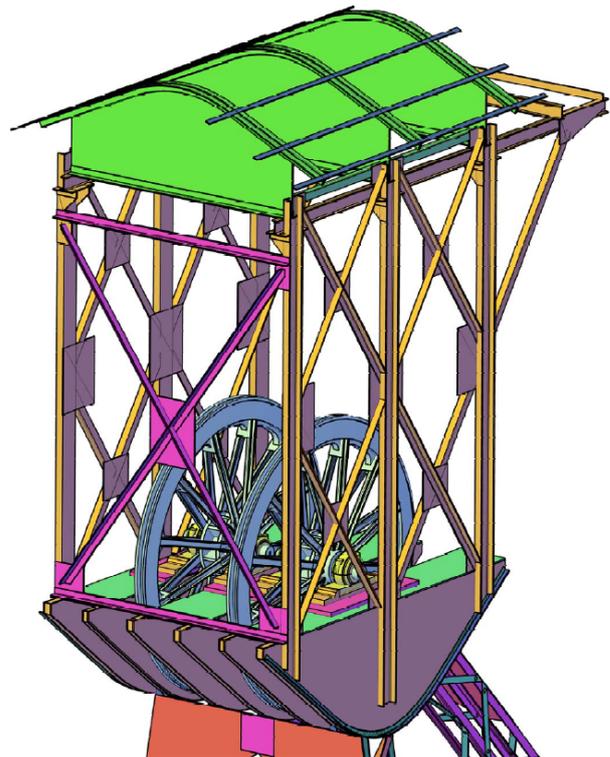


Fig. 16 Roof structure.

4.12 Enclosure of pulleys and cover

The cover is a corrugated metal plate that allows the pipeline and drainage of storm-water (fig. 17).

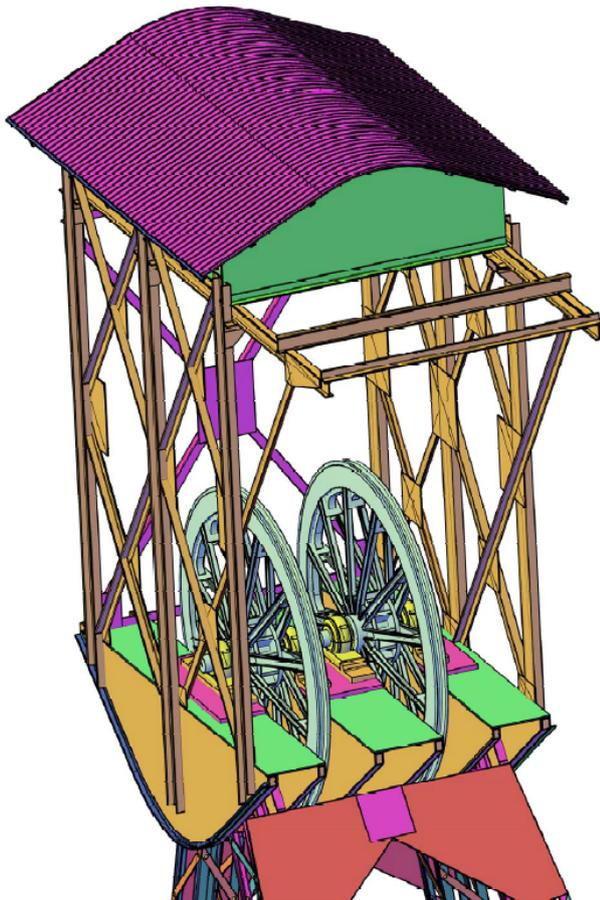


Fig. 17 Enclosure of pulleys and cover.

4.13 Guardrail

They are placed on both sides of the enclosure of pulleys and their mission is to protect the operator against falls that performs maintenance tasks. They consist of square-section hollow profiles (fig. 18).

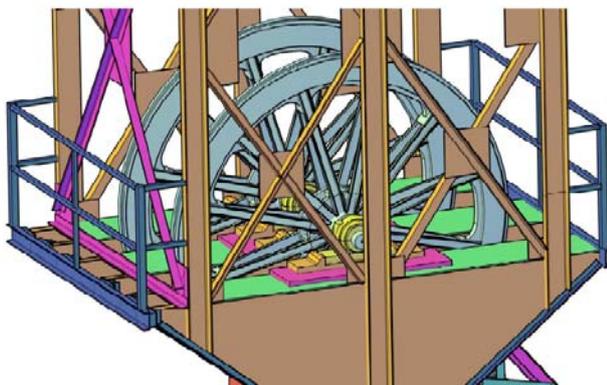


Fig. 18 Guardrails.

4.14 Access ladder

It enables access to the top of the tower, its basic structure being constituted by profiles with rectangular steps of circular section. It is attached to the lateral side of one of the uprights (fig. 19).

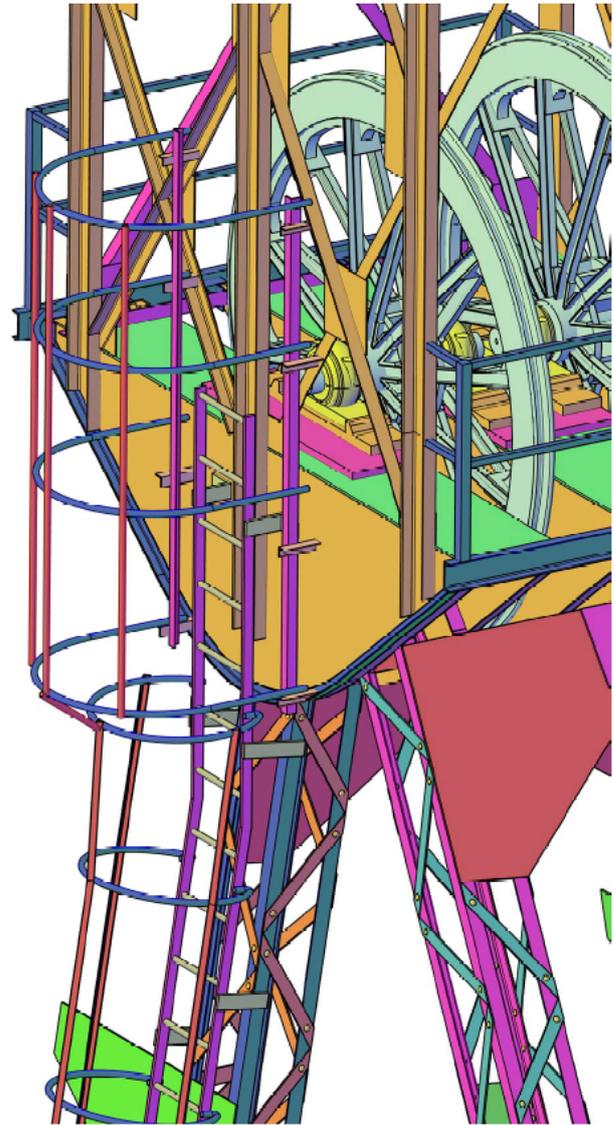


Fig. 19 Access ladder.

4.15 Outside guideway of cages

They support the cages when they are outside of the extraction well pithead and are formed by angle and U sections.

They are attached to the uprights and to the perimeter walls (fig. 20).

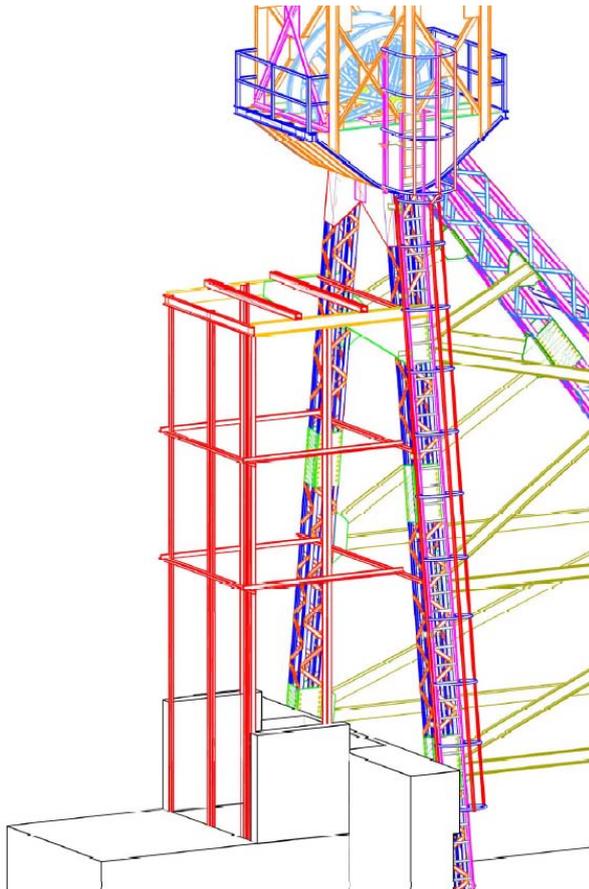


Fig. 20 Outside guideways of cages.

4.16 Cages

They let the transportation staff and material into the deposit, and its movement along the entire length of the main shaft. It consists of angle and U sections.

The movement of the cage is opposite of one over the other, ie while a cage is climbing, the other moves in the opposite direction, thus offering less resistance to advance (fig. 21).

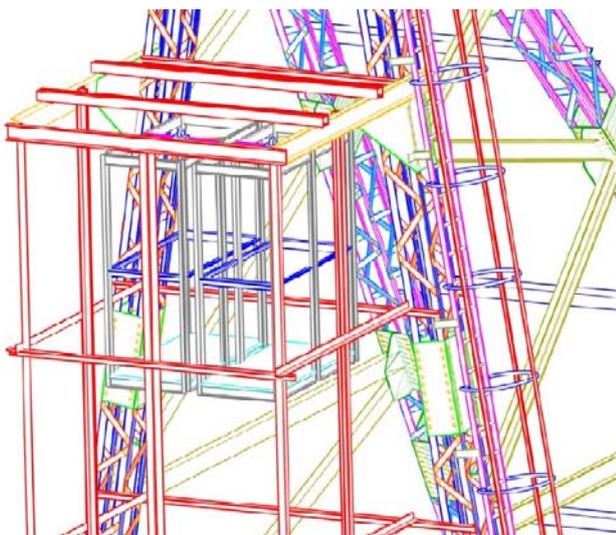


Fig. 21 Cages.

4.17 Overview of the metallic headframe

In figure 22 shows an overview with all elements of the metallic headframe and the rest of the set (fig. 22).

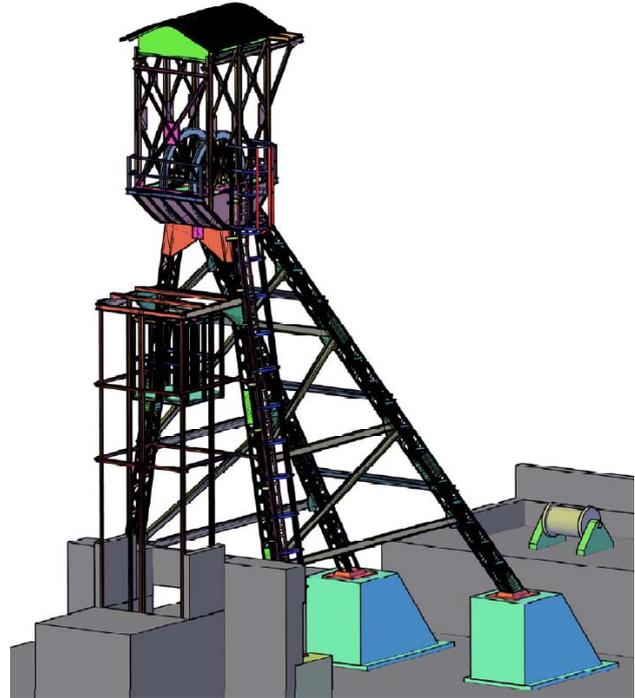


Fig. 22 Overview of the metallic headframe.

5 Conclusion

It has obtained the three-dimensional model of a metal headframe performed from all the elements that constitute it, thanks to CAD techniques.

The fieldwork performed 'in situ' is supported by empirical measurement techniques. It has resulted essential because from the information collected through the dimensional drawings and depth photographic report, it has been possible to obtain relevant information that has allowed obtaining a reliable model of headframe which will be a key element in future actions such as computer animation or relating to computer-aided engineering, particularly stress analysis or displacement.

In the other hand, although the geometrical documentation could have used other techniques such as dimensional analysis perspective based on a photograph, or the use of 3D laser scanning point cloud obtained to define the models, we believe that these techniques given sufficient empirical accuracy to meet the overall objective of this research.

Finally, the work done by the application of engineering graphics, greatly contributes to the preservation and valorization of rich historical mining industry in our country that is often neglected and suffered the plundering.

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