People's Democratic Republic of Algeria
Ministry of Higher Education and Scientific Research
Kasdi Merbah University - Ouargla
Faculty of Applied Sciences
Department of Mechanical Engineering

Order number: …………
Serial number: …………

A dissertation submitted in fulfillment
of the requirements for the degree of Master

Domain: Science and Technology
Field: Mechanical Engineering
Specialty: Mechanical Manufacturing and Production

Title:

STUDY AND DESIGN OF A SAND CONVEYOR BETWEEN THE SIDES OF A ROAD

Presented by:
Hicham LAZRI
Abdelhamid NAIMI

Publically defended on: June, 16 2022

Before the jury:

Chairman	Mr. Mourad BOUKHATEM	Lecturer (class B)	UKM Ouargla
Supervisor	Mr. Mehdi KHALFI	Assistant professor (class A)	UKM Ouargla
Examiner	Mr. Abdelhafid GHERFI	Assistant professor (class A)	UKM Ouargla

Academic year: 2021/2022

Acknowledgment

First of all our thanks are to Allah for giving us the strength and wisdom to help us go through this splendid journey in our university, and for blessing us with all his goodness.

Next our thanks are to our supervisor in this work Mr. Mehdi KHALFI assistant professor at Kasdi Merbah University of Ouargla for his guidance and patience with us while we worked on this dissertation. Your help will always be a milestone in our academic life.

We are deeply grateful to all members of the jury, Mr. Mourad BOUKHATEM, Lecturer at Ouargla's University, and Mr. Abdelhafid GHERFI, assistant professor at Ouargla's University for agreeing to read this manuscript and to participate in its defense.

We extend our sincere thanks to all members of the Department of Mechanical Engendering, and all those who provided a helping hand to us from far or near, directly or indirectly to finish this dissertation.

And finally to all the colleagues that we have met on this journey, without the help of all of you, this wouldn't have achieved.

Hicham & Abdelhamid

Special thanks

To my father who always has been a great role model, a truly self-made man and who helped me grow into the man I am today I give my best thanks.

To my mother who worked all her life to help achieve my goals and provide whatever support I needed. And who taught me lessons I shall never forget.

To my brother who always looked after me. He was a perfect older brother, and a second father. Your advices will always be remembered.

To all my family members whether close or far, I wouldn’t have made it without your encouraging and great support.

To all the friends and classmates I met during this journey, whose help got me to this point; your advices enlightened me and your encouragement kept me moving.

Hicham Lazri

Special thanks

To my father who worked hard raising me and made sure I grew up as a good man with the dedication to succeed and reach my dreams

To my amazing mother, who filled me with all lessons of politeness and taught me how to be a respectful man.

To all my siblings who shared my life with me while growing up you helped me grow up and evolve, no amount of gratitude will ever be enough.

To all my friends and colleagues who I shared with on this long and great journey.

Abdelhamid Naimi

Summary

- **English:**

Blowing sand in arid areas has always had its effect on infrastructure, from buildings to roads. Most commonly it creates an issue to vehicle transportation by blocking the roads. And In desert areas like the North African Sahara and Middle East having functional highways is essential to the economy. Multiple solutions have been discussed on the matter and the most known ones are generalized in two basic ideas, either by protecting the road installing fences or by creating a buffer zone between the road and the sand to keep safe. The use of conveyors in the transportation of materials is very common including sand, especially in construction sites and mines. The idea of this structure is based on the idea of creating a buffer zone on both sides of the road. By creating a bridge over the road using a mixture of belt conveyor and a screw conveyor installed on a truss structure in the shape of a triangle, the height of the structure is 5.5 m and width is 10 m to protect the cars with wheels for transportation.

- **Français:**

Dans le sud de l'Algérie, cette région où le climat est désertique, les moyens de transport sont d'une nécessité absolue pour le déplacement de marchandises, le transport des ressources logistiques ou simplement les voyageurs. Plus précisément, dans le sud-est, la région considérée comme la plus riche du pays, où plus d'un million et demi d'habitants y vivent et se déplacent en l'absence d'une bonne infrastructure convenable pour le transport ferroviaire; le transport routier devient une alternative nécessaire plus que maximale. L'enjeu climatique fait en sorte que ce type de transport rencontre plein de problèmes, le plus fameux qui sort du lot est : Le mouvement constant des sables qui bloque les autoroutes localisées entre les dunes. Plusieurs solutions ont été préconisées et essayées. Mais le temps avait prouvé que ces dernières n'étaient rien de plus d'une semi solution majoritairement provisoire. Notre méthode consiste à déplacer le sable sur l'extrémité de la route en utilisant des convoyeurs établies et supportés par une structure métallique. Cette idée assure une opération optimale sans bloquer la circulation ou causer le moindre dérangement aux utilisateurs de la route.

- **العربية:**

لطالما كان لتطاير الرمال في المناطق القاحلة تأثير على حياة قاطنيها. اكثرها شيوع هو خلق مشاكل في مجال نقل المركبات عن طريق إغلاق الطرق. وفي المناطق الصحراوية مثل الشرق الأوسط و الصحراء الكبرى في شمال إفريقيا ، فإن وجود طرق سريعة فعالة أمر ضروري للاقتصاد, لقد تم مناقشة العديد من الحلول حول هذا الموضوع وتم تعميم أكثرها شهرة في فكرتين أساسيتين، إما عن طريق حماية الطريق بتثبيت الأسوار أو عن طريق إنشاء منطقة عازلة بين الطريق والرمل للحفاظ على سلامتها. لطالما كان استخدام الناقلات في نقل المواد شائعًا جدًا بما في ذلك الرمال، خاصة في مواقع البناء والمناجم, يعتمد هذا الهيكل على فكرة إنشاء منطقة عازلة على جانبي الطريق, عن طريق إنشاء جسر فوق الطريق باستخدام مزيج من الحزام الناقل وناقل لولبي مركب على هيكل تروس على شكل مثلث، يكون ارتفاع الهيكل 5.5 مترا وعرضه 10 امتار لحماية السيارات ذات العجلات الخاصة بالنقل

Table of contents

List of figures

Nomenclature

dt	*The tensile force [N]*
μ	*Coefficient of friction*
N	*The normal specific pressure of the pulley on the tape*
P	*Total pressure*
Ω	*Rotation speed of the Archimedes screw [rad/s]*
Q	*Volumetric flow rate* $[m^3/s]$

Introduction

In the recent years, the discovery of vast hydrocarbons fields in the deserts regions around the world made them a strong player in each country's economy and stability. And having access to them was a necessity to ensure the well performance of such resources and also to support the working teams there.

Those regions soon grew to become major urban regions with people from different kinds of backgrounds living in them, as people come from all kinds of regions to be able to work either in the hydrocarbons fields or in serving the booming and growing new urban areas.

A perfect example of that is the region of south east of Algeria, which includes densely populated cities as Ouargla, Touggourt, Biskra, El Oued and the city of Hassi Messaoud which is the economical heart of Algeria. With a combined population of almost a million and half, these cities need a very competent system of transport to maintain the needs of its habitants.

With the very limited railways and trains in the region, and much more limited airways destinations (with their high cost tickets), it is up to the roads to connect the entire region. But, like anyone of these transportations modes, the roads have their limitations; one of its issues is the moving sands blocking the roads and the highways after sandstorms, the sand dunes that block the roads completely or partially do not just obstruct the traffic but also are a major danger to road users and their safety.

The regular wind especially in spring and the open stat of the region gives the sand a free space to move, causing all kinds of hazards from simple road blocking because of sand dunes to very dangerous accidents that can ends in fatal results.

From many solutions already done around the world, the main idea of them is to prevent the moving of the sand on the road and this by using fences on the roadsides or using loaders to carry the sand to other side of the road according to the wind direction.

In our region, we have seen that loaders are used to carry the sand to other side of the road to unblock the blocked roads (between Ouargla and Touggourt for example), this solution presents a risk to the road users while the loaders crosses the road to the other side.

To contribute in the solution of this problem, we have got an idea that centers not only on the concept of moving the sand according to the wind direction, but also avoiding the blocking of the road before the sandstorm and even after it while cleaning the road from sand dunes. We consider using a couple of conveyors fixed on a moving steel structure; a kind of bridge to carry the sand between the two sides of the road without blocking or even disturbing the traffic.

To clearly present this idea, we have established this document that is divided into three sections, each one includes a part of the work we have done in order to better present our idea and our possible contribution to solve the problem of the sands blocking the traffic after the sandstorms. The first chapter of it is a background literature of the road protection from moving sands followed by general information on conveyors in the second chapter and then the third and final chapter contains the conception of the bridge that we have talked about previously.

Chapter I
Road Protection from Moving Sands

I.1 Introduction

Drifting sand and migrating dunes present a major threat to agriculture, forestry, roads, railways, and other communication and distribution systems in many parts of the world. The problems are particularly acute in desert regions where the ground surface is covered by dry loose sands, precipitation is rare, and vegetation is almost absent. Attempts to limit the damage caused by blowing sand have a long history. Such measures that include avoiding, removing, transporting, trenching, planting, paving, paneling, fencing, and oiling have been suggested [1; 2].

The need for more effective measures of sand control has become more apparent in the past 50 years owing to economic growth and urban development related to exploitation of oil and gas resources in arid areas such as the Middle East [2; 3], northern Africa and central Asia.

The techniques to control blown sand have been operated in four distinct natural and social circumstances: wind-erosion control on agricultural fields; the control of dust; the management of coastal dunes and dunes in semi-arid areas; and the control of sand dunes and drifting sand in deserts [4].

Figure I-1: *Blocked road*

I.2 Importance of the highways

The importance of the highways in the region of Sahara can easily be seen in the huge use, and also in their high utility in the economic activity, without neglecting the main part of it being usable by most habitants.

In arid regions the highways represent the main artery to maintain the movement of individuals, merchandise and resources. As they are cheaper and faster and capable of covering much bigger areas than most other means of transport.

The biggest example stands in the eastern southern part of Algeria, being a growing and booming economic hub for multiple reasons, having to move multiple agricultural products into and out of the region, to both satisfy a large population, and the special products coming from it.

By knowing that the region represents the main source of incomes in the whole region, having issues with the highways can interrupt the function of the working machines, the transportation of all kinds of trucks, heavy equipment, prefab houses and also food to the workers in those hydrocarbon wells.

There is also the large number of vehicles registered in that part of the country, having more than 50000 new moving vehicles registered in the last 10 years who are constantly moving on those roads recording an average of 70 to 250 km a day (to attend work or university), makes some roads having to serve between 300 to 500 vehicle per one hour.

And because they are also used to the transportation of fuel, a blocked road can create fuel shortage and led to multiples economic losses as we have seen in the last years, also there is the waste of people’s time on long lines to obtain it.

Figure I-2: *Hassi Messaoud - Ouargla road*

I.3 Blowing sand

It has been recognized for some time that dust storms tend to occur more frequently during the day and less frequently at night. Early accounts of exploration and settlement in arid regions often contain vivid descriptions of dust storms that occur preferentially during daylight hours. For example, the Scottish explorer, James Bruce, while searching for the source of the Nile in North Africa, describes ‘moving pillars of sand’ that tend to form ‘immediately after sun-rise’ and he describes a ‘Simoom’ forming at eleven in the ‘forenoon’ and ceasing at ‘twenty minutes to five’ [5].

Jehudi Ashmun (1826), an early settler of Liberia, provides an account of a Harmattan dust event that ‘commenced about nine o’clock in the morning,’ peaked in intensity between noon and two in the afternoon, and gradually diminished in strength and ‘subsided entirely, after prevailing six hours’.

In a report on the Kharga Oasis, published at the end of the nineteenth century, John Ball, of the Geological Survey of Egypt, wrote that violent sandstorm winds of the Libyan Desert were ‘never experienced both at night and in the daytime: in the case of the strong gales lasting several days, the wind always abated at sunset, beginning again about 9 a.m. on the following morning’ [6].

The observed diurnal cycle of blowing sand and dust results from a process involving the interaction between solar insolation, thermal instability, atmospheric turbulence, and the movement of sand grains by wind. During the day, solar insolation is strong and thermal instability is at a maximum. Thermal instability enhances convective mixing within the atmosphere producing a downward transport of high momentum winds from the upper levels of the atmosphere to the surface layer, thereby enhancing surface winds [7; 8].

This momentum transfer occurs as swirling vortices or eddies swept along by the main flow. The larger eddies intermittently produce signify can’t gusts that may exceed the critical threshold of the surface to produce bursts of blowing sand. As satiating sand grains move across the surface under the influence of gravity, they repeatedly strike the soil surface and bring about the release of fine particulate matter. Once airborne, dust particles tend to become suspended and may be transported over great distances [9].

I.4 Blowing sand damages

Blown sand presents problems to the highway in different ways, depending on sand dune geomorphology, local wind regime, route direction and the disturbance created in highway construction. In general, blown sand can bring damage to the highway by deposition of its drift, encroachment of moving dunes, erosion of the roadside slope and avalanche of the slip faces of large dunes in road-cutting areas [4].

I.5 Blown sand control

Based on the type and extent of the blown sand damage principles for designing the blown sand control system of the highway are:

In the very active sand sections attempts are made to increase the surface roughness to prevent blown sand drift from generating in the shelter system and upright fences are set in the frontal edges to prevent sand drift from entering the shelter system. In the wind erosion sections, efforts are made to consolidate the side slope of highway from being eroded. In the fast moving small dune sections dune-fixing measures are taken to prevent the mobile dunes from encroaching. In the coarse sand-covered or salt-crusted flat sections the stable surface nearby the highway is protected from disturbance and side slopes of the highway are smoothed to transport the passing sand drift over. In high road embankment sections over which wind is accelerated the side slopes are rounded, smoothed and consolidated to form cross-sections resistant to wind erosion but favorable for sand drift to pass. Disturbance to the natural vegetation is avoided; in the sections, nearby oil field where oil workers live vegetative measures are taken to control blown sand on one hand and provide pleasing environment on the other [4].

I.5.1 Upright fences

The function of upright fences, which are set at the upwind frontal edges, is to block sand drift from entering shelter system, change the nearby airflow field, and prolong the shelter system's time of efficacy. Fences have to be renewed every a few years because sand will accumulate immediately nearby once they are set. Three kinds of upright fences were employed:

- Porous reed fences 1.1 m high and with porosity about 35% are used on small dunes where the sand drift is not very strong.
- Close clustered reed fences 1.3 m high and with porosity less than 10% are used on large dunes where the sand drift is very strong. The reed clusters are 5–7 cm in diameter.

- Porous nylon net fences 0.8 m high and with porosity about 60% are used in the inter dune flats where sand drift is the weakest to speed up the construction work.

All the three kinds of upright fences effectively checked the sand drift and changed the airflow field but the close clustered reed fences prove to be the most effective, as is evidenced by the field measured airflow fields around different upright fences.

The upright reed fence and clustered reed fence usually have an affected fetch of 20–25 times the fence height. To save cost the 10–20 m wide belt behind fence was remained unprotected for sand to accumulate. The sand drift on the windward slope increases from the foot to crest. Upright fences are set on the windward slope, 1–2 m to the crest to check the stronger sand drift [4].

Figure I-3: *Roadside cement fence*

I.5.2 Checkerboard barriers

Global climate changes and human activities are increasingly exacerbating desertification of land [10]. Dust storms are becoming increasingly frequent and, because their effects may be felt far from their point of origin, are attracting worldwide attention [11]. Sand-control measures have been dominated by efforts to return farmland to forest or other vegetation types, such as grassland, by planting trees and grasses to protect vulnerable land. These efforts will no doubt play an important role in improving the ecological environment. However, in regions where the eco-environment is in very poor condition, damage from blowing sand is an extremely serious problem and is difficult to control. As a result, sand-control engineering seems to be essential to protect important areas such as oil field installations, roads and living environments.

Semi-buried sand barriers in a checkerboard pattern offer a cheap, effective and widely used measure to control near-surface sand flow. Straw of wheat, rice, reeds and other materials is placed in the shape of a checkerboard and half is buried in the sand and the other is exposed. The checkerboard sand barriers can be installed at various sizes:

- 0.5 × 0.5
- 0.5 × 1.0
- 1.5 × 1.5
- 2.0 × 2.0

Figure I-4: *Checkerboard barriers*

I.5.3 Reed checkerboard barriers

The function of reed checkerboard barrier is to increase the aerodynamic roughness of ground surface so that the wind speed exerted on sand particles is below the initiation threshold, whereby sand drift is checked and a shifting dune stabilized. Field measurements show that the aerodynamic roughness length can be increased 400–600 times by checkerboards along the highway. Because of the easy availability of reeds, reed checkerboards constitute the main body of the shelter system.

The advantage of reed checkerboards over straw checkerboards used in other areas of China lies in their longer time of efficacy. The 1 m × 1 m specification was chosen for the reed checkerboard barrier considering the economic and construction feasibility and the fact that the aerodynamic roughness decreases almost linearly with an increase in the specification [12].

The exposed height of checkerboard is 10–15 m above the ground surface. Checkerboard barrier is also used as the pioneer measure for vegetative methods because the fine sedimentation deposited within checkerboards is favorable for the germination of some ephemeral plant when precipitation occurs [4].

Figure I-5: *Reed checkerboard barriers*

I.5.4 Chemical and clay fixers

The function of sand fixers is to cement sand surface to increase its resistance to wind erosion. The main chemical fixers include emulsified crude oil, emulsified asphalt, high-salinized water, L-P polymer. The easily available clay mixed by the local high-salinized water is another kind of sand fixer. Most of the chemical fixers prove to be effective but their cost is prohibitive, so they were primarily used to consolidate side slopes of high road embankment to form round and smooth cross sections favorable for sand transport over [4].

I.5.5 Artificial vegetation

Permanent stabilization of mobile sand can often only be achieved effectively through the development of a vegetation cover. However, attempts at vegetative stabilization should consider the inter-relationships between the following habitat factors: character of substrate, thickness of sand deposit, degree and nature of salinization, water storage capacity, nutrients and structure of soil, quantity and quality of available water, etc. [2].

Along the highway the most outstanding limiting factor is water. The conditions favorable for vegetation along the highway include rich solar radiation and ground-water in some places. So the key to establishing artificial vegetation is to select proper plant species and develop techniques to irrigate using the high-salinized ground water. Wells are made to pump the ground-water for irrigation. Drip irrigation proves to be the most ideal management method because it saves water and results in less salt accumulation. Large scale extension of vegetative measures is difficult along the highway because irrigation by the high-salinized ground-water in the desert is a fund and labor consuming tasks. Plant seedlings are fragile and easily damaged by blown sand at the beginning stage. The vegetative solution requires the use of a combination of mechanical, chemical and botanical methods at least until the vegetation has become firmly established. Usually, the blown sand is first stabilized by reed checkerboards barriers within which vegetation is planted [4].

Figure I-6: *Roadside plants*

Chapter II
General Information on Conveyors

II.1 Introduction

Bulk material handling systems are linked to a transport process continuous or discontinuous. The discontinuous system was until the beginning of the twentieth century the only means of transporting materials over long distances.

With the appearance of continuous transport systems, discontinuous handling is entered its phase of hypertrophy, because the conveyor belts are not handicapped by any problem loading, accelerating, braking or unloading.

However, this modern means of transporting bulk products, despite its reliability and economy has had difficulty establishing itself in the heavily dominated transport market, at the time, by the marketing of truck manufacturers.

The preferred field of the belt conveyor is the transport of all materials in general in particular, minerals, and this in all industrial sectors. We find also belt conveyors for the transport of isolated loads such as (bags, boxes, crates).

The considerable technological development of frame conveyor belts textile and new mechanical drive means, very frequently positions today the conveyor as a direct rival of the truck, of the railway … [13].

II.2 Conveyor definition

The conveyor is an automatic handling system that makes it possible to move finished or raw products from one station to another by the power transmission mechanism. The latter is transmitted from a driving shaft to one or more receiving shafts by through belts or chains.

Generally a conveyor is a mechanism composed of several elements including the purpose of transporting an isolated load (boxes, bins, bags, etc.) or a bulk product (soil, powder, food...) from point A to point B.

The product or merchandise being placed on a belt or on a sheet moves uniformly in a closed circuit. The speed of movement is relative to the rotational speed of the motor and can be reduced or increased according to the will of the operator taking into account a few parameters such as productivity and production rate [13].

II.3 Historical briefing

After the discovery by Michelin of manufacturing processes allowing the grip total of a rubber-to-steel mixture, the conveyor belt proved to be an ideal mechanization which is capable of becoming an equivalent partner to very powerful slaughter machinery by its continuous method of evacuation of the product and its possibility of ensuring significant flows.

The first appearance of belt conveyors dates from 1795 with a leather band and from there we can cite the sand carrier of the Russian engineer Lapotine (in 1860) put in service in the exploitation of alluvial gold deposits in Siberia.

From that time on, their scope of application had not ceased to extend until Goodyear gave them a momentum with the production of the first metal cords belt and since 1950 the equipment of the lignite mines of Germany offered them a wider field of application [16].

The year 1970 marks the beginning of a new stage with the achievement of the greatest conveyor in a single section of 13.172 km installed in New Caledonia with a transport capacity of 1000 t/h followed a little later by a set of 96 km in eleven sections (Western Sahara), the longest of which is 11.6 km.

In 1980 a new step was taken both in terms of power, length, and that of flexibility with the launch of the project to equip the mine ramp of coal from Selby (England) with a section of 14,930 km [13,15,16].

Currently, belt conveyors are considered an essential means of continuous transport in mining and industrial enterprises, the rate of conveyorization [15] continues to increase currently, and in 1960 it was less than 5% for open-air transport, as was the case in Germany, which carried out 1% of the transport of land of discovery, whereas in 1990 it rose directly to 30%.

Germany, Czech Republic, Slovakia and Poland achieve the 50% displacement of all the volume of rock by conveyors and the situation is analogous to the USA, the former USSR, and France [17].

For the year 1980, the former USSR alone evacuated 200 million soft rocks prevail a 10 kilometer chain of conveyors spread over twenty-one quarries and a chain of 3000 kilometers in underground mines [18, 19].

To generally illustrate the use of conveyor belts around the world and the performances achieved, we have drawn up Table I.1, published by Michel LEQUIME and Edmond BARIQUAND in which the authors only designate the carriers of large rectilinear or curvilinear crossing.

The belt conveyor is the most commonly implemented system thanks to the advantages mentioned below:

- The very reduced service personnel consequently and a more work output raised.
- Continuity of load flow which is reassuring for large excavator's throughput, packaged at a high rate, at the same time the transport equipment mining and, allows the automation of the complex process.
- Possibility of transporting loads on land with slopes up to 18° (45° to 60°) under special conditions.

II.4 Belt Conveyor

II.4.1 Definition

Belt conveyors (Figure II-1) are characterized by the type of belt conveyor used (materials, texture, thickness) and by the position of the group of motorization (central or end).

In all cases, a belt conveyor consists of:

- A control drum and its reduction motor
- An end roller
- A carrying frame with a sliding plate which provides support for the belt
- A conveyor belt**.**

Modular belt conveyors allow, thanks to their rigid acetal belt, to accumulate loads (with friction between the belt and the objects transported). The band is in fact a plastic chain which comes to mesh in sprockets also in plastic. In terms of maintenance, the advantage is not having centering and tension of belt to perform, unlike a conventional belt conveyor [20].

Figure II-1: *General view of the conveyor belt*

II.4.2 Components

a. The belt:

The belt transports the raw material from the tail to the head of the conveyor. She comes in two main forms, flat and troughs, any strip have two sides.

- The external face, which is in contact with the transported materials.
- The internal face, which is in contact with the rollers or the drums [20].

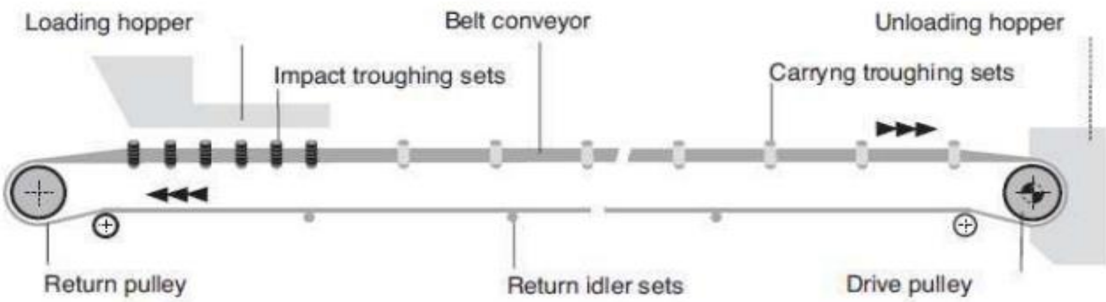

Figure II-2: *Basic drawing of a belt conveyor*

b. The pulleys:

The pulleys used in belt conveyors have the function of driving the tape or cause it to change direction. The drums can be covered with a coating to increase the coefficient of friction between the belt and the drum, to reduce wear by abrasion of the latter or create a self-cleaning effect [21].

- **Drive pulley**

The shift drum surface can be left in a normal finish or have a rubber coating whose thickness is calculated according to the power at transmit [19].

The diameter of the pulley is sized according to the category and type of belt, as well as calculated pressures on its surface.

- **Return pulley**

The surface of the crankcase does not necessarily need to be provided with a coating, except in some cases [21]. The diameter is normally smaller than that intended for the control drum.

- **Constraint pulley**

They serve to increase the winding arc of the tape; generally speaking, they are used in all cases where it is necessary to deflect the tape at the devices counterweight tensioners, mobile unloading devices, etc.

Figure II-3: *Constraint pulley*

c. Rolls

They support the belt and rotate freely and easily under load. Those are the most important components of the conveyor and they represent a considerable part of the total investment.

It is essential to size them correctly to guarantee the plant performance and economic operation [21].

➢ **Carrier stations**

Carrying rollers are generally fixed on mounting brackets welded to a crossbar or support. The angle of inclination of the side rollers varies between 20° and 45° [21].

Figure II-4: *Attaching the rollers to the support station*

➢ **Lower support stations**

Call also back strand, they can have a single roll across the entire width or two rollers forming a "\/" and inclined at 10°, according to figure 9 [21].

Figure II-5: *Lower support stations*

d. Tension devices

The effort required keeping the belt in contact with the drive drum and the inclination of the walls must be according to the way the product is transported, its trajectory, as well as the speed of the conveyor.

The particle size and density of the product, as well as its physical properties, such as humidity, corrosion, etc., are also of importance for the design [21]. According to their mode of operation, the tension systems are divided into two main groups:

- Fixed tension system.
- Self-adjusting tension system.

- **Self-regulating system**

This system keeps the preload constant while ensuring that the tension allowable band will not be exceeded. The most commonly used form is of a counterweight. The best effect is normally obtained by placing the counterweight at near the drum motor [21].

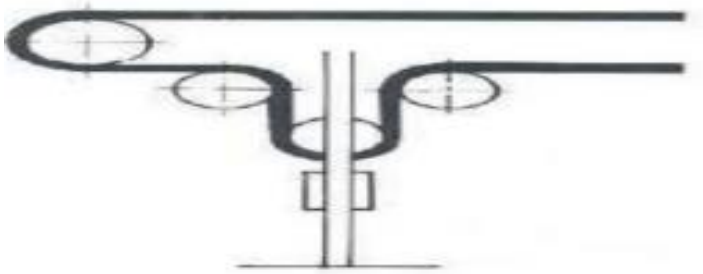

Figure II-6: *Self-regulating system*

- **Fixed tension system:**

Screw tension is often employed for short length conveyors with moderate load; this system (see Figure II-7) requires constant monitoring and frequent adjustment, mainly when commissioning a new band [21].

Figure II-7: *Fixed tension system*

- **Hopper**

The hopper is designed to facilitate the loading and sliding of the product in absorbing the shocks of the load and avoiding clogging and damage to the belt.

It allows immediate loading of the product and solves the problems of accumulation [21].

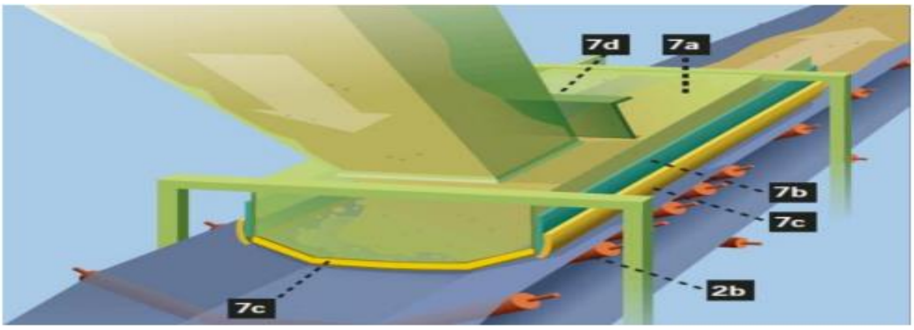

Figure II-8: *Loading system*

The hopper consists mainly of the following elements and in accordance with Figure II-8:

- 7a: Hopper Body: This is a guide, controls material flow.
- 7b: Guide rail: it centers the material or the isolated loads on the belt or the steer in a given direction.
- 7c: Sealing flap: prevents material from leaking from the sides (sealing flap side) or from the rear (rear sealing flap).
- 7d: Regulation gate: it controls the flow

e. Covers for conveyors

Covers for conveyors are of fundamental importance when it is necessary to protect the transported product from the ambient air and to ensure proper operation of the facility.

Figure II-9: *Conveyor cover*

f. The chassis

The chassis is the metal part on which the support stations are installed of the conveyor; it is generally fixed to the floor [21].

g. Motor

In this configuration, the motor, gearbox and bearings constitute a complete assembly, enclosed and protected inside a casing, which directly drives the bandaged. This solution eliminates all the complications associated with external transmissions, couples, etc. [22].

II.4.3 Traction force transmission by pulley

The transmission of the tensile force from the drive pulley to the belt takes place by grip. It is assumed that the elastic tensile member is in motion on the surface of the pulley then the change in tension in any loose element of the band (dx) can be determined by the following equation [23].

$$\frac{dT}{dx} = \mu \times N \tag{II-1}$$

Where:

- $\boldsymbol{dt}$: *The tensile force required for the considered element* $\boldsymbol{dx}$.
- µ: *Coefficient of friction of the belt on the pulley.*
- $\boldsymbol{N}$: *The normal specific pressure of the pulley on the tape.*

To determine the normal specific force N, we consider the section infinitely smallest of the band dx, on the angle $d\alpha$.

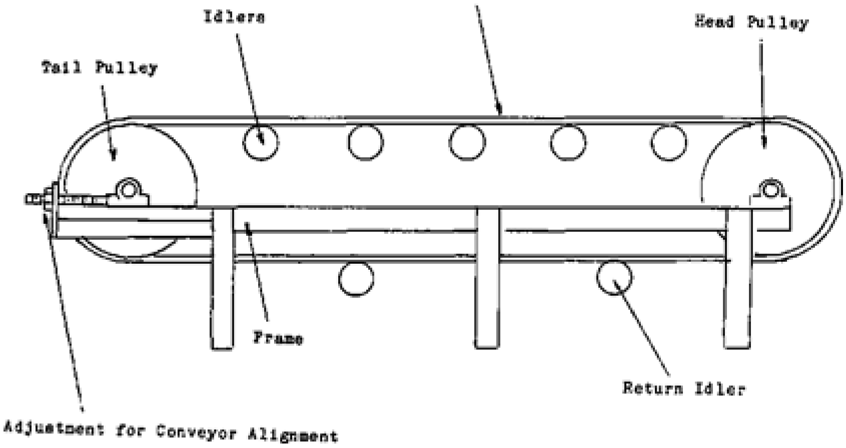

Figure II-10: *Diagram of a pulley*

From this we can deduce the total pressure exerted on it P

$$P = N \times dx \tag{II-2}$$

In this case P represents the resultant of the tensions T and $T + dT$

From the sine theorem we get:

$$\frac{\boldsymbol{p}}{\sin \boldsymbol{\alpha}} = \frac{\boldsymbol{T}}{\sin(90 - \frac{d\alpha}{2})} \tag{II-3}$$

As $d\alpha$ is infinitely small we set: $sin\ d\alpha \cong \alpha$

$$\sin(90 - d\alpha/2) = \cos d\alpha/2 \cong 1 \tag{II-4}$$

$$\frac{P}{d\alpha} = T \tag{II-5}$$

By replacing P with its new value

$$Td\alpha = Ndx \qquad \text{(II-6)}$$

It only remains to determine dx according to the radius of the Pulley R

$$\frac{dx}{2} R \sin\frac{d\alpha}{2} \cong \frac{Rd\alpha}{2} \rightarrow dx = rd\alpha \qquad \text{(II-7)}$$

II.5 Screw Conveyors

II.5.1 Definition

A screw conveyor mechanism consists of a rotating helical screw blade, called a "flighting", usually within a tube, to move liquid or granular materials. They are used in many bulk handling industries. Since the screw conveyor came into general use a little over a century ago for moving grains, fine coal and other bulk material of the times, it has come to occupy a unique place in a growing area of material handling processing. Today, modern technology has made the screw conveyor one of the most efficient and economical methods of moving bulk material.

The working principle of the Screw Conveyor is based on same principle as the Archimedes Screw that was used in ancient times in Greece and Egypt to draw water for irrigation purposes or to drain water from low lying mining areas. Archimedes' screw consists of a screw (a helical surface surrounding a central cylindrical shaft) inside a hollow pipe. The screw is turned usually by a windmill or by manual labour. As the shaft turns, the bottom end scoops up a volume of water. This water will slide up in the spiral tube, until it finally pours out from the top of the tube and feeds the irrigation systems.

The basic transport mechanism is that the material resting between two adjacent screw flights on the same axis is promoted to slip down the face of the rising side of the flight as the screw rotates. This action moves the product forward at the rate of one pitch per rotation of the screw, provided the material does not spill over the center shaft to fall back into the proceeding pitch space as when the cross-sectional loading exceeds the height of the Centre tube or the machine axis is excessively inclined.

Screw conveyors are but one class of screw type solids handling device, albeit a major form in industrial applications. Other types of helical screw-based solids handling machines are commonly described as ‘screw feeders’, ‘screw elevators’, ‘hopper discharge screws’ and ‘metering screws‘. Many forms of processing operations also utilize helical screws in their composition and many of the features described will equally apply to their operating circumstances [24].

II.5.2 Archimedes screw

The Archimedes screw consists of a screw (a helical surface surrounding a central cylindrical shaft) inside a hollow pipe. The screw is usually turned by windmill, manual labor, cattle, or by modern means, such as a motor. As the shaft turns, the bottom end scoops up a volume of water. This fluid is then pushed up the tube by the rotating helicoids until it pours out from the top of the tube.

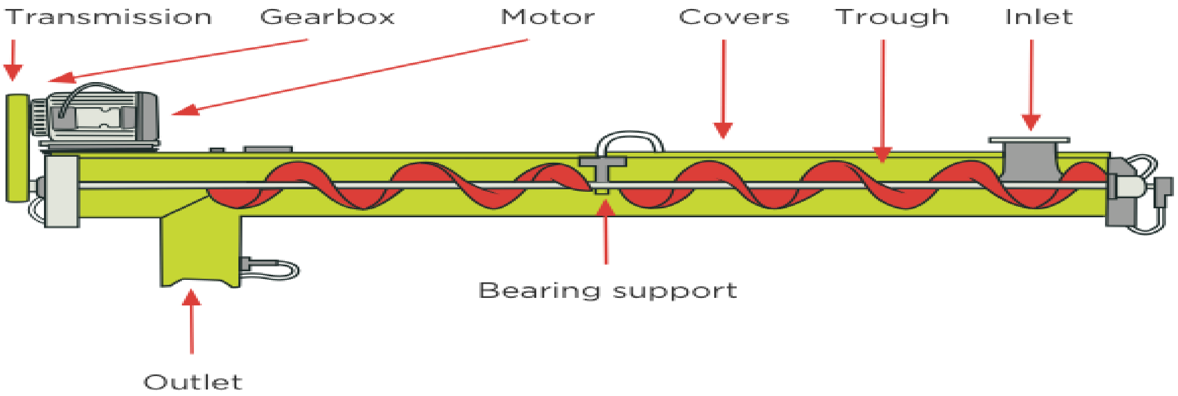

Figure II-11: *Diagram of the screw conveyor*

The contact surface between the screw and the pipe does not need to be perfectly watertight, as long as the amount of fluid being scooped with each turn is large compared to the amount of water leaking out of each section of the screw per turn. If water from one section leaks into the next lower one, it will be transferred upwards by the next segment of the screw.

The design of the everyday Greek and Roman water screw, in contrast to the heavy bronze device of Sennacherib, with its problematic drive chains, has a powerful simplicity. A double or triple helix was built of wood strips (or occasionally bronze sheeting) around a heavy wooden pole. A cylinder was built around the helices using long, narrow boards fastened to their periphery and waterproofed with pitch [25].

Based on the common standards that the Archimedes screw, designers use this analytical equation [26]:

$$D_0 = \left(16\pi Q/\sigma\omega(2\vartheta_0 - \sin 2\vartheta_0) - \delta^2(2\vartheta_i - \sin(2\vartheta_i)\right)^{1/3} \quad \text{(II-8)}$$

ω: Rotation speed of the Archimedes screw (rad/s)

Q: Volumetric flow rate (m^3/s)

Chapter III
Functional Analyze and Design

I.1 Main functions

The followings are the basic functions that the structure will perform; it will also give an early look on the overall design of it.

The conditions that must be assured in it are:

- This structure must be capable of moving sand effectively.
- The strength of the metallic structure must ensure its durability and resistance towards deformation.
- The metallic structure must be within the proper measurements of the road, to maintain its task without having to interrupt the users of the road it must be 5.5 meters of height and 10 m of width.
- The structure should have a system of transportation, over both short and long distances, a set of wheels with a proper engine for the short ones.
- This structure must be capable of changing its height in order to be transported over long distances without having to worry about low bridges and cables.
- The conveyors must be covered to protect the users of the road from the possibility of sand falling right in the middle of the highway.
- There must be a proper way to transport the sand into the conveyor belt on top of the structure and it must be as vertical as possible.
- The structure must have a collecting part where sand will be stored before it's moving to the other side of the road.
- It should also have a means to throw it a bit further from it to avoid any bits of sand falling back into the road.

I.2 The metallic structure

This part of the metallic structure is made to maintain a couple important tasks which are:

- The conveyor belt will be on it, and tighter with the upper part of it will covered with a piece of cloth.
- It will also be where the screw conveyor will be added and removed, and will also be the one tasked with holding them while both of them are doing their function.
- This dimensions of this part will create the proper width needed to move the sand across the highway (5.5 m) as shown in

This part will be made of steel, it will be 10 m wide and on the sides the height will be 2.5 m. As shown in figure III-1.

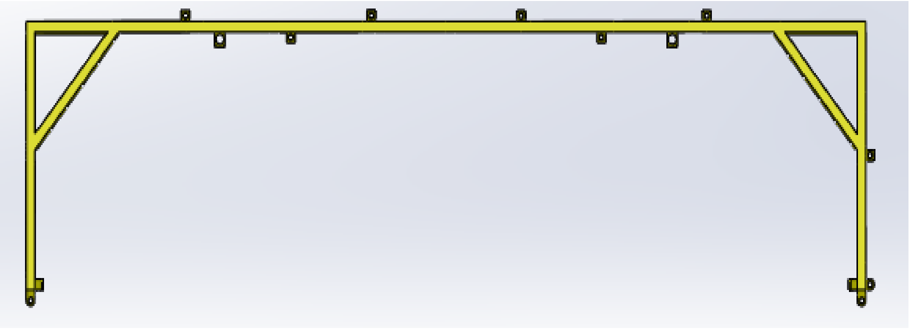

Figure III-1: *Structure 'A' front view*

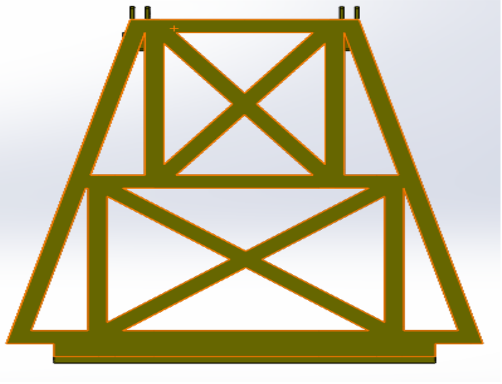

Figure III-2: *Structure 'A' side view*

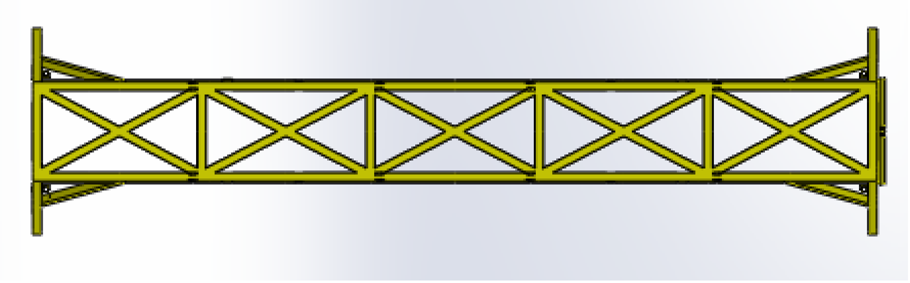

Figure III-3: *Structure 'A' up view*

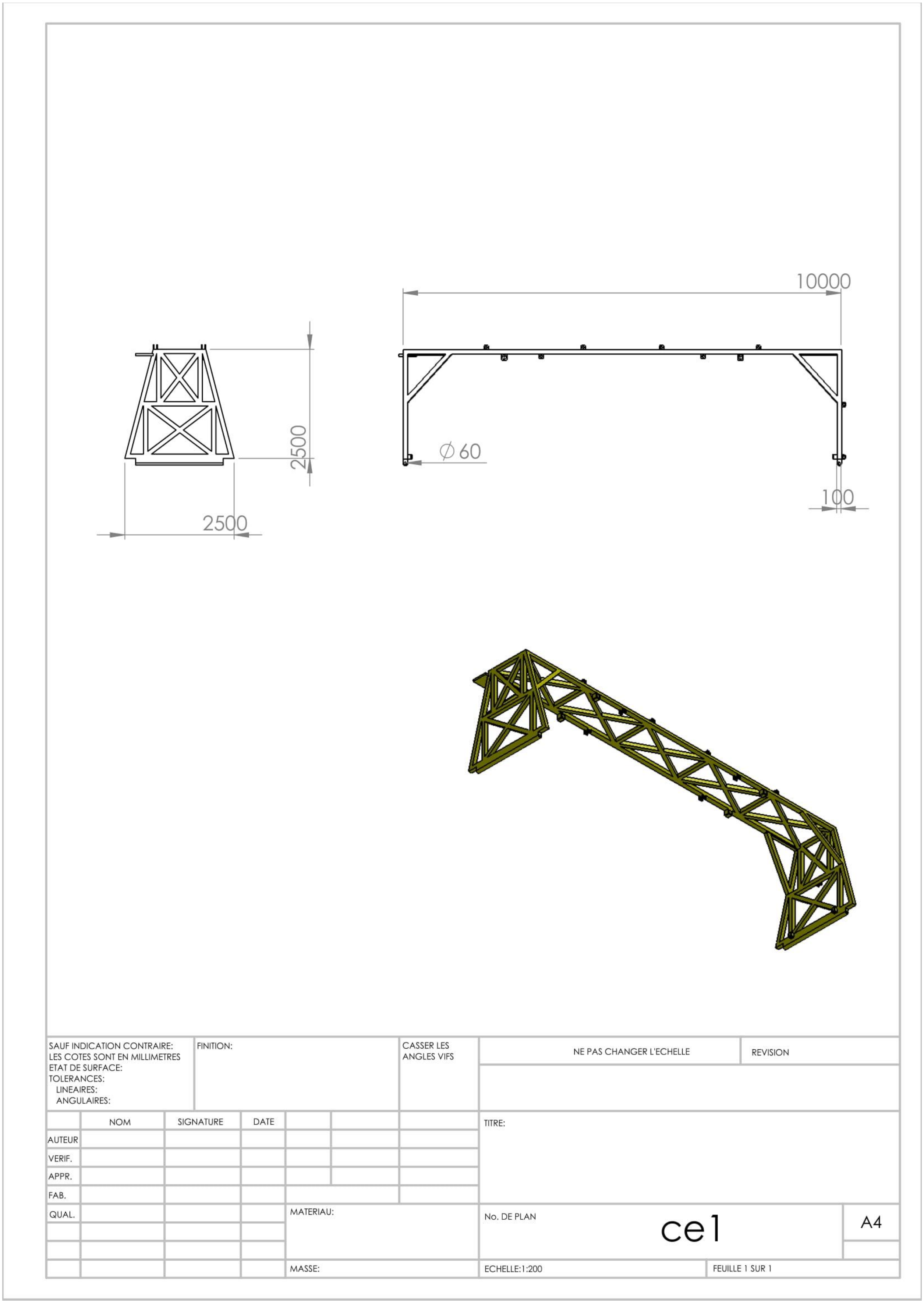

Figure III-4: *Metallic structure 'A'*

The part 'B' will be responsible for:

- Serving as a base to hold most of the structure together.
- It will be capable of turning around to help change the height the whole build.
- The dimensions are also fulfilling the role of keeping the whole build higher than 5.5m and with it being 3m and being turn able will help reduce it from the height when it's being moved.

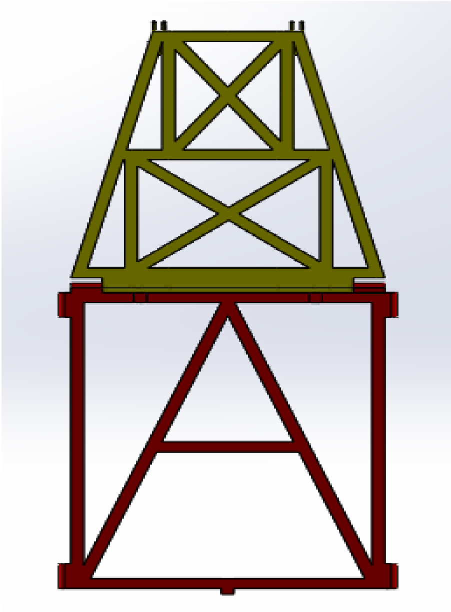

Figure III-5: *Structure 'B' side view*

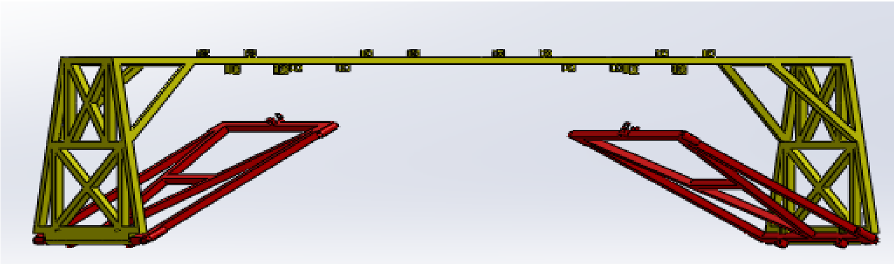

Figure III-6: *Structure 'B' wide view*

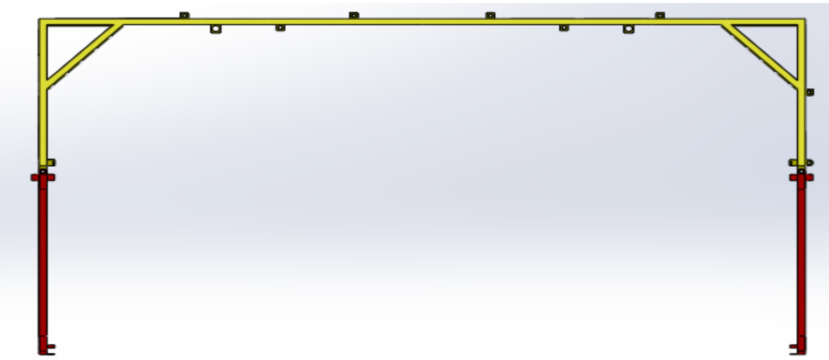

Figure III-7: *Structure 'B' front view*

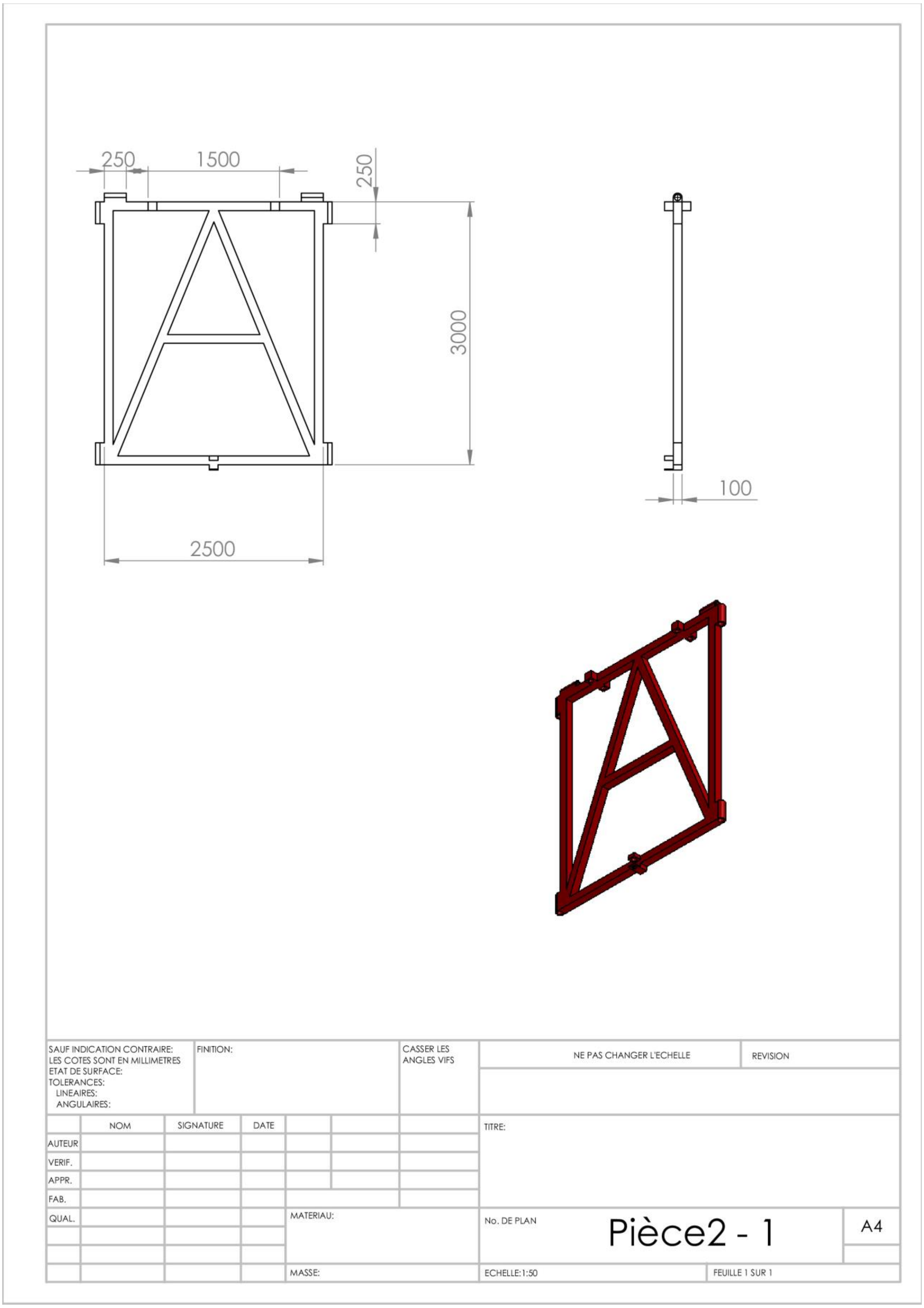

Figure III-8: *Metallic structure 'B'*

The part 'C' will serve few purposes:

- It will contain the wheels and their engines.
- It will give more width and stability to the whole build.
- The existence of axis will also help during the whole height change.

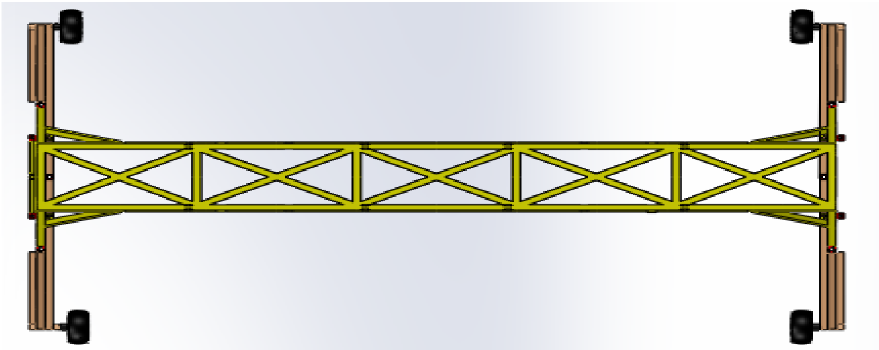

Figure III-9: *Structure 'C' up view*

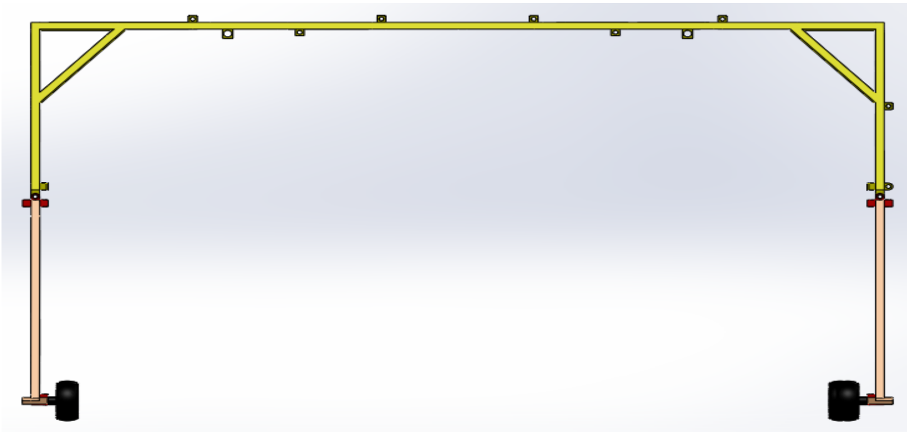

Figure III-10: *Structure 'C' front view*

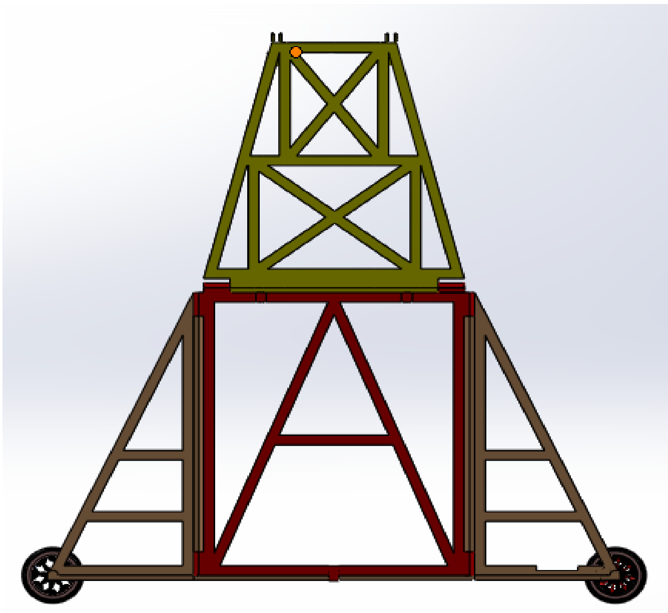

Figure III-11: *Structure 'C' side view*

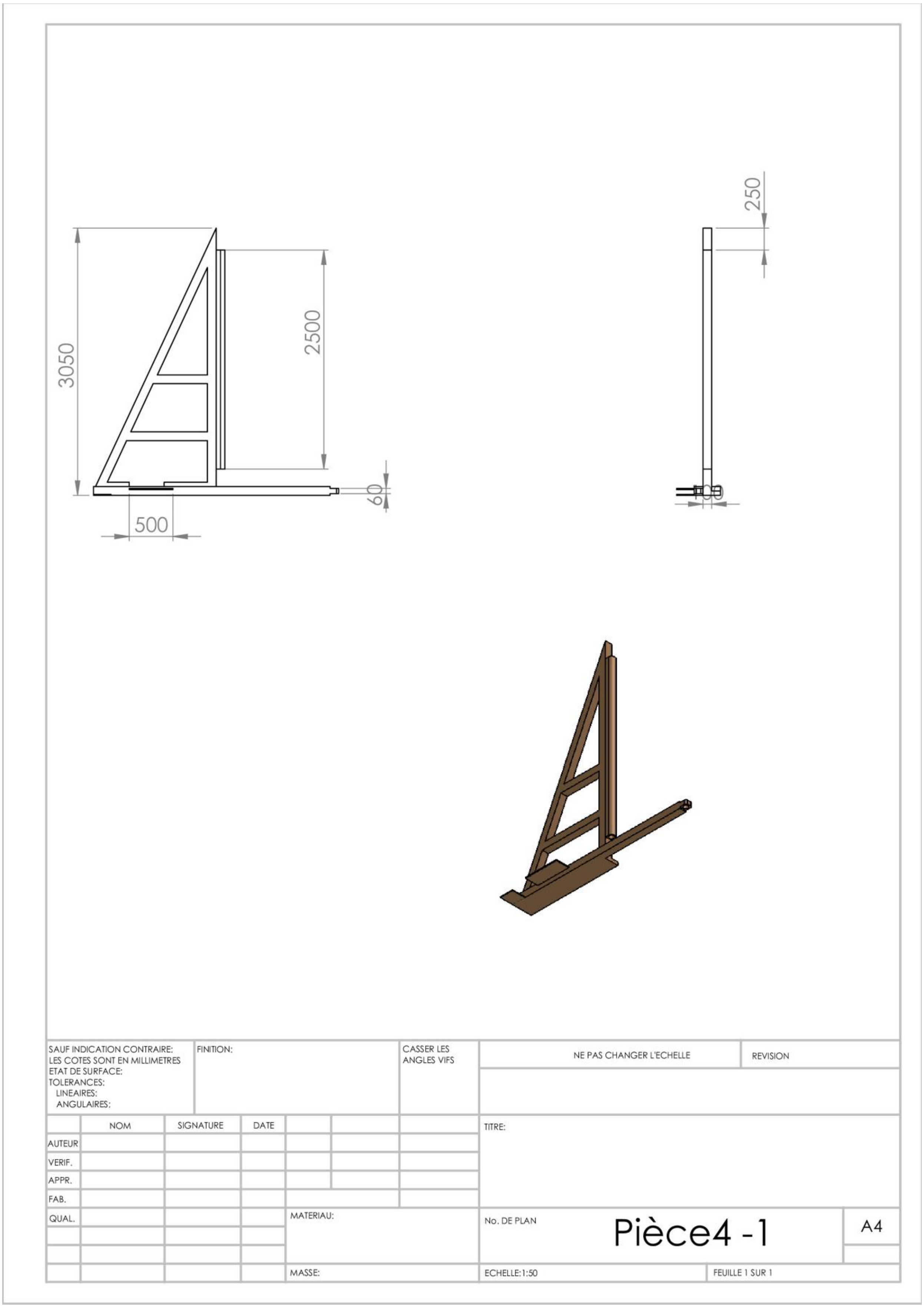

Figure III-12: *Metallic structure 'C'*

I.3 The conveyors

I.3.1 Conveyor belt

The conveyor belt will help us:

- Move sand across the road with its capability of moving objects long distances.
- The conveyor can do it more effectively, it won't need to stop or start over for every new amount of sand, it will treat every amount of sand with same highly productive method.
- The conveyor will require though:
- A good electric engine
- A cloth cover to stop the sand from falling from the sides
- A solid and strong basses to help maintain the weight of both the conveyor and the sand on it
- The length of the conveyor must be 10m to fulfill the main goal of the structure, not interfering with the road activity.

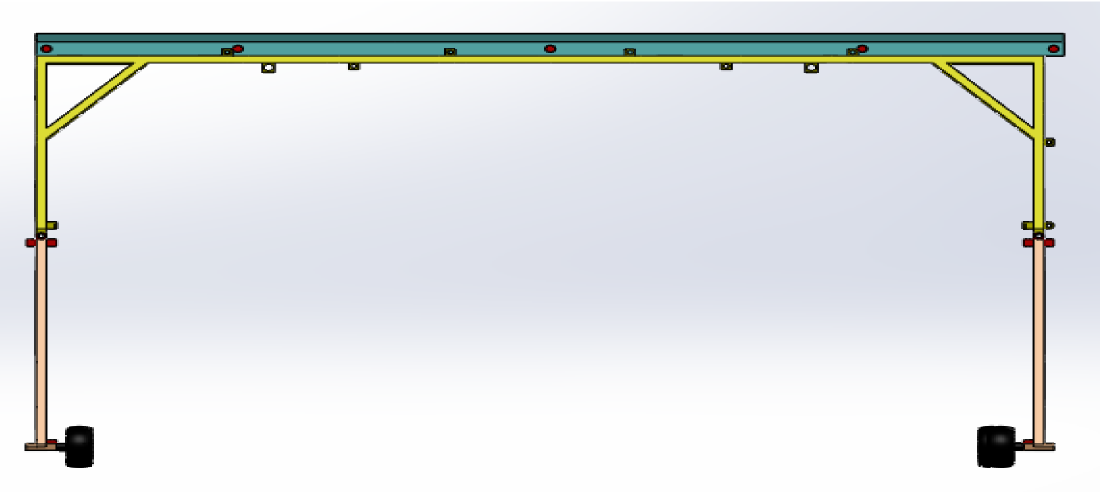

Figure III-13: *Belt conveyor front view*

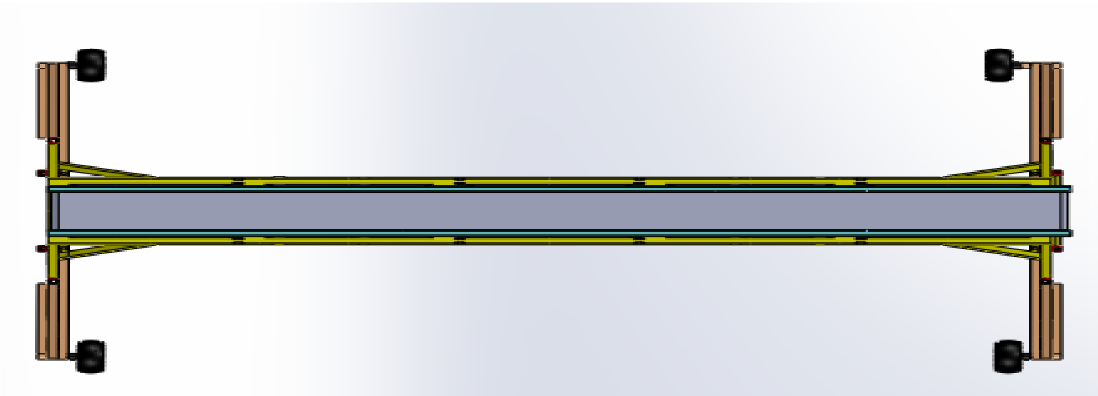

Figure III-14: *Belt conveyor up view*

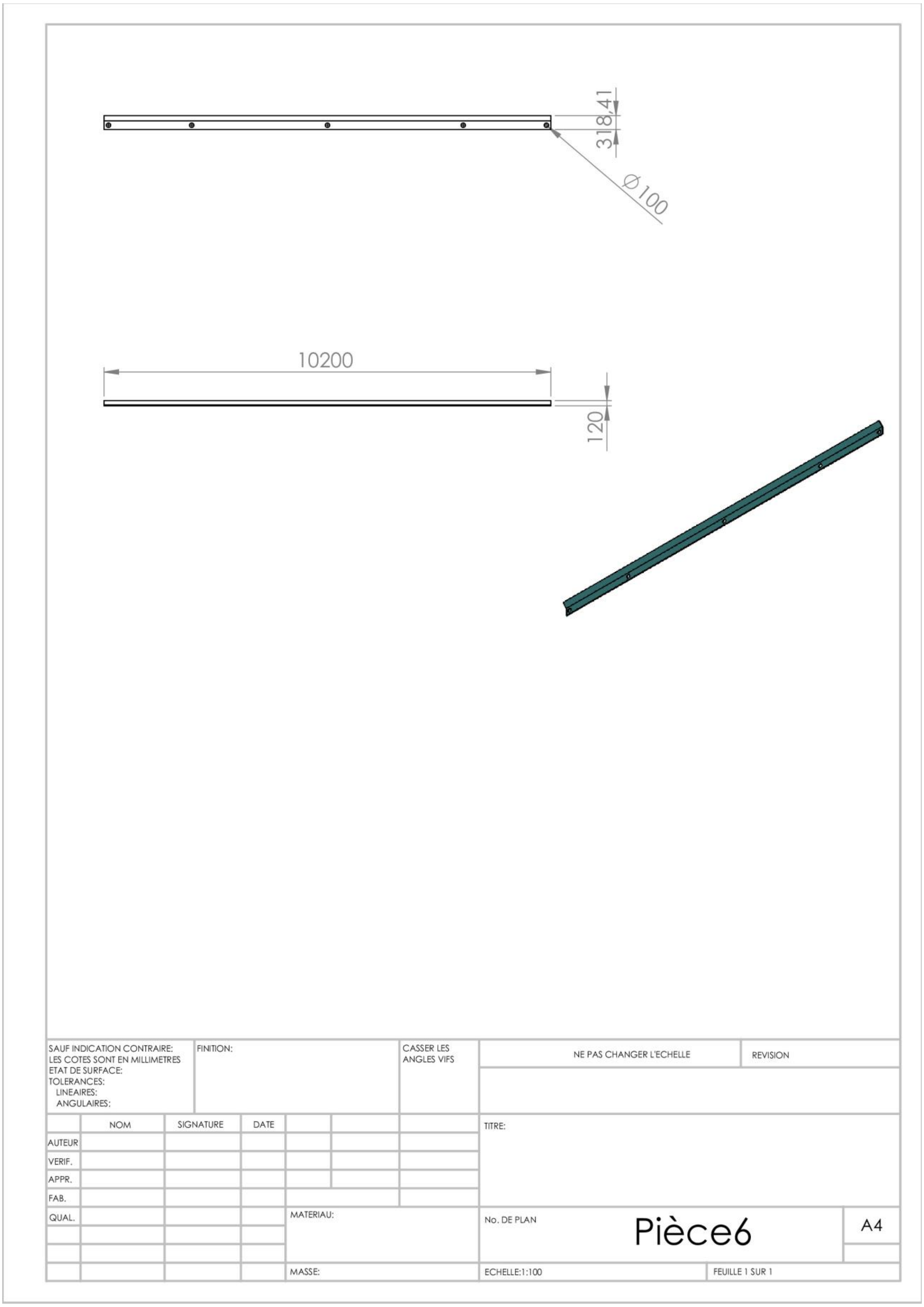

Figure III-15: *Belt conveyor*

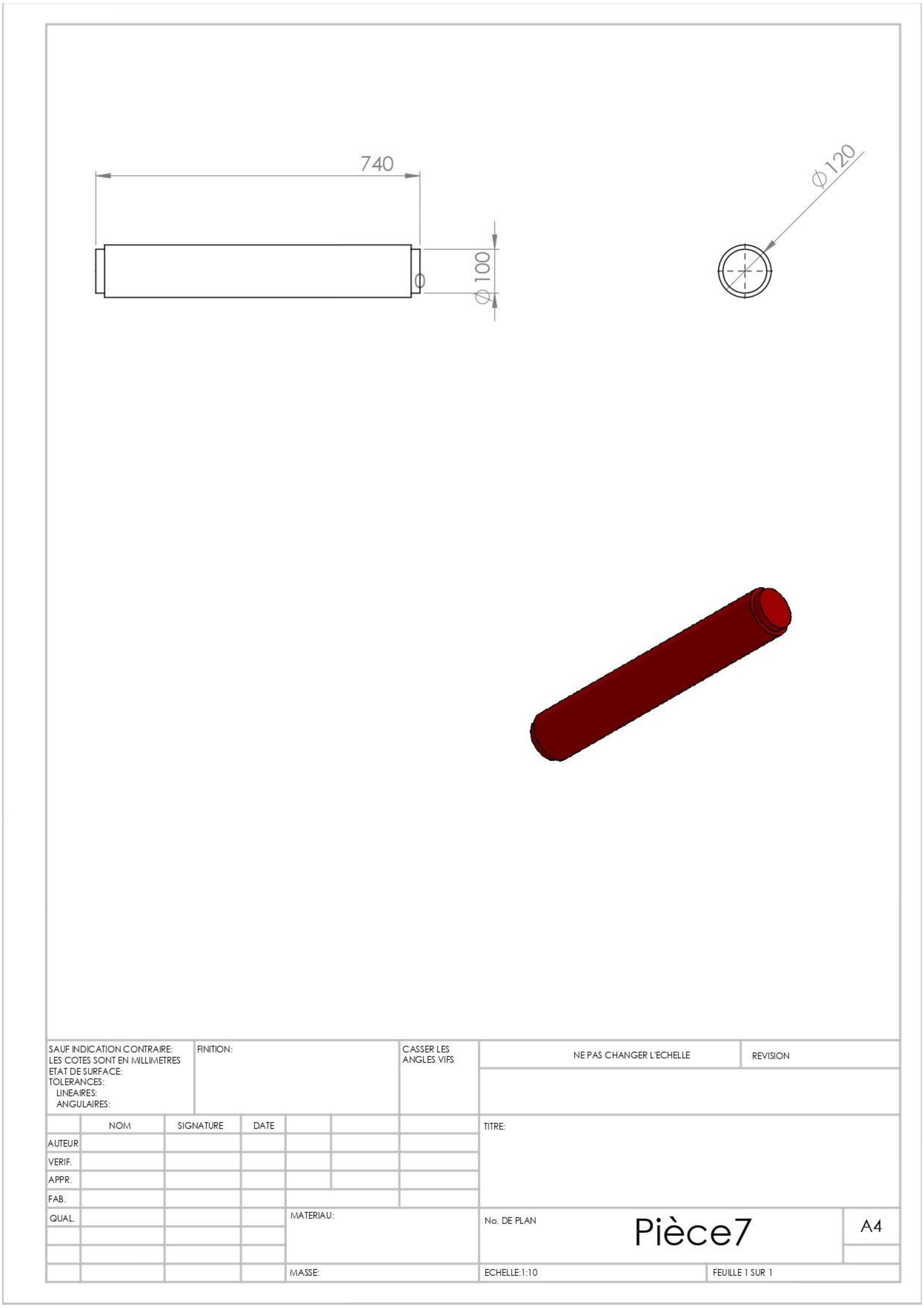

Figure III-16: *Belt conveyor pulley*

I.3.2 Screw conveyor

The screw conveyor will be used for one principal role, the task of lifting sand up from the lower part of the structure to the belt conveyor in a continuous way and not at once which help the conveyor move the sand in organized amounts and not in one large pile.

The screw conveyor must have these features:

- The cover of the screw conveyor must have a circular shape, to ensure that the sand won't fall of the sides of the screw blade.
- The whole conveyor must be removable so it won't bother with the transportation of the structure

The height of the conveyor must be 5.5m to fulfill the main goal of the structure, not interfering with the road activity

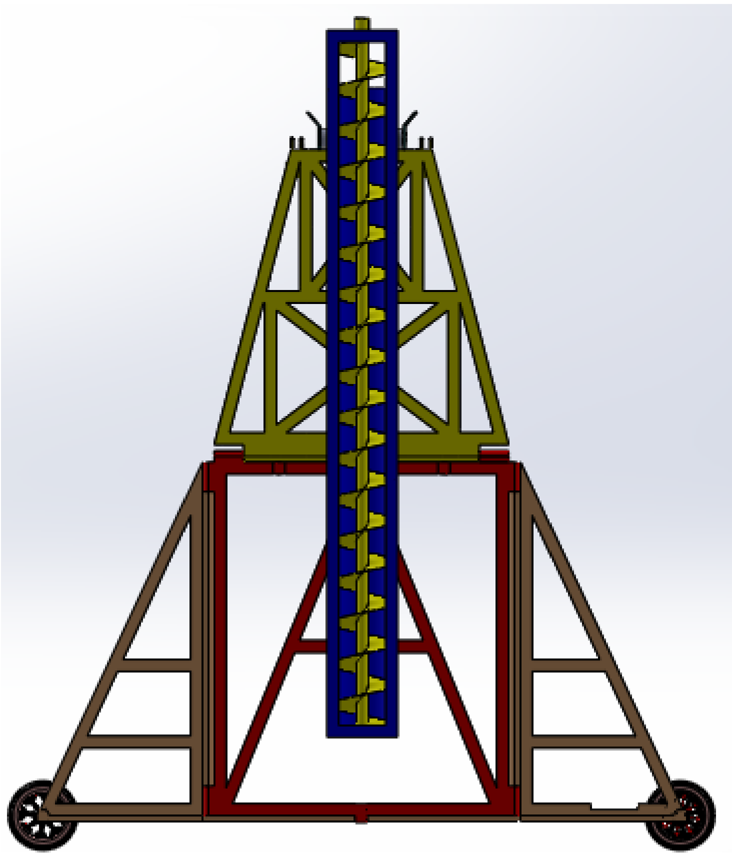

Figure III-17: *Screw conveyor front*

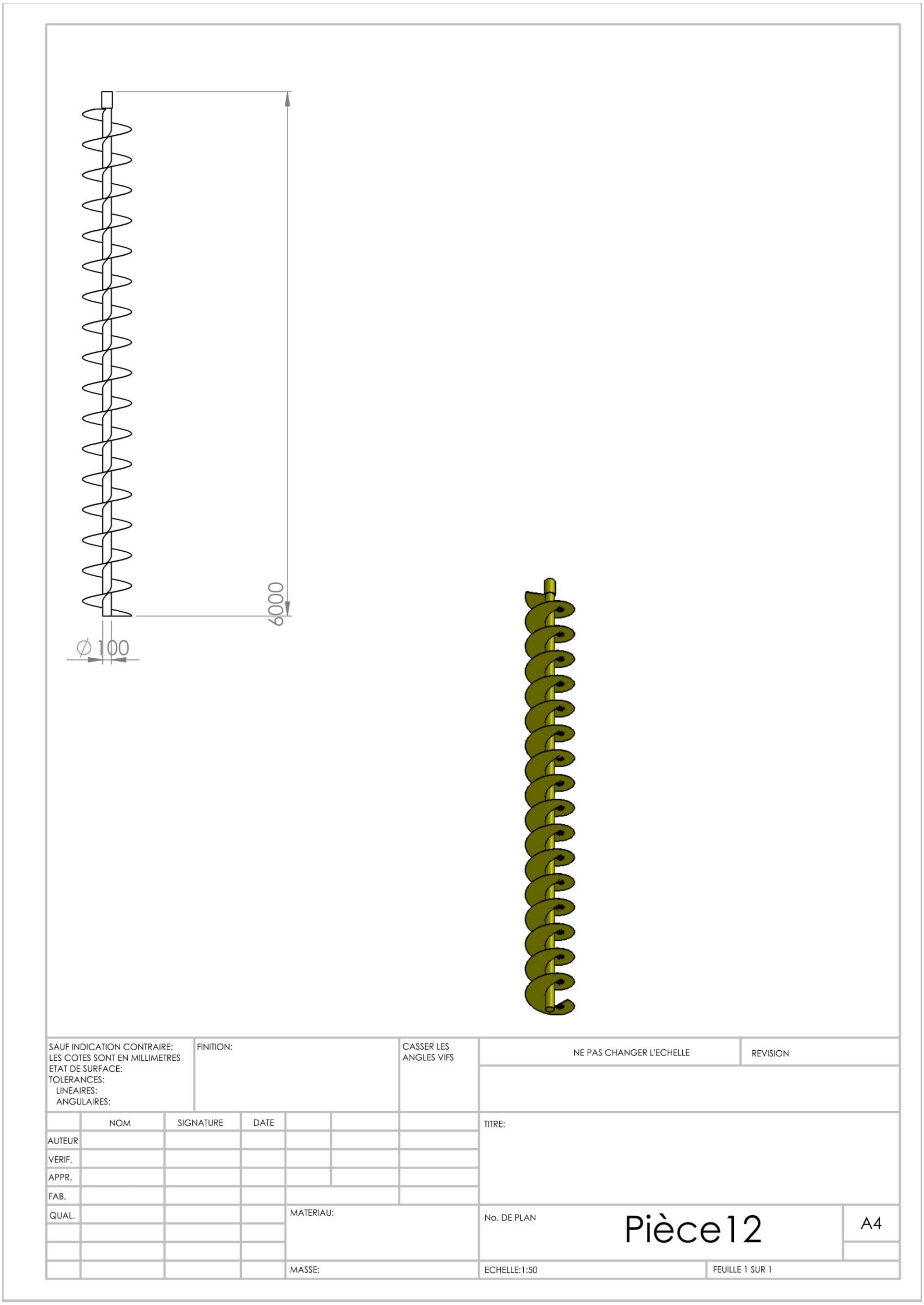

Figure III-18: *Screw in the screw convetor*

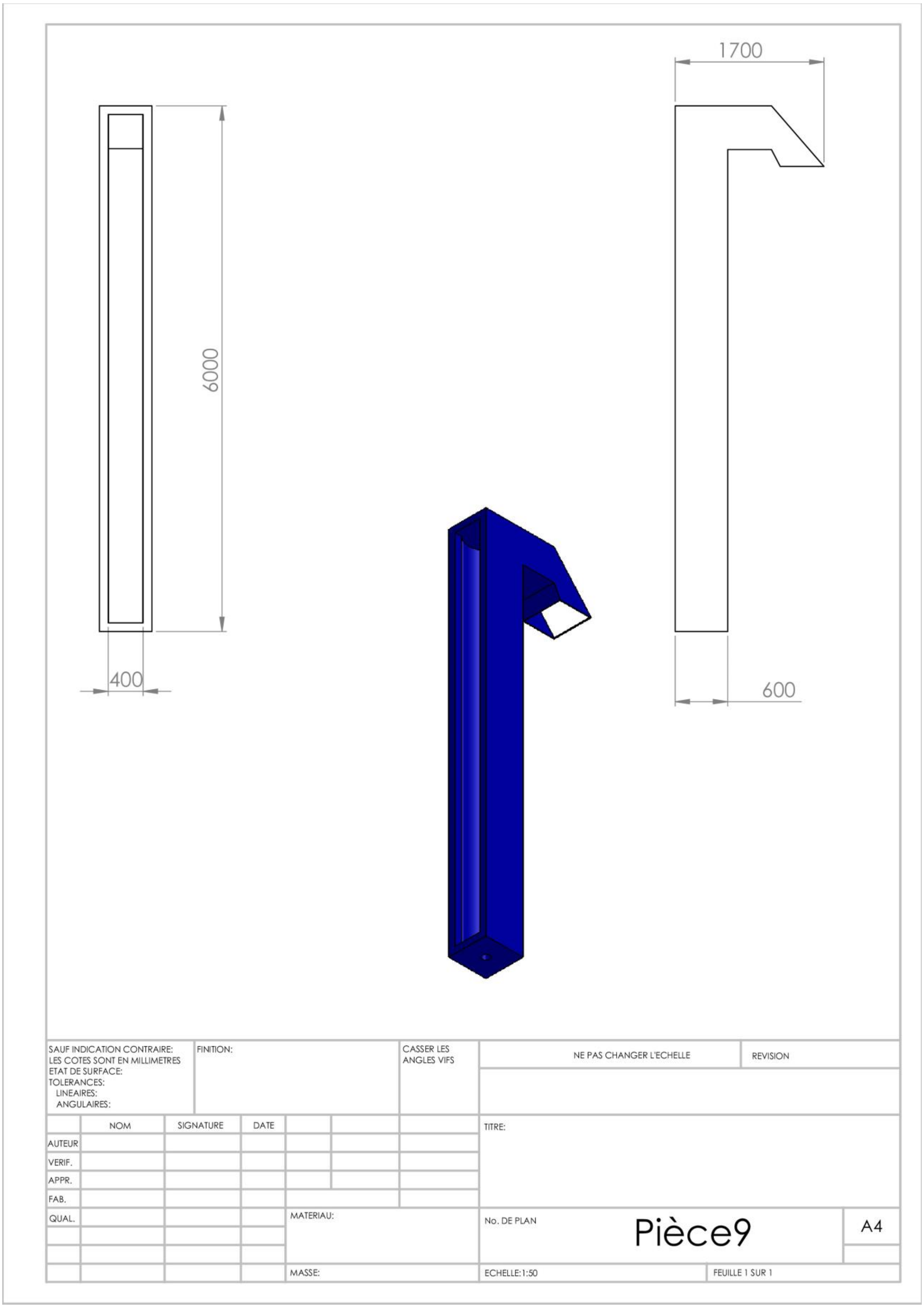

Figure III-19: *Screw conveyor cover*

This box is added to help

- Store the sand keep feeding the screw conveyor regularly
- Be the place where the assisting loader drop the sand, the measurements of 2m×3m

Figure III-20: *Feeding box front view*

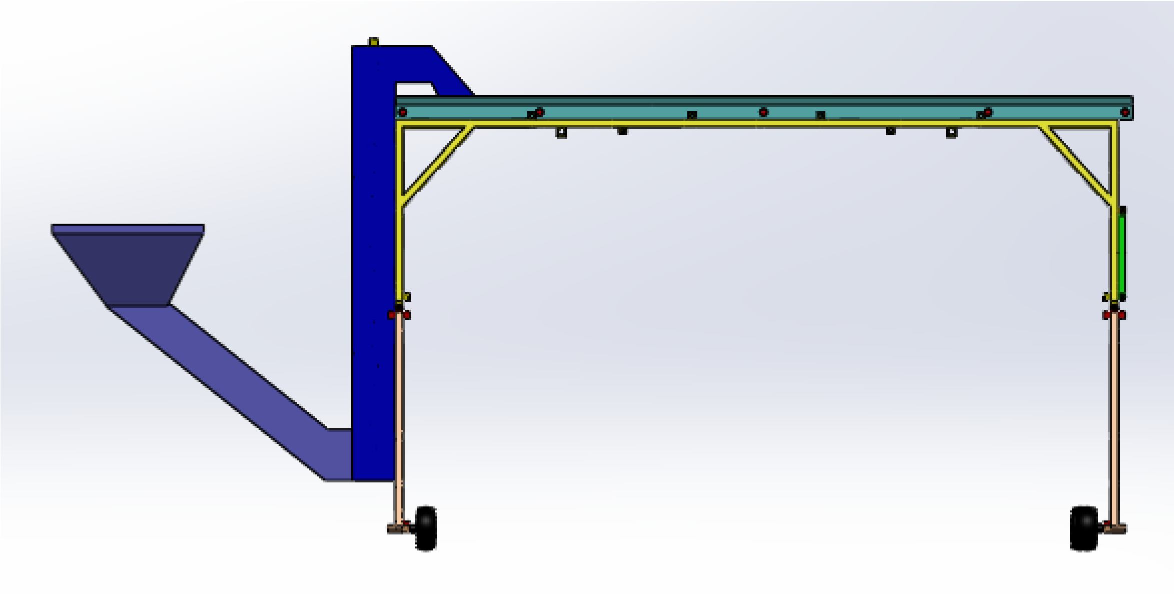

Figure III-21: *Feeding box side view*

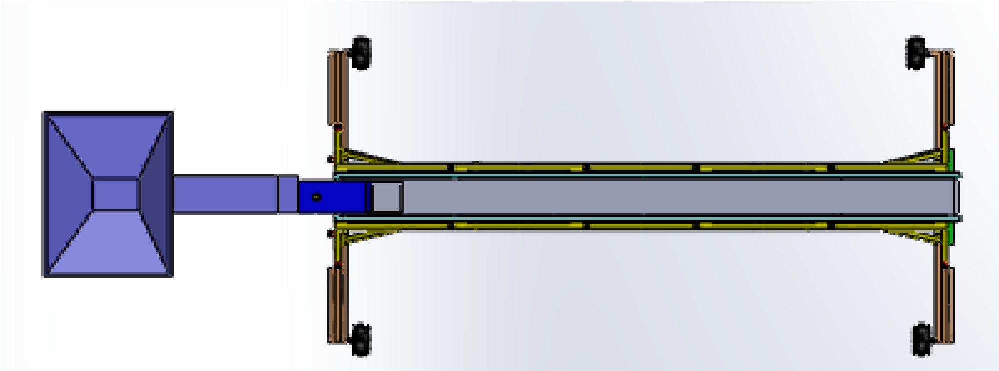

Figure III-22: *Feeding box up view*

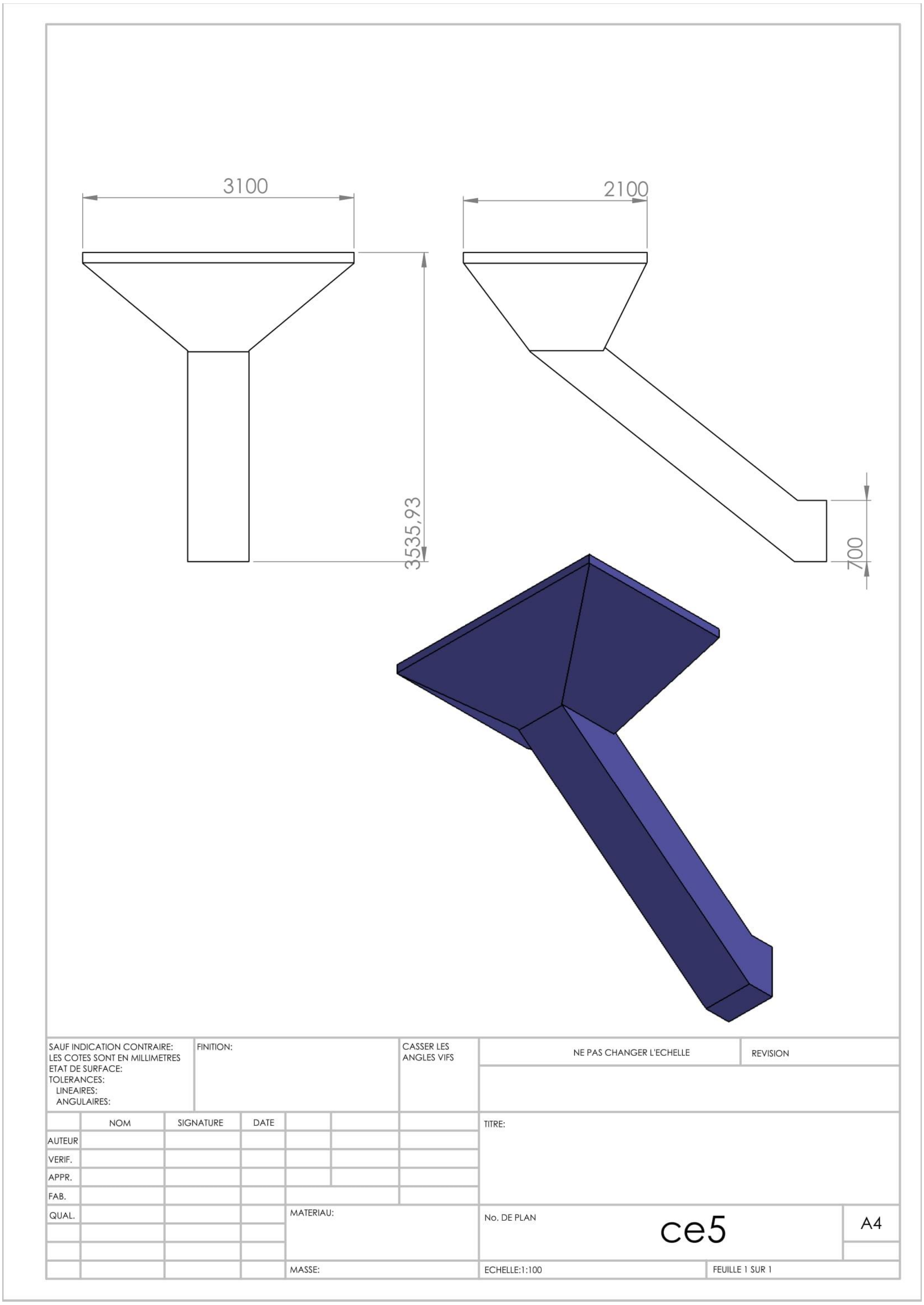

Figure III-23: *feeding box*

I.4 Electrical motors

The electrical motors play a vital role in this structure they are responsible for:

- Acting the two conveyors, with proper power and speed to ensure the organized moving of sand.
- Moving the whole structure, powering the wheels with a small amount power to help the structure cover a proper distance during its work

The electrical motors will need though:

- An electrical power source (electrical generator) which be connected to all the engines on the structure and can maintain while it's moving.
- To be controllable from distant, to facilitate the operation and make the movement of the structure more effective.

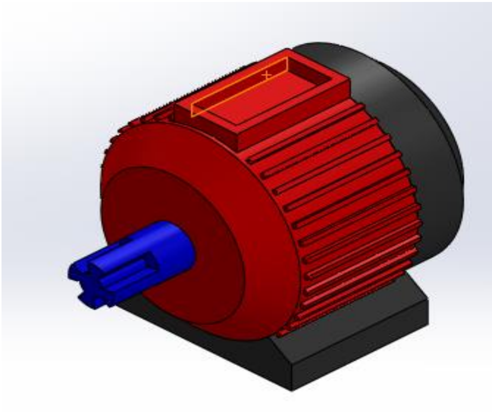

Figure III-24: *Electrical motor*

Figure III-25: *Screw conveyor connected to the electrical motor*

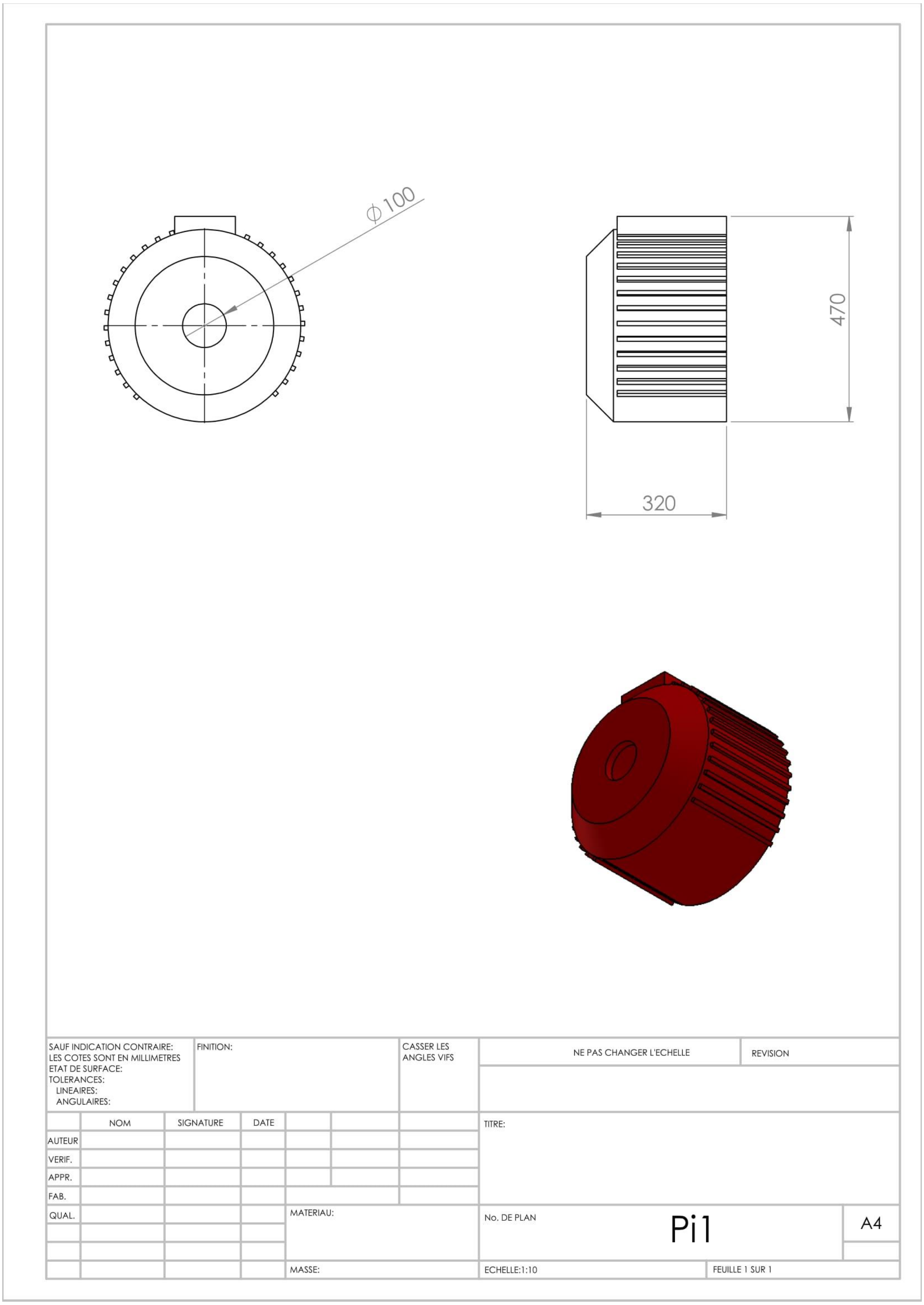

Figure III-26: *Engine part 1*

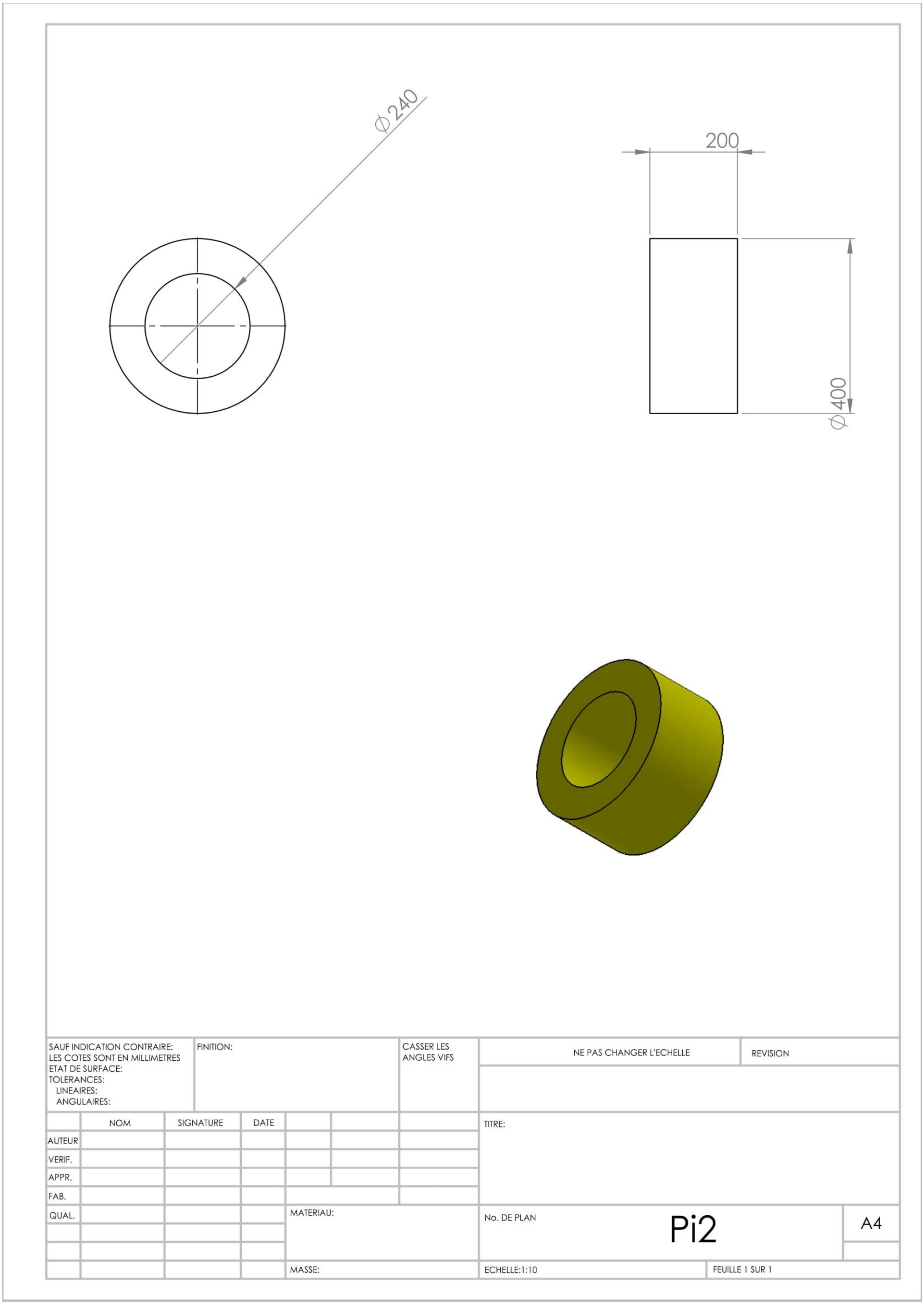

Figure III-27: *Engine part 2*

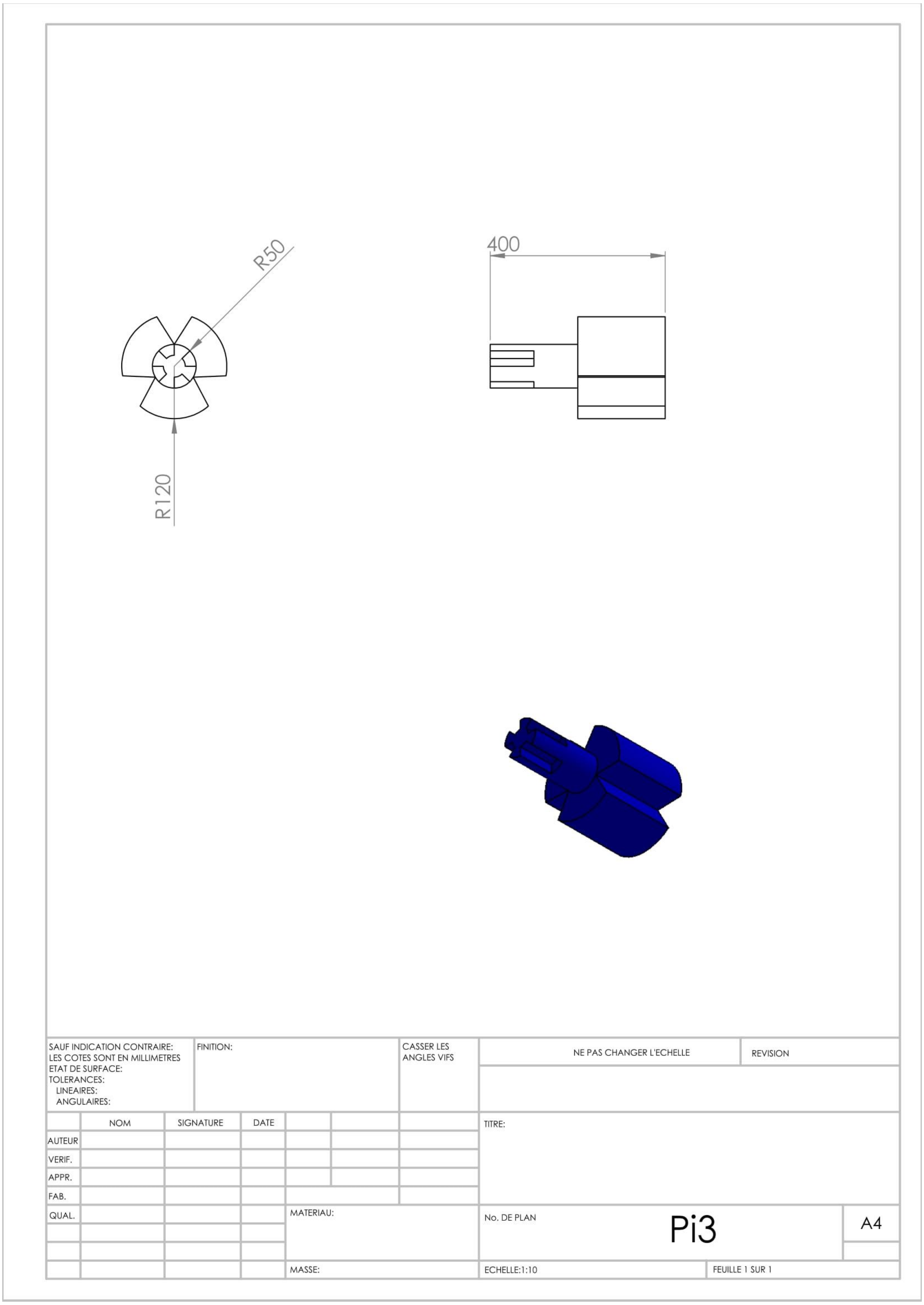

Figure III-28: *Engine part 3*

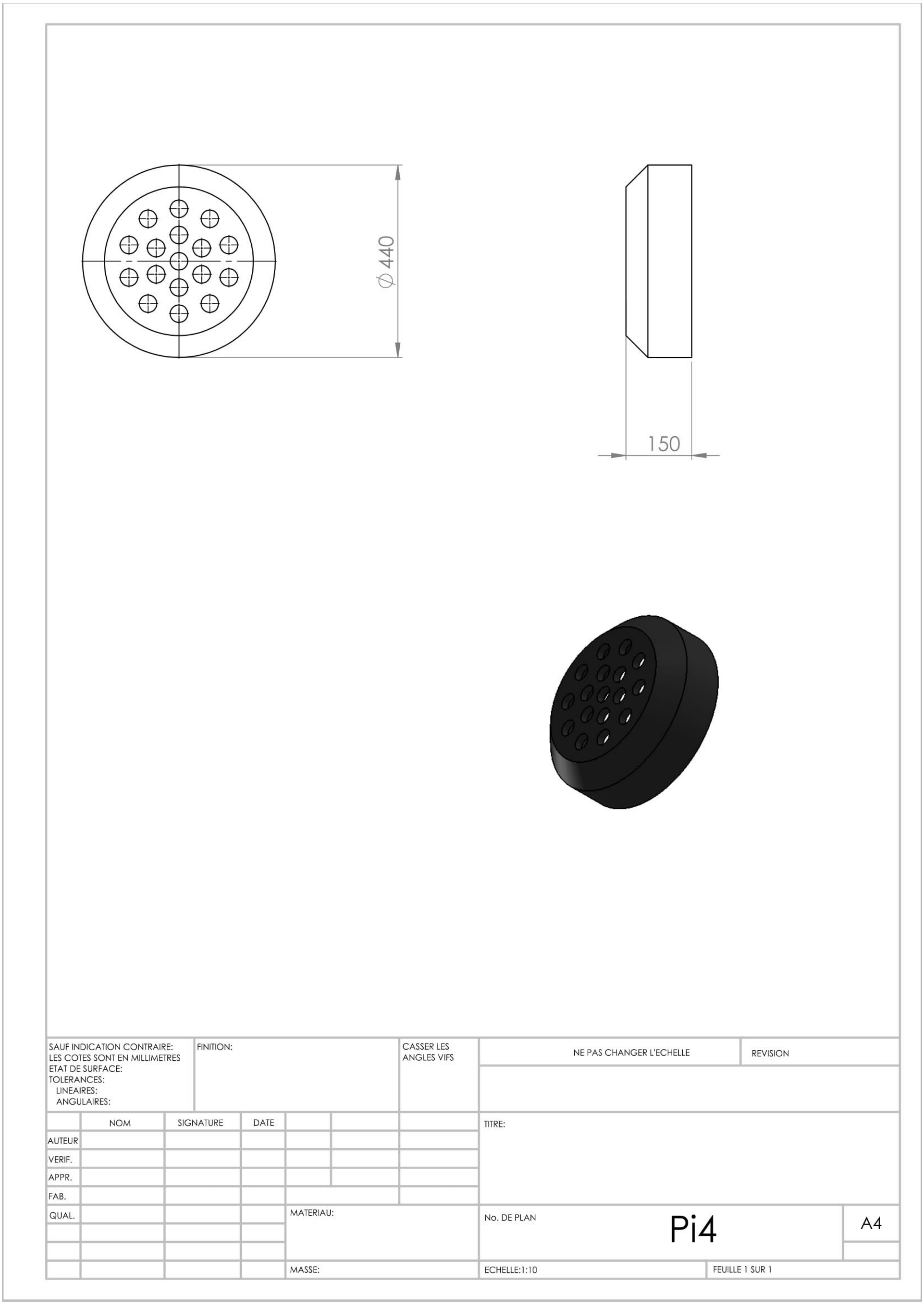

Figure III-29: *Engine part 4*

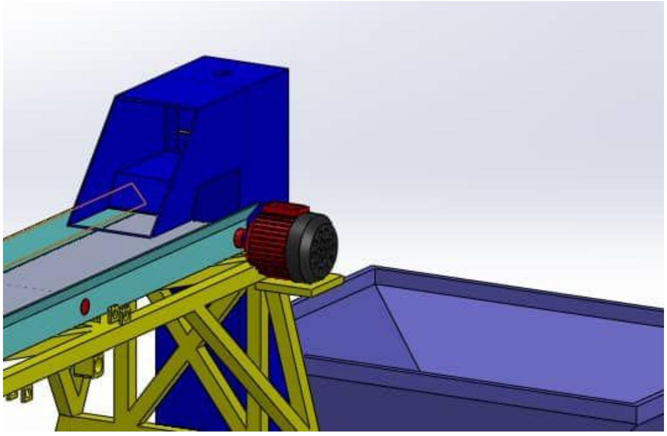

Figure III-30: *Belt conveyor connected to the electrical motor*

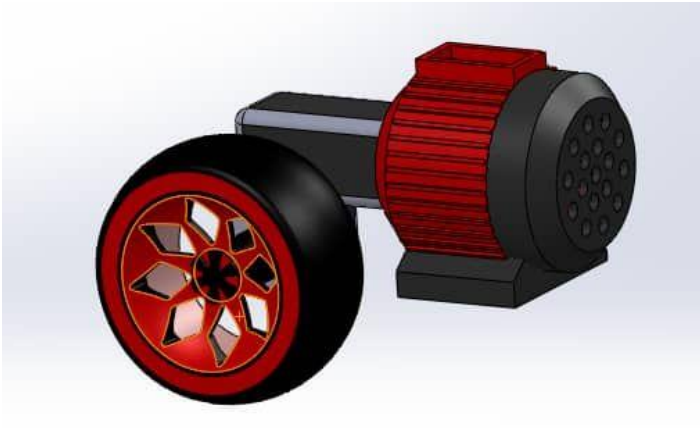

Figure III-31: *Wheel connected to the electrical motor*

I.5 Wheels

The wheels powered by the electrical motors when the structure is working or they're simply being towed during its transportation.

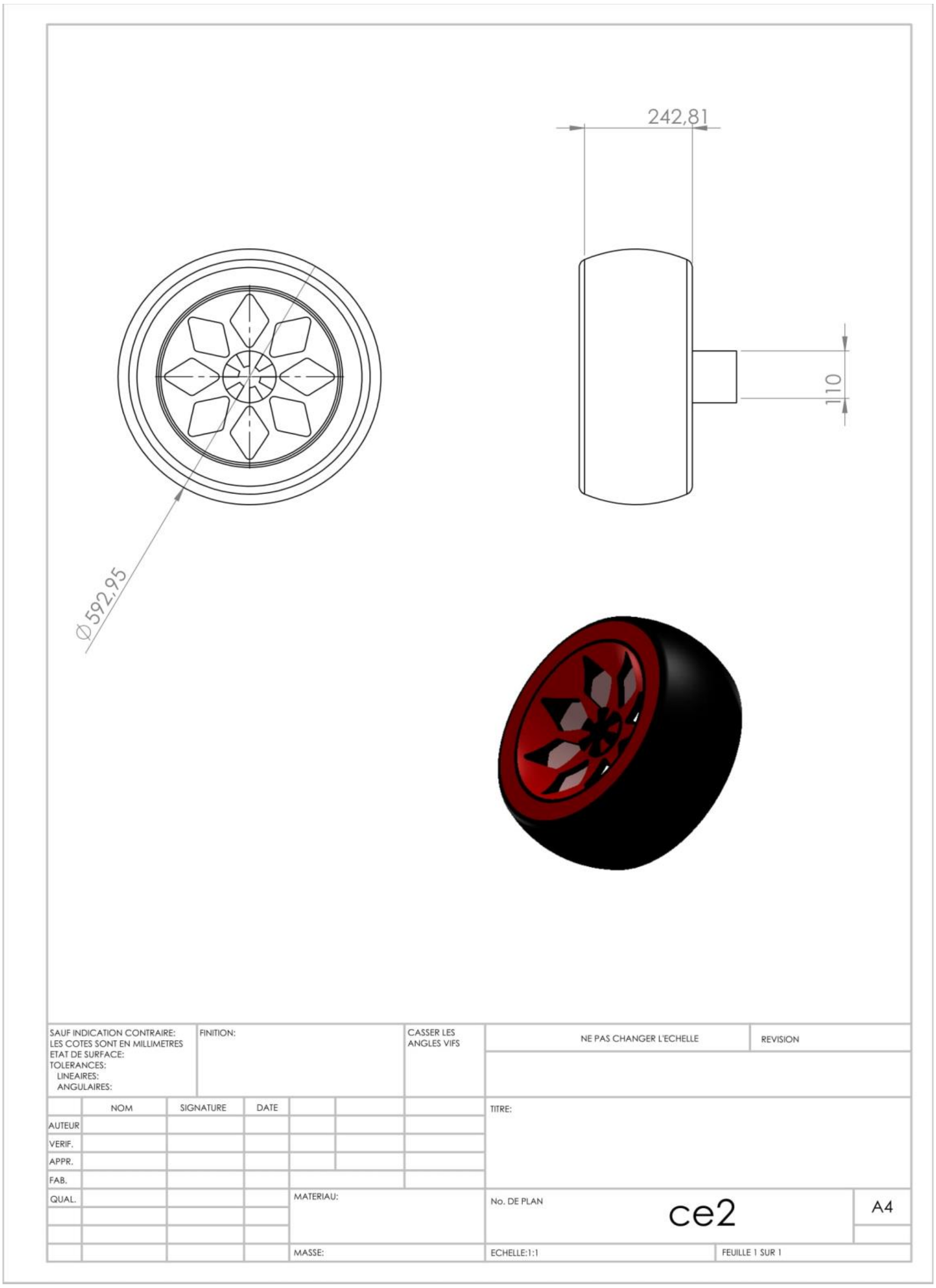

Figure III-32: *Wheel*

I.6 Additions

- This part will move the sand a bit further from the road to ensure that it won't crawl back in.

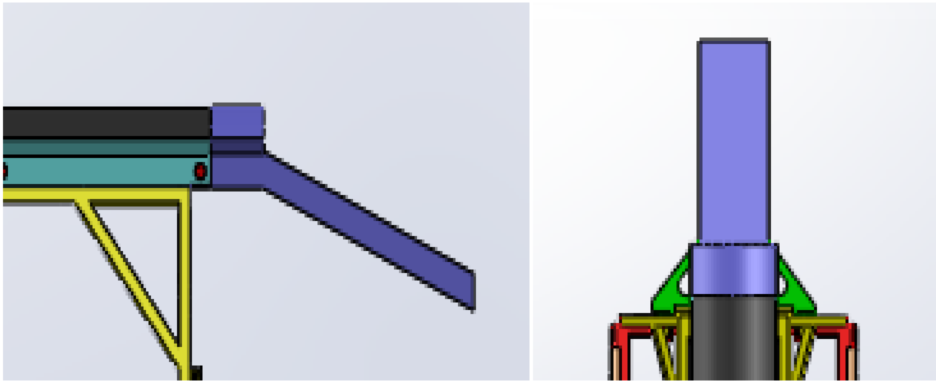

Figure III-33: *Slide*

- During long distance transportation the structure will need to pulled, this addition will allow that and help it stay balanced during the movement in figures

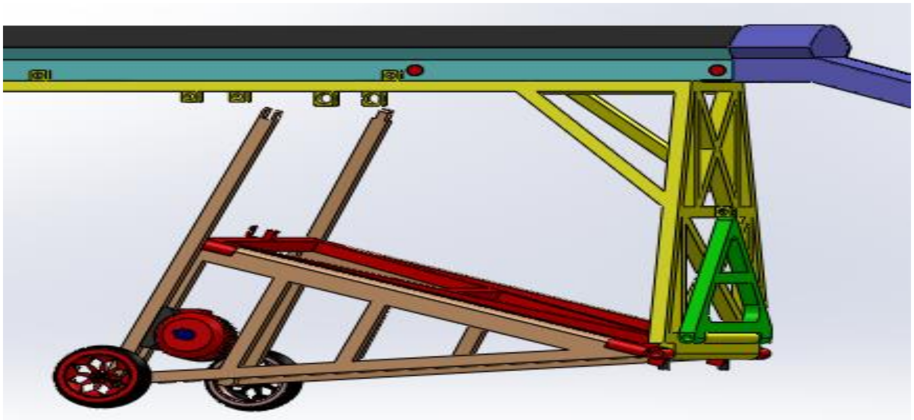

Figure III-34: *Towing part on the structure*

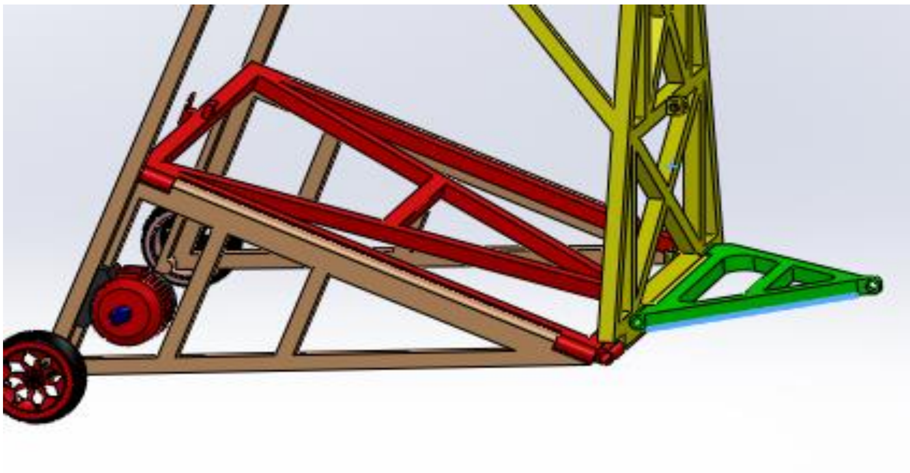

Figure III-35: *Towing part during usage*

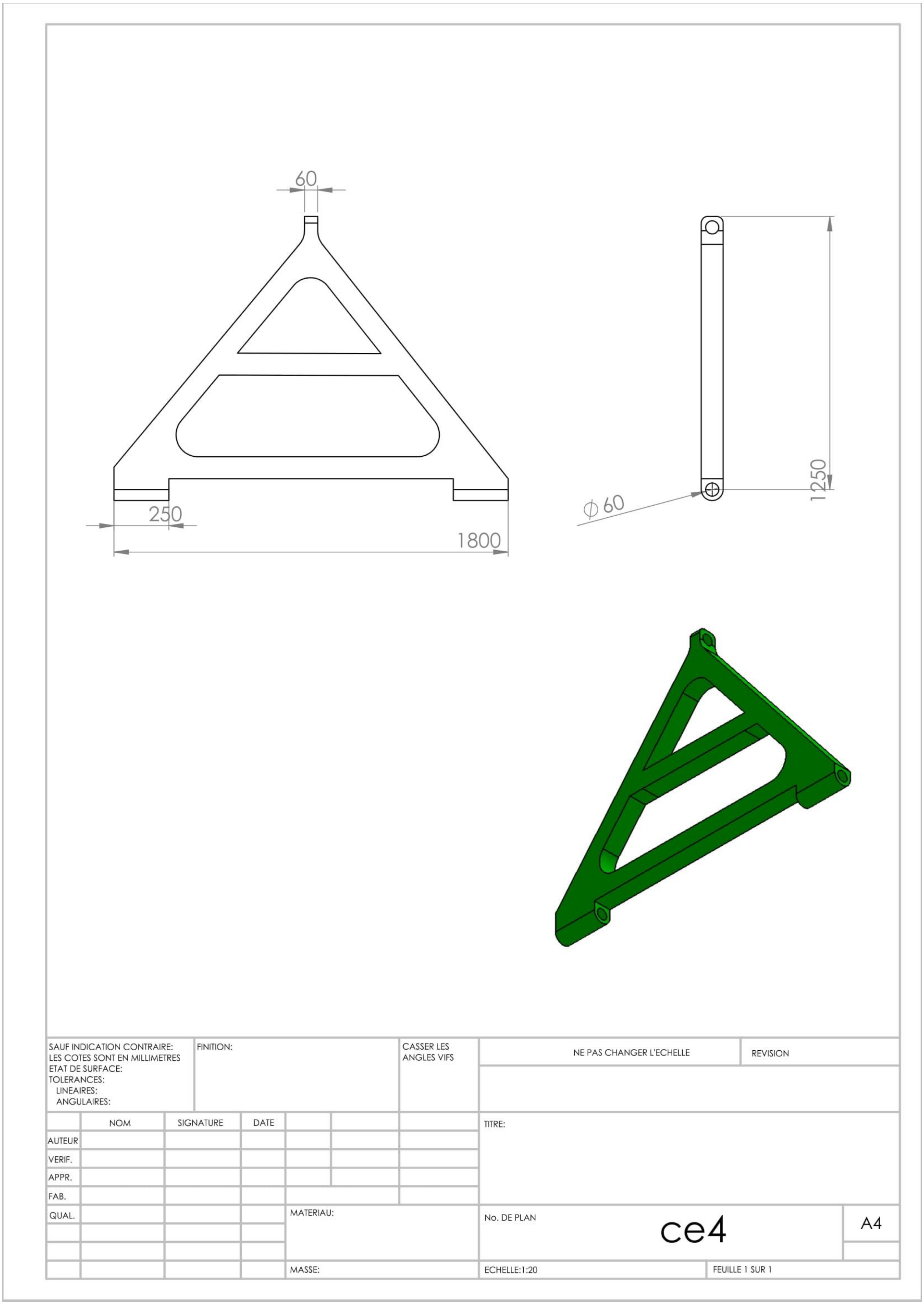

Figure III-36: *Towing part*

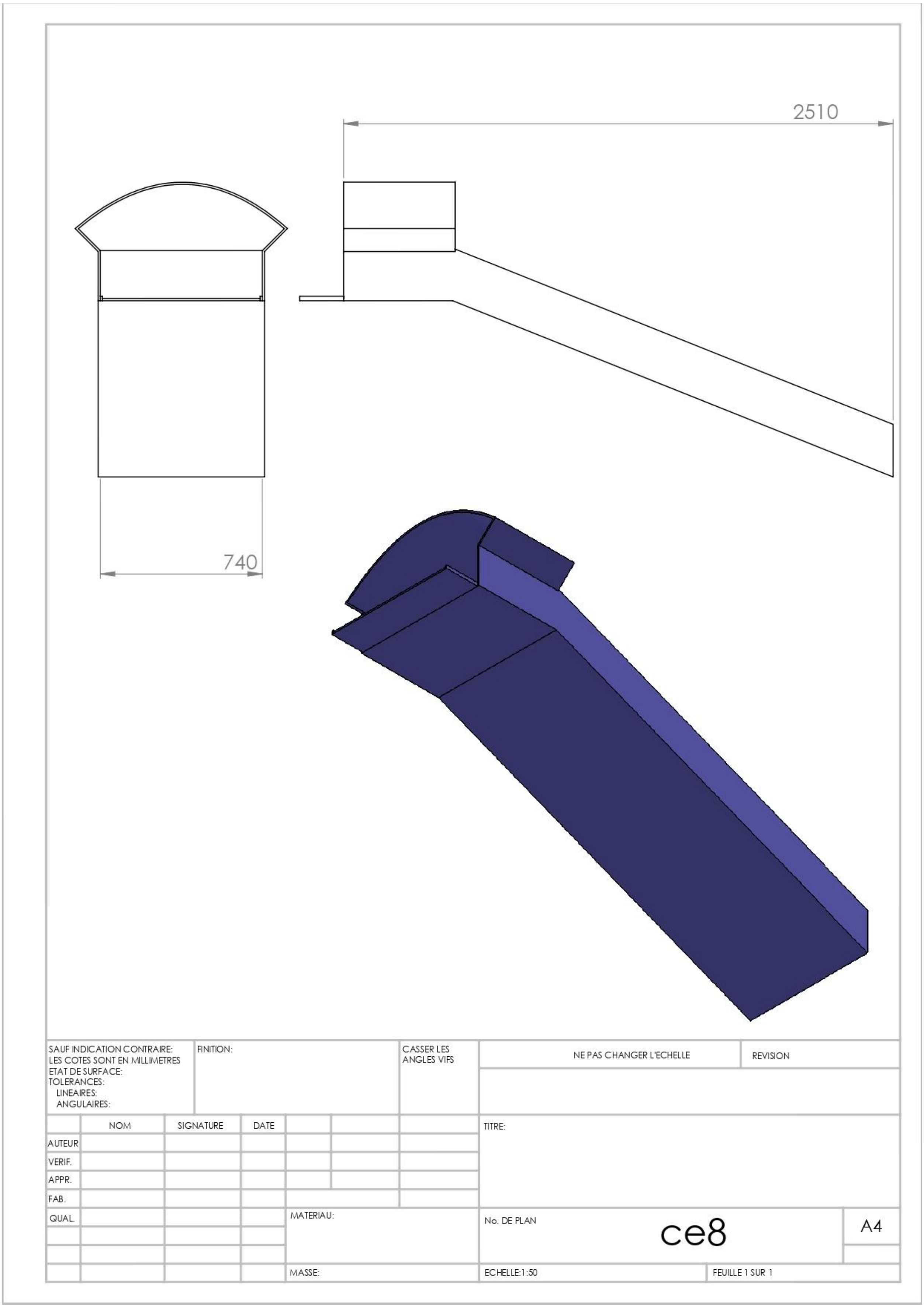

Figure III-37: *Slide*

These additions will allow:

- Keeping the stability of the structure around the regions where rotating axes exist. Making the areas A, B and C linked. As shown in figures (III-25 /III-26)
- The simplicity of them makes removing and placing them a much easier task at hand.

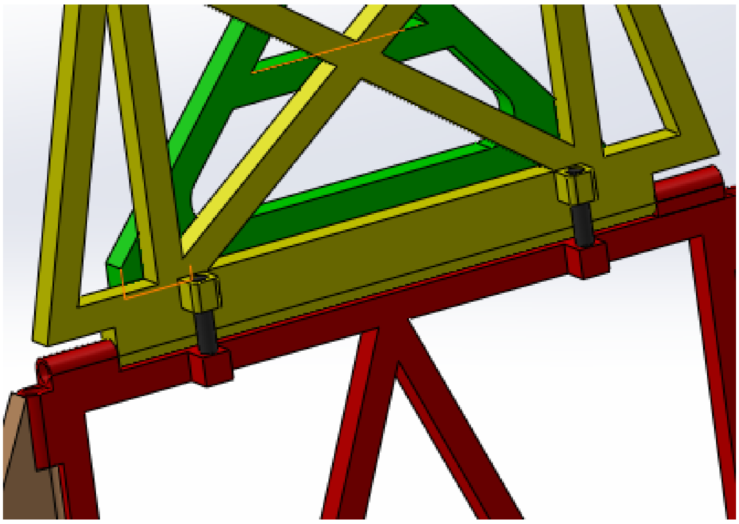

Figure III-38: *Connection between 'A' and 'B'*

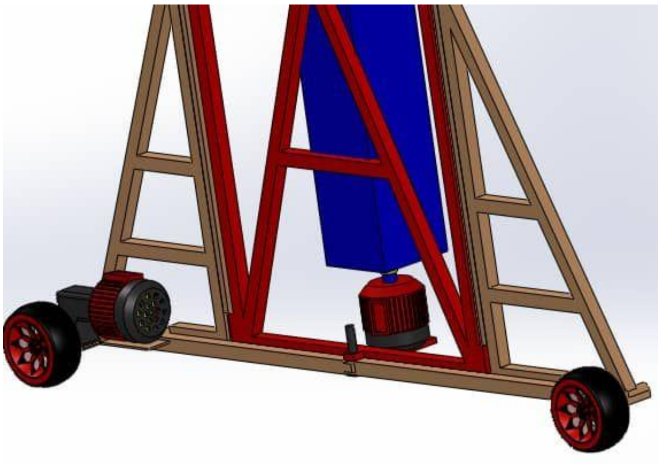

Figure III-39: *Connection between the two sides of 'C' and 'B'*

I.7 Final design and tasks

During this mode the structure will perform in the following way:

- The structure will be place across the road and the ends will be adjusted according to the wind.
- It will be connected to generator and will remain so through the whole operation.
- The whole structure will move alongside the road to cover the whole blocked area.
- The assisting loader will move the sand into feeding box on next to the screw conveyor.

- The screw and belt conveyors will both work in connected manner to move the sand one vertically and the other horizontal, both powered by electrical engines.
- The slide at the end will help throw the sand a bit further from the road.
- All the conveyors will be covered during the operation to protect the road from the sand that might fall
- The feeding box can also be replaced by vacuum air blower for smaller amount of sand (figure III-43).

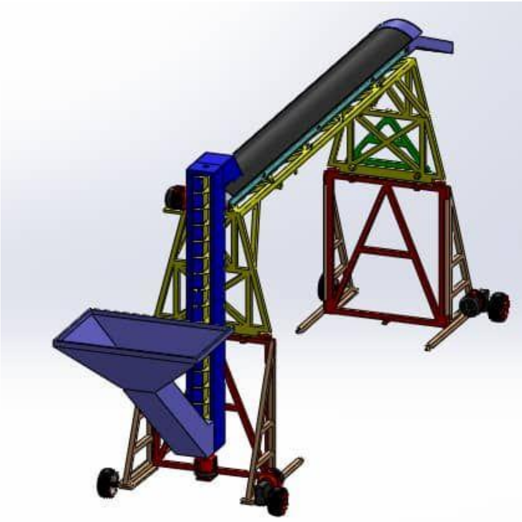

Figure III-40: *Full structure wide view*

Figure III-41: *Full structure opposing up view*

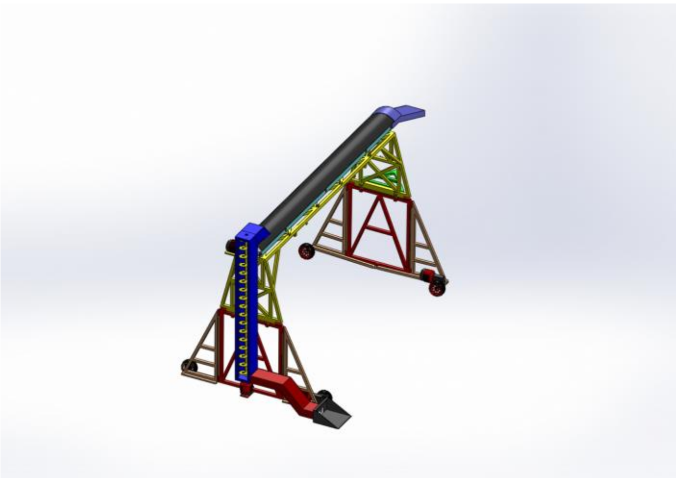

Figure III-42: *Full structure with a vacuum air blower*

During the transportation the structure will take the following shape, it will be towed from the front. It will also have the slide, the screw conveyor and the feeding box all removed and placed on top of it to help move it faster. The measurements of the structure will be 10m in length, 2.5 in both height and width.

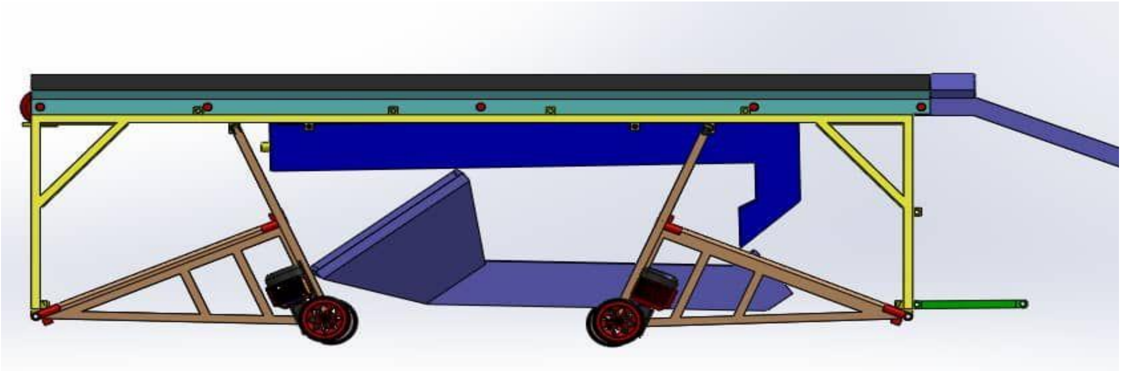

Figure III-43: *The structure in transportation mode front view*

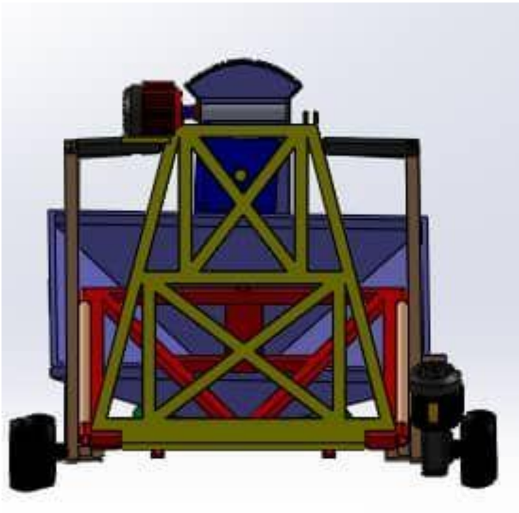

Figure III-44: *The structure in transportation mode side view*

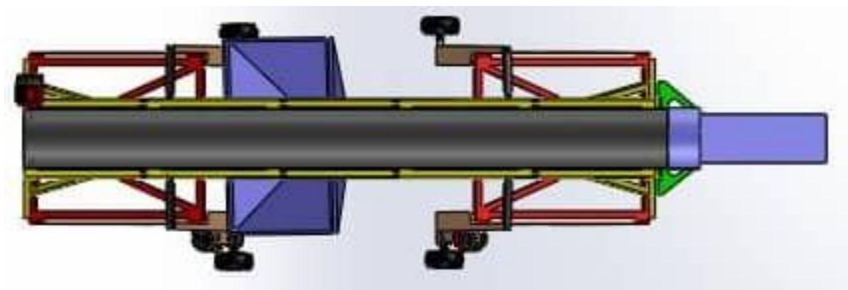

Figure III-45: *The structure in transportation mode up view*

Conclusion

In the end the issue of blocked roads because of sand will remain as the main the danger to the transportation operations in dessert regions. The constant attempt of figuring out solutions will be a continuous effort that will be essential to the dessert cities, even as most ideas and efforts have been quite not so helpful or at best not fulfilling enough.

Our project here remains an attempt that builds on the preceding failures, and adjusting to the difficulties they continue to face. Presenting a solution that can easily be both corrective and preventive. Our structure will help protect and serve the road while not blocking or interrupting it, while also keeping the operation moving sand much cleaner and productive.

The structure here while is able to work is still open to more modification, leaving not as a half solution but as a beginning to a long series of evolutions and changes that could lead to the final answer to the original issue, and making it even closer to perfection.

References

[1] Kerr, R.C., Nigra, J.O., 1952. Eolian sand control. Bulletin of the American Association of Petroleum Geologists 36, 1541–1573.

[2] Cooke, R.U., Brundsen, D., Doornkamp, J.C., Jones, D.K.C., 1982. Urban Geomorphology in Drylands. Oxford University Press, Oxford, 324.

[3] Pye, K., Tsoar, H., 1990. Aeolian Sand and Sand Dunes. Unwin Hyman Ltd., London, 396 pp.

[4] Zhibao Dong*, Guangting Chen, Xingdong He, Zhiwen Han, Xunming Wang, Journal of Arid Environments 57 (2004) 329–344.

[5] Bruce J. 1790. Travels to Discover the Source of the Nile, in the years 1768, 1769, 1770, 1771, 1772 and 1773. Five Volumes. G.G.J. and J. Robinson: London.

[6] Ball J. 1900. Kharga Oasis: Its Topography and Geology, Survey Department, Public Works Ministry, Geological Survey Report 1899, Part II. National Printing Department: Cairo; 116 pp.

[7] Sreenivasaiah BN, Sur NK. 1937. The thermodynamics of dust storms. Current Science 6: 209–212.

[8] Takemi T, Yasui M, Zhou JX, Liu LC. 2005. Modeling study of diurnally varying convective boundary layer and dust transport over desert regions. Scientifi c Online Letters on the Atmosphere 1: 157– 160. DOI. 10.2151/sola.2005-041

[9] John E. Stout, Earth Surface Process and Landforms 35, 314–318 (2010)

[10] Wang, T., Zhao, H.L., Xiao, H.L., 1999. The progress on sandy desertification study in China. Journal of DesertResearch 19 (4), 299–311.

[11] Wang, S.G., Dong, G.R., Chen, H.Z., Li, X.L., Jin, J., 2000. Advances in studying sand-dust storms of China. Journal of DesertResearch 20 (4), 349–356

[12] Lin, Y.Q., 1980. The efficiency of straw check-board shelter system in controlling blown sand. In: Institute of Desert Research, Chinese Academy of Sciences (Ed.), Studies on the Blown Sand Control in Shapotou, Tengger Desert. Ningxia People'sPublishing House, Yinchuan, pp. 49–59.

[13] Léon Dubois, Lafarge Coppée. 150 ans d'industrie, Paris, Belfond, 1988, 324 pp.

[14] F. V. Hetzel and R. K. Albright, Belt conveyors and belt elevators, New York, London, 1941.

[15] G. M. Metcalfe, G. A. R. Prentice, Conveyor Belting in Canada, Canadian Mining Journal, no. 3,1958.

[16] Peskovozdlyarazrabotkizolotyhpromyslov, GazetaVostotchnoiSibiři « Amour », Irkoutsk, n° 1, 1861.

[17] P. N. Goulenkov, Primenenietransporterovpriotkrytyhrazrabotkah, Ougol. Moscow, n° 110, 1934.

[18] N. V. Berezin, B. Ia. Finkelchtein, Podemno-transportnyemachiny, Machgiz, Moskva, 1951.

[19] Faddeev B. V. Historique de l'utilisation des convoyeurs à bande dans les travaux miniers, histoire des sciences, tome 24, n°1, 1971. 61-66 pp.

[20] Latrechekaddour ,boumagoudaloubna, Conception d’un convoyeur à bande, thème de master, 2011, 65 pp.

[21] L. Melco, Informations techniques pour l'étude et la conception des convoyeurs à bande, 2015, 88 pp.

[22] DUNLOB, Constructeur de bandes pour convoyeurs, site internet : www.Dunlop.com, consulter le 22 Fevrier 2019.

[23] Kozhushko, G. G. Calcul et conception de convoyeurs à bande, manuel pédagogique, Ekaterinburg, Ed. UralUniversity, 2016, ISBN 978-5-7996-1836-0, 232 pp.

[24] SantanuChakarborthy ,Anshuman Mehta, IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 11, Issue 5 Ver. IV (Sep- Oct. 2014), PP 01-13.

[25] Dalley, Stephanie; Oleson, John Peter (2003). "Sennacherib, Archimedes, and the Water Screw: The Context of Invention in the Ancient World". Technology and Culture. 44 (1): 1–26.

[26] YoosefDoost, Arash; Lubitz, William David (December 2021). "Design Guideline for Hydropower Plants Using One or Multiple Archimedes Screws". Processes. 9 (12): 2128.