



School of Science and Engineering

Capstone Report

CONCEPTION OF A MANUAL BRICK MACHINE

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Final Capstone Report – Badr-eddine El Abbassi

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A handwritten signature in blue ink, appearing to be 'DST' with a long horizontal stroke extending to the right.

Acknowledgment

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Abstract

The purpose of this project is to provide the logistical support for the extension of concrete to the region of Zaouiat Sidi Abdslam. One of the obstacles to this approach is the lack of a low-cost, locally produced manual press, with performances as good as those known on the international market. Thus the studied points are:

The analysis of the needs necessary to the design of such a machine.

- The proposal of a new press from a range of solutions.
- Partial sizing of the proposed press.

A demonstrative prototype has been analyzed to better understand certain operating problems and machining constraints.

Finally, recommendations are made for the second phase of the project which will focus on the realization of our future press.

Introduction

In the ceramics industry, there is a large number of presses used for the shaping of bricks. Several are usable for stabilized soil. While others have undergone transformations and some have even been specially designed for the manufacture of compressed soil blocks. There are still some that have a particular potential, but that must be adapted.

These presses are generally very simple , they require relatively low investments compared to other types of presses such as the mechanical, hydraulic and pneumatic. Some of these machines, already exist on the market (GEO 50, UNATA) and work efficiently. However, the fact remains that in Morocco, they are relatively expensive as their transportation and customs fees make it nearly impossible to get such machines. This is one of the main reasons that led to the need to design a manual press that would be locally produced by local industries, at a lower cost and as reliable as the others. So, with the supervision of Dr. Asmae Khaldoune, a project of designing a prototype that could be made by any black-smith in the country, took place. This press will be a typical solution to help us in our project of helping to build a thermal efficient house in the region of GUIGOU.

The first phase of the project will be an analysis of the materials used in the process. We will also go through a needs analysis so that we will design our desired press.

Methodology

The first task that needed to be done in this project was to check if the project in itself was doable. I first checked some already existing presses in the market. Knowing that those machines were very expensive, I tried to make a design for a manual press.

The second task toward making the design, was to analyze existing designs. These designs were working perfectly. However, each design had its own strong and weak points. My mission was to detect the best suited one that I will base all my research on. In order to do that, I had to analyze some of the solution designs that I came up with. Some of them were newly designed while the others were already existing on the market.

After choosing the design that will suit us, I had to do a full force analysis. This full analysis will help me dimension this machine so that it will be both efficient and effective. This machine will be easy to make, easy to maintain and especially easy to use.

Litterature Review

Bricks



Figure 1 Picture Showing Bricks

History

Ever since man has learned to build, the earth has always been one of the main building materials used. It is only since the appearance of cement that soil techniques have been abandoned in urban areas and industrialized countries.

Currently, another third of the world's population lives in earthen dwellings.

The Soil

The soil is a very widespread natural resource. It comes from the degradation of the source rock, following climatic and chemical erosion phenomena. all soils have very different characteristics depending on their provenance.

The use of soil in construction has many advantages:

- it is often locally available in quantity.it does not require energy (except terracotta, which requires a lot of energy and often leads to deforestation);
- it is a healthy and ecological material (heat inertia and hygrometric regulation);
- it is a recyclable material.

Traditional earth building techniques are numerous. the most common are:

- mud (packing of racks).
- rammed earth (clay in shuttering forms).
- adobe (molded raw earth dried in the sun).
- the tether (shaped earth).
- straw earth (lighter and more insulating material).
- Compressed earth (compressed earth brick is an approach to the modernization and standardization of the use of earth material in construction).

There are old buildings that contain other elements in addition to the earth such as wood, stone or plants. The different natural elements are those that people find in their immediate environment.

Analysis Of The Soils Used For The Manufacture Of Bricks

Each type of soil has adapted construction techniques.

The "Ideal" Soil

The ideal soil does not exist. If using a nearby soil. In most cases it can be used as is or by amending it (with gravel, sand, binders ...). For bricks, it is an earthen concrete composed of gravel, sand, silt and clay (it is necessary to remove the top layer of the soil and the organic elements).(7)

We are looking for a soil containing about (3)

- 1/3 of gravel
- 1/3 of sand
- 1/3 of fine elements (silt + clay)

Gravel, sand and silt are structural elements and clays act as glue. For bricks, we try to have about 15 to 25% of the total clays. This percentage varies according to the granulomere of the inert elements in the analyzed soil: the finer the elements, the more surface to be coated, the more clay will be needed (within a certain limit beyond which there would be too much withdrawal). It also varies according to the quality of the clays (clays are more or less active, depending on their bonding surface: one gram of clay covers, depending on clays, from 10 to 80 m²).

The Soil's Analysis

It is useful to carry out qualitative analyzes of the soil that one wishes to use for construction. To make these analyzes, it is necessary to carry out (to have a sufficiently representative sample) several samples, in several places of the planned place of extraction.

These field analyzes provide indications for performing manufacturing tests. But it is only in view of the quality of the bricks and other manufactured elements that one will be able to decide on the choice of a soil.

The soil used for bricks must have certain characteristics among which(7)

- COHESION: the presence of good quality clays in sufficient quantity, which will bind all the elements together
- PLASTICITY: ability to deform the material without weakening
- COMPRESSIBILITY: ability to densify during compaction
- GRANULOMETRY: good representation of all fractions of elements, so that they organize themselves without leaving gaps

Sieving Analysis

Sieve analysis can be done in two ways: dry or underwater. We realize that if we do the sieving with dry earth and if we do the sieving with the same soil but under water, we obtain sometimes totally opposite results. This is due to the presence of clays nodules that behave dry as gravel and, therefore, remain with the gravel sieving.

On the other hand, under water, these clays disperse and pass through all the sieves. We must therefore draw the right conclusions from the tests: how will the clays behave in the field contained in the earth that we will use? What is the percentage of clays that will actually behave as active elements? Hence the need, despite the tests carried out, to test the quality of the bricks manufactured before starting construction.(5)

Analysis By Settling

We first separate the fine sands from silts and clays.

For this, pour the rest of the sieve 0.2 mm (T 0.2) in a container filled with water. After stirring the mixture, allow to stand for one minute. Quickly, the fine sands fall to the bottom of the container. The liquid containing the silt-clay mixture is recovered in suspension in a container. As

soon as they are dried, we weigh the fine sands recovered. To recover silts and clays, the slime-clay mixture must be allowed to stand in suspension long enough. The decantation water must be gently removed, taking care to remove only water that does not contain clays (the clays remain in suspension for a very long time).

To accelerate the removal of water, it is possible to use a plasterboard on which the silt-clay mixture is deposited. The paste obtained is recovered with a spatula.

Compared to the starting sample $P = 100\%$, we find the remaining weight of the clay-silt complex by successively deducting the weighing of the different sieves and the weighing obtained by settling of the fine sands.

Realization Of The Mixture

The volume of mixture to be prepared should not exceed one to two wheelbarrows of soil at a time, so that the moisture of the mixture does not have time to change. For information :

- a wheelbarrow = 60 L
- a bucket of mason = 10 L

In the same way, it is important, on a construction site, to reduce the movements related to the manufacture of bricks.

The mixing phase is very important: you have to make a very homogeneous mixture. It is dry in three stages: sieving the soil, adding sand (if necessary), mixing, adding cement (if making stabilized bricks), mixing (moving the pile at least three times), then adding the water needed by checking with the test described above. Knowing this, one can calculate the displacements so that the area of the last mixture is at the foot of the press.(3)

Need To Compact The Stabilized Soil

Compaction is one of the key operations for obtaining good resistances. Compacting the soil, is to make contained particles have the maximum contact points. It will also make sur that there is only minimized voids between them, so that all the particles will be nested within each other.

If a compaction fault is harmful, it should also be known that the search for maximum compaction, using for example two operators is not economical and may result in the rupture or deformation of certain organs of the press.(2)

For good manufacturing consistency, the grit-cement mixture placed in the mold, should preferably be weighed with an accuracy of plus or minus 50g.(2)

How To Compact The Concrete

To compact the concrete, one can:

- Exercise shock on the material repeated by tamping.
- Use mechanical, hydraulic or manual presses.

Optimal Dimensions Of Bricks

The dimensions of the blocks depend first of all on the thickness of the wall that one wants to obtain, 15 cm represent an optimum. Below this thickness, there is a risk of being too weak and thus not stable in construction.

A second requirement is to have manageable blocks. 15x20x40 represent maximum dimensions and can weigh from 26 to 27 kilos. Such blocks can be transported without boards as soon as they are made.(2)

Compactness Versus Wear Resistance

The resistance is higher on the lower face of the concrete than on its upper face. This is explained by the fact that with the CINVA-RAM, the compaction is obtained by an upward vertical movement of the lower plate, the upper plate remains fixed. The compaction is better at the lower part of the concrete. It has also been found that good compaction is a factor in the durability of concrete, since it is more resistant to wear.(1)

BRICKS Presses

In the ceramics industry, there are a large number of presses for the shaping of bricks. Many are used for stabilized earth. Others have undergone transformations and some have been specially designed for the manufacture of compressed soil blocks. There are still some that have a particular potential, but that must be adapted.

These presses are generally very simple and require relatively low investments compared to other types of presses (mechanical, hydraulic and pneumatic). However, the fact remains that in Morocco, they are relatively expensive. And this is one of the main reasons that led to wanting to design a manual press that would be locally produced by local industries, at a lower cost and as reliable as the others.(1)

These presses are generally simple, easy to maneuver, easily modifiable compared to other types of presses (mechanical, hydraulic and pneumatic). They are relatively expensive. And this is one of the main reasons that led to the design of a hand press that would be locally produced by local industries, at a lower cost and as reliable as the others.(1)

Selected Presses

There are some particularly interesting presses that exist. their operating way is also delicate and require a lot of notions. There also some other presses that have been newly designed. Technical characteristics will be given to show the performances and especially the limits of these presses.

The "ELISON BLOCKMASTER"

It is a manual press made in India. There are four models giving different bricks or blocks. Thus to build a building, it will require at least two models. The walls and cupolas require bricks of different sizes. Hence a weak point that deserves to be improved. For example, by a system of interchangeable molds.



Figure 2 The "ELISON BLOCKMASTER"

The "CINVA-RAM"

This manual press was developed in Bogota, Colombia, in 1952 by the Inter-America Housing and Planning Center (4), is well known and widely used, and gives birth to models based on the same

principle. The results have made it possible to define a certain number of criteria for the choice of manual presses. CINVA-RAM is one of the most used presses in the world, but it has some weak points that we will try to show by describing the essential elements that constitute it.(7)

The box

It is a rectangular metal mold formed of four sheets of which two of 15 mm thick and two of 8 mm thick, mounted on four feet. It is the frame of any mechanism and is bolted to a base that ensures stability.(7)

The Lid

Two different covers have been designed: the first is released from the mold and comes to rest behind the machine on two supports, the second pivots around an axis located on the side of the mold, it is this mode which has been commercialized (this press is no longer manufactured by its manufacturer) (ref) and which has the disadvantage of scraping the soil initially introduced into the mold (thus decreasing the strength of bricks) rather than tamping it.(7)

The lever

It is placed in two notches on the lid. It transmits its movement to the piston by two connecting rods. In the vertical position, two hooks are locked on a cross member, which makes the lever-connecting rod assembly integral.

The piston: it is a cylinder surmounted by a rectangular plate. It is guided by two adjustable angles which constitute sources of wear having significant consequences on the quality of the bricks, because this wear offsets the compression piston, and consequently a lack of homogeneity of the bricks. And here we think that a piston guide with a cylinder would reduce wear.(7)



Figure 3 THE "CINVA-RAM"

The "TEK Block"

It is a hand press that was developed in Ghana by the Department of Habitat Research and Planning. (Ref). It has the same operating principle as the CINVA-Ram except the automation at the opening and closing of the lid. Thus, handling is easier and can speed up the pace of production.(7)



Figure 4 The "TEK BLOCK"

The "GEO 50"

It is a manual press on soil which was designed and realized by the soil center in LAVALETTE in France. It has a double-acting compression system.(7)



Figure 5 The "GEO 50"

The PALAFITTE

It is a manual press that was built in a single copy, seeking to combine the benefits of CINVA-Ram and TEK BLOCK in 1974. Its main advantage and automation of the opening and closing of the press.(7)

The TERSTARAM

It is a manual press, also known as "Land-Crete" and "Stadibloc". It has a number of improvements that have made it the best hand press available on the market.

Thanks to its gradual improvement, the TERSTA-RAM press can produce bricks of various sizes. Also its folding lid, allows to ensure a slight pre-compaction of the expanded material and therefore

a better quality of bricks (good resistance). The TERSTARAM has two main disadvantages which are the height of price and the difficulty of handling (very robust).(7)



Figure 6 The "TERSTARAM"

Characteristics Of Presses

Type Of Press

We differentiate the presses according to the source of energy:

- Manual: in this case compaction is provided by one or more persons by means of a lever or pestle system.
- Mechanical: the compaction is done by a system of lever or shelling which is mechanically actuated by a gasoline engine, diesel or electric.
- Hydraulic: the energy of an engine is transmitted to the compaction plate by means of a hydraulic system.

- Pneumatic: the energy of the motor is transmitted to a pestle via a pneumatic system.

Compression Mode

The compression can be done according to two modes:

-Static pressure, compaction is ensured by the relatively slow approximation of two surfaces between which is the product to be compacted, which is retained laterally.

-Dynamic pressure, compaction is obtained by pounding the product in a mold. The pressure exerted on the brick is difficult to control.

Problem's Analysis

Data

- The product to be reduced is bricks
- The reduction rate is 1.4

Objectives

Primary Objectives

- Simplicity of the press
- Ease of use
- Compact
- Ease of manufacture

Secondary Objectives

- Easy transportation
- Easy maintenance
- Accessibility of all mechanical parts

Restrictions

- Low manufacturing cost
- final pressure of the compression: 3 bars
- Dimensions of the mould (310mm x 150mm x 150mm)
- Materials for manufacturing existing on the market.

Evaluation Criteria

Table 1 Evaluation Criteria Table

Criteria	Weighting (%)
Simplicity	20
Cost of manufacture	25
Ease of use	10
Easy demoulding	15
Ease to manufacture	15
Stability	10
maintenance	05

Generation Of Solutions

It is at this stage that we propose several solutions while explaining their main characteristics. In this phase of design, it is very important not to block the creative imagination. That is to say, in other words, that we must list all the solutions that come to mind without any restriction. Existing presses will also be used for similar applications or for different applications (e.g. manual press for shaping stabilized clay bricks). It should be noted that it is from these different that the final solution will come out.

Solution 1

For this press, compacting is ensured by a plate whose displacement is controlled by the rotation of a large screw. The connection between the plate and the screw is via a bearing that can withstand axial forces. The rotational movement is given to the screw by means of a crank placed at its upper part, it is also possible thanks to the tapping done in the middle of the top cover of the mold. The demolding is done from the bottom by the same process used during compression. The top and bottom covers can swing around pivots and their closing is done by hooks.(6)

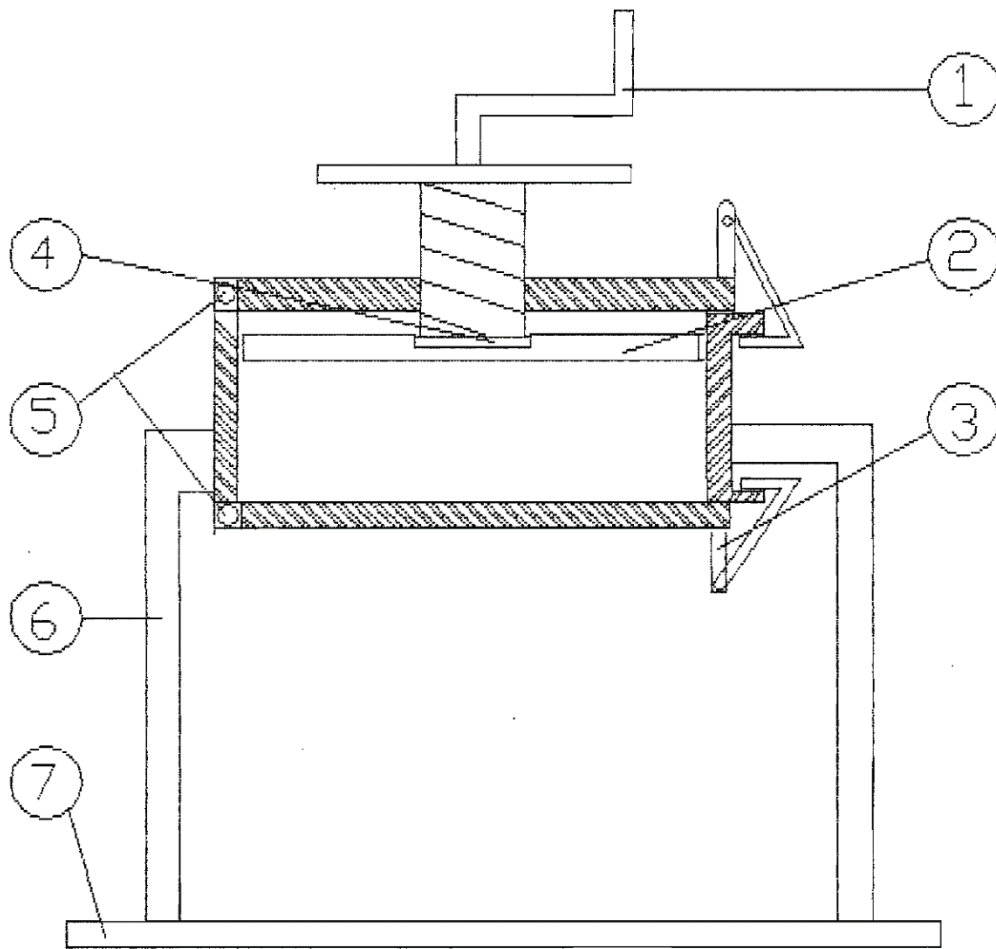


Figure 7 Solution 1 Solid Work's design

LEGEND:

- 1) crank
- 2) compression plate
- 3) blocking system
- 4) bearing
- 5) pivots
- 6) support
- 7) base

Solution 2

It is a press whose compaction system consists of a crank-slide mechanism. At the end of the slider we have a tray which in descending phase ensures the compression of the material.

The compression lever is fixed by a ball joint to the top cover. Demolding is done from the bottom because of the presence of a tilting lower lid and under the action of the compression plate.(6)

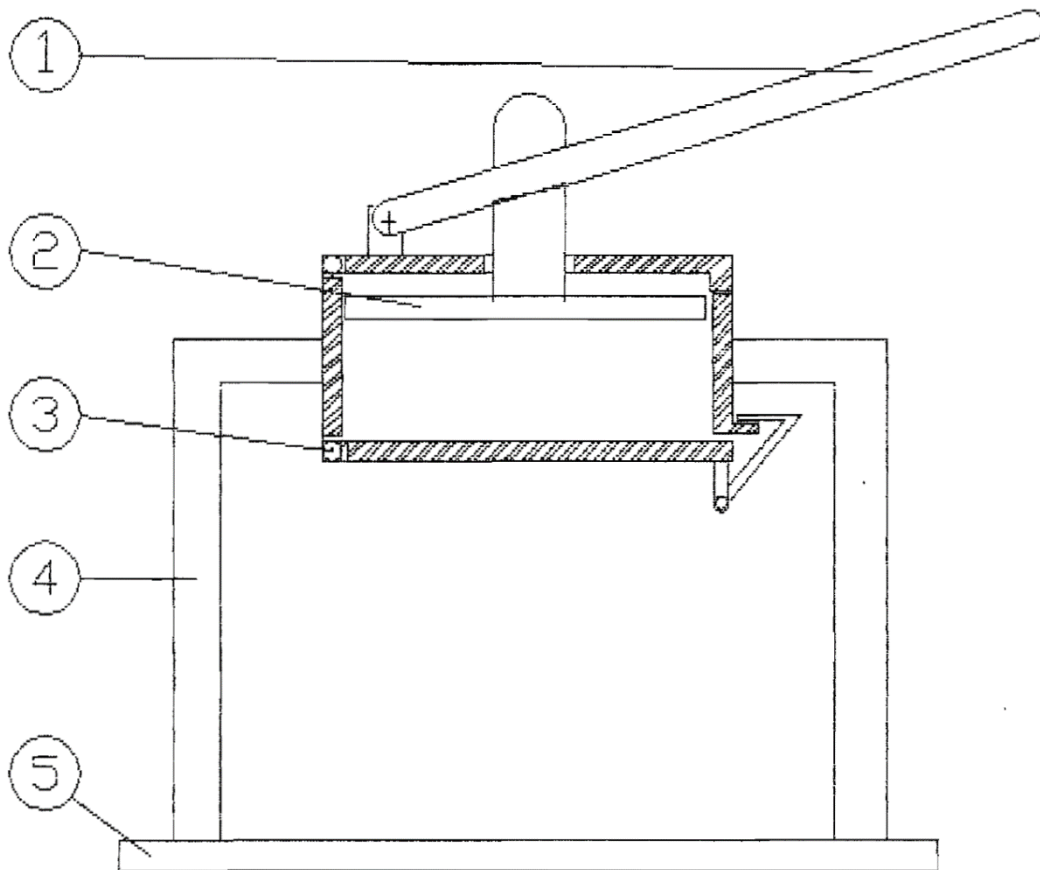


Figure 8 Solution 2 Solid Work's design

LEGEND:

- 1) Compression lever
- 2) Compression plate
- 3) Pivot
- 4) Support
- 5) Base

Solution 3

Here too, compaction is performed by a crank-slide system. guidance is provided by the top cover. We also have the compression lever which is attached to the latter by means of a ball joint. However, for this manual press, the release is done by the upper part, thanks to the use of a second mold that fits into the first. It should be noted that this second mold has only three faces: two lateral and one lower. The two side faces are provided with handles for extracting the second mold from the first. The demolding is therefore manual.(6)

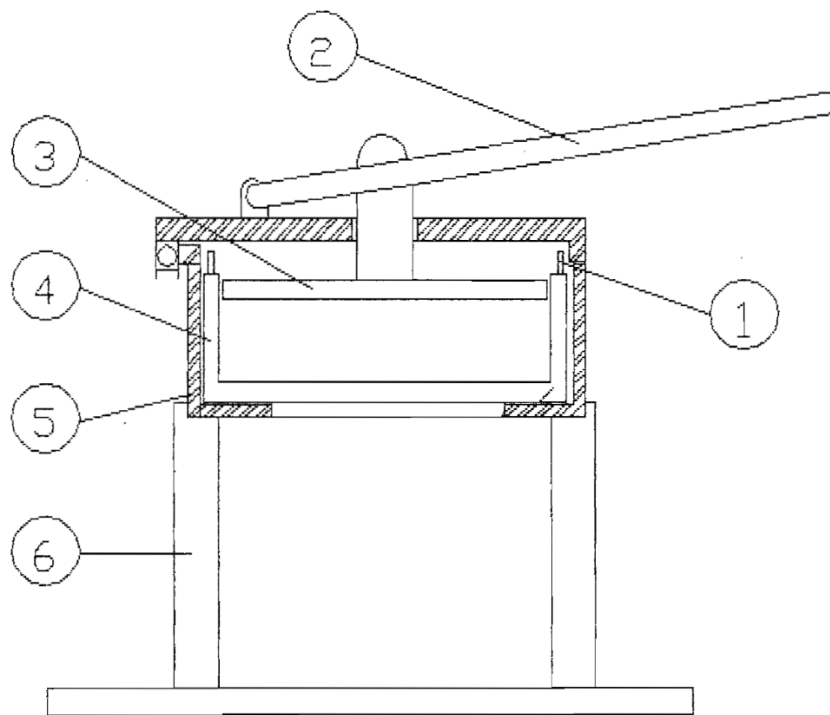


Figure 9 Solution 3 Solid Work's design

LEGEND

- 1) handle
- 2) compression lever
- 3) compression plate
- 4) Inner mold
- 5) outdoor mold
- 6) support

Solution 4

This press consists of a fairly complex system that provides the two main functions, i.e. compaction and demolding. The system is actually composed of two crank-slide mechanisms. A superior mechanism that allows compacting and another lower loaded demolding. The two mechanisms are connected by a cam which in compaction phase eliminates the demolding mechanism and actuates the latter once the top cover of the mold is opened. It should be noted that the coefficient of friction between the cam and the demolding lever must be low hence the need for a careful choice of their manufacturing materials.(6)

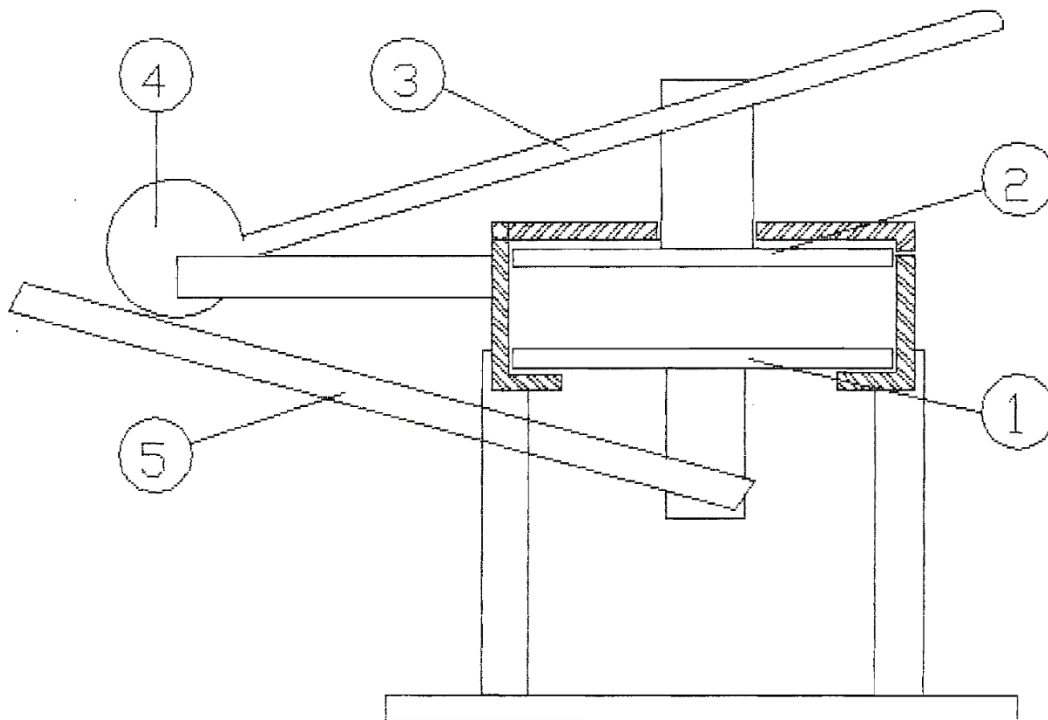


Figure 10 Solution 4 Solid Work's design

LEGEND:

- 1) demolding tray
- 2) compression plate
- 3) compression lever
- 4) cam
- 5) demolding lever

Solution 5

In the case of this press, unlike the previous, the plate and the compacting mechanism are located at the bottom of the mold. compaction is always done by a crank-slider mechanism. And it is this same mechanism that ensures demolding. To do this simply remove the locking system of the top cover and fold the latter on the other side with the help of the compression lever. To prevent this press from tipping during compaction, it must be firmly attached to the ground.(6)

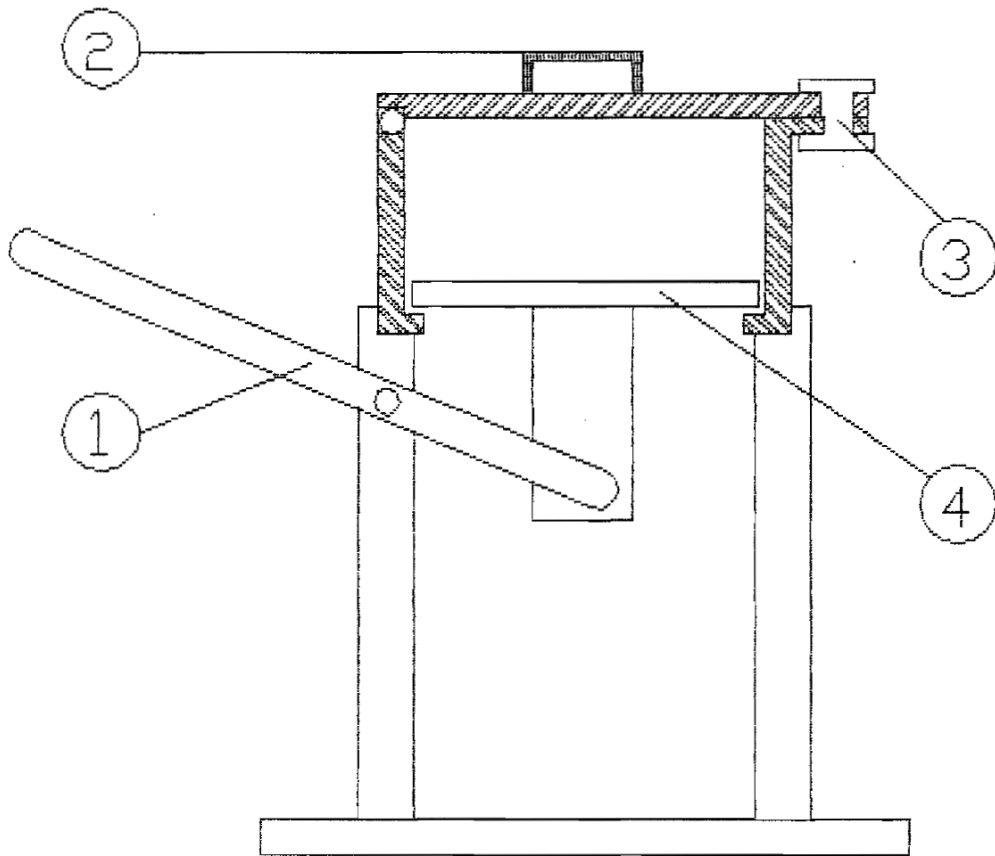


Figure 11 Solution 5 Solid Work's design

LEGEND:

- 1) compression lever
- 2) handle
- 3) blocking system
- 4) compression plate

Practicability Study

At this stage of the development of the press, the needs analysis, that the goals and specifications of the press have been established to the best of our knowledge. It is now through the feasibility study that we will dissect all the solutions that were found during the generation of solutions and see if they meet the criteria that had been set beforehand. It will therefore be necessary for each solution to answer different questions such as:

- Are the objectives achieved?
- Are the restrictions respected?
- Does the solution face realization problems?

So we will take the solutions one by one and we will try to see if they meet the requirements of departure.

Solution 1

The main flaw of this solution is that its manufacture will not be very simple because of the machining of the large screw. The demolding being done from below could pose some problems. On the other hand the control of compaction can be done very easily.

Solution 2

Here we are dealing with a fairly simple and easy-to-perform press. But as for the previous solution, the demolding is quite delicate, it would be advisable to do it by the bottom of the mold.

Solution 3

This press is also quite simple. And because of its configuration (nesting of two molds), it has a very simple demolding that is done manually. Its use is a bit difficult.

Solution 4

It is a press that has a very reliable mechanical release. Its main drawback is its complexity due to the use of two crank-slide mechanisms. Its realization appears at first sight delicate.

Solution 5

This press has the advantage of being simple and easy to use.

The main criticism that could be made to it is that it needs a good ground fixation to prevent it from tipping during molding and demolding operations, resulting in a fairly low stability. The locking system of the top cover could also be a problem. This press has a good mechanical release.

Choice Of The Final Solution

Through the feasibility study, we notice that there are two solutions that generally meet the initial criteria, which are solutions 3 and 5. It is therefore on one these two solutions that our choice will fall.

There are several decision techniques. We will be using the simple decision matrix. This matrix systematizes decision-making between the various solutions to the problem. To do this, we associate a return to each of the solutions for each of the evaluation criteria already established in the "problem definition" phase. The columns of the matrix are associated with the different solutions. The lines relate to the evaluation criteria already fixed and their relative weighting. The score of each solution is obtained by summing the elements of each line, previously multiplied by the weighting factors of the appropriate criteria.

Table 2 Decision Matrix Table

Evaluation criteria	Weighting	Solution 3	Solution 5
Simplicity	20	A	A
Cost	25	B	B
Easy to use	10	A	C
Easy to demould	15	A	A
Easy to build	15	B	A
Stability	10	D	B
Maintenance	05	A	A
result	100	345	330

A: excellent (4 points)

B: Good (3points)

C: Average (2 points)

D: Mediocre (1 point)

According to the decision matrix we will systematically opt for the third solution which seems to be the most efficient. Our study will be based on this specific solution.

Dimensioning Of The Press

Calculation Of Sliding Crank System

The system takes at the end and at the beginning of compression the following configurations:

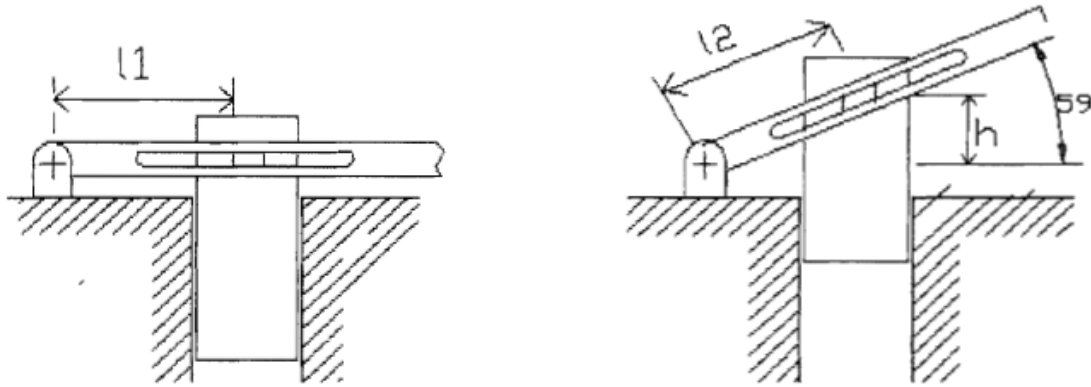


Figure 12 Sliding Crank System at the Beginning and the End of Compression

here we will determine l_2 knowing l_1 and h . (4)

with $l_1 = 60$ mm

h is the piston stroke = 100 mm

$$\tan \alpha = \frac{h}{l_1} = \frac{100}{60} = 1.67$$

where we get

$$\alpha = 59$$

l_2 is given by:

$$l_2 = \frac{l_1}{\cos \alpha} = \frac{60}{\cos 59} = 116.6 \text{ mm}$$

so the slot of the compression lever has a minimum length

$$l = l_2 - l_1 = 116.6 - 60$$

$$l = 56.6 \text{ mm}$$

Calculation Of The Forces

when isolating the different elements of the compression system, we get the following figures(6)

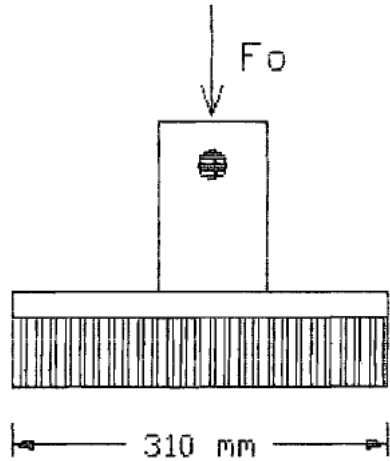


Figure 13 force Acting on the Compression Plate

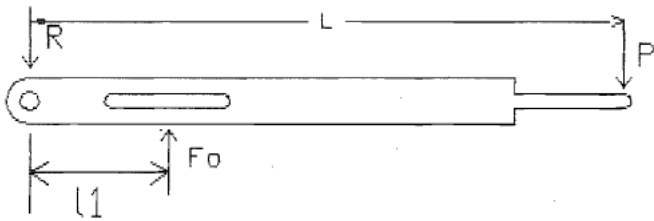


Figure 14 Forces Acting on the Lever

the force F_c is the resultant force of the compression pressure which is equal to:

$$F_c = P_0 * A \text{ where } P_0 = 3 * 10^5 \text{ pascals}$$

$$A = (310 * 150) \text{ mm}$$

$$F_c = 13950 \text{ N}$$

from the figure, we can see that

$$F_c = F_0 = 13950 \text{ N}$$

In this case we neglect the friction between the guide cylinder and the compression cylinder as well as between the compression plate and the inner mold.

* At this stage, we can calculate the length of the compression lever according to the free body diagram of the lever.

R is the reaction at the pivot.

P is the exerted force by an average user, so we will assume that his weight will be equal to 70kg.

$$P = M * G = 70KG * 9.81 \frac{m}{s^2}$$

we have seen before that $l_1=60$ mm.

by adding the sum of the moments according to the pivot we get the following formula:

$$P * L = F_0 * l_1 \text{ where } L = \frac{F_0 * l_1}{P}$$

so

$$L = \frac{13950 * 0.06}{687} = 1.22m$$

we get then

$$R = P - F_0 = 13950 - 687$$

$$R = 13263 N$$

Dimensioning Of The Interior Mould Plate A And B

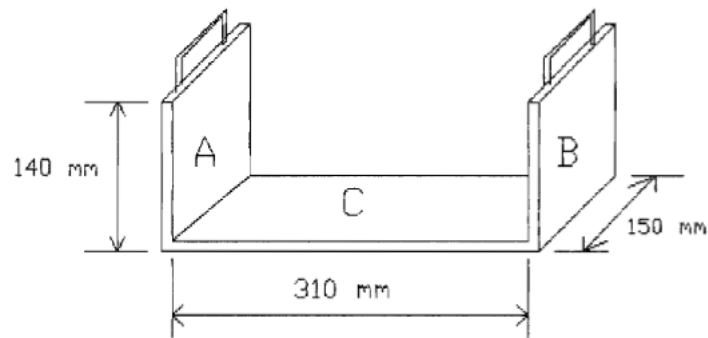


Figure 15 Dimensions of the Interior Mold

The plates A and B are identical and have evenly distributed load and the same conditions at the edges. Consequently, they will have the same dimensioning.

* Conditions at the edges: three free sides and one closed.

* Loading: load evenly distributed over the entire surface.

The surface at the end of the compression is:

$$(80 * 150)mm = 24800 mm^2$$

The charge at the end of the compression is: $3 * 10^5 N/mm^2$

This load can be considered as a linear load uniformly distributed along the 80 mm. The charge therefore becomes:

$$(3 * 10^5 N/m^2) * 0.15 = 45 KN/m^2$$

so, we get the following diagrams:

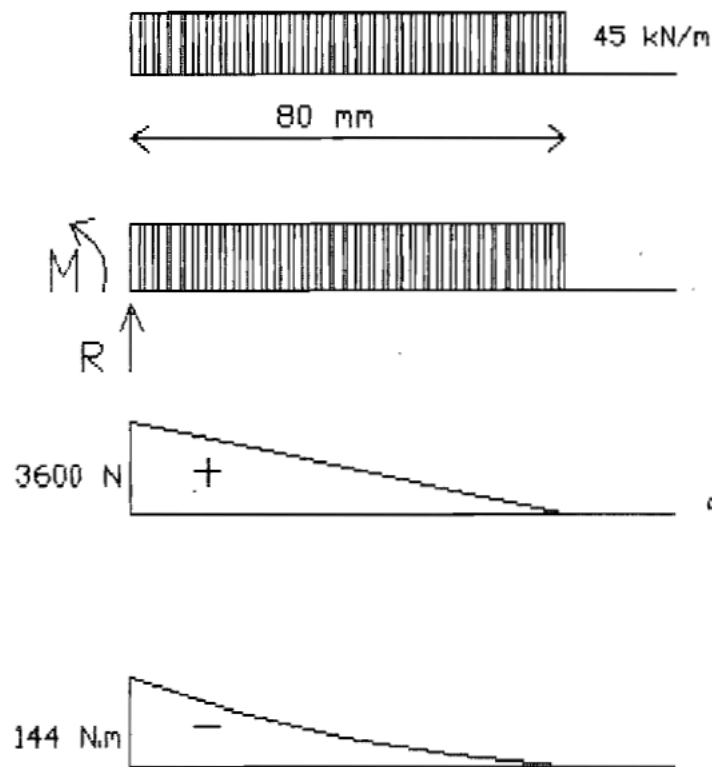


Figure 16 Shear Force and Bending Moments' diagrams

the reaction at R

$$R = L * W = 0.08^2 * 45000 = 3600N$$

maximum moment

$$M_{max} = \frac{W * L^2}{2} = 144N * m$$

Calculating The Thickness Of Plates A And B

let σ be the tension constraint to extreme fibbers.

We have $\sigma = \frac{6 * M}{a * e^2}$ where $e = \sqrt{\left(\frac{6 * M}{a * \sigma}\right)}$.

With

$$a = 150 \text{ mm} \text{ and } \sigma = \frac{\sigma_{adm}}{FS} = \frac{235}{2} N/mm^2$$

we then obtain:

$$e = \sqrt{\frac{6 * 144}{0.15 * 117.5 * 10^6}} = 7 \text{ mm}$$

the thickness of both plates A and B is 7mm.

Plate C

four of the sides are normally supported. In this case we have:

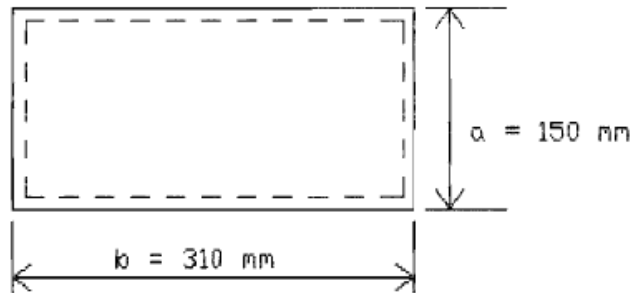


Figure 17 Dimensions of Plate C

$$\alpha = \frac{b}{a} = 2.07$$

we will take the according coefficients to $\alpha = 2$.

We also have the Poisson's ratio, $\nu = 0.3$, $E = 200 \text{ GPA}$ and $P_0 = 3 * \frac{10^5 \text{ N}}{\text{m}^2}$

The maximum moments according to span a and b are:

- Span b:

$$\begin{aligned} (M_x)_{max} &= C_2 P_0 a^2 \\ &= 0.1017 * 0.15^2 * 3 * 10^5 = 686.5 \text{ N} * \text{m} \end{aligned}$$

- Span a:

$$(M_y)_{max} = C_3 P_0 a^2$$

$$= 0.0464 * 0.15^2 * 3 * 10^5 = 313.2 N * m$$

the total maximum moment is given by the following formula:

$$M_{max} = (M_x)_{max} + \nu * (M_y)_{max} = 686.5 + 0.3 * 313.2 = 781 N * m$$

Calculating The Thickness Of Plate C

We have

$$\sigma = \frac{6 * M}{e^2} \text{ where } e = \sqrt{\left(\frac{6 * M}{\sigma}\right)}$$

So

$$e = \sqrt{\left(\frac{6 * 781}{117.5 * 10^6}\right)} = 6.31 \text{ mm}$$

since we have holes we introduce a constraint factor $K_t=2.0$. we get then $\sigma = 58.75 * 10^6$

then

$$e = \sqrt{\left(\frac{6 * 781}{58.75 * 10^6}\right)} = 8.9 \text{ mm}$$

$$e = 8.9 \text{ mm}$$

Dimensioning Of The Exterior Mould

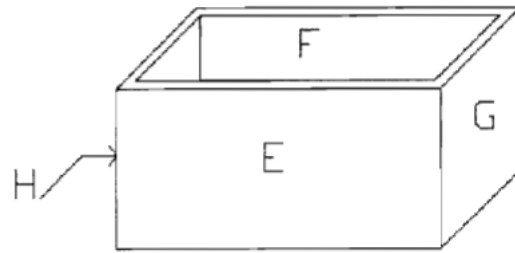


Figure 18 Dimensions of The Exterior Mould

Plates E And F

The plates E and F are identical. They have an evenly distributed load and the same conditions at the edges. Hence, they will have the same dimensioning.

Conditions at the edges: 3 fixed sides and 1 free side.

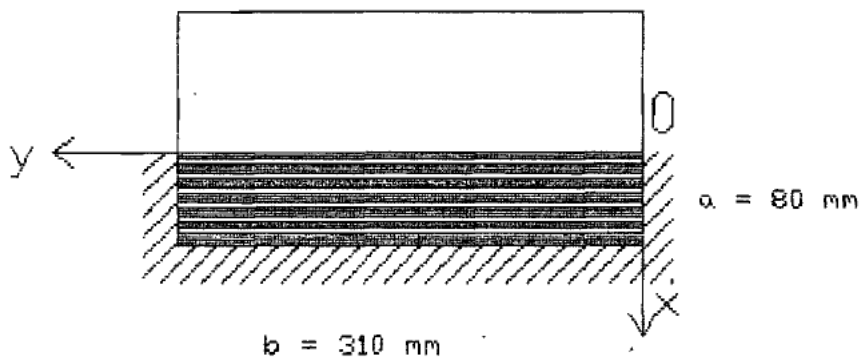


Figure 19 Reference Axes

We have

$$a/b = 80/310 = 0.258$$

In the table giving the values of the different coefficients, we do not have a column corresponding to $a/b = 0.258$. It will therefore be necessary to find the corresponding coefficients to extrapolate.

We have

$$\frac{y_1 - y}{x_1 - x} = \frac{y_2 - y_1}{x_2 - x_1}$$

$$y_1 - y = \frac{y_2 - y_1}{x_2 - x_1} * (x_1 - x)$$

we have then

$$y = \frac{y_2 - y_1}{x_2 - x_1} * (x_1 - x) + y_1$$

$$y = \frac{0.258 - 0.3}{0.4 - 0.3} * (y_2 - y_1) + y_1$$

Table 3 Coefficient Table

a/b	0.30	0.40	0.258
C ₁	-0.0048	-0.0014	-0.0062
C ₂	-0.0026	0.0070	0.0008
α	-0.3833	-0.2783	-0.4274
β	-0.0131	-0.0242	-0.0038
C ₃	0.0078	0.0173	0.0038
γ	-0.0333	-0.0545	-0.0244

$$(M_x)_{x=a/2, y=b/2} = C_1 P_0 b^2 = -0.0062 * 3 * 10^5 * 0.31^2 = -178.7N * m$$

$$(M_y)_{x=a/2, y=b/2} = C_2 P_0 b^2 = -0.0008 * 3 * 10^5 * 0.31^2 = 23.1N * m$$

$$(M_y)_{x=0, y=b/2} = C_3 P_0 b^2 = -0.0038 * 3 * 10^5 * 0.31^2 = 109.6N * m$$

$$(M_x)_{x=a/2, y=0} = \beta P_0 b^2 = -0.0084 * 3 * 10^5 * 0.31^2 = -242.2N * m$$

$$(M_y)_{x=0,y=0} = \gamma P_0 b^2 = -0.0244 * 3 * 10^5 * 0.31^2 = -703.5 N * m$$

$$(M_y)_{x=a,y=0} = \alpha P_0 b^2 = -0.4274 * 3 * 10^5 * 0.08^2 = -920.6 N * m$$

$$(M_y)_{x=a,y=b/2} = 0$$

we have according to span x and y:

$$(M_y)_1 = v * M_x + M_y = 0.15 * (-821) = -123 N * m$$

$$(M_x)_1 = (M_x)_{x=a,y=b/2} + v_1 * (M_y)_{x=a,y=b/2} = -821 N * m$$

we can see

$$(M_x)_1 = M_{max}$$

this moment corresponds to $v = 0.30$. we will look for the moment corresponding to $v = 0.30$, that is given by:

$$(M_x)_2 = \frac{1}{1 - v^2} * [(1 - v_1 * v_2) * (M_x)_1 + (v_2 - v_1) * (M_y)_1]$$

$$(M_x)_2 = \frac{1}{1 - 0.15^2} * [(1 - 0.15 * 0.30) * (-821) + (0.30 - 0.15) * (-123)]$$

$$(M_x)_2 = -821 N * m$$

Calculating The Thickness Of Plates E And F

we have

$$e = \sqrt{\left(\frac{6 * M}{\sigma}\right)} = \sqrt{\left(\frac{6 * 821}{117.5 * 10^6}\right)}$$

$$e = 6.5 mm$$

H And G Plates And Bottom Plates Of The Exterior Mold

The plates H and G work in tension under the action of the plates E and F, but they are retained at their bases by the plates of the lower part of the outer mold, so their dimensioning is not necessary.

A small check shows us that any plate of thickness equal to the thickness of plates E and F is suitable. It is the same for the plates of the lower part of the outer mold which are supported from below by the feet of the press.

Dimensioning Of The Compression System

Calculation Of The Thickness Of The Compression Cylinder

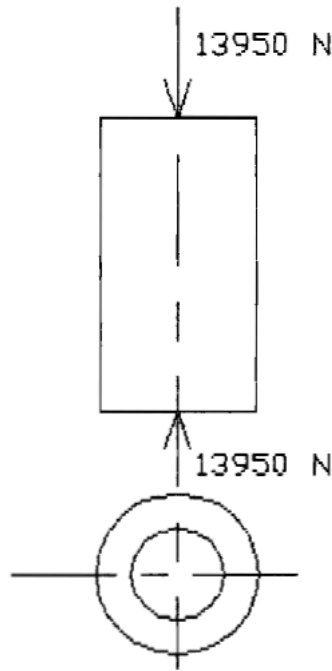


Figure 20 Force Acting on the Compression Cylinder

we have (10)

$$\sigma_{adm} = \frac{F_1}{A} = \frac{13950}{\frac{\pi * d^2}{4} - \frac{\pi * (d - 2 * e)^2}{4}} = \frac{13950}{\frac{\pi}{4} * [d^2 - (d - 2 * e)^2]}$$

$$\sigma_{adm} = \frac{13950}{\pi * (e * d - e^2)}$$

from that we get the following values for e:

$$e_1 = 59.4 \text{ mm and } e_2 = 0.64 \text{ mm}$$

so consequently, we will take the smallest value.

So

$$e_1 = 0.64 \text{ mm}$$

Calculation Of The Thickness Of The Compression Plate

Let's make the following simplifying assumptions:

The load applied by the compression cylinder is a concentrated point load.

The uniformly distributed load is transformed over the entire surface into a uniformly distributed linear load.

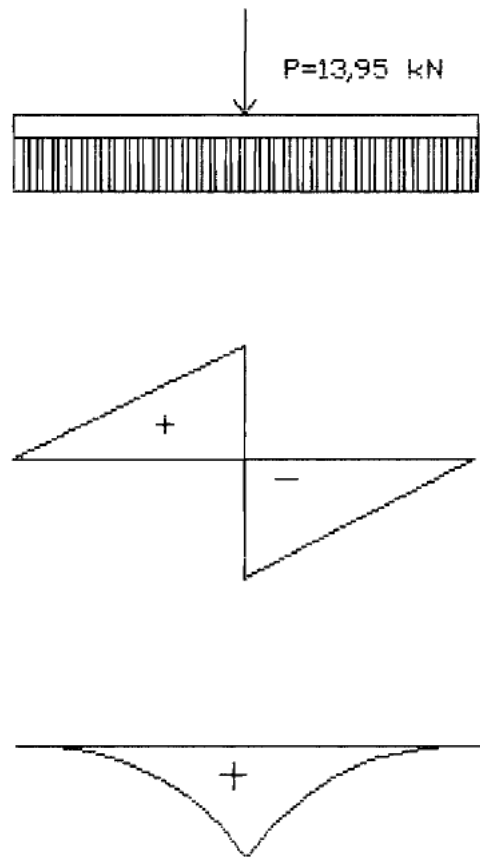


Figure 21 shear Force and Bending Moment's Diagrams

Calculation Of The Shear Forces

To the left of the concentrated load P we have (10)

$$v = P_0x \text{ for } 0 \leq x \leq L/2$$

to the right of P, we have

$$v = P - P_0x \text{ for } L/2 \leq x \leq L$$

Calculation Of The Maximum Bending Moment

We have

$$M_{max} = \frac{P_0L^2}{8} = 541 \text{ N} * \text{m}$$

the thickness “e” of the compression plate is calculated by this formula

$$e = \sqrt{\left(\frac{6 * M}{0.15 * 117.5 * 10^6}\right)} = 13.5 \text{ mm}$$

Dimensioning Of The Cylinder's Axis Of Compression

We have the following diagrams

Calculation Of The Reactions:

$$R_1 = R_2 = \frac{13950}{2} = 6975 \text{ N}$$

Calculation Of Maximum Moment:

$$M_{max} = \frac{P * l}{4} = \frac{13950 * 0.06}{4} = 209 \text{ N} * \text{m}$$

Calculation Of The Axis' Diameter:

From (10)

$$\sigma = \frac{M * d/2}{I} \text{ with } I = \frac{\pi * d^2}{64}$$

so

$$\sigma = \frac{M * d/2}{\frac{\pi * d^2}{64}} = \frac{32 * M}{\pi * d^3}$$

so, we solve for d

$$d = \left(\frac{32 * M}{\pi * \sigma}\right)^{\frac{1}{3}}$$

consequently

$$d = 26 \text{ mm}$$

Dimensioning Of The Pivots' Axis

Following the same assumptions, we get

$$R_1 = R_2 = 6632N$$

$$M_{max} = \frac{13263 * 0.06}{4} = 199 \text{ N * m}$$

then we can get the diameter of the pivot's axis

$$d = \frac{32 * 199}{\pi * 117.5 * 10^6} = 0.026$$

$$d = 26 \text{ mm}$$

Dimensioning Of The Compression's Lever

The moments diagram gives us as a maximum bending moment

$$M_{max} = P * a = 687 * 1.16 = 797 \text{ N * m}$$

the section to which we will apply the maximum moment have the following configuration

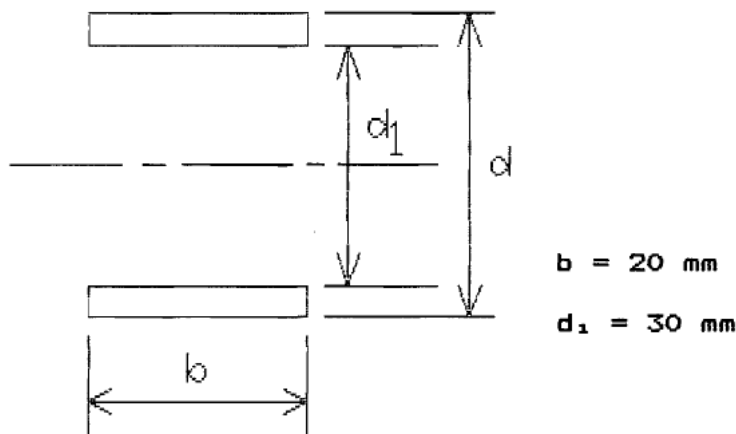


Figure 22 Cross section of the Compression Lever

the maximum constraint is given by:

$$\sigma = \frac{M * c}{I} \text{ with } I = \frac{b * (d^3 - d_1^3)}{12}$$

the constraint becomes

$$\sigma = \frac{\frac{M * d}{2}}{\frac{b * (d^3 - d_1^3)}{12}} = \frac{6 * M * d}{b * (d^3 - d_1^3)}$$

we then get the following equation

$$d^3 - 0.002 * d = 2.7 * 10^{-5}$$

$$d = 50 \text{ mm}$$

Calculation Of The Lever's Tube Of Compression

For a distance “a” from the pivot’s axis we have the value of the moment at that point equal to:

$$M = 686 * (1.22 - a)$$

$$M = 700.7 \text{ n * m for } a = 200 \text{ mm}$$

now we will dimension the tube at that point

we have from the constraint equation

$$d = \left(\frac{32 * M}{\pi * \sigma} \right)^{\frac{1}{3}}$$

so

$$d = 40 \text{ mm}$$

Pivot's Calculation

The pivot consists of two rectangular plates each having a length of 90 mm and a width of 50 mm. Each of the plates is also pierced to receive the axis of the pivot, this hole has a diameter of $d = 30$ mm. The plates will be dimensioned in traction. We therefore have the following configuration for each plate:

We have

$$F = \frac{13263}{2} \text{ and } \sigma_{adm} = \frac{F}{A} * K_t = \frac{13263}{2 * 0.02 * h} * K_t$$

with h equals to the width of each plate

$$K_t = 2$$

we get

$$h = \frac{13263 * K_t}{2 * 0.02 * \sigma_{adm}} = \frac{13632}{0.02 * 117.5 * 10^6} = 5.6 \text{ mm}$$

so

$$h = 6 \text{ mm}$$

after this Force analysis we get that :

- Thickness of plate A and B of the interior mold should be 7mm.
- Thickness of plate c of the interior mold should be 6 mm.
- Thickness of plate E and F of the exterior mold should be 6.5 mm.
- Thickness of the compression cylinder should be 0.64 mm.
- Thickness of the compression plate should be 13.5 mm.

- Diameter of the cylinder's axis of compression should be 26 mm.
- Diameter of the compression lever should be 50 mm.
- Diameter of the lever's tube of compression should be 40 mm.
- The height of the pivots is 6 mm.

Conclusion

After choosing the right solution for us, we went through an overall analysis. This analysis would help us figure out the best measurements for our prototype. We should remember that the reason behind our whole project was to minimize the costs and be able to produce a machine that may be used in the rural area. By going through this analysis, we managed to design a machine that is at the lowest budget possible while not forgetting efficiency.

After going through all these analyses, we managed to get a final design for our prototype. We have all the needed measurements in order to go through the next step. Hopefully, our next step will indeed be our realization step. Our prototype, based on our design, should be fully operational and functional.

With that being said, we have nevertheless been able to note that the results obtained concerning the design, sizing as well as the characteristics of the press, are quite satisfactory and can therefore be the basis of the popularization of this product. We can thus contribute in a significant way to our project that consists of building a thermal efficient house model.

Recommandations

The first recommendation would be to realize a prototype of the desired machine so that we can get an absolute idea of the machine's proportions. I would also recommend to use bronze between the cylinder and the compressions axis. We can use bronze so that we can reduce the friction between the material.

The third recommendation would be to give an approximation of the costs so that we can build our desired prototype.

We should also determine the weight, efficiency and the desired compression rate. The final step would be to optimize those characteristics for an optimal outcome.

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Appendix

TABLE 13.1 Formulas Obtained by the Theory of Flexure of Slabs, Giving Approximate Values of Bending Moments per Unit Width and Maximum Deflections in Rectangular and Elliptical Slabs Under Uniform Load (Given by Westergaard)^a

	Moments in span <i>b</i>		Moments in span <i>a</i>		Values of <i>C</i> at maximum deflection for $w_{\max} = C(1 - \nu^2) \times (pb^4/Eh^3)$
	At center of edge $-M_{b,e}$	At center of slab $M_{b,c}$	At center of edge $-M_{a,e}$	Along center line of slab $M_{a,c}$	
Rectangular slab, four edges simply supported	0	$\frac{1}{8}pb^2$ $1 + 2\alpha^2$	0	$\frac{pb^2}{48}(1 + \alpha^2)$	$\frac{0.16}{1 + 2.4\alpha^2}$
Rectangular slab, span <i>b</i> fixed, span <i>a</i> simply supported	$\frac{1}{12}wb^2$ $1 + 0.2\alpha^4$	$\frac{1}{24}pb^2$ $1 + 0.4\alpha^4$	0	$\frac{pb^2}{80}(1 + 0.3\alpha^2)$	$\frac{0.032}{1 + 0.4\alpha^2}$
Rectangular slab, span <i>a</i> fixed, span <i>b</i> simply supported	0	$\frac{1}{8}pb^2$ $1 + 0.8\alpha^2 + 6\alpha^4$	$\frac{1}{8}pb^2$ $1.08\alpha^4$	$0.015pb^2 \left(\frac{1 + 3\alpha^2}{1 + \alpha^4} \right)$	$\frac{0.16}{1 + \alpha^2 + 5\alpha^4}$
Rectangular slab, all edges fixed	$\frac{1}{12}wb^2$ $1 + \alpha^4$	$\frac{1}{8}pb^2$ $3 + 4\alpha^4$	$\frac{1}{24}wb^2$	$0.009pb^2(1 + 2\alpha^2 - \alpha^4)$	$\frac{0.032}{1 + \alpha^4}$
Elliptical slab with fixed edges; axes <i>a</i> and <i>b</i> , $b/a = \alpha$	$\frac{1}{12}wb^2$ $1 + \frac{2}{3}\alpha^2 + \alpha^4$	$\frac{1}{24}pb^2$ $1 + \frac{2}{3}\alpha^2 + \alpha^4$	$\frac{1}{12}pb^2\alpha^2$ $1 + \frac{2}{3}\alpha^2 + \alpha^4$	$\frac{1}{24}pb^2\alpha^2$ $1 + \frac{2}{3}\alpha^2 + \alpha^4$	

^aPoisson's ratio $\nu = 0$ (see Eq. 13.69). *b* = shorter side, *a* = longer side, $b/a = \alpha$.