

# ARCH TEST BENCH IE



**SEMICIRCULAR  
ARCH**

**LOW ARCH**



**Tests on  
arc form openings construction**





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## CDROM CONTENTS

This folder CDRom is available in the A4 Company catalog (ref "CD-ARSU").

### It contains :

- The folder in FreeHand, Illustrator and PDF versions.
- Product photos, synthesis images, perspectives in DXF format.
- **The full product 3D modeling in its various versions with 3D SolidWorks, Parasolid and eDrawings files.**

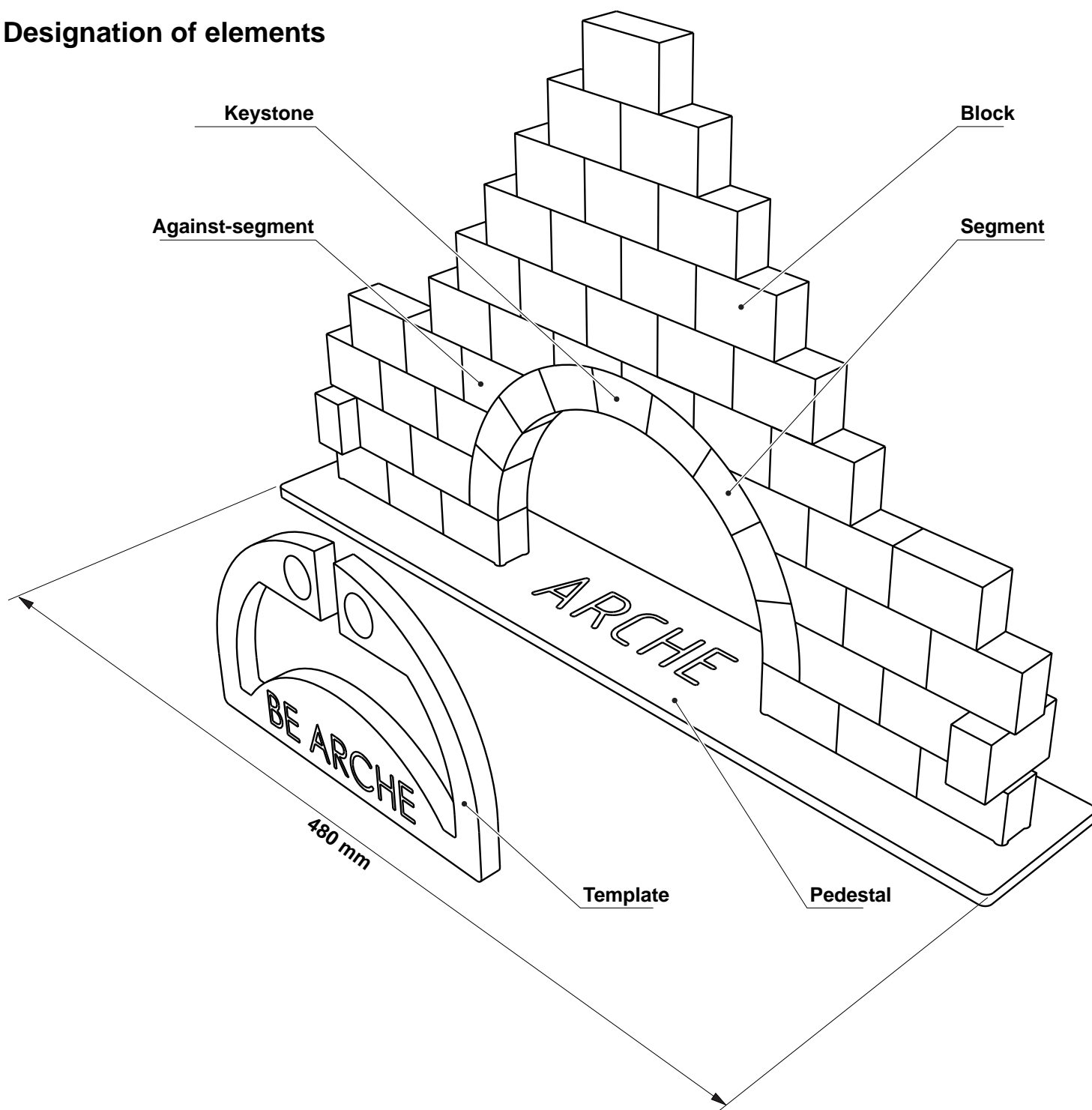
### This folder and CDRom are duplicable for students, in college internal use\*

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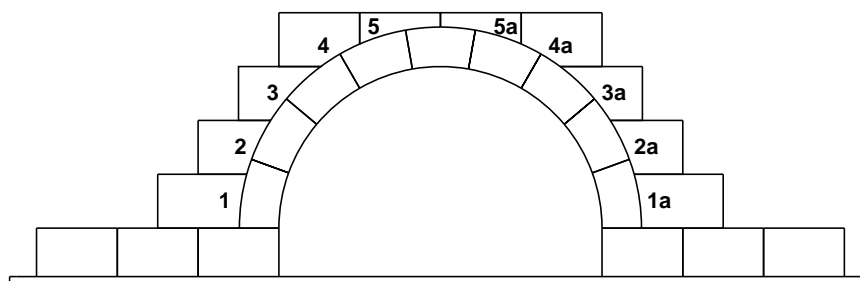
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# Presentation of the semicircular Arc (Ref. BE-ARCH1)

## Designation of elements



## Positioning drawing of against-segments\*

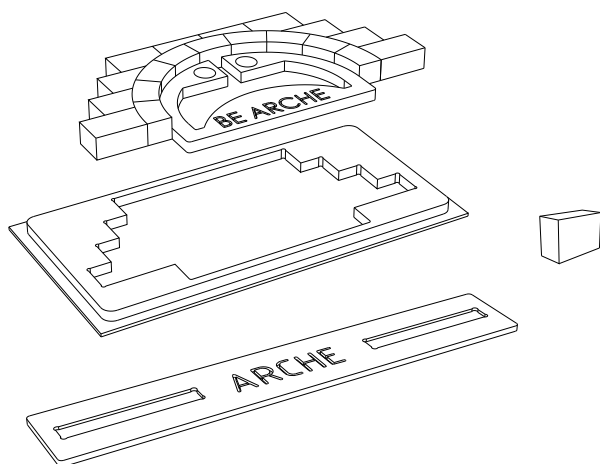


\* In case of loss or breakage, the complete voussoirs set and cons-voussoirs is available : ref. BE-ARCH1-VOUS

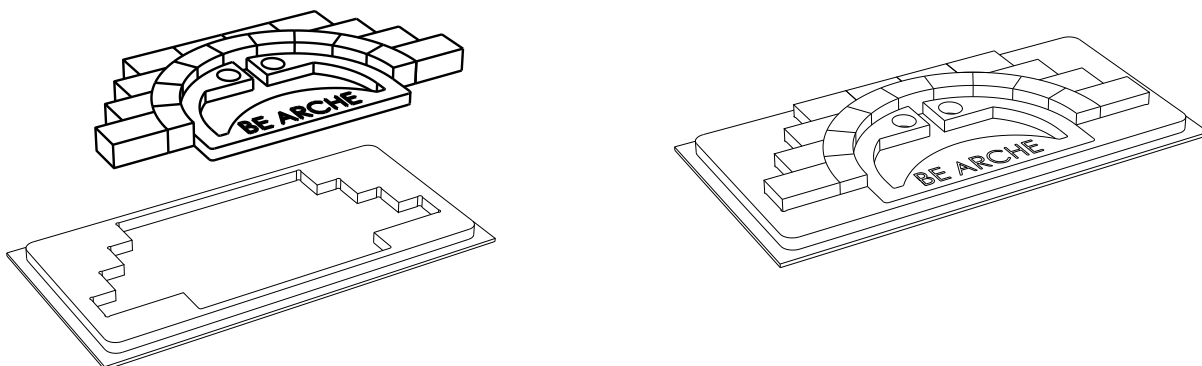
## Nomenclature of the semicircular Arc test bench

An expanded PVC 360 x 185 x 10 storage plate including :

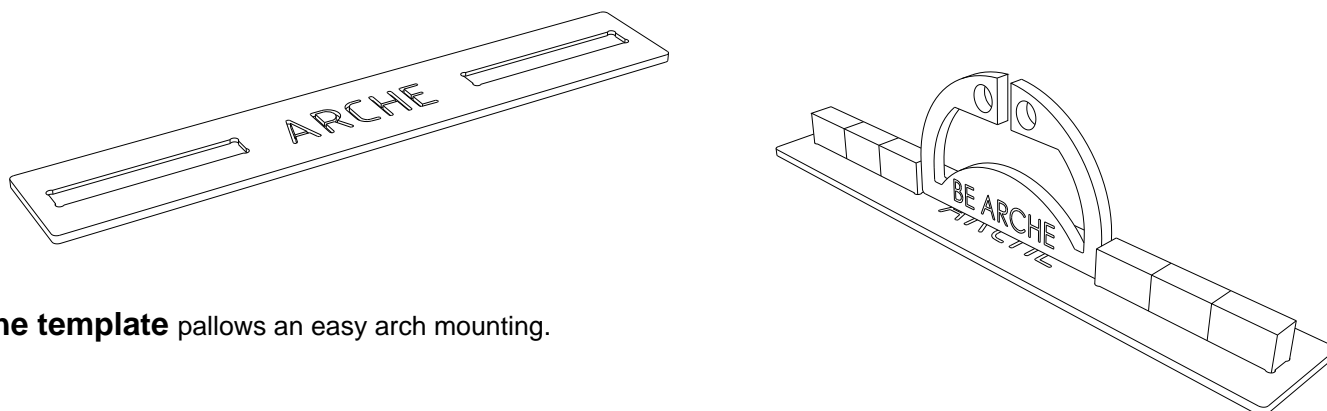
- 7 polyethylene (brick color) ;
- 10 polyethylene cons-voussoirs (brick color) ;
- An expanded PVC 180 x 115 x 10 template.
- An expanded 480 x 80 x 6 pedestal ;
- A bag of 36 polyethylene blocks 45 x 30 x 20 (white color).



**The test bench storage plate** allows to quickly check if the test bench is complete.



**The pedestal** with groove foundation, allows to align and lock the first row blocks.

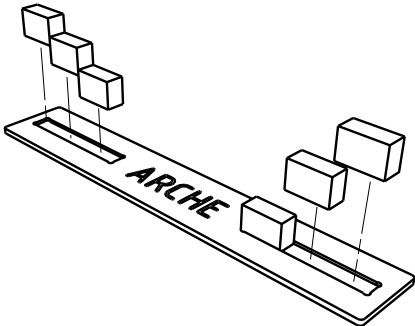
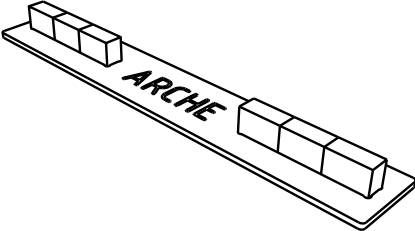
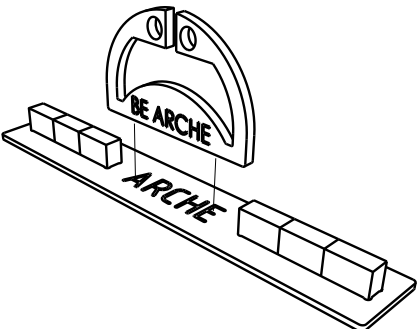
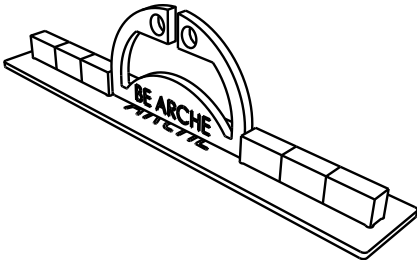
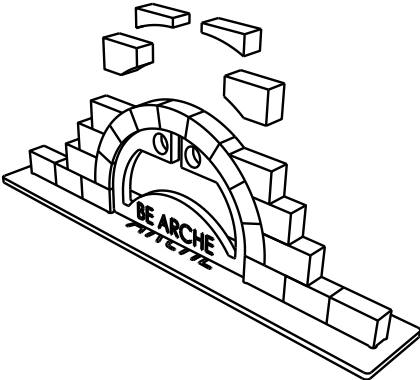
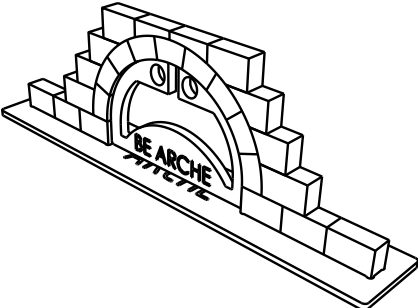
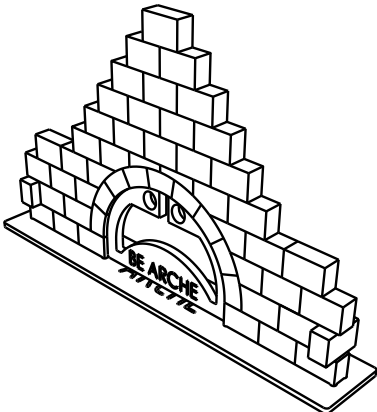
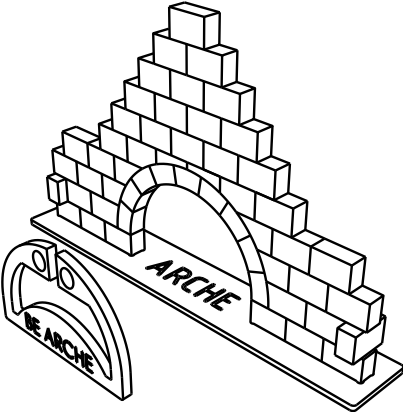


**The template** allows an easy arch mounting.

**The 17 elements** of the roof and the **36 blocks** are of polyethylene : it's a rigid and light material, soft-touch whose edges don't intersect. Food grade, it's mainly used for kitchen utensils making (cutting boards, countertops, etc.).



Mounting sheet for semicircular arche on the pedestal

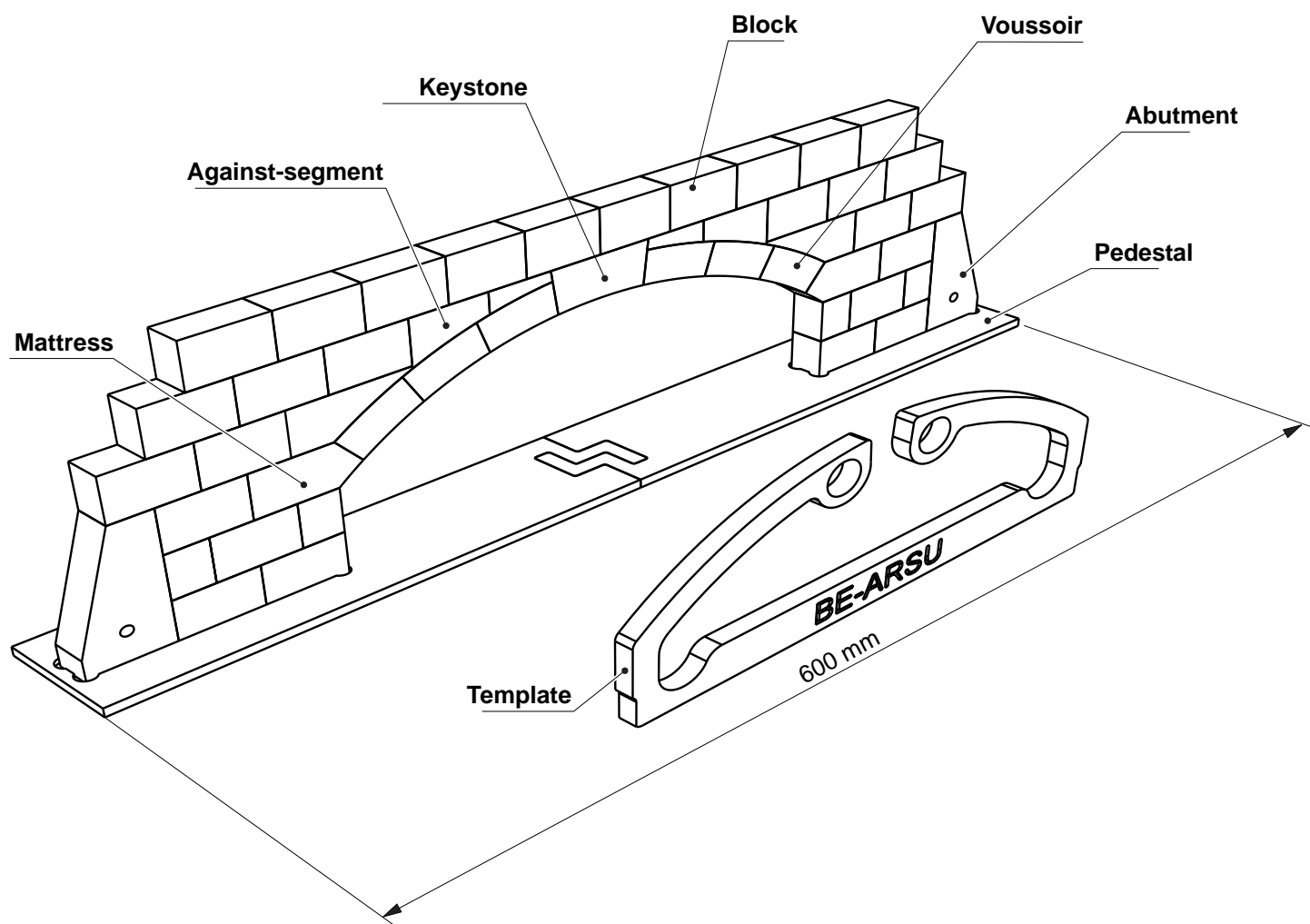
Step 1	Step 2
	
Step 3	Step 4
	
Step 5	Step 6
	
Step 7	Step 8
	



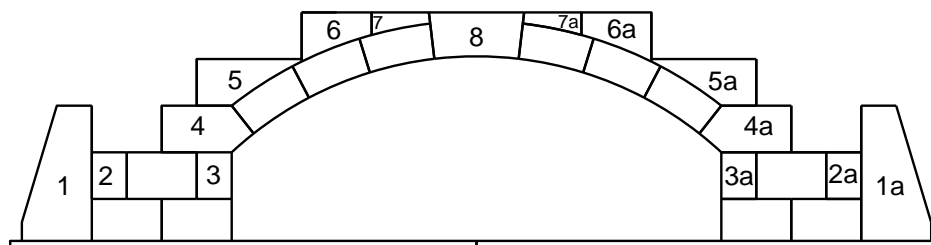


# Presentation of the low Arc test bench (Ref. BE-ARSU)

## Designation of elements



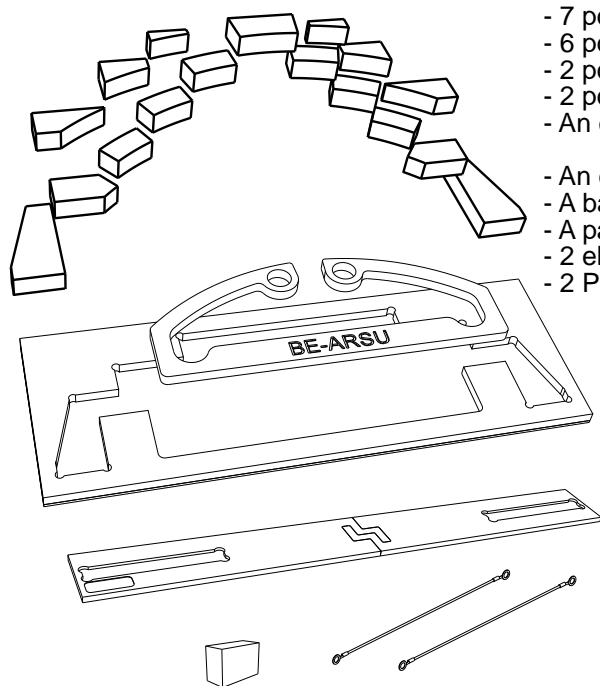
## Positioning drawings of abutments, half-blocks, mattress, cons-voussoirs and keystone



\* In case of loss or breakage, the complete set of 17 parts (brick color) is available in detail (ref. BE-ARSU-VOUS).



## Nomenclature of the low Arc test bench

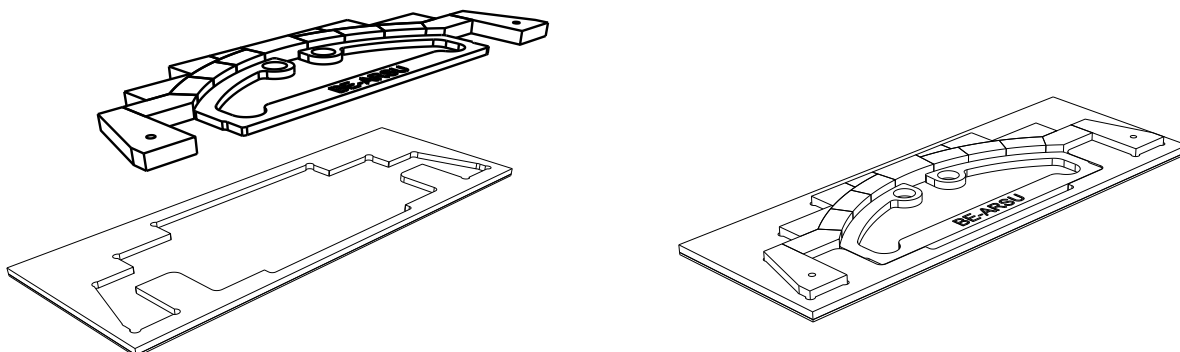


An expanded PVC 515 x 190 x 10 storage plate including :

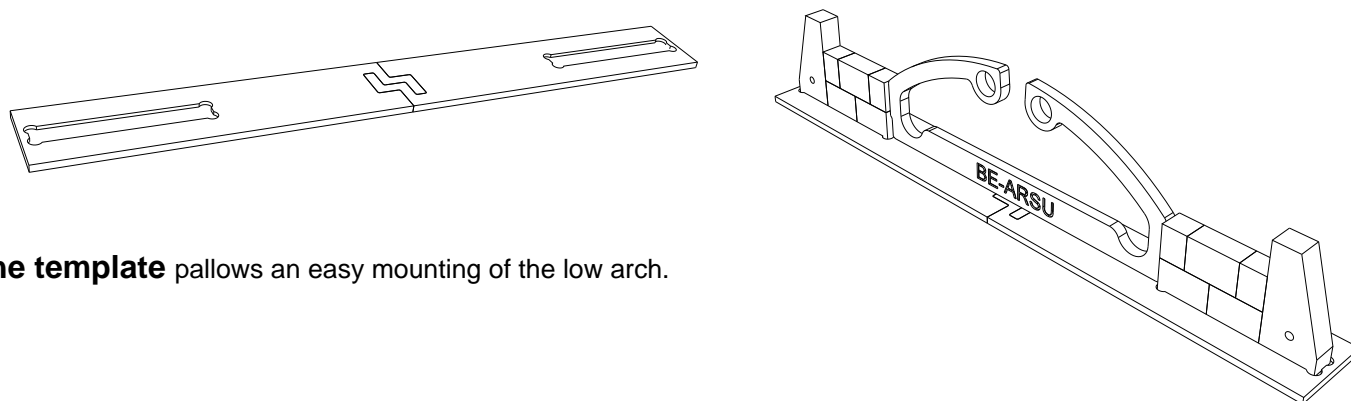
- 7 polyethylene voussoirs (brick color) ;
- 6 polyethylene cons-voussoirs (brick color) ;
- 2 polyethylene mattress (brick color) ;
- 2 polyethylene abutments (brick color) ;
- An expanded PVC 345 x 120 x 10 template.
- An expanded 600 x 70 x 50 pedestal ;
- A bag of 36 polyethylene blocks 45 x 30 x 20 (white color).
- A package of 4 rigid PVC half-blocks 30 x 22,5 x 20 ;
- 2 elastic straps ;
- 2 PVC rods (Diameter : 6 - length : 50)



**The storage plate** allows to quickly verify that the test bench is complete.



**The pedestal** with foundation groove, to align and lock the first row blocks.



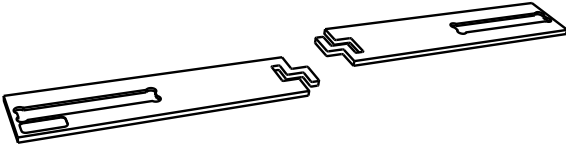
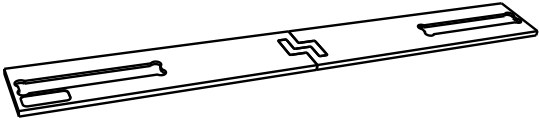
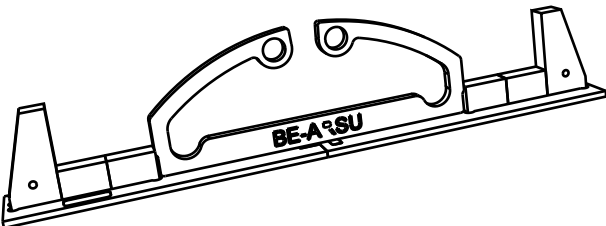
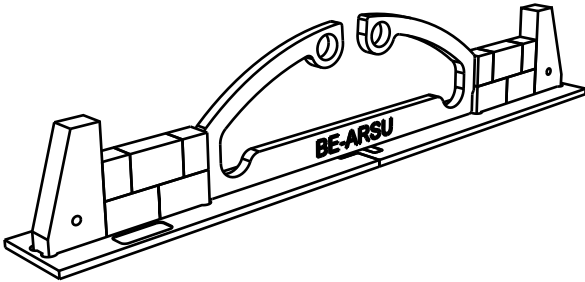
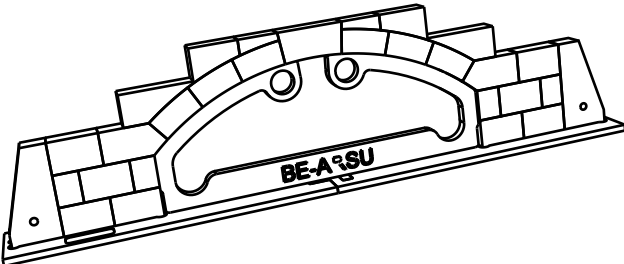
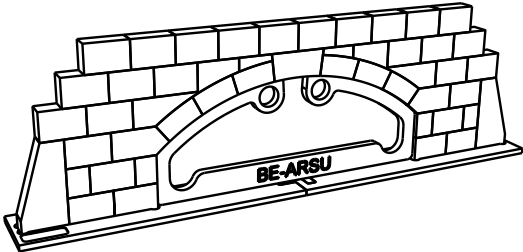
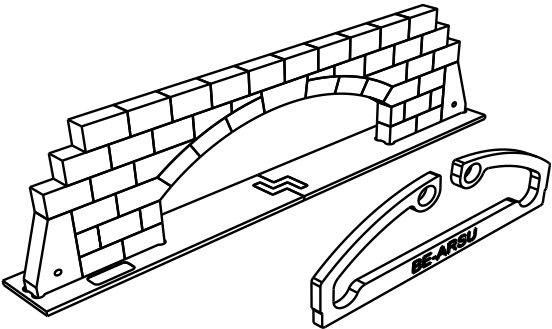
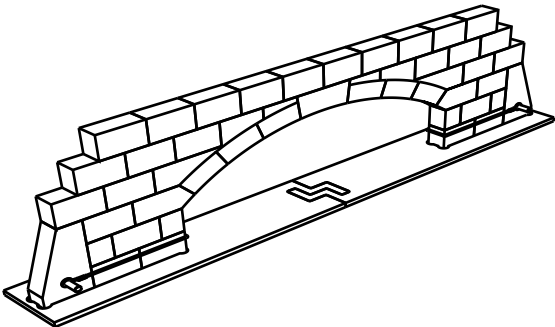
**The template** allows an easy mounting of the low arch.

**The 17 elements** of the roof and the **36 blocks** are of polyethylene : it's a rigid and light material, soft-touch whose edges don't intersect. Food grade, it's mainly used for kitchen utensils making (cutting boards, countertops, etc.).

**The bloce** en eol yétkylallow to stabilize the arch with a lowered wall on either side. They allow also investigations about the construction method of a stable wall.



Mounting sheet for the lowered arch on the pedestal

Step 1	Step 2
	
Step 3	Step 4
	
Step 5	Step 6
	
Step 7	Step 8
	



# Educational presentation

## The educational interest

Both test benches “**semicircular Arc**” and “**lowered Arc**” allow students to seek technical solutions in housing and works fields in the fifth class.

Both supports are independent by default. However if you have both test benches you can use them successively or together in the classs.

Both test benches leads students to think about a arc opening construction principle. The “ Lowered Arc “ test bench allow to add the chaining principle.

They allow to investigate about a wall and an arch strength rmade by blocks stacking (structure by stacking or with continuous walls, masonry).

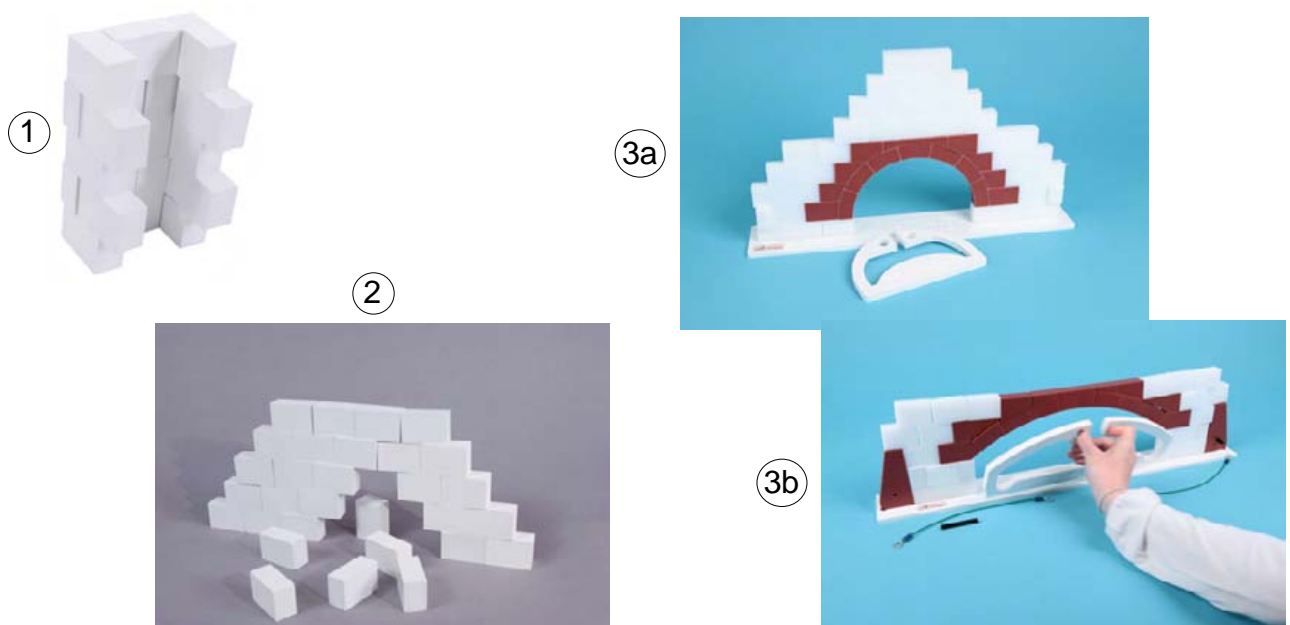
After assembling test benches, students make experiences and observe that :

- efforts are transmitted laterally ;
- a construction stability and strength depends on the weigth or the laterally resistance of lateral walls and structures.

These educational supports allow to work within three problem-situations.

- ① How to build solid walls by stacking blocks ?
- ② How to make a solid opening in a construction ?
- ③ How to make an opening like an arc ?

All can be treated as a centre of interest : “ The **constructions strength** “.



A progressive investigation

These problems will allow to work on knowledge “ technical **solutions** ”

and “ **functions** ” of the fifth class technology program and to implement the following capabilities of “ Technical object analysis and designing ” approach :

- Modify all or part of a structure or and assembly to comply a given service function ;
- Identify the retained technical solution to make a service function ;
- Compare, on various technical objects, the retained technical solutions to meet the same service function.

These research may be extended through “ **Materials used** ” and “ Technical object **evolution** ” approach and enroll in continuity in the interest centre : “ The **constructions strength** “.

## Best points of both test benches

### Their simplicity

A limited number of blocks allows easy manipulations without excessive loss of time.

### Their convenience

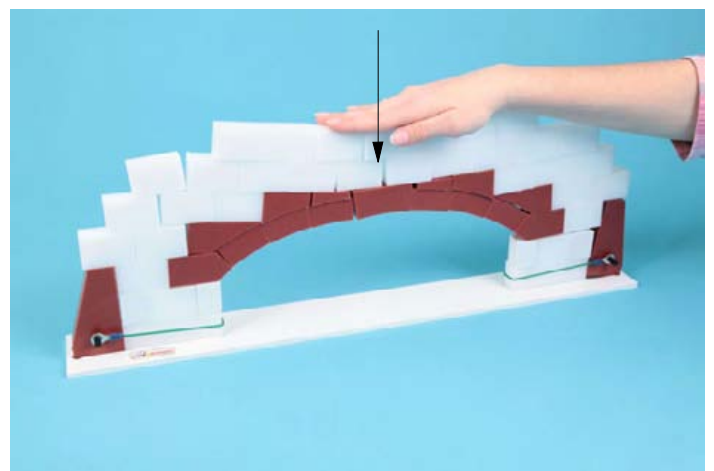
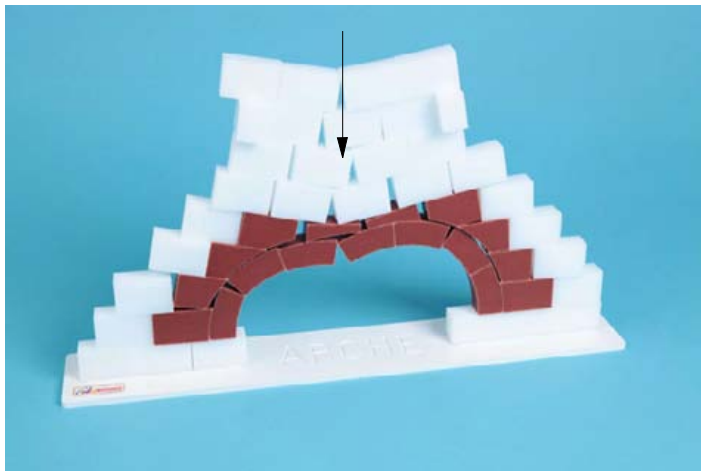
Parts are large enough (20 mm) for a stable stacking.

The vault parts are stored on a support that allows the teacher to rapidly control if the test bench is complete.

### Their similarity to the real

The 17 parts provided in each test bench and the mounting template allow the test bench behavior as in the reality.

In the “ Lowered Arc “ test bench both rods and both elastic straps allow to show a chaining technical principle to solidify a construction.



Experimentations in the classroom

## Classroom use

These both test benches are by default independent educational supports. However if you have both you can use them successively or together in the classroom.

Both test benches allow to search and explain the technical solution to obtain a solid arch :

- the “ **semicircular Arc** “ test bench allows in particular to work from the constraint “ support heavy loads “ .
- the “ **Lowered Arc** “ test bench allows in particular to work from the “ increase the range “ constraint and to see the chaining principle.

Te various activities could also be complemented by using the other test benches :

- Types of bridges (Ref. BE-PONA) ;
- Beam with iron (Ref. BE-POUT) ;
- Chaining (Ref. BE-CHAIN) ;
- Concrete blocks (Ref. BE-PARP) ;
- Lattice frame (Ref. BE-PTRA) ;
- Bungalows (Ref. K-BUNGA-01).

## Activity 1 - How to build solid walls by stacking blocks ?

### 1. General remark

#### Materials needed :

36 white polystyrene blocks (manipulation 1).

For the specific bonding manipulation it's necessary to have concrete blocks (Ref. : BE-PARP or BE-PARP-PARPAING) and sand mortar with small spatulas (Ref. COL-BRIK-1K2) (manipulation 2).

Two manipulations and investigations are proposed to the following question :

**“ How to build solid walls by stacking blocks ? ”**

#### Remark

This issue is related to the following construction functions and constraints :

- Service function : constructions allow to protect humans from elements ;
- Constraint : wall must support heavy loads (floors, roofs, etc.) and participate in the overall dwelling or art structure strength (bridge, tunnel, etc.).

### 2. Manipulations and investigations proposed

From the following problem **“ How to build solid walls by stacking blocks ? ”**, students make assumptions such as : “ to build a solid wall large blocks are needed (parpens for example) on top of each other “.

#### Manipulation - experimentation 1

The 1st manipulation is to build two types of wall by stacking blocks, then test the walls strength (with a rule for example).

#### Knowledge acquisition and structuring :

Students draw the two walls built or stick the labels proposed (see resource document) and captions. They note with the teacher the relative conclusions of the manipulation and the essential knowledge to remember. It's important to distinguish with students the technical principles : simple stacking and stacking with intersecting of blocks.

#### Manipulation - experimentation 2

Wall construction with a binder.

#### Remark

This manipulation requires ramekins and “sand mortar” (ref. COL-BRIQ-1K2). These elements aren't provided in the ARCS test benches but in the parpen model. Mortar preparation : *1 dose of water for 7 doses of mortar.*

*\*Note : the “sand mortar” proposed can be re-diluted into water to recycle blocks.*

#### Knowledge acquisition and structuring

Students draw or stick their construction (see resource document). They note with the teacher the relative conclusions of the manipulation.

#### Knowledge mobilization

It's possible to extend the activity by offering to students internet research about building and structure origin with arched openings from the following Web sites :

Arts and crafts : [www.arts-et-metiers.fr](http://www.arts-et-metiers.fr)

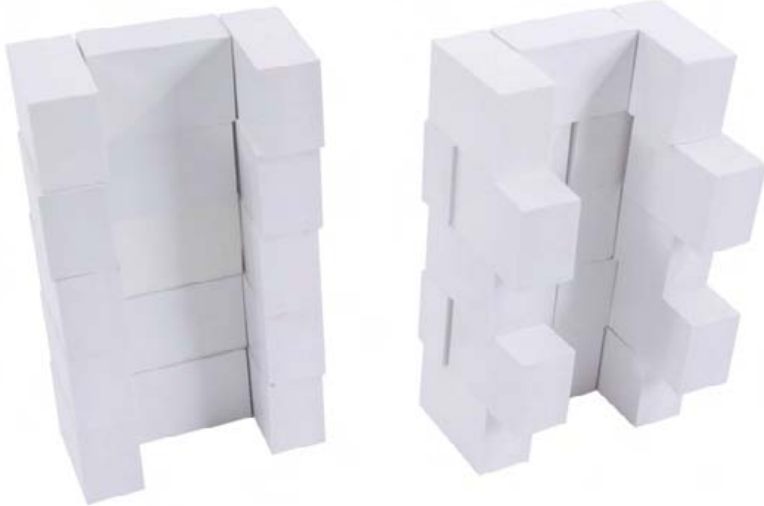
Architecture site : [fr.structurae.de](http://fr.structurae.de)

## Activity 1 - How to build solid walls by stacking blocks ?

### Manipulation - Experimentation 1 - To build a solid wall

#### Work to do :

In accordance with the two photos below, build each type of wall with blocks and test their strength by pushing on them with an object (a ruler for example).



#### In the book or workbook

Describe the manipulation performed.  
Stick and label the pictures provided by your teacher.  
Make a record of this manipulation.  
Sating a technical principle to build solid walls from stacked blocks.

### Manipulation - Experimentation 2 - Increase a wall strength

#### Work to do :

Mount a wall with intersected blocks and stick with sand mortar or wallpaper glue).  
After drying test the wall strength.

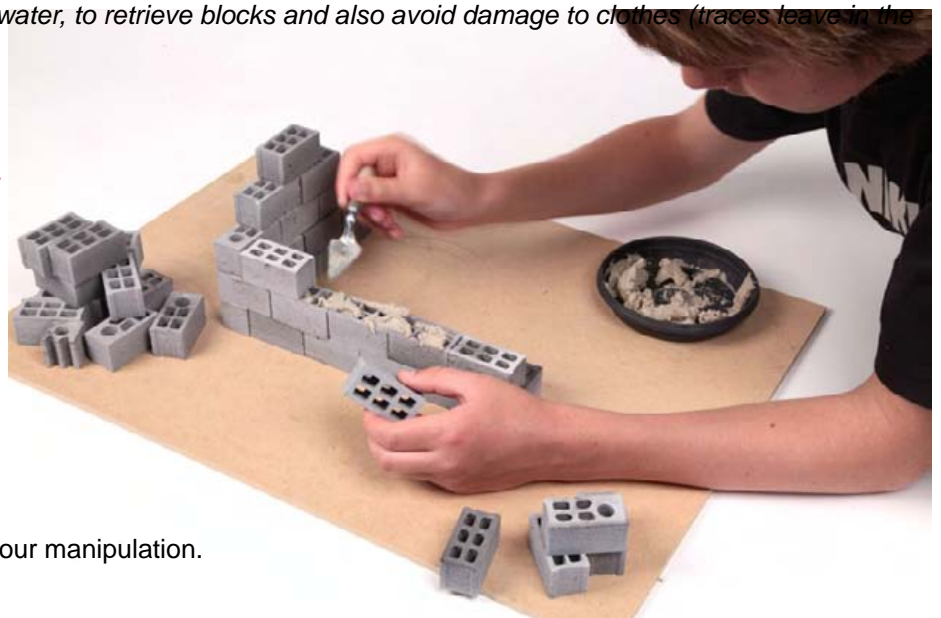
#### Note :

*Recipe with the sand mortar : 7 volumes of mortar for one volume of water.*

*Once dry this mortar can be rediluted into water, to retrieve blocks and also avoid damage to clothes (traces leave in the first wash).*



To retrieve blocks, immerse constructions into a basin of hot water during about 20 minutes.



#### Dans le cahier ou le classeur

Glue the mounted wall photo and explain your manipulation.  
Make a record of this manipulation.

What general conclusion may be found from these manipulations 1 et 2 ?

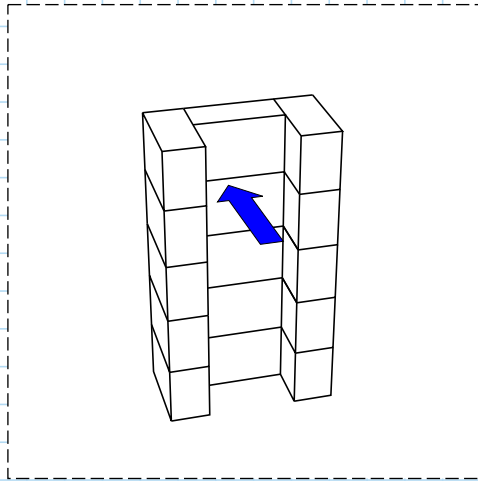


## Activity 1 - How to build solid walls by stacking blocks ?

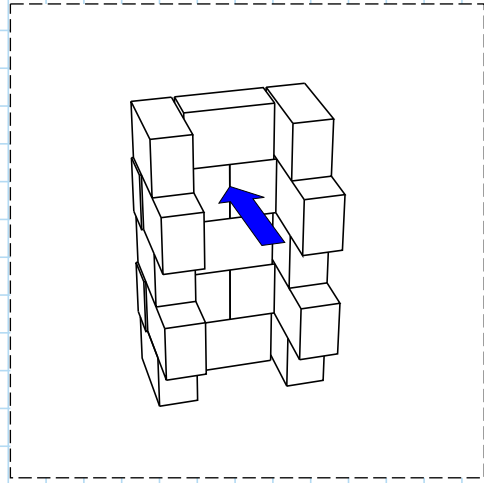
### How to build solid walls by stacking blocks ?

#### Manipulation - experimentation 1- To built a solid wall

I installed and test strenght of both wall types by pushing with an object (rule).



Simple blocks stacking.



Intersected blocks stacking.

#### Report

- When i push on the stacked blocks wall, it isn't very strong. It has no cohesion.
- When i push on the stacked and intersected blocks wall, it's stronger.

Intersected blocks are held together (they are embed).

#### Conclusion

To build a strong wall the following technical principle can be applied : intersect blocks (bricks, parpens, etc.).

#### Manipulation - experimentation 2 - Increase the wall strength

##### Report

I assembled blocks with glue.

It's noted that the wall is stronger when blocks (bricks, parpens, etc.) are bound together by glue.

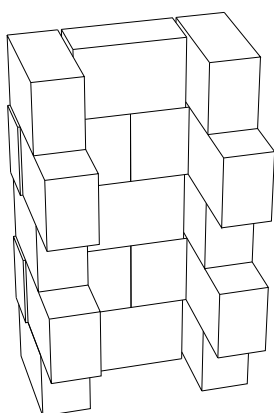
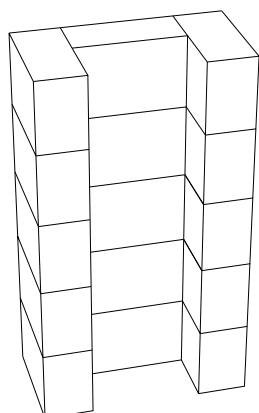
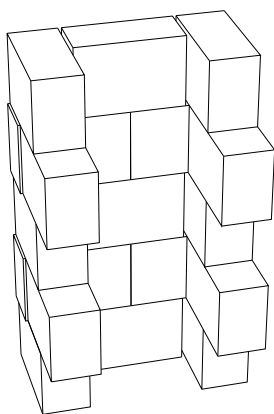
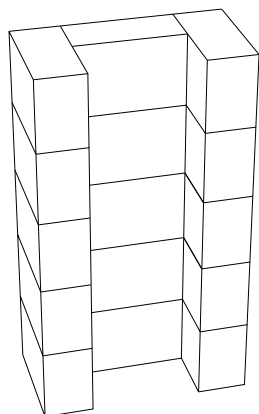
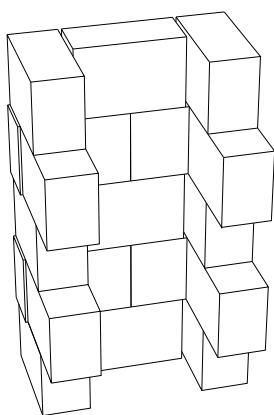
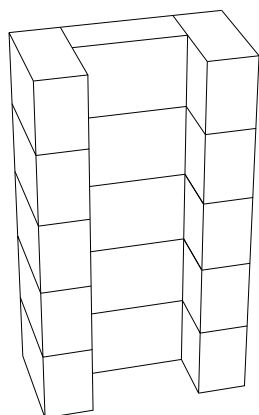
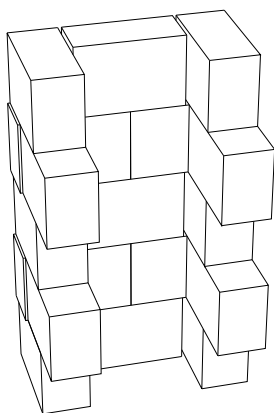
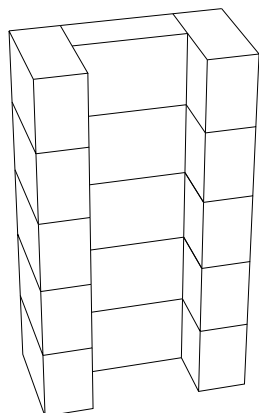


#### General conclusion

For a more solid wall, intersect and glue blocks.

## Activity 1 - How to build solid walls by stacking blocks ?

Thumbnails - Drawings and/or photos to be cut (for 4 students).



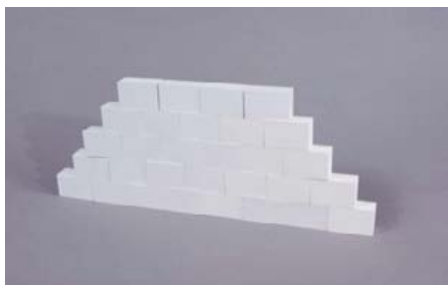
## Activity 2 - How to build a solid opening in a construction ?

### Materials needed :

36 white polystyrene blocks for each students group.

### Manipulation - experimentation

To build a wall of 5 rows high and 8 blocks for the base (see below example of photos).



Ask students to make an opening (free form) in the wall.



Manipulations synthesis : we can realize an opening by removing blocks but it weakens the wall if it exceeds 3 blocks opening wide, the wall is falling down. Students make propositions to increase the opening strength.

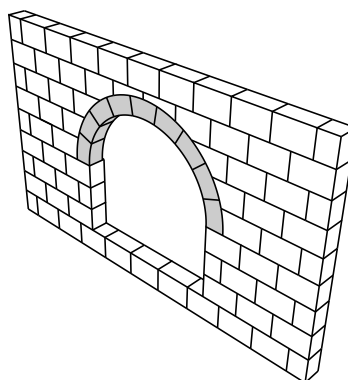
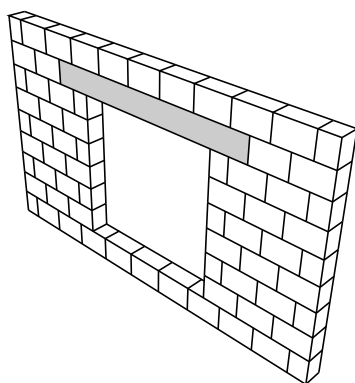
### Conclusion

If we remove blocks from a construction wall, it's fragile.

More blocks are removed, more fragile is the construction and can fall down.

To make an opening without too fragile construction, one can not simply remove blocks ; you must use a technical solution to consolidate openings : the lintel or arc.

One can observe and comment (drawings, photos, near environment, etc.) the "lintel" and "arc" solutions.



### Knowledge acquisition and structuring :

Students draw the two wall built or stick the labels proposed (see resource document) and legends. They note with the teacher the relative conclusions of the manipulation and the essential knowledge to remember.

That manipulation and the conclusion associated introduce 3a and/or 3b activities related to arc form openings (semicircular and lowered).

## Activity 2 - How to build a solid opening in a construction ?

### Manipulation - expérimentation- Construire une ouverture solide

Tp build a wall by stacking interlocked blocks.

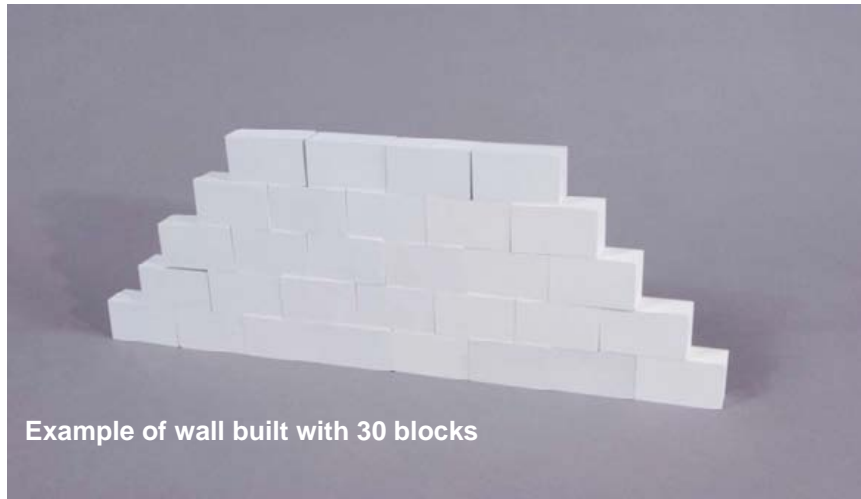
Achieve the greatest opening as possible in a wall, to allow passage.

#### Materials required :

The 36 white polystyrene blocks bag.

#### Constraints to comply

The wall should be 5 rows high and 8 blocks for the base (see example below).



### In the book or workbook

#### 1st step

- Glue and label 1 and 2 pictures provided by your teacher.
- Explain the manipulation performed.
- What conclusion can we tell from this manipulation ?
- Research two technical solutions allowing to perform a strong opening in a stacked blocks wall.

#### 2nd step

- Glue and label 3 and 4 pictures provided by your teacher.
- Color the lintel and arc.
- Explain the lintel or arc role in an opening.

#### 3rd step

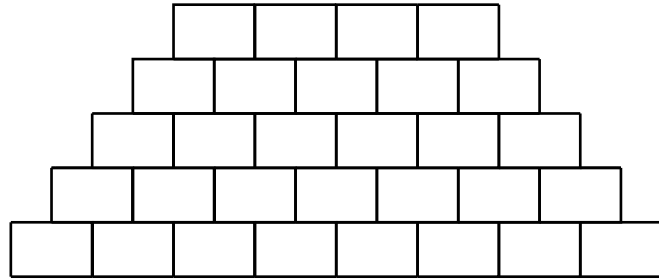
- What general conclusion can we tell from this manipulation ?

## Activity 2 - How to build a solid opening in a construction

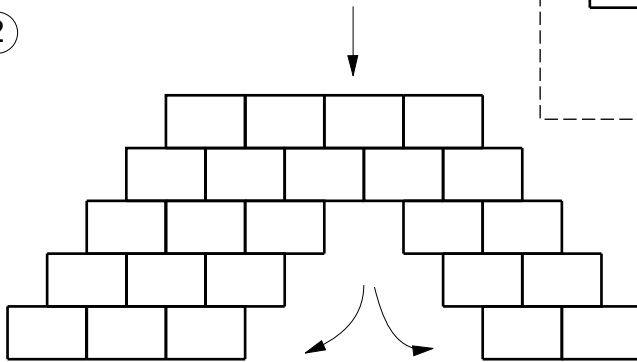
### How to build a strong opening in a construction ?

I built a wall with stacked and interlocked blocks

①



②



I made an opening by removing blocks  
If we remove more blocks the wall is falling down

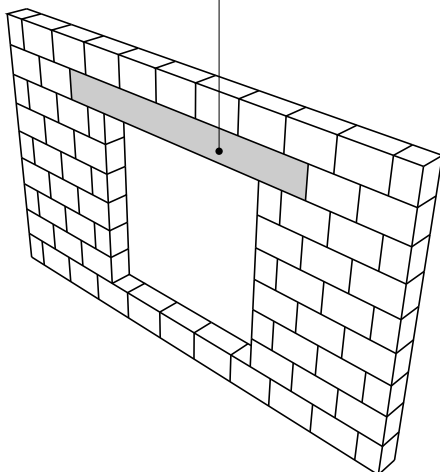
### Report

By removing blocks to make an opening, it weakens the wall. If we remove too many blocks the wall is falling down. This solution to make an opening isn't suitable for the construction remains strong. You must use a technical solution to consolidate openings such as lintel or arch.

### Two technical solutions

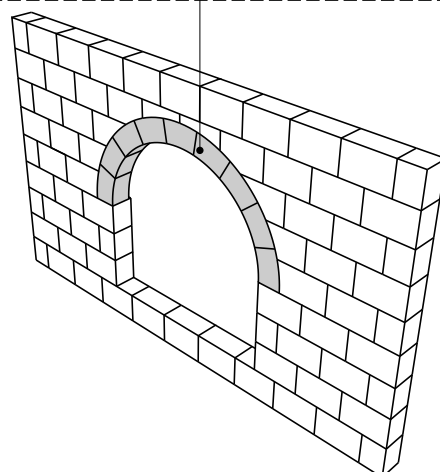
Beam (wood)  
or lintel (stone)

③



The arch

④



Example of consolidated openings with a lintel or arch

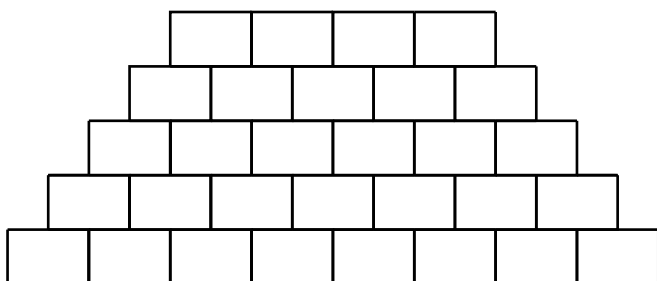
### General conclusion

For a strong opening use one of the two following technical solutions : lintel or arch.

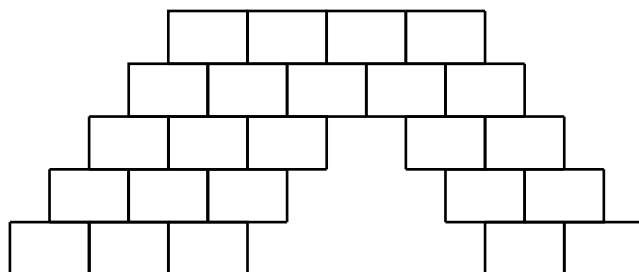
## Activity 2 - Resource document

Thumbnails - Drawings and /or photos to be cut (for 2 students).

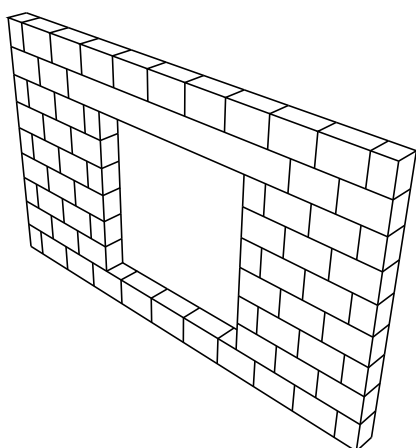
①



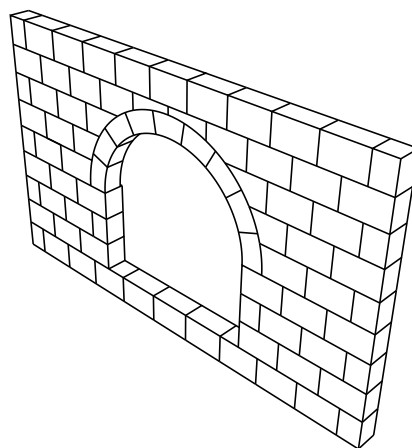
②



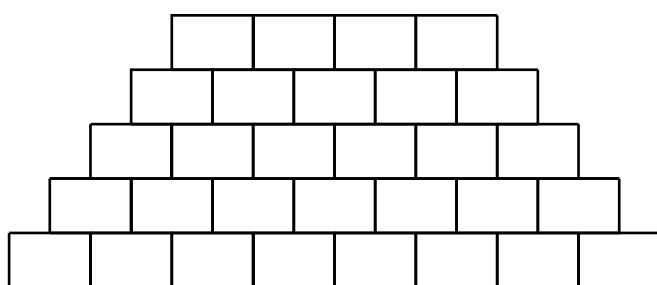
③



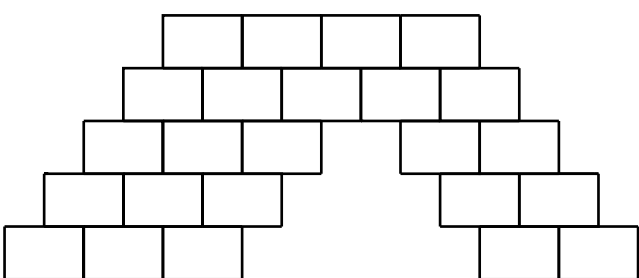
④



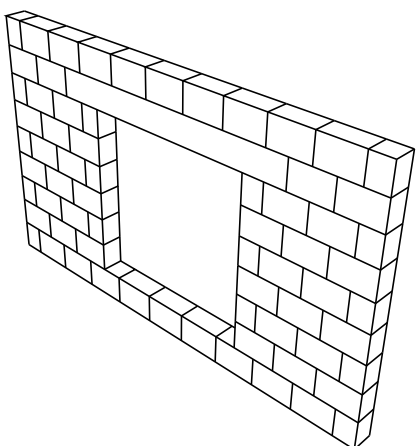
①



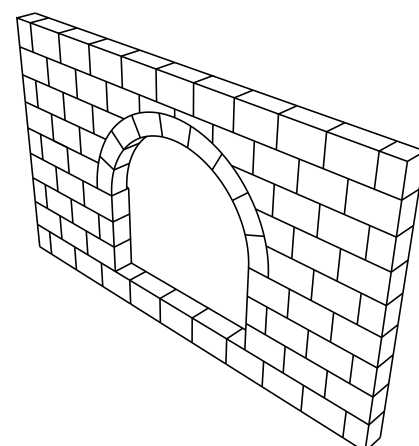
②



③



④



## Activity 3a - How to make an arch opening (semicircular) ?

### Programs

This activity will allow to work from knowledge “ technical **solutions**” and “ **functions** ” of the 5th school program and implement the following approach capabilities

“Technical object analysis and design” :

- Modify all or part of a structure or an assembly to comply a given service function ;
- Identify the technical solution retained to make a service function ;
- Compare, on different technical objects, the technical solutions retained to answer to a same service function.

The whole can be treated in the interest centre “ the constructions strength “.

**Materials needed** : BE-ARCH1 test bench complete.

### Manipulation - Experimentation 1

Problem presentation (arches location and service function) and specific construction constraints on semicircular arch openings : loads to be supported (floors, roofs, etc.) are important. One could use the scheme available as thumbnails to be cut to help students to understand the technical terms (page 23).

Mounting the arch without pattern then with it.

#### Remark :

At start the template isn't given. Each students group seek for support solutions (for example blocks use as prop) and the conclusion is that a mounting system (scaffold, template, etc.) would be more practical. In a second step the teacher let available the template provided in the test bench.

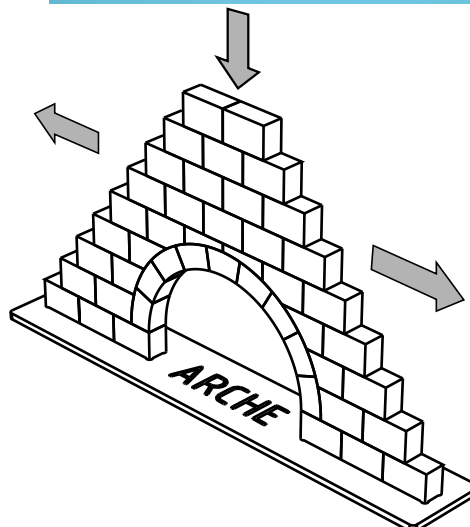
Conclusions are noted under teacher guidance on the book or workbook.

### Manipulation - Experimentation 2

#### Test the arch strength

The arch is mounted and students are asked to push on it with the hand to test its strength and see how it supports the effort. The conclusion is that efforts are transmitted laterally. Then strong lateral structures are needed (or heavy). These conclusions are noted in the book or workbook under teacher guidance.

**Remark** : In the classroom you can see the video of the test bench mounting sheet (page 4).



#### Knowledge mobilization

It's possible to extend the activity by offering students Internet research about origine and/or evolution of arch openings from the following sites :

Arts and business : [www.arts-et-metiers.fr](http://www.arts-et-metiers.fr)

Architecture site : [fr.structurae.de](http://fr.structurae.de)



## Activity 3a - How to make an arch opening (semicircular) ?

### Manipulation - Experimentation 1 - Mounting the semicircular arch test bench

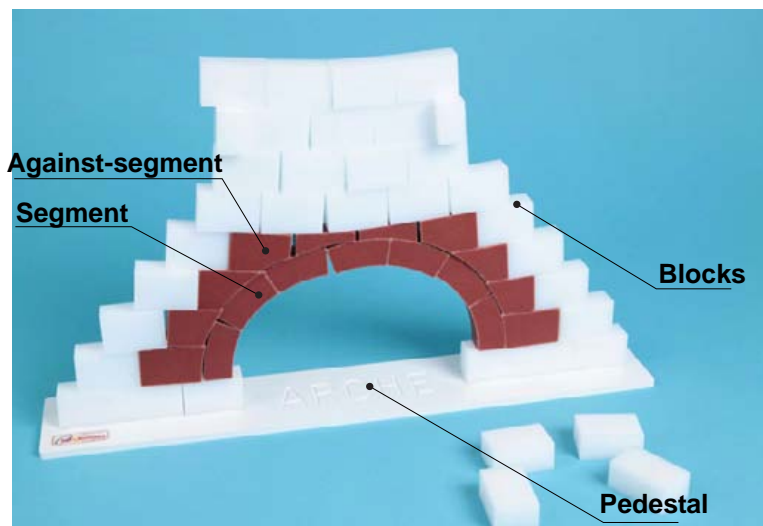
You have a test bench to achieve an arch (semicircular arch) that includes :

- 1 pedestal ;

A storage plate comprising :

- 7 segments ;
- 10 against-segments ;
- 36 blocks.

Starting from the pedestal, mount the arche using the main test bench elements.



### In the book or workbook

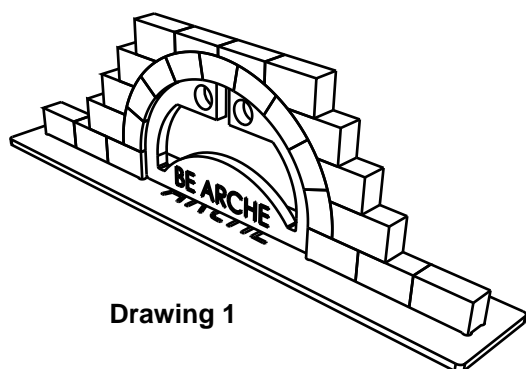
- Search and note the definition of an arch and the semicircular arch form.
- Make a sketch of the mounted arch by showing the solution you have chosen to facilitate in particular the vault mounting.
- Explain what difficulty is met to mount an arch.
- Describe the technical solution allowing to mount an arch more easily.

### Manipulation - Experimentation 2 - Test an arch strength

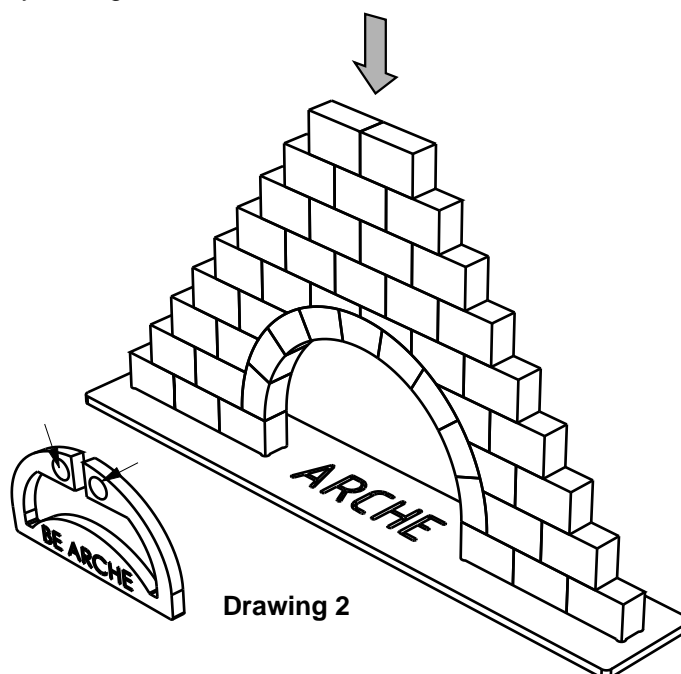
Mount the arche using the template (Drawing 1).  
add 4 blocks rows and remove the template (Drawing 2).

Remark : to remove the template closer the two holes with your fingers.

Press with the hand on the top.



Drawing 1



Drawing 2

### In the book or workbook

- What do we see ? (make a sketch)
- What to do for an arch is more resistant to load ?
- Draw a technical solution technique to enhance the arch strength.
- Search on the Internet the construction period of the first semicircular arches.

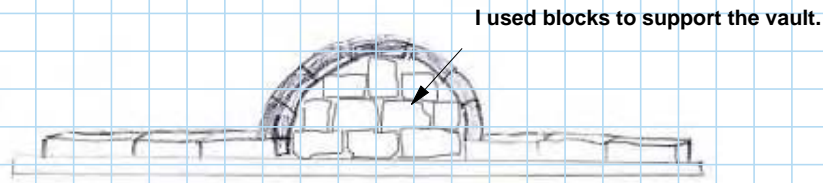
### Test bench storage

Gather segments, against-segments and the template in the storage plate and also the 36 blocks.

## Activity 3a - How to make an arch opening (semicircular) ?

### Mounting the semicircular arch test bench

An arch is an arch-shaped opening. A semicircular arch has the semicircle form.



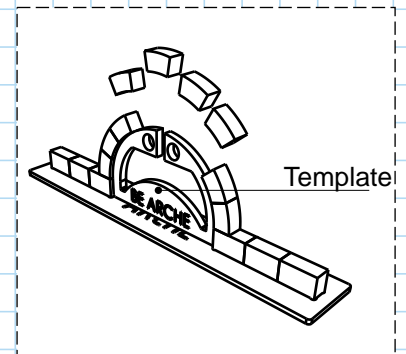
#### Report

The vault is rigid after the last segment (keystone) placed. For its assembly, it must be supported until the last segment is placed.

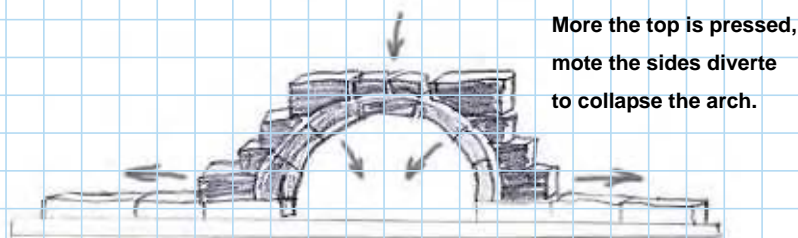
Initially we have used blocks as support then to facilitate assembly we have used a template.

#### Conclusion

In modern constructions a scaffold or a shoring is used to support the vault during its construction and thus facilitate its assembly.



### Test of arch strength

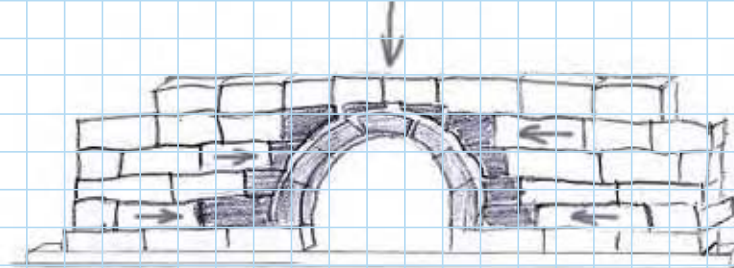


#### Report

When you press on the top of an arch, the sides diverte and the arch may fall down.

The vertical pressure on the arch is transmitted horizontally on both sides.

#### Research a technical solution



#### Report

For an arch doesn't collapse under a too heavy load (walls, roofs) the sides must be strengthened to resist to lateral pressure. Walls or heavy structures can be added on sides, or apply the arch on a solid support (terrain, etc ...).

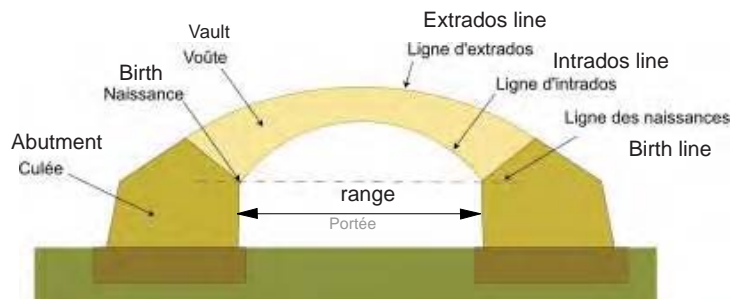
### Extension - Research on the Internet

The semicircular arch was invented during Roman period. (Source : website of the "Arts et Métiers" museum).

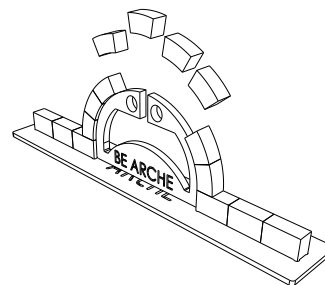
## Activity 3a - How to make an arch opening (semicircular) ?

Thumbnails - Drawings and/or photos to be cut (for 4 students).

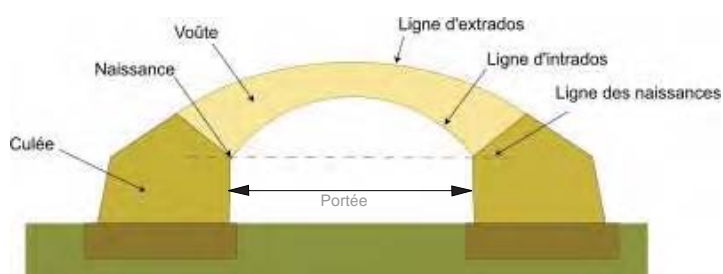
**Arch scheme**



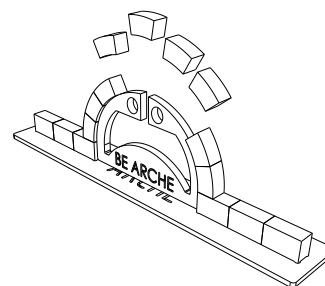
Source : Wikipédia



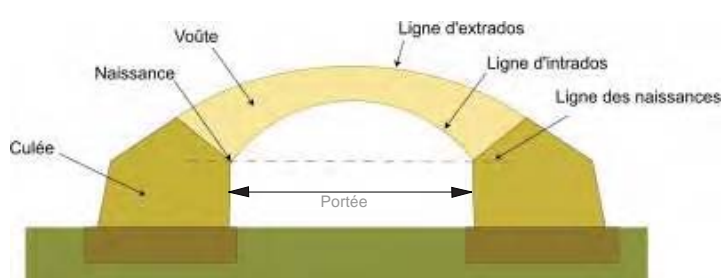
**Arch scheme**



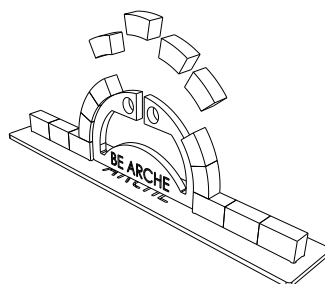
Source : Wikipédia



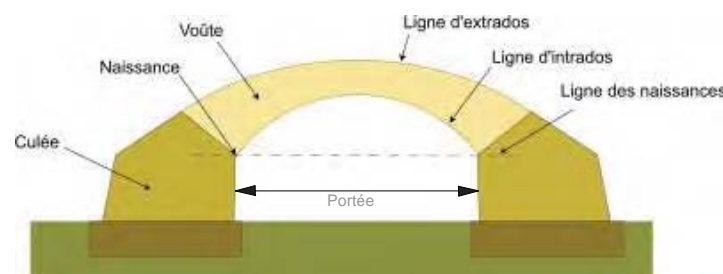
**Arch scheme**



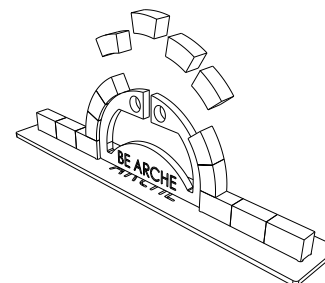
Source : Wikipédia



**Arch scheme**



Source : Wikipédia



## Activity 3b - How to make an arc opening (dropped) ?

### Programs

This activity will allow to work on technical knowledge “**techniques**” and “**functions**” of the 5th school program and implement the following capabilities according to the apTechnical object arch is and designu ivantes :

- Change all or part of a structure or an assembly to comply a given service function ;
- Identify the technical solution retained to achieve a service function ;
- Compare on different technical objects, the technical solutions retained to meet a same service function.

The whole can be processed in the inLa solidité d strengthens constructions .

**Materials needed** : BE-ARSU test bench complete.

### Manipulation - Experimentation 1

Problem presentation (location and service function of dropped arc openings) and specific construction constraints for this opening type : increase the range. The scheme can be used available as thumbnails to be cut to help students to understand the technical terms (page 27).

#### Mounting the dropped arc test bench

All parts of the test bench are provided except the template. During this manipulation students have many difficulties to assemble the dropped arc opening (it falls down) because its stability is related to the lateral structures weight or resistance. Student find support solutions (for example using blocks as prop). The teacher proposes then to use a template.

### Manipulation - Experimentation 2

#### Test the arch strength

The template, two flanges and two rushes are given.

Arch is mounted with the template.

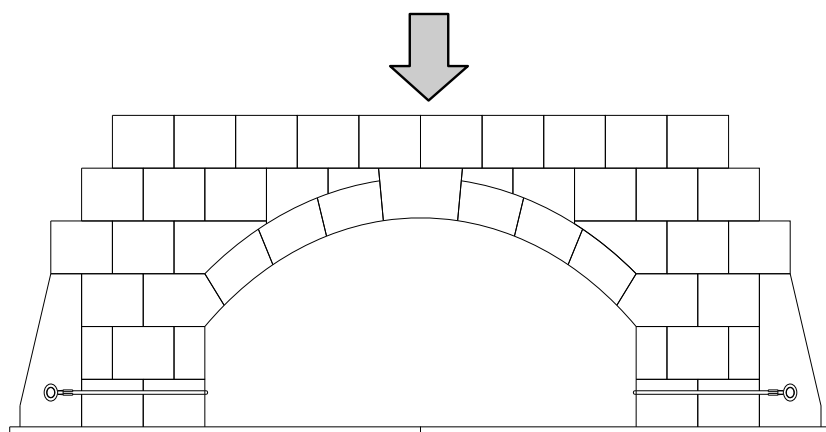
A student remove the template and another one support the two abutments if the two abutments aren't supported, the arch is falling down because the lateral pressure is too high.

The teacher ask students to start again adding the two rods and the two elastic flanges at assembly start as indicated on the student sheet photo.

Conclusion : the test bench is stable and strength.

When the range is large, the lateral structures must be strong (abutments for a bridge or spurs for a building) and chain (linking) the elements.

**Remark** : In the classroom it's possible to project a video of the test bench mounting sheet (page 8).



#### Knowledge acquisition and structuring :

Student note with the teacher the conclusions relative to the manipulation and the essential knowledge to remember.

#### Knowledge mobilization

It's possible to extend the activity by offering students to make research on the Internet about the main dropped arc buildings and structures in particular from the following websites :

The “arts et métiers” : [www.arts-et-metiers.fr](http://www.arts-et-metiers.fr)

Architecture website : [fr.structurae.de](http://fr.structurae.de)

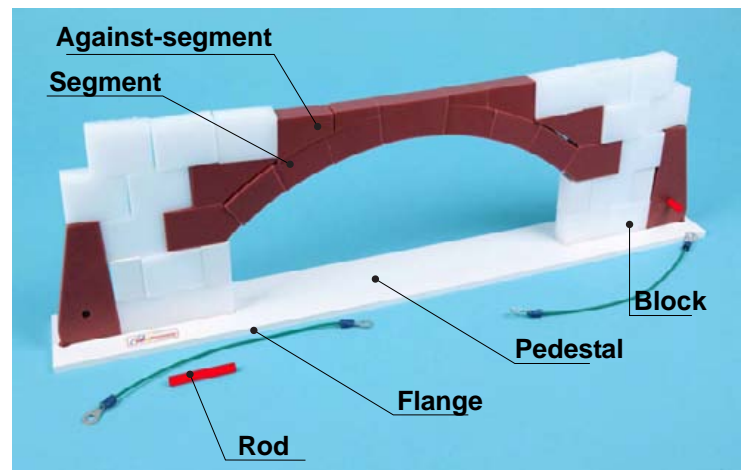
## Activity 3b - How to make an arc opening (dropped) ?

### Manipulation - Experimentation 1 - Mounting the dropped arc test bench

You have a test bench to make an arch (dropped arc) that includes :

- 1 pedestal
- a storage plate comprising :
  - 7 segments ;
  - 6 against-segments ;
  - 2 springs boxes ;
  - 2 abutments ;
- 36 blocks ;
- 4 half-blocks ;
- Two flanges and two rods.

Assemble the two parts of the pedestal and mount the arch using the main test bench elements.



### In the book or workbook

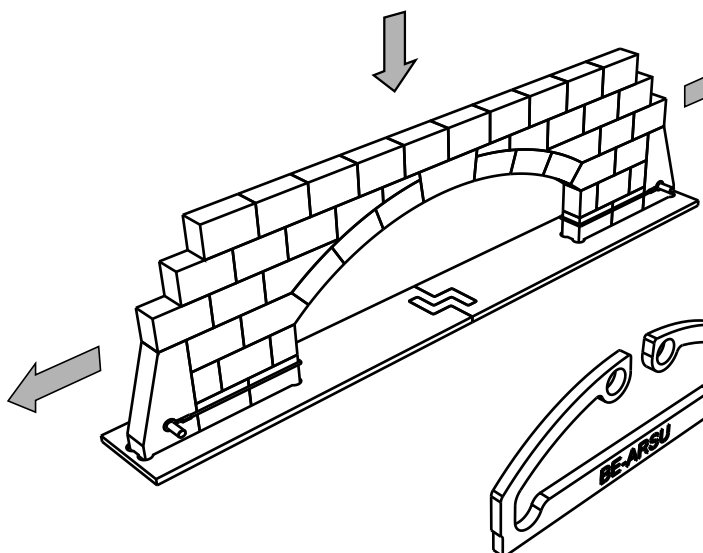
- Research and note the definition of an arch and the dropped arc form.
- Make a sketch of the arch mounted showing the solution you have chosen to facilitate the mounting.
- Explain what difficulty you meet to assemble an arch.

### Manipulation - Experimentation 2 - Test the arch strength

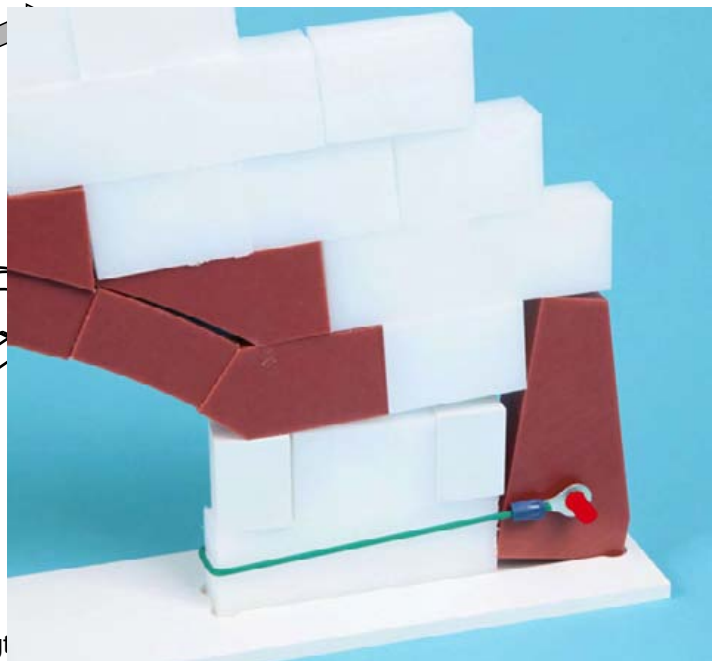
Assemble the arch using the template, two flanges and rods (red color) provided by your teacher. Add 1 row of blocks and remove the template (Drawing 2).

Remark : to remove the template close the two holes with your fingers.

Press with the hand on the arch top.



 At start mounting think to use the two elastic flanges and the two rods to chain blocks and abutments (see photo below).



### In the book or workbook

- What do you see ? (make a sketch)
- What to do to have an arch better resistant to a load ?
- Draw the technical solution used to increase the arch strength
- Research on the Internet two structures built with dropped arches.

### Test bench storage

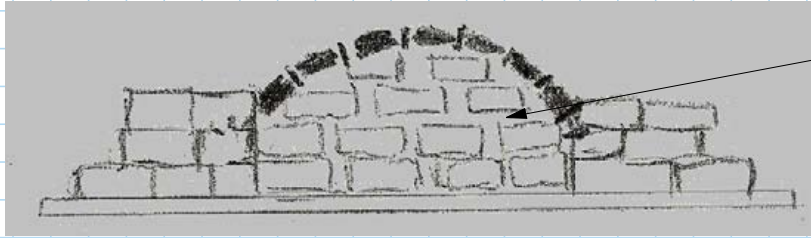
Gather segments, against-segments, spring boxes and abutments in the storage plate and also the 36 blocks and 4 half-blocks.



## Activity 3b - How to make an arc opening (dropped) ?

### Mounting a dropped arc opening

An arch is an arc-shaped opening. A dropped arc has by definition an oval form (half-ellipse).

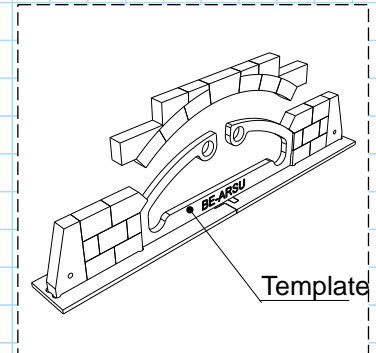


I have used blocks to support the arch.

#### Report

The arch resist only when the last segment (keystone) is placed. To assemble it, it must be supported until the last segment is placed.

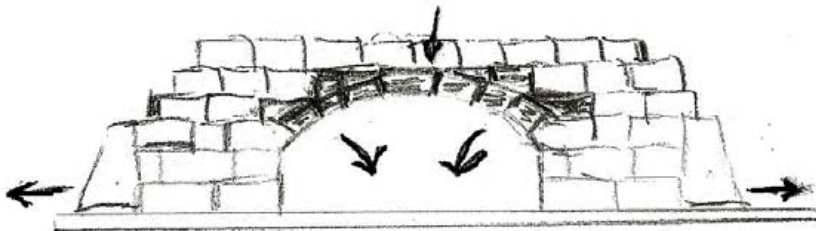
Initially we have used blocks as support then to facilitate mounting we have used a template.



#### Conclusion

In modern constructions we use a scaffold or a shoring to support the arche during its construction and thus facilitate its assembly.

### Test an arch strength



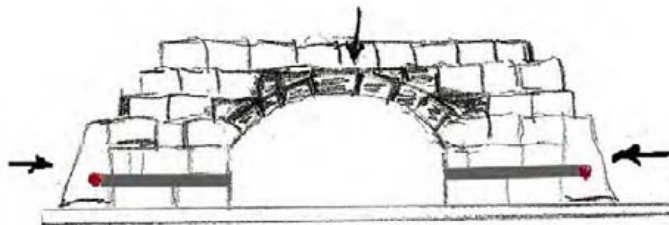
The more we press on the top, the more sides divert and finally the arch is falling down.

#### Report

When we press on the arch top, sides divert and finally the arch is falling down.

The vertical pressure on the arche is transmitted horizontally to the sides.

#### Research a technical solution



We put a flange around abutments to increase the arch strength.

#### Report

For an arch doesn't falls down when the range is large sides must be strengthened in order to resist to the lateral pressure.

### Extension - Research on the Internet

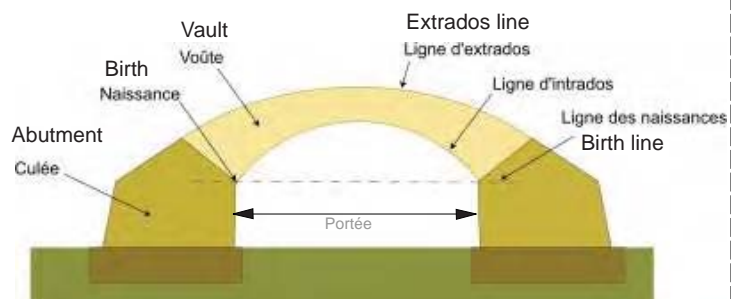
Le Ponte Vecchio in Florence (Italy)

The bridge of sighs - Venice - Italy

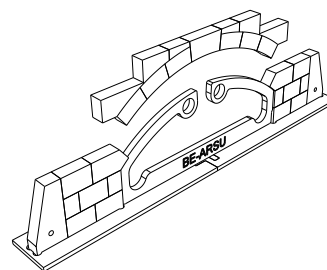
## Activity 3b - How to make an arc opening (dropped) ?

Thumbnails - Drawings and/or photos to be cut (for 4 students).

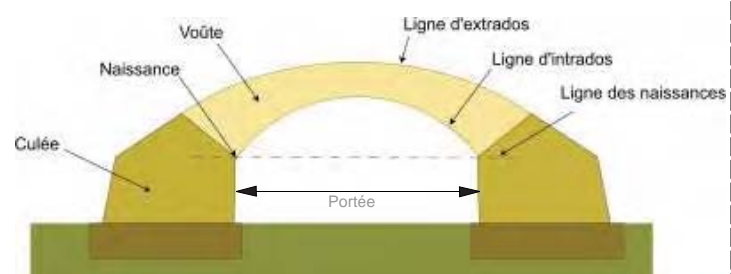
**Arch scheme**



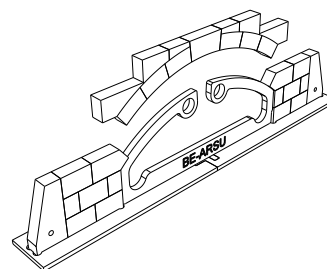
Source : Wikipédia



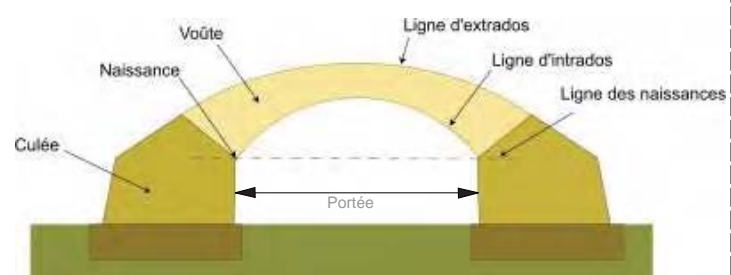
**Arch scheme**



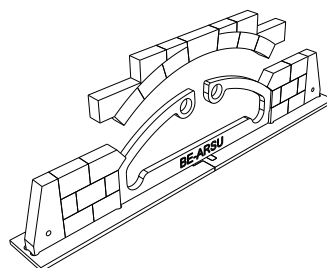
Source : Wikipédia



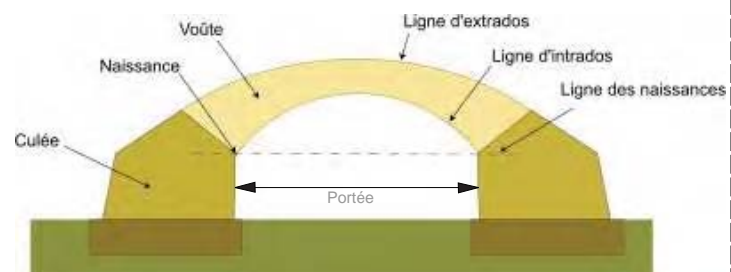
**Arch scheme**



Source : Wikipédia



**Arch scheme**



Source : Wikipédia

