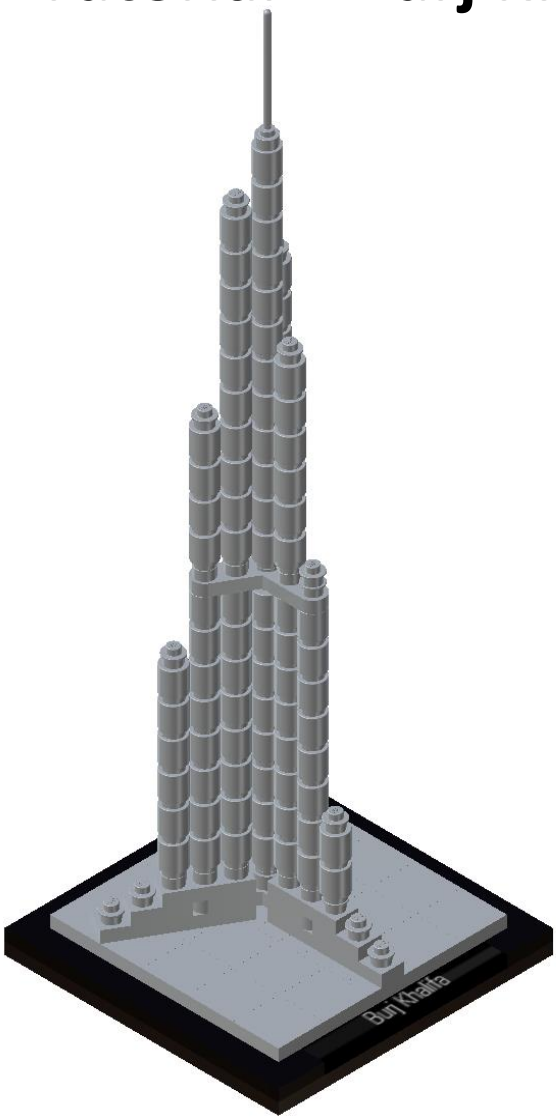
CATIA V5

Part & Assembly modeling

Tutorial – Burj Khalifa Lego Replica



Mihai Grumezescu

Burj Khalifa Dubai

Burj Khalifa a fost proiectat ca fiind piesa centrala a unui proiect de dezvoltare mult mai mare care ar include 30.000 de case, 9 hoteluri (inclusiv Downtown Dubai), 3 hectare de parcuri, cel putin 19 turnuri rezidentiale, Dubai Mall si lacul Burj Khalifa de 12 hectare.

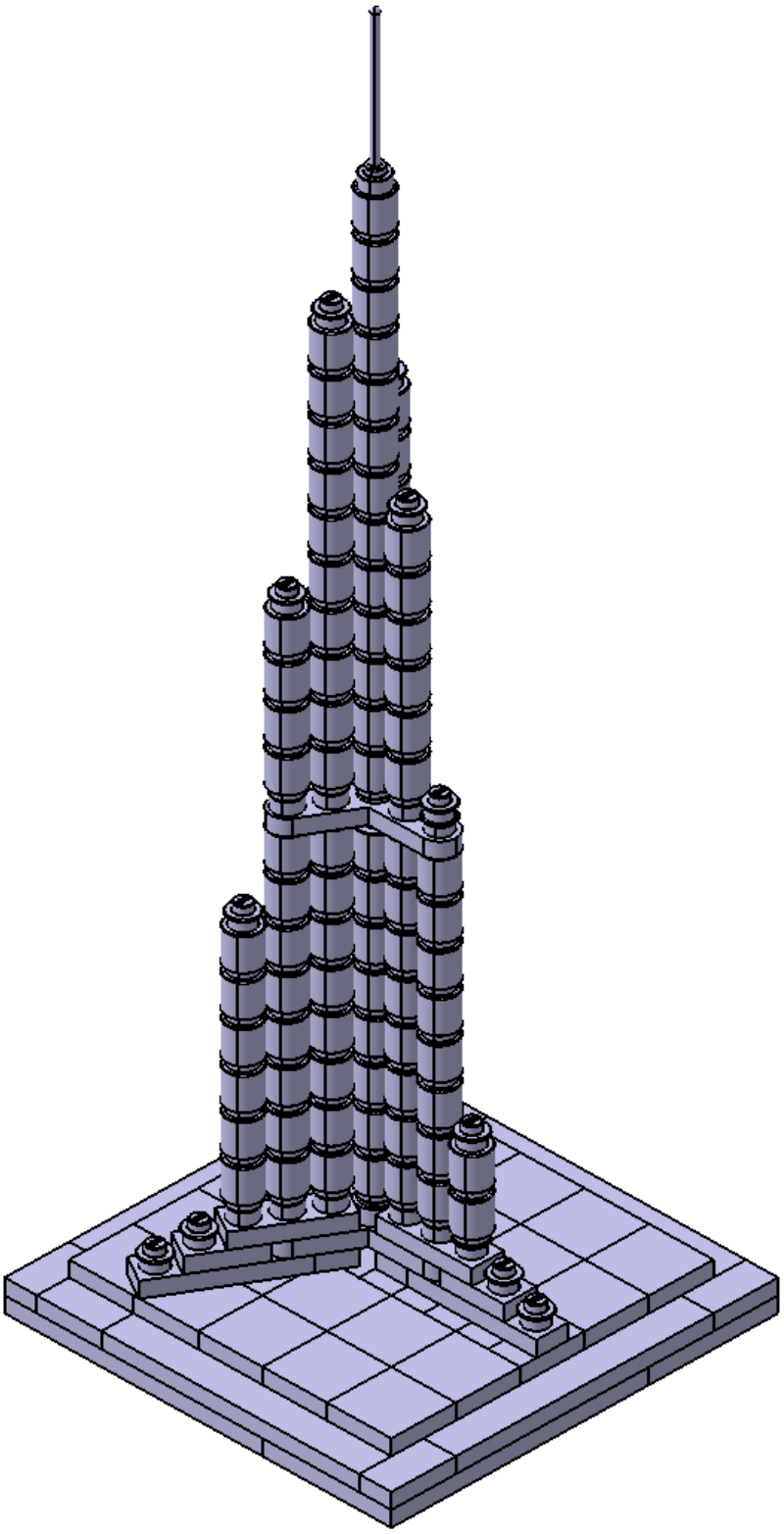
Recorduri doborate:

- **Cea mai inalta cladire existenta (829.8m);**
- **Cea mai inalta cladire construita (829.8m);**
- **Cea mai inalta cladire fara sustinere (829.8m);**
- **Cladirea cu cele mai multe etaje (163);**
- **Cladirea cu cel mai inalt etaj locuibil;**
- **Cele mai lungi distante parcurse de un lift (504m);**
- **Clubul de noapte situat la cea mai mare inaltime (etajul 144);**
- **Restaurantul situat la cea mai mare inaltime (etajul 122; 442m).**

Date interesante:

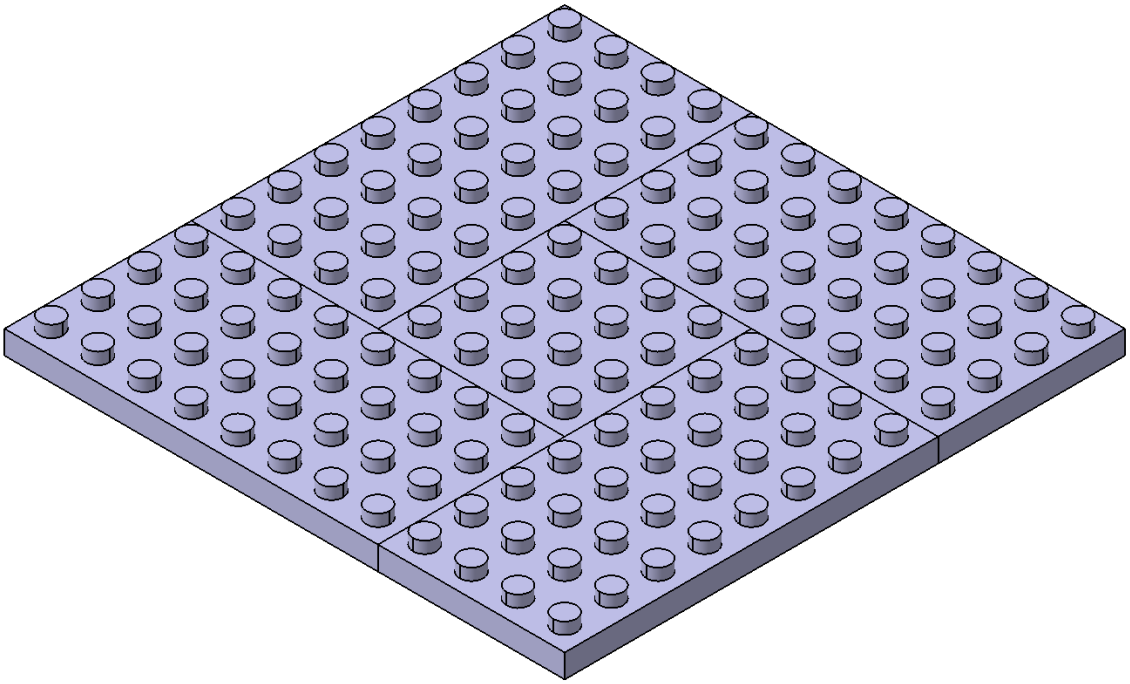
- ✓ **Greutatea betonului folosit este echivalenta cu greutatea a 100.000 de elefanti;**
- ✓ **Varful cladiri este vizibil de la o distanta de 95 km;**
- ✓ **A fost nevoie de 22 milioane de ore de munca pentru constructia cladirii;**
- ✓ **In cea mai aglomerata perioada a construnctiei erau 12.000 de muncitori pe santier.**

Burj Khalifa Lego Replica

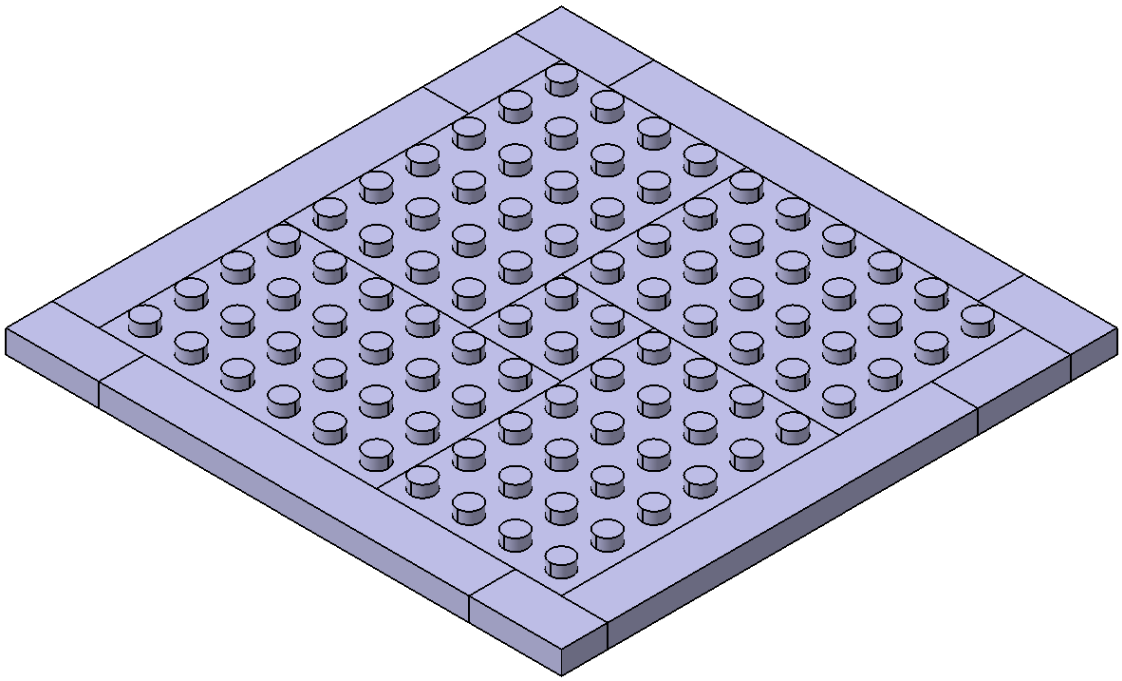


Vom incepe prin impartirea turnului in 5 subansambluri:

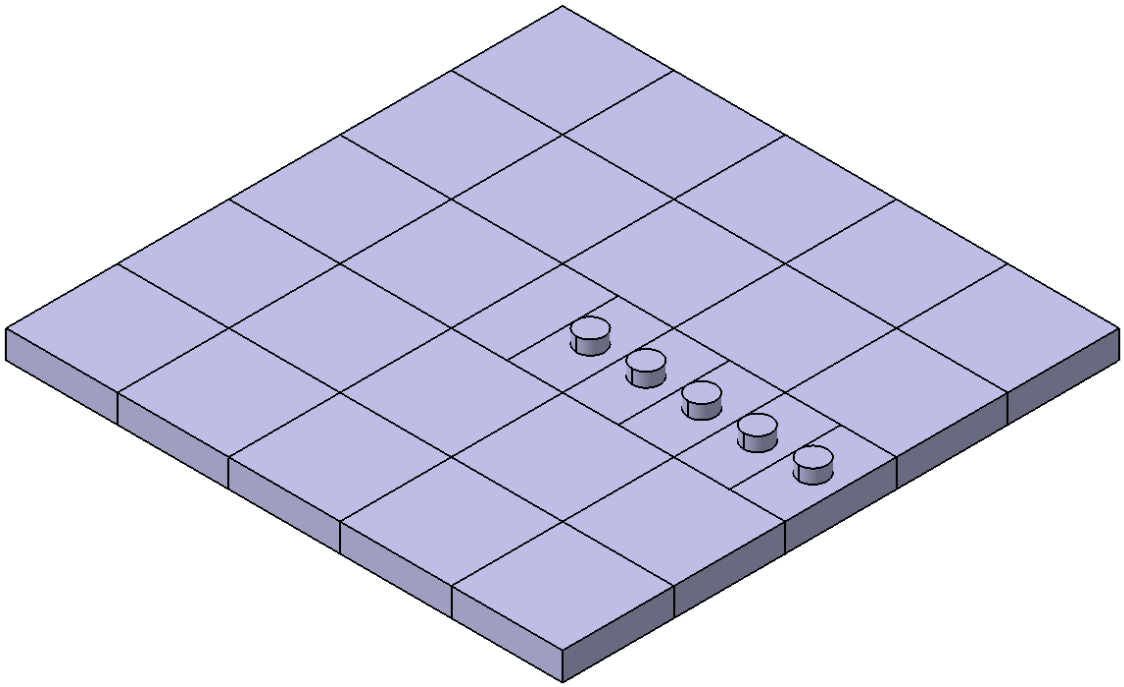
I. 1st Floor



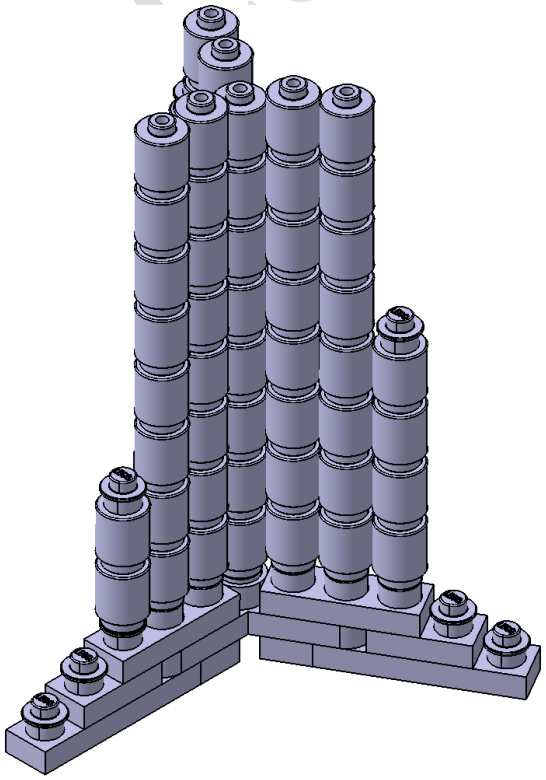
II. 2nd Floor



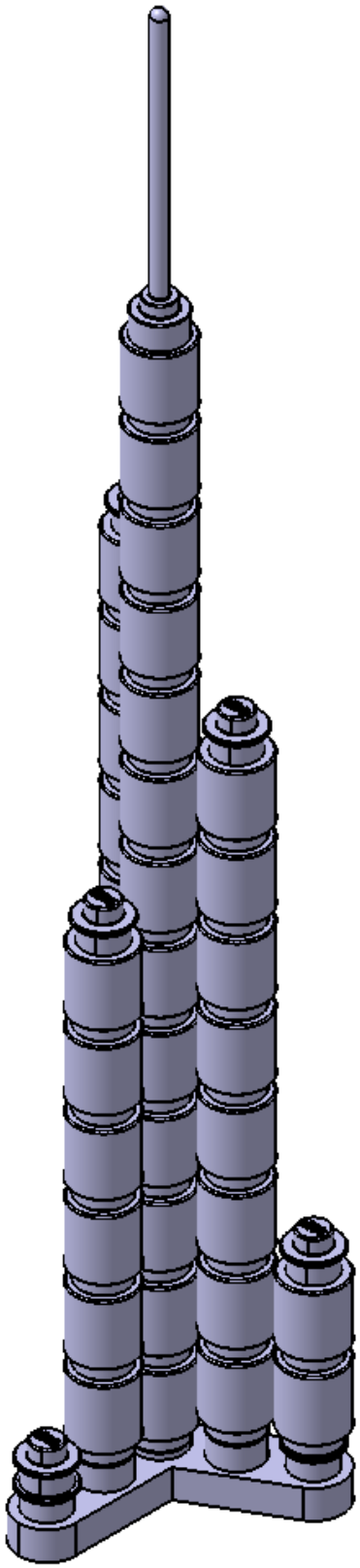
III. 3rd Floor



IV. 4th Floor



V. 5th Floor



Primul ansamblu (1st Floor)

Vom incepe constructia primului ansamblu prin proiectarea pieselor necesare:

Mai jos avem desenul de executie al primei piese ce face parte din ansamblul "1st Floor". Denumirile pieselor sunt de fapt codurile cu care pot fi gasite piesele in catalogul *"LEGO"*.

In imaginea de mai jos gasim desenul de executie al piesei 303526:

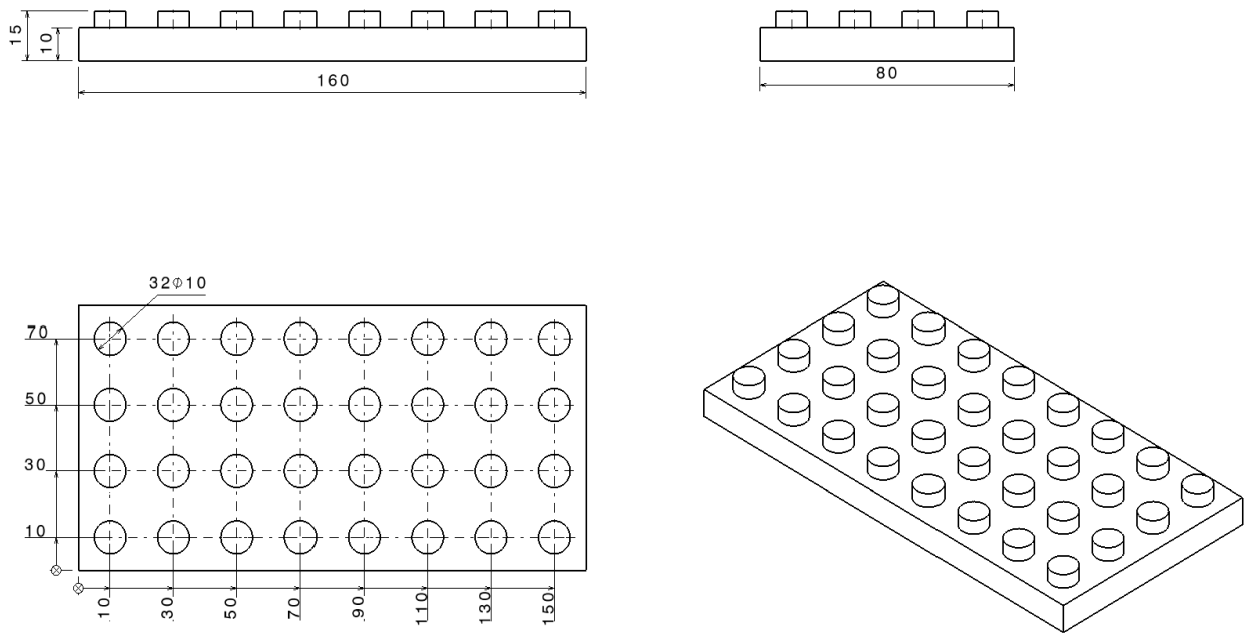
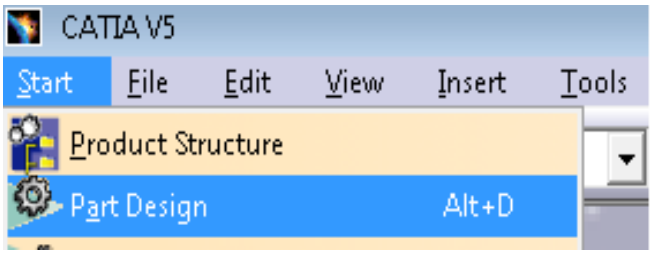
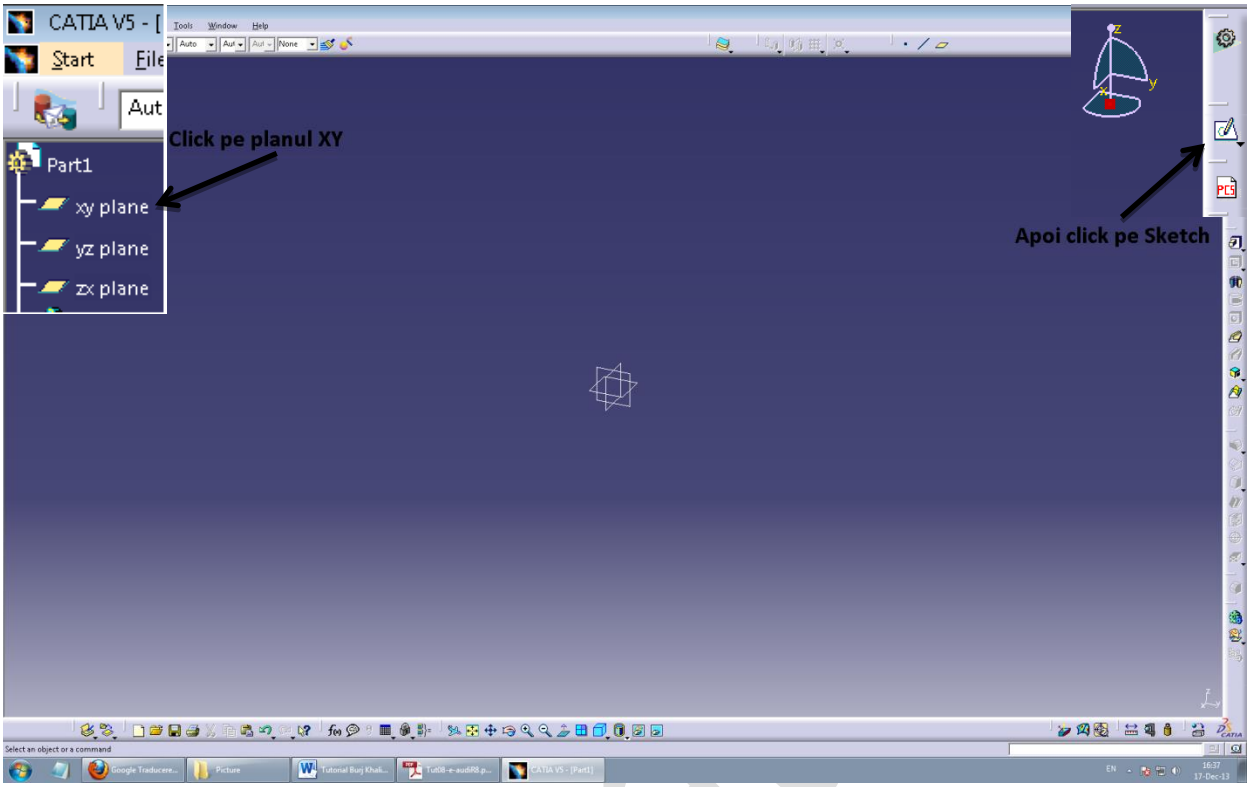


Fig.1 Piesa 303526

Pentru constructia primei piese vom intra in modulul *"Part Design"*. Daca nu il gasim direct in meniul *"Start"* acesta poate fi gasit in *"Mechanical Design"*

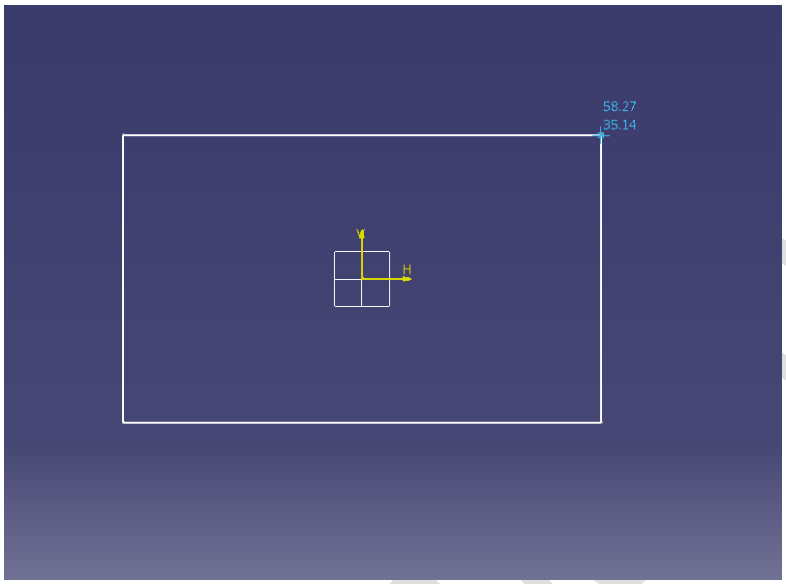


Aici vom selecta planul XY si vom crea o schita in care vom desena un dreptunghi centrat cu laturile de 160mm respectiv 80mm.

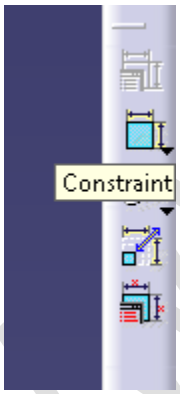


Dreptunghiul centrat "centered rectangle" poate fi gasit in meniul de "Rectangle".

Dupa ce ati selectat "centered rectangle" se face click in origine si apoi oriunde in spatiul de lucru.



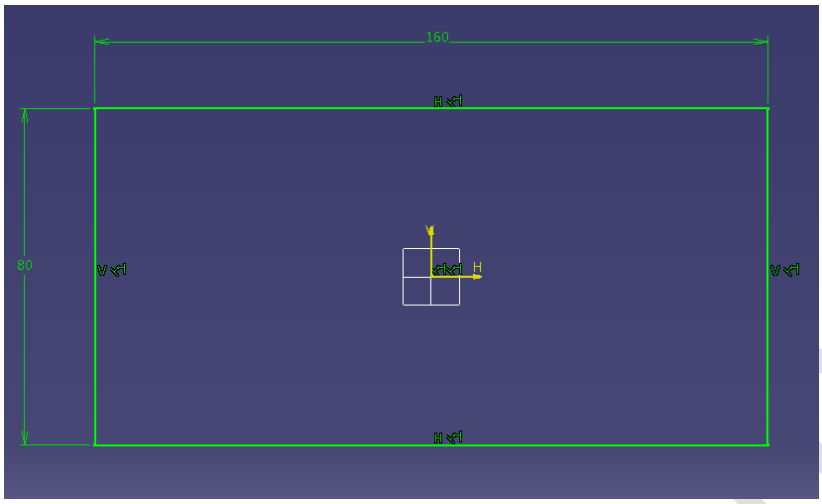
Urmatorul pas este dimensionarea dreptunghiului, aceasta se face cu instrumentul de cotat *"constraint"*, ca in imaginea urmatoare.



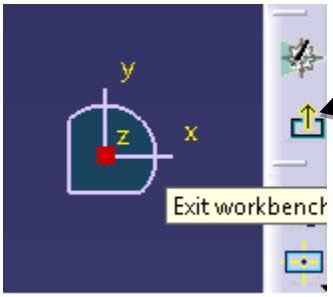
Dreptunghiul se va cota in felul urmator:

- Se face click pe *"constraint"* ;
- Click pe o latura a dreptunghiului;
- Click in spatial de lucru;
- Pentru editarea cotei se face dublu click pe cota.

Se va proceda identic si pentru cea de-a doua latura. In imaginea de mai jos vom vedea dreptunghiul constrans complet.

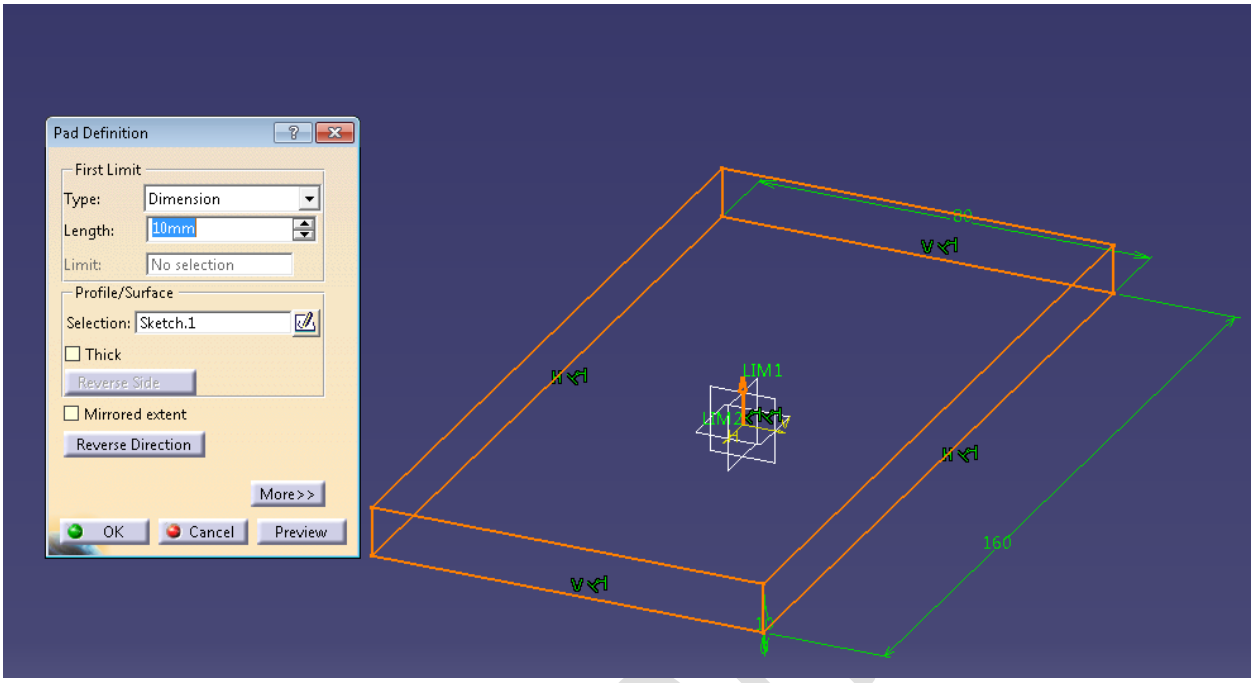


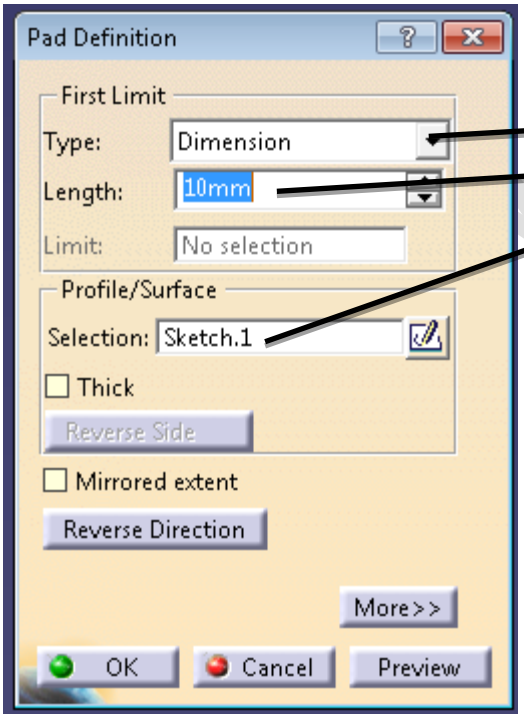
In continuare vom iesi din *"Sketch"* cu comanda *"Exit workbench"*.



Acum, pentru a transforma dreptunghiul in paralelipiped vom folosi comanda *"Pad"*.

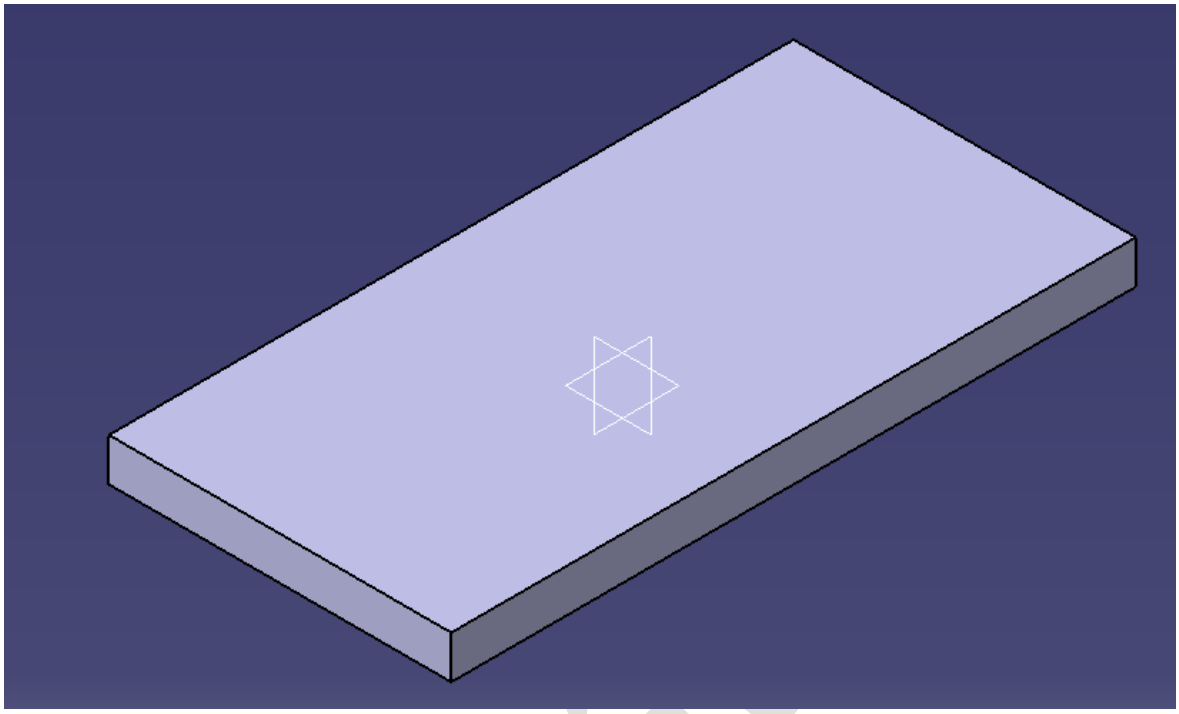
In urmatorul pas vom completa fereastra ce va aparea ca in modelul de mai jos.



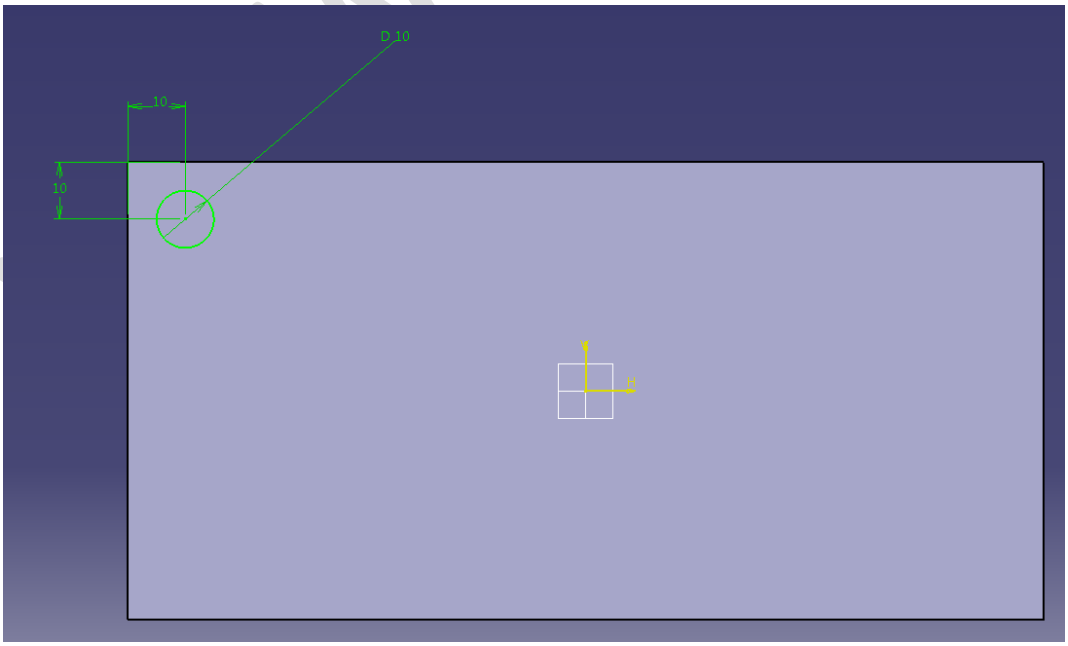


Modul de definire a inaltimii.
Inaltimea paralelipipedului.
Schita care va suferii modificarea.

La final apasam *"Ok"* si obtinem urmatorul rezultat.

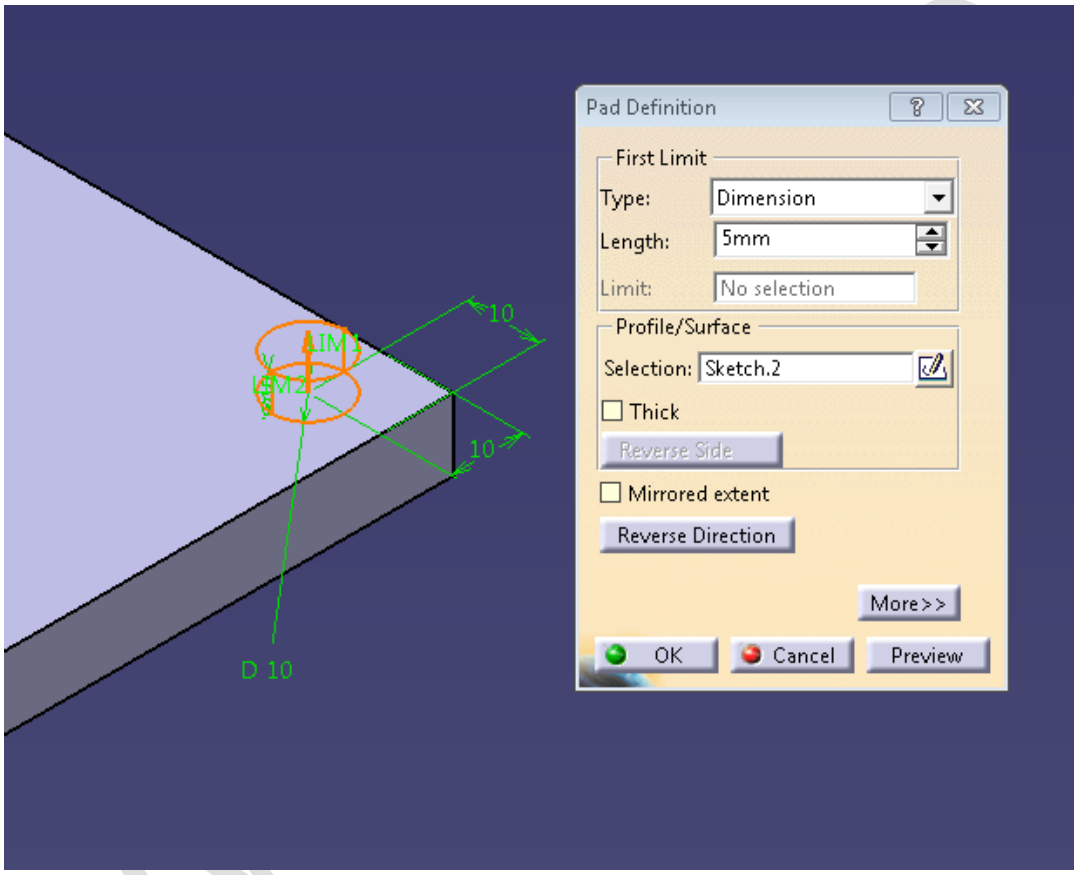


In continuare vom crea elementele de prindere. Pe suprafata superioara a paralelipipedului vom crea o schita in care cu ajutorul comenzii *"Circle"* vom desena un cerc de diametru 10 mm la o distanta de 10 mm de doua laturi ale corpului ca in figura de mai jos:



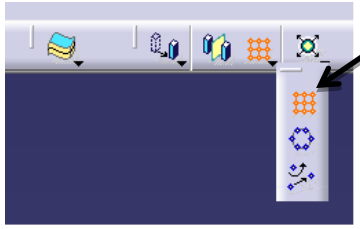
Pentru cotarea cercului se face click pe *"Constraint"*, click pe cerc apoi click in spatiul de lucru. Iar pentru pozitionarea cercului, cu aceasi comanda "constraint" se face click pe centrul cercului, click pe una din laturi si click in spatiul de lucru. Se procedeaza identic pentru cea de-a doua cota de pozitionare. Cu dublu click se editeaza cotele.

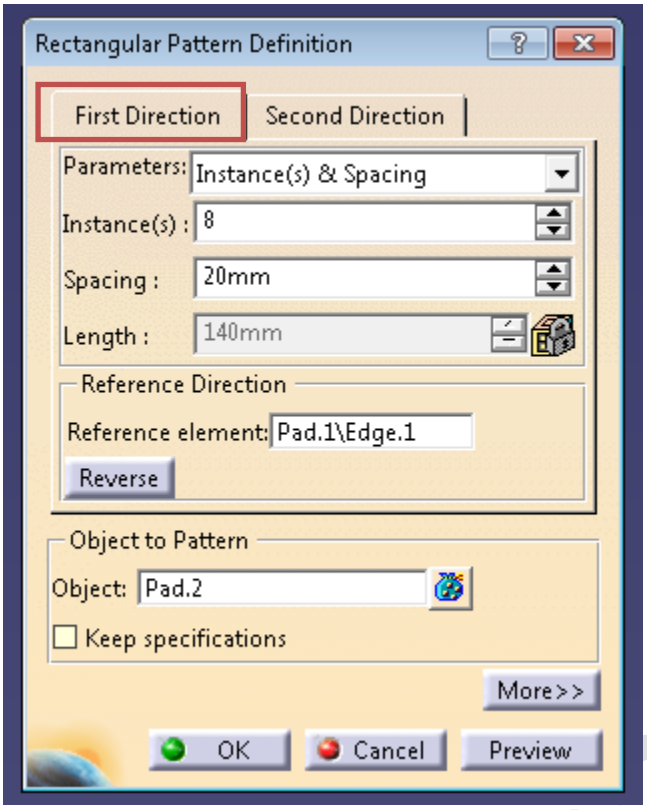
Dupa ce schita este constransa complet (cercul este de culoare verde) se iese din schita si cu ajutorul comenzii *"Pad"* se creeaza un cilindru de inaltime 5 mm.

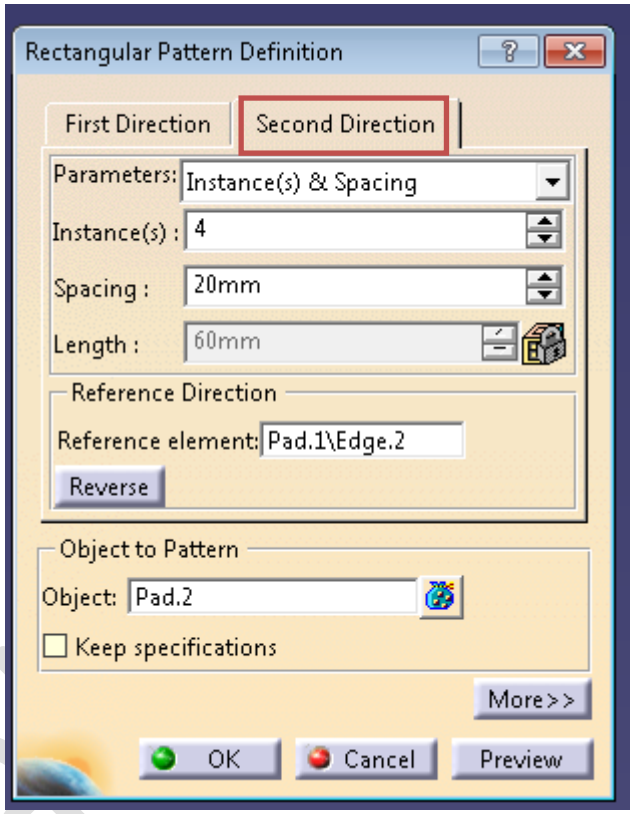


Cu ajutorul butonului *"Reverse Direction"* puteti controla directia in care va fi creat cilindrul. La final se apasa *"Ok"*.

Pentru crearea celor 32 de elemente de prindere vom utiliza comanda *"Rectangular Pattern"*. Se face click pe *"Rectangular Pattern"* si se completeaza campurile ca in modelul de mai jos:



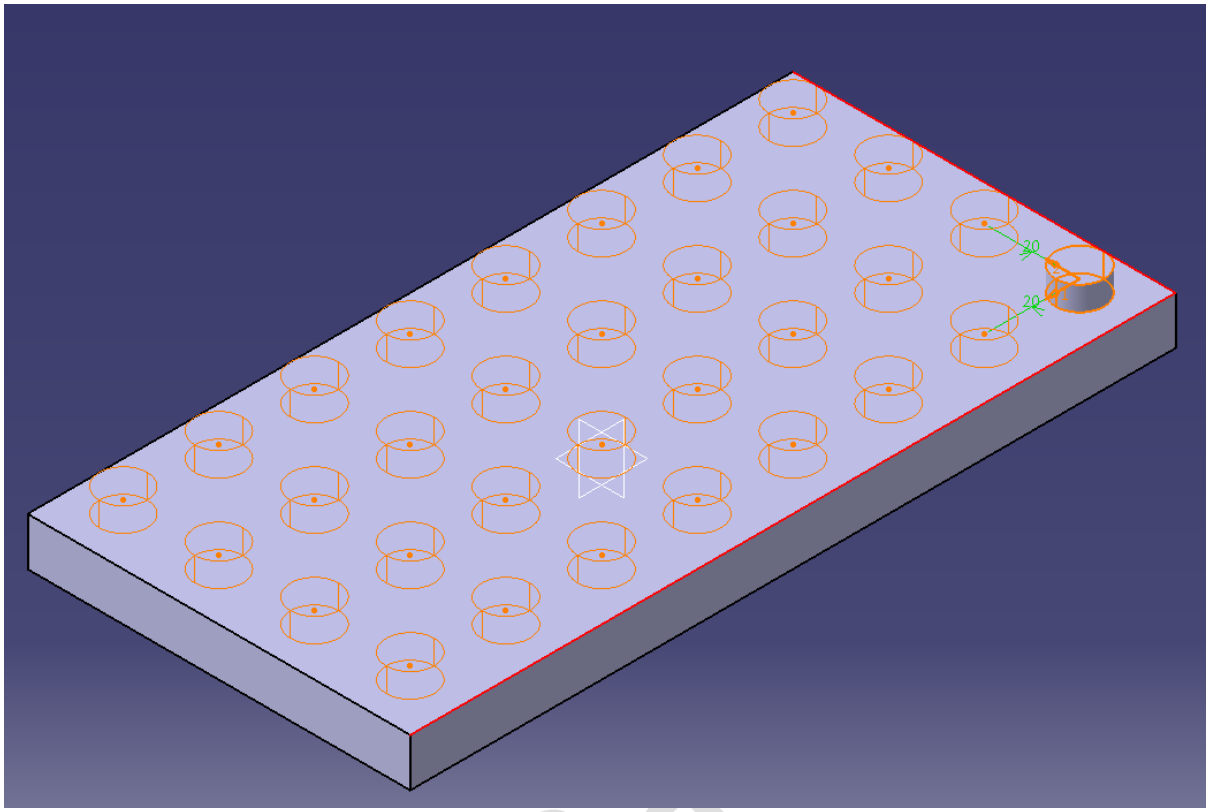




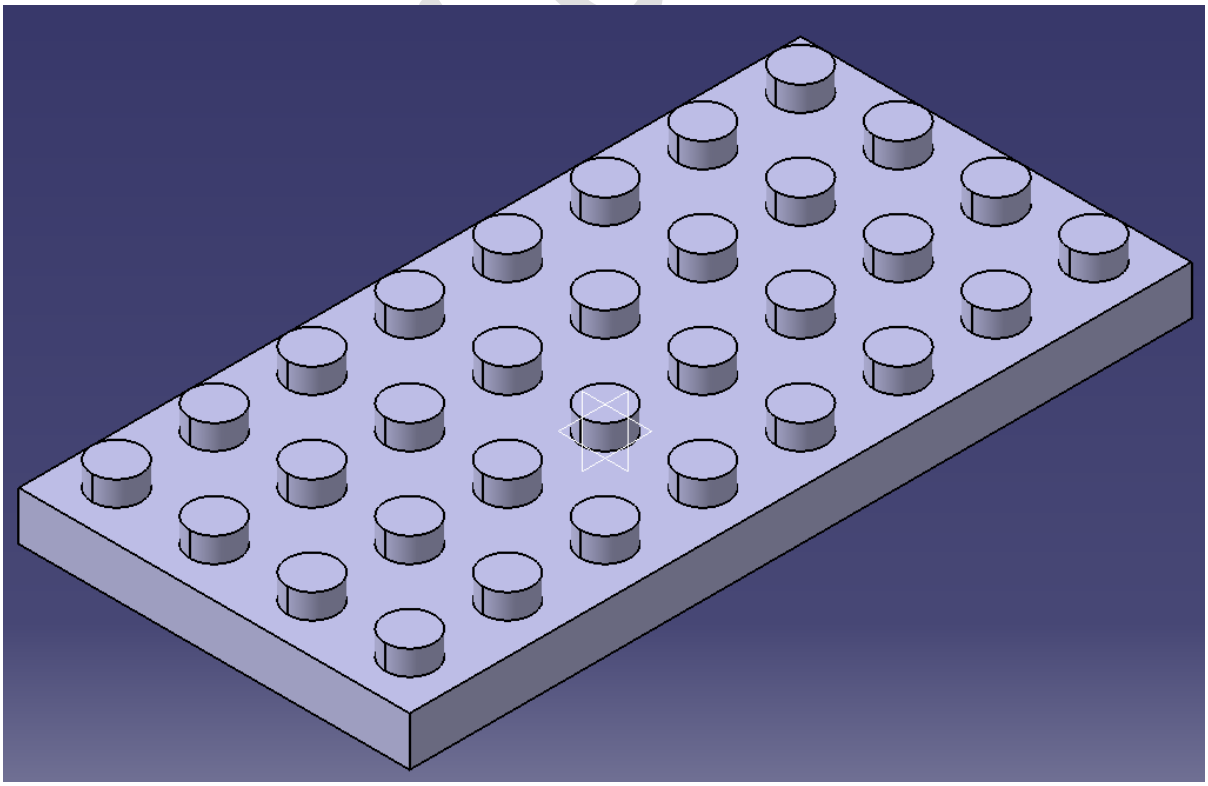
In primul camp se va alege optiunea *"Instance(s) & Spacing"* ,optiune care ne da posibilitatea de a stabili cate instante cream si la ce distanta intre ele. In cel de-al doilea camp este valoarea care defineste numarul instantelor iar in cel de-al treilea camp distanta dintre doua instante consecutive. La *"Reference element"* se stabileste directia dupa care vor fi create instantele iar la *"Object to pattern"* obiectul care va fi multiplicat.

Pentru a crea toate cele 32 de elemente ne vom folosi de cele 2 directii disponibile iar campurile vor fi completate ca in imaginile de mai sus cu mentiunile ca la *"First Direction"* ca element de referinta vom alege una din cele 4 muchii mai lungi iar la *"Second Direction"* vom alege o muchie scurta. La *"Object to Pattern"* vom alege *"Pad.2"* care este de fapt cilindrul creat anterior.

Daca toate campurile au fost completate corect rezultatul este urmatorul.



In acest caz vom apasa *"Ok"*, iar rezultatul final va fi ca in imaginea de mai jos:



Pentru a crea cele 32 de elemente de prindere avem 3 variante diferite, si anume:

- **31 de schite cu cate un cerc, fiecare pozitionat ca in desenul de executie al piesei si pentru fiecare schita folosindu-se comanda *"Pad";***
- **O schita cu cele 32 de cercuri pozitionate ca in desenul de executie dupa care folosim o singura data comanda *"Pad";***
- **O schita cu un cerc pozitionat ca in prezentare, apoi folosim comanda *"Pad"* pentru crearea unui cilindru pe suprafata pe care a fost creata schita, iar pentru multiplicare se va folosi comanda *"Rectangular Pattern"* (varianta folosita in prezentare).**

Urmatorul pas este salvarea piesei, eu utilizand pentru numele lor codurile din catalogul *"LEGO"* aceasta fiind piesa cu numarul 303526.

Urmatoarea piesa (4243819) va fi construita cu ajutorul pasilor de mai sus dar tinand cont de desenul de executie de mai jos:

In imaginea de mai jos gasim desenul de executie al piesei 4243819:

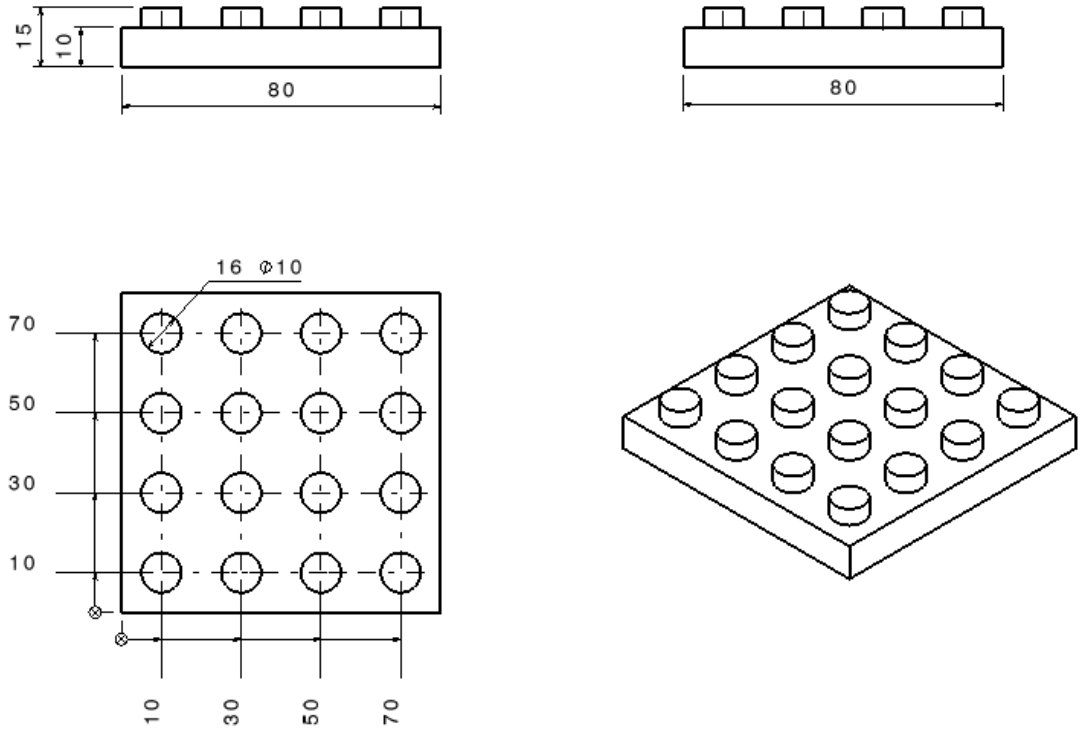
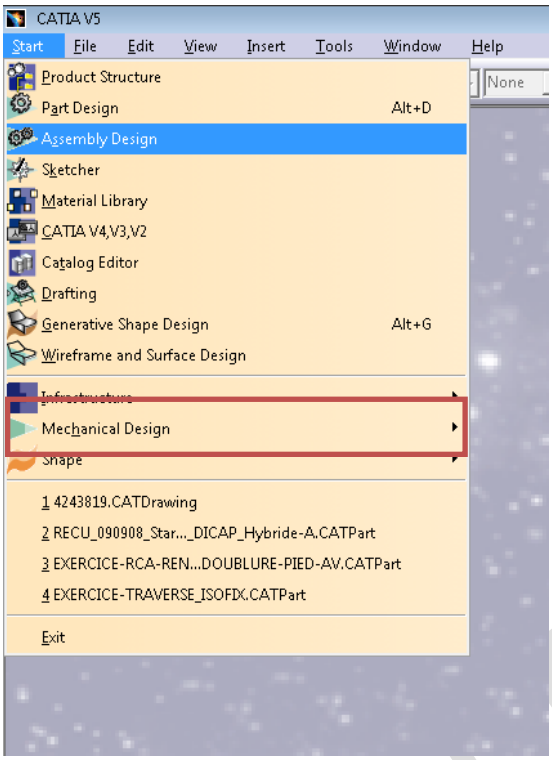
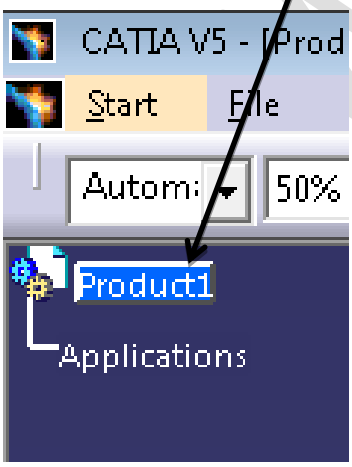


Fig.2 Piesa 4243819

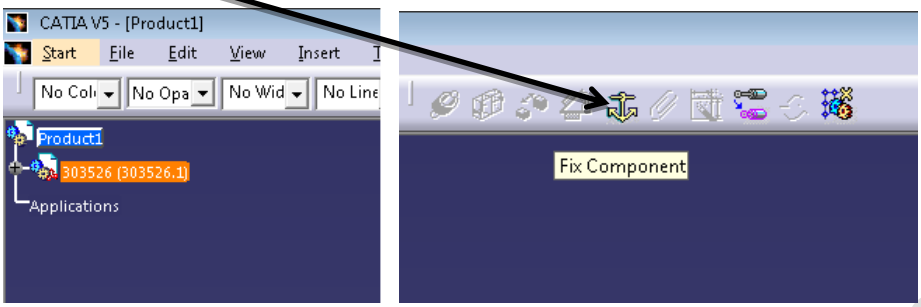
Dupa crearea celor doua piese ne putem apuca de constructia primului ansamblu. Pentru a intra in modulul de asamblare se face click pe *"Start"* apoi pe *"Assembly Design"*. Daca nu apare direct in meniul *"Start"* acesta poate fi gasit in *"Mechanical Desing"*.



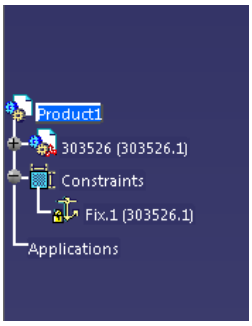
Pentru a insera prima piesa se face click pe *"Insert"* -> *"Existing Component"* apoi dam click pe *"Product1"*, iar in fereastra ce va aparea vom cauta piesa 303526, o selectam si apoi click pe *"Ok"*.



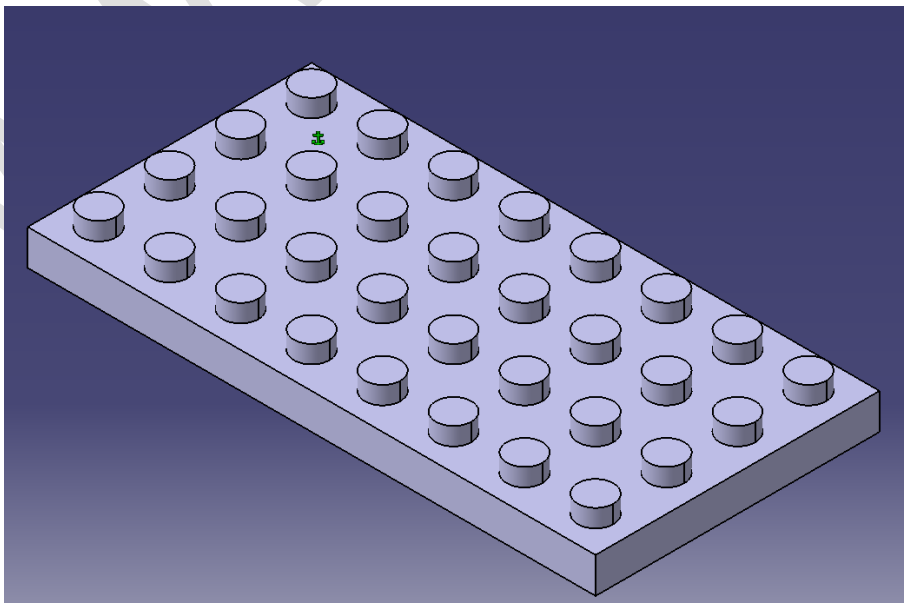
In acest moment piesa a fost inserata in ansamblul nostru dar poate fi mutata liber in spatiu. Pentru a fixa piesa o vom selecta din arborescenta iar apoi dam click pe *"Fix Component"*, ca in imaginile de mai jos.



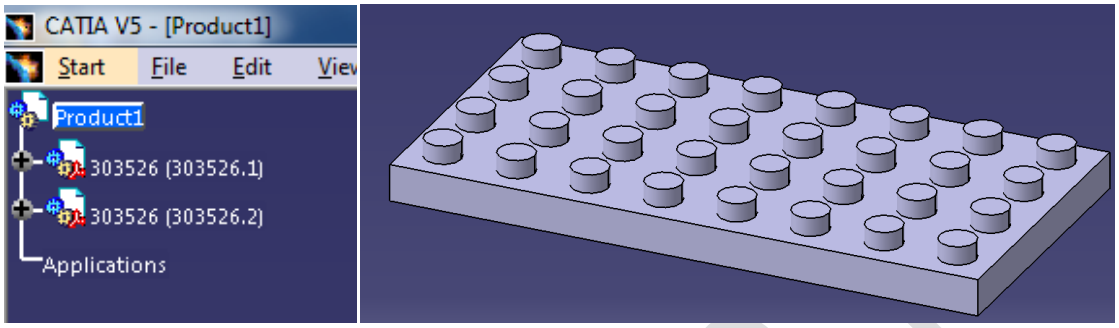
Dupa ce am fixat piesa va aparea o ancora verde pe piesa iar in arbore va aparea o ramura noua numita *"Constraints"* unde vor fi inserate toate constrangerile dintre piese.



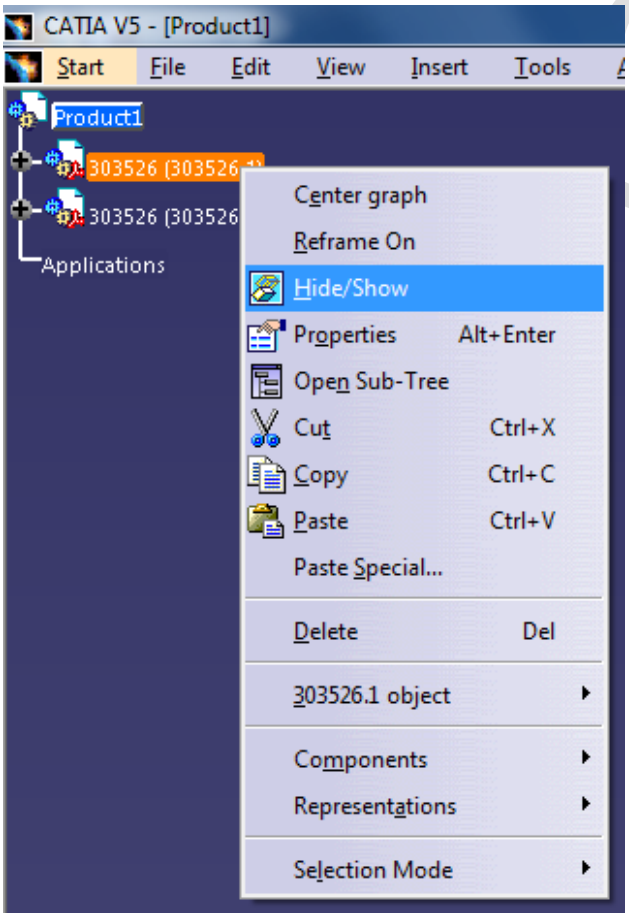
In acest moment ea nu mai poate fi mutata decat prin stergerea constrangerii din arborescenta.



Prin procedeul prezentat mai sus vom mai insera inca o data piesa cu numarul 303526. Desi in arborescenta ne arata ca in ansamblul nostru sunt doua piese, in spatiul de lucru este vizibila doar una deoarece cea de-a doua piesa a fost inserata suprapusa peste prima.

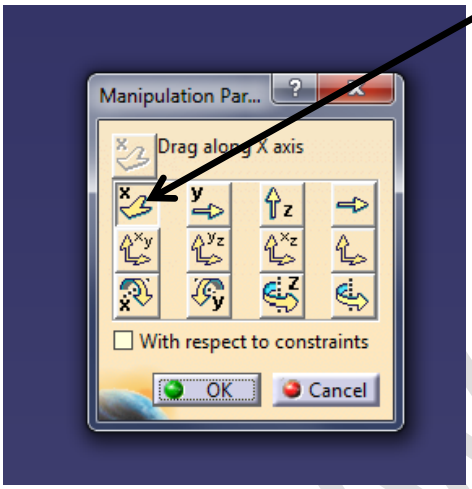


Acum vom selecta prima piesa din arborescenta si vom apasa click dreapta, iar din meniul ce va aparea vom selecta *"Hide/Show"*. Acest lucru face ca prima piesa sa dispara si va ramane doar a doua piesa.

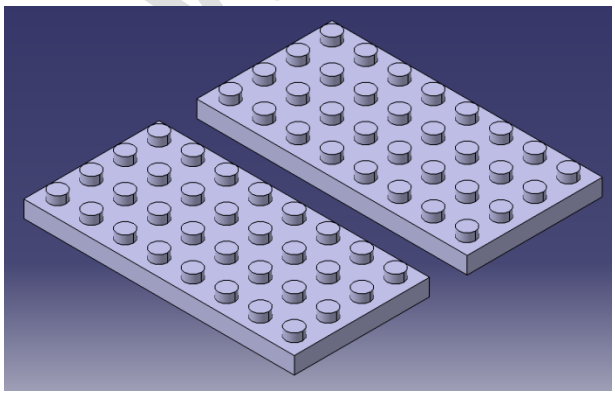


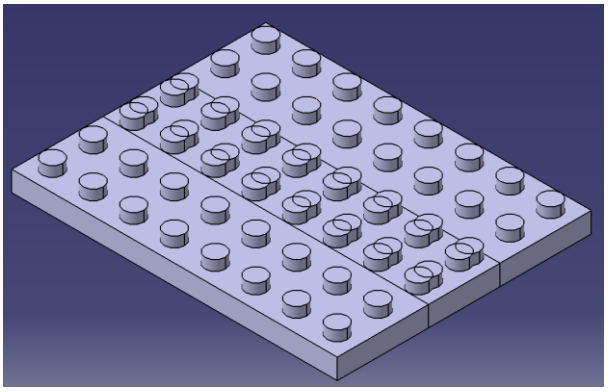
Pentru a putea manipula piesa si a o fixa in corespondenta cu prima piesa, va trebui sa o deplasam astfel incat cele doua piesa sa nu mai fie suprapuse. Pentru acest lucru vom da click pe butonul *"Manipulation"* din bara de meniu *"Move"*, ca in imaginea de mai jos.

Din meniul aparut se selecteaza *"Drag along X axis"*, se selecteaza piesa si se deplaseaza pe directia X.



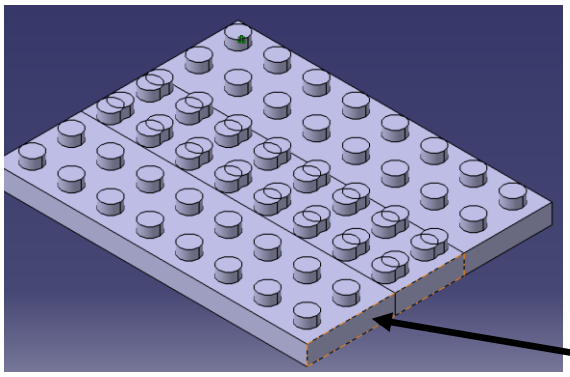
Dupa ce ati facut acest lucru vom da din nou click dreapta pe prima piesa si se va alege din nou *"Hide/Show"*, pentru a aparea si prima piesa. In functie de cat de mult ati deplasat a doua piesa in momentul cand apare prima piesa sunteti in unul din cele doua cazuri prezentate mai jos (indiferent in care din cele doua cazuri va aflati putem merge mai departe) :



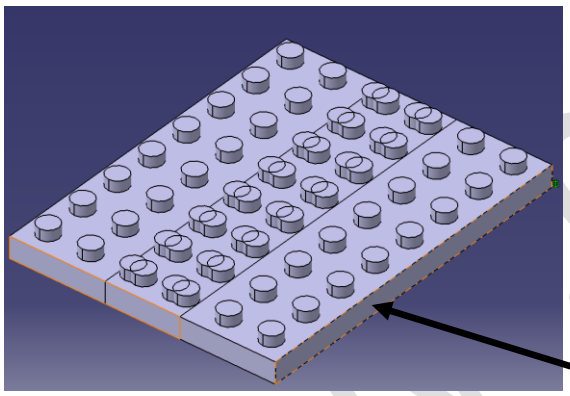


Pentru a fixa cea de-a doua piesa in pozitie vom face click pe *"Contact Constraint"* apoi click pe cea de-a doua piesa iar in final click pe prima piesa inserata.

Click 1

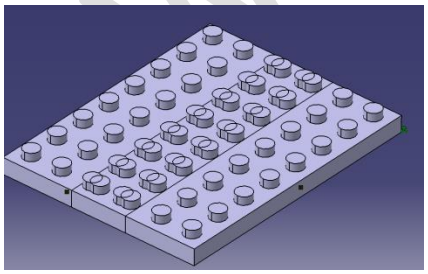


Click 2



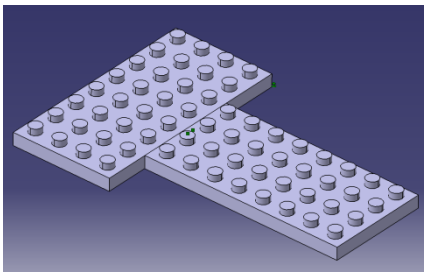
Click 3

In acest moment vor aparea doua patratele mici pe fetele pe care ati dat click dar piesele inca nu s-au miscat, pentru a vizualiza piesele in pozitia constransa vom avea nevoie de un update acest lucru facandu-se prin apasarea tastelor *"Ctrl+u"*.

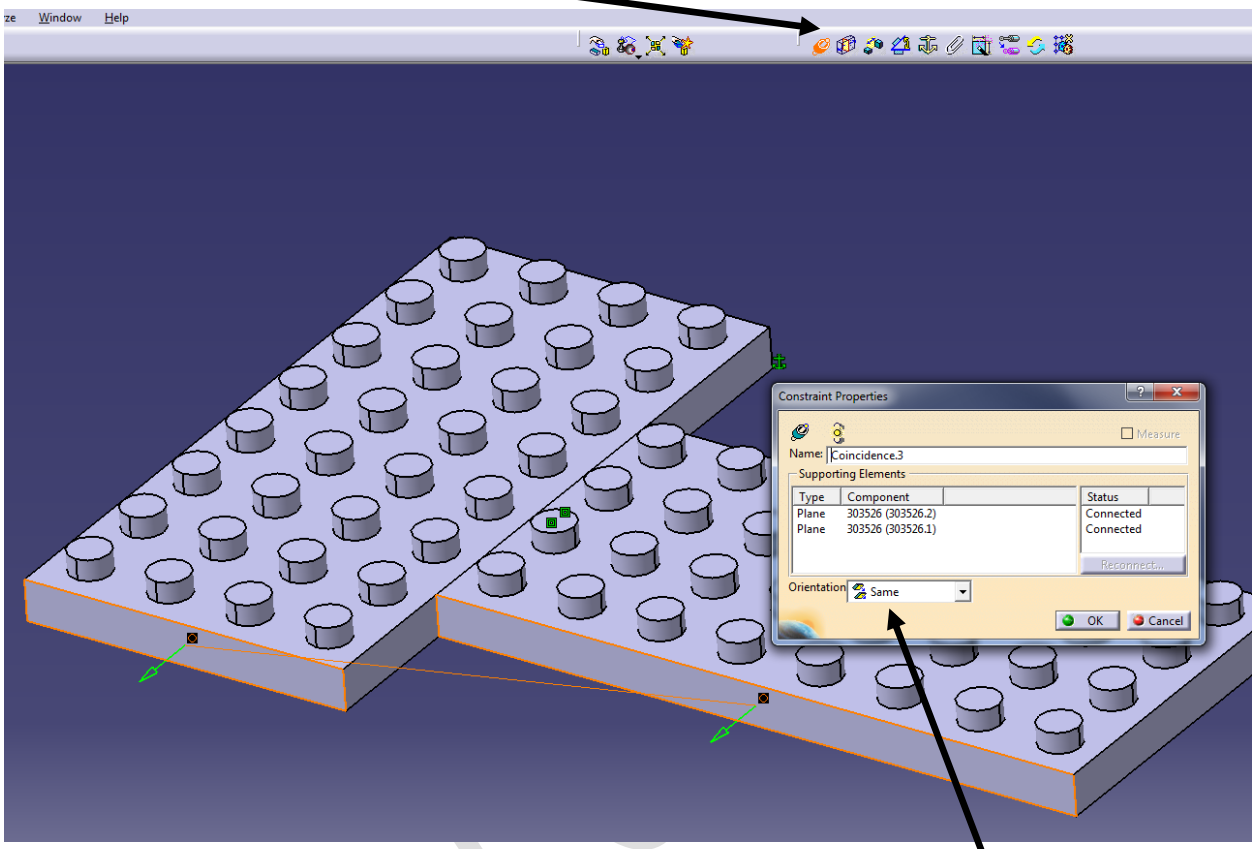


Inainte

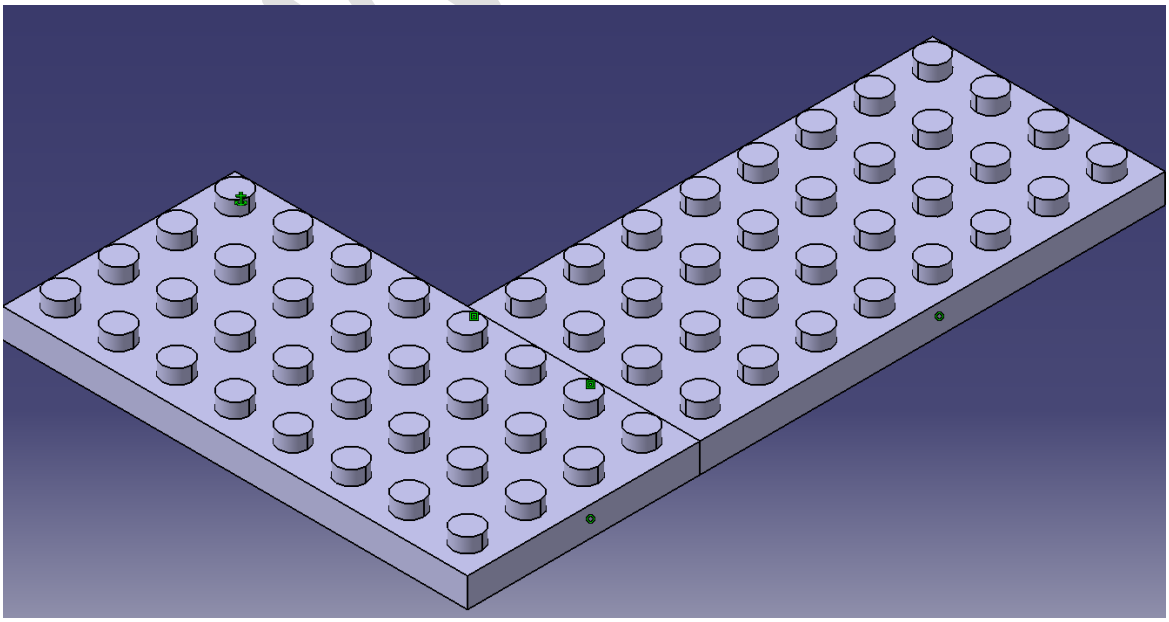
Dupa



Pentru a constrange a doua piesa in pozitia finala vom mai face inca o constrangere de tip *"Coincidence"* intre doua fete ca in imaginea de mai jos.



Vom face un update si dupa aceasta constrangere, iar daca orientarea este corecta vom avea urmatorul rezultat.



Pe baza celor explicate mai sus se creeaza primul ansamblu ca in imaginea de mai jos.

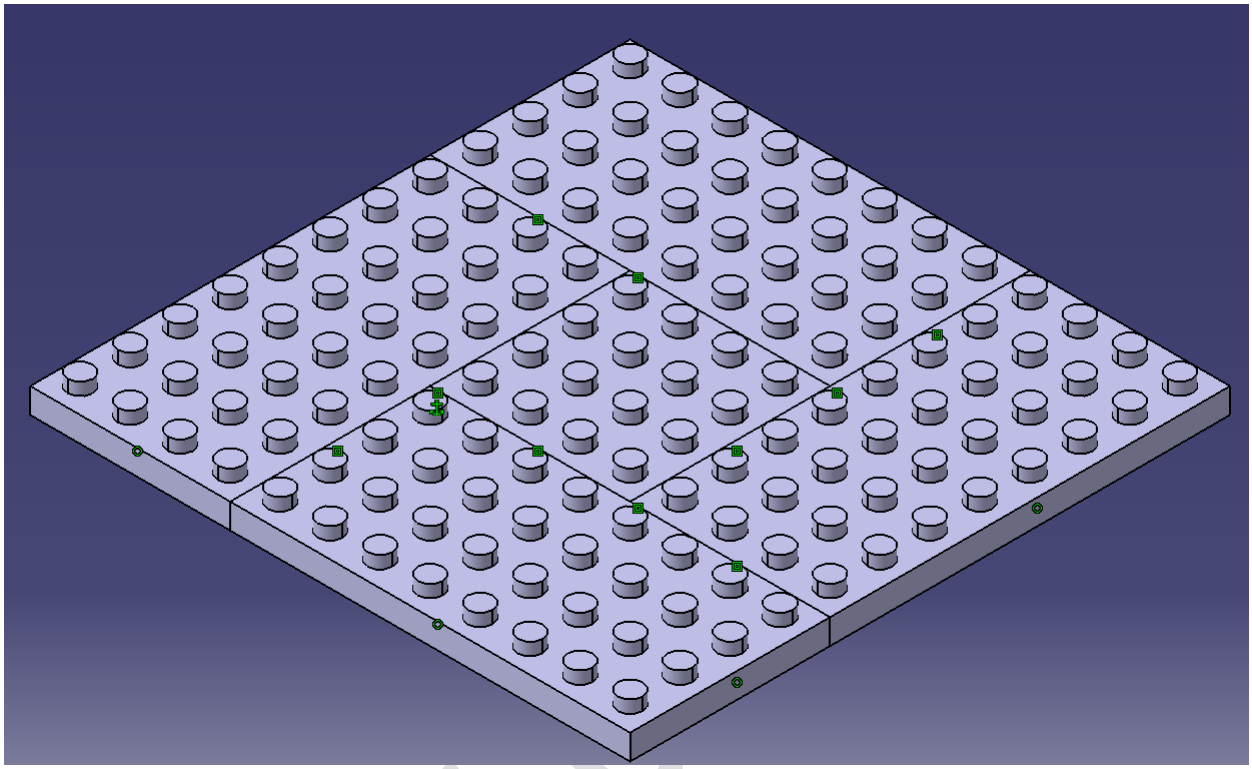
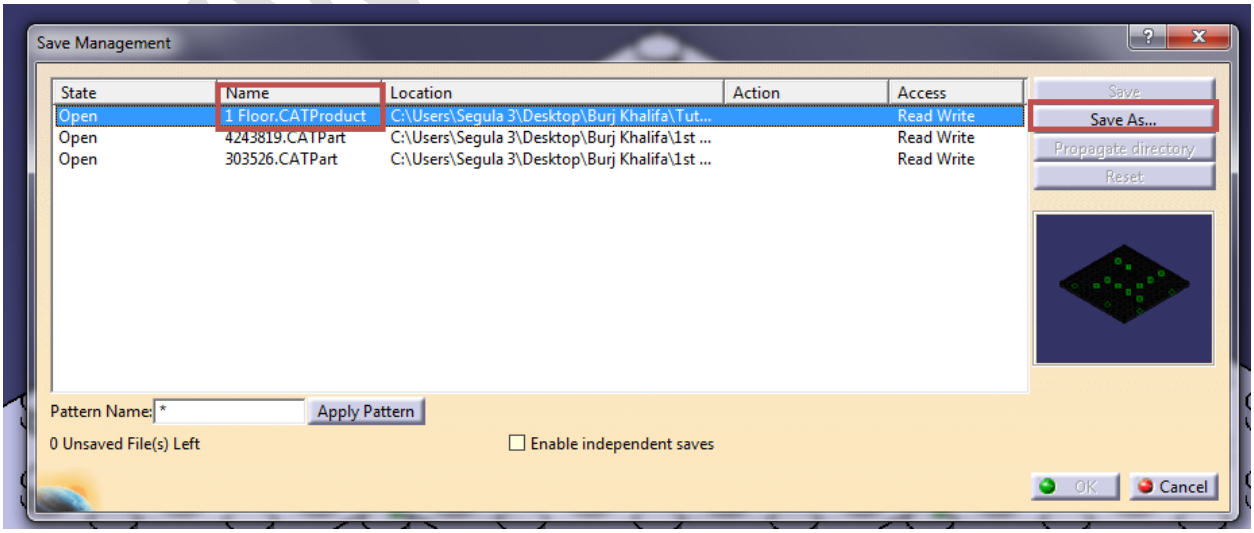
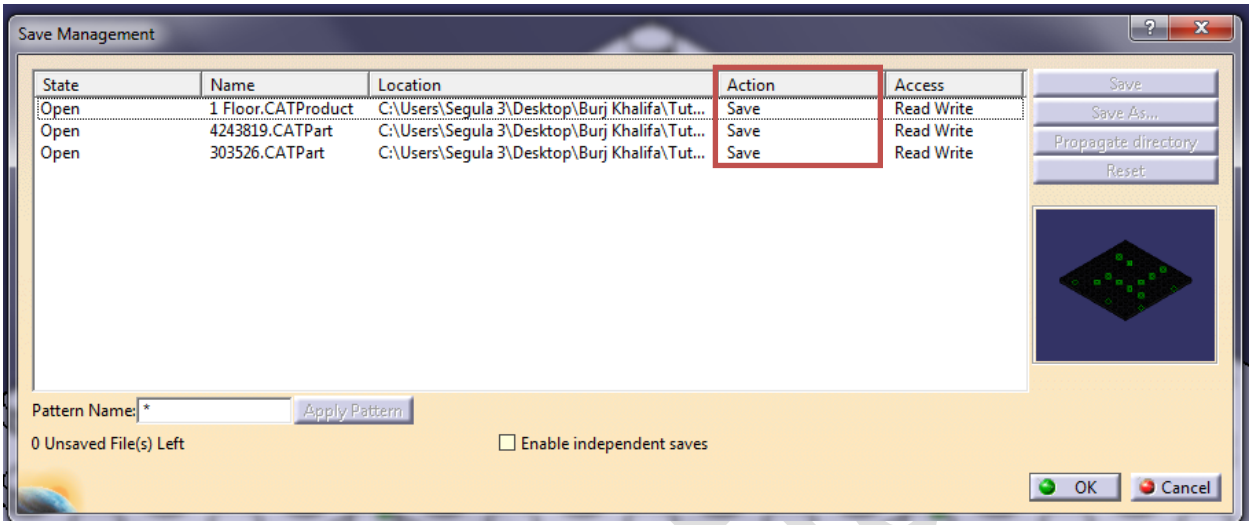


Fig.3 Primul ansamblu (1st Floor)

Pentru a salva un *"Assembly"* vom da click pe *"File"-> "Save Management"*, apoi din lista de fisiere se selecteaza *"CatProduct"* si se alege *"Save As"*. Se stabileste folder-ul destinatie si se salveaza ansamblul.



Dupa ce ati salvat product-ul se va activa optiunea *"Propagate directory"*, acest lucru va face ca toate piesele din ansamblu sa fie salvate in acelasi folder ca si ansamblul (aceasta este singura metoda corecta de a salva un *"Catproduct"*).



Cu acesta ultima etapa am incheiat constructia primului ansamblu *"1st Floor"*. Vom inchide toate ferestrele ce au legatura cu primul ansamblu, si ne vom apuca de constructia pieselor pentru cel de-al doilea ansamblu.

Al doilea ansamblu (2nd Floor)

Cu ajutorul explicatiilor de mai sus se vor realiza piesele din desenele de executie de mai jos iar la final ansamblul. Singura adaugire este ca pentru a face gaurile in loc de comanda *"Pad"* se va folosi comanda *"Pocket"*.

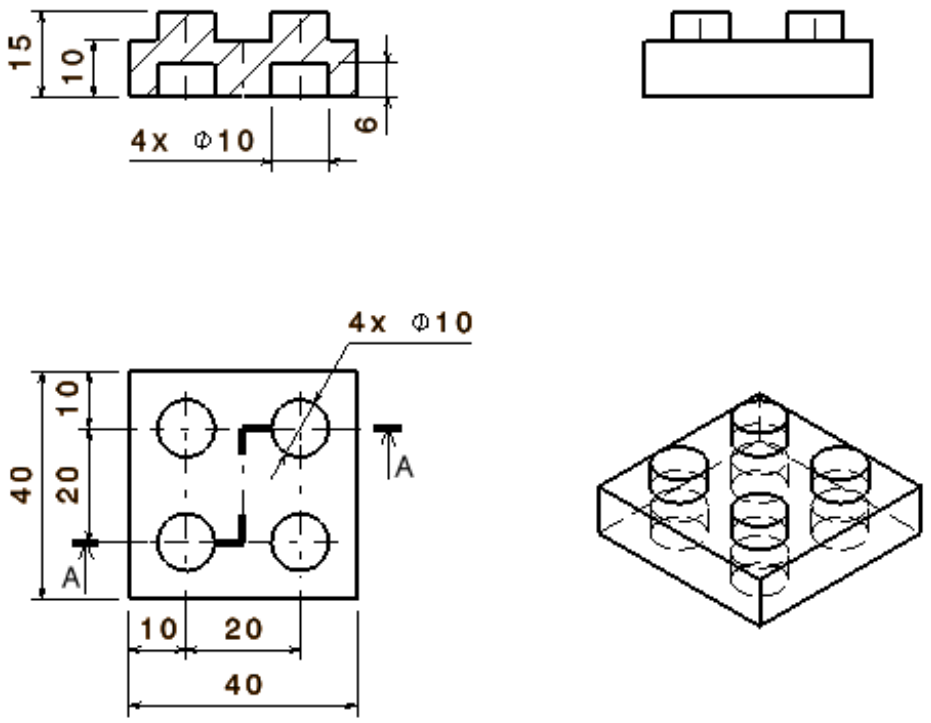


Fig.4 Desen executie 302201

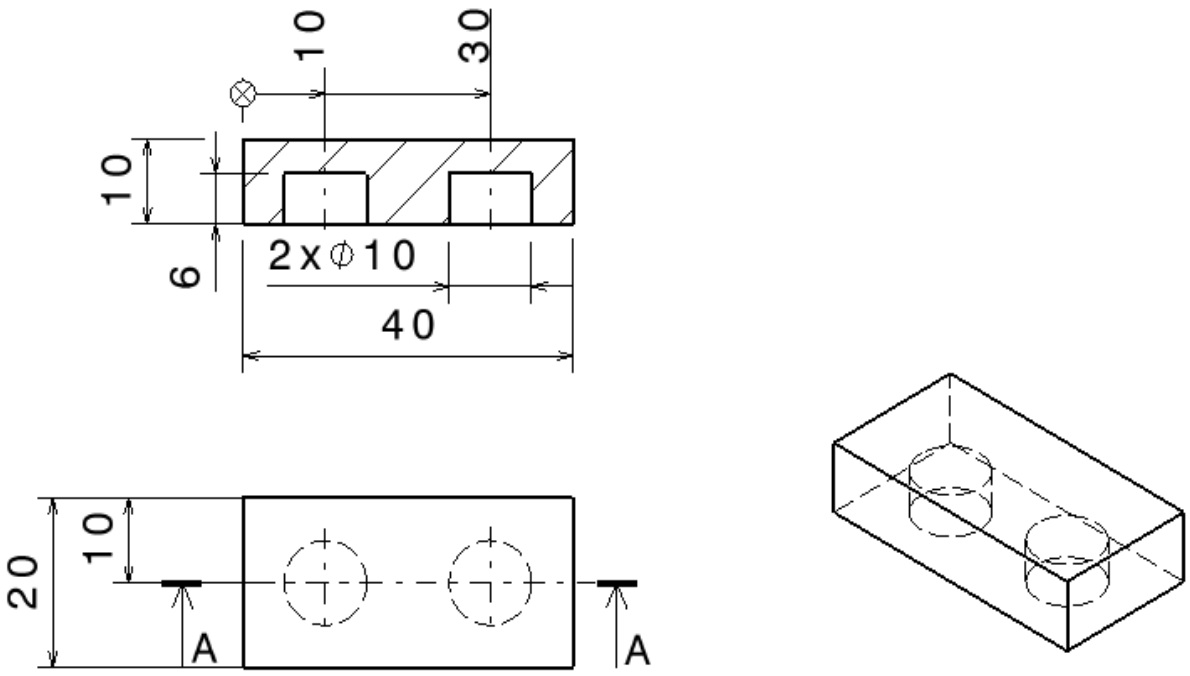


Fig.5 Desen executie 306926

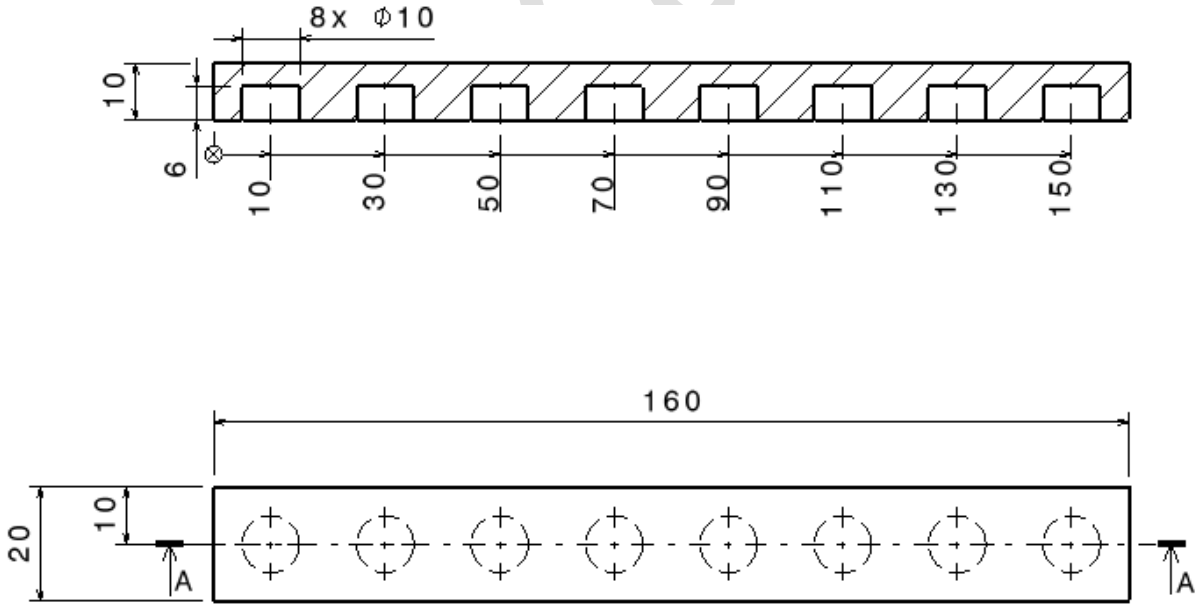


Fig.6 Desen executie 416226

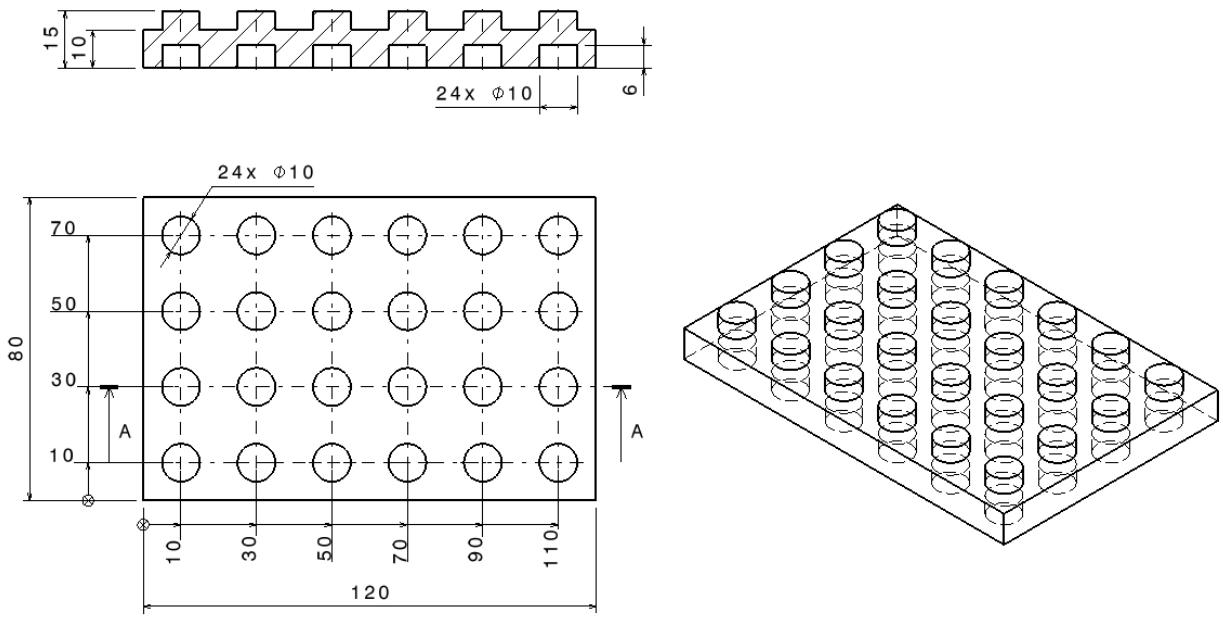


Fig.7 Desen executie 4211404

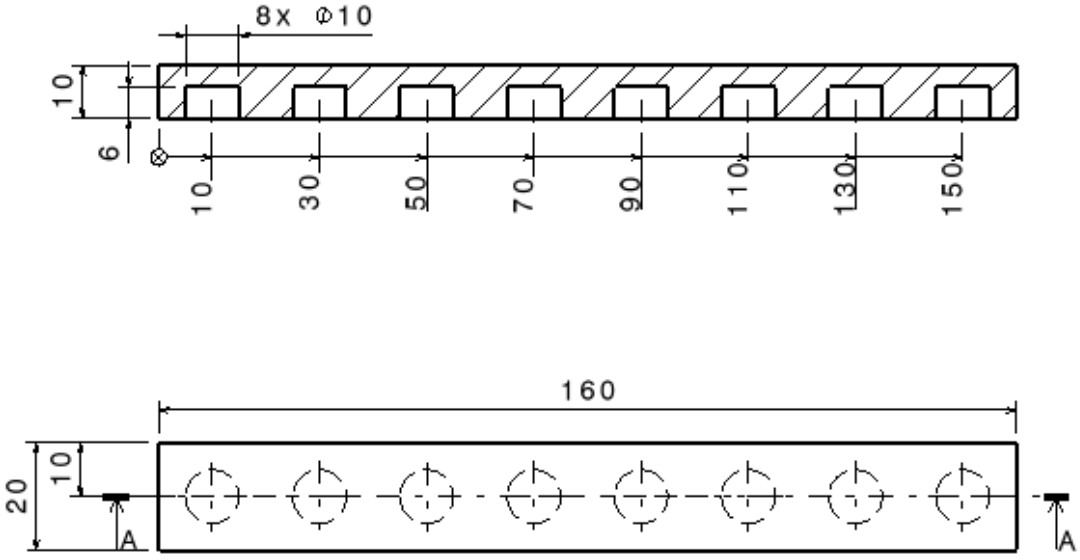


Fig.8 Desen executie 4638309

Desi piesa 416226 si 4638309 este una si aceasi , avem nevoie de amandoua deoarece pe cea din urma va trebui sa imprimam numele turnului.

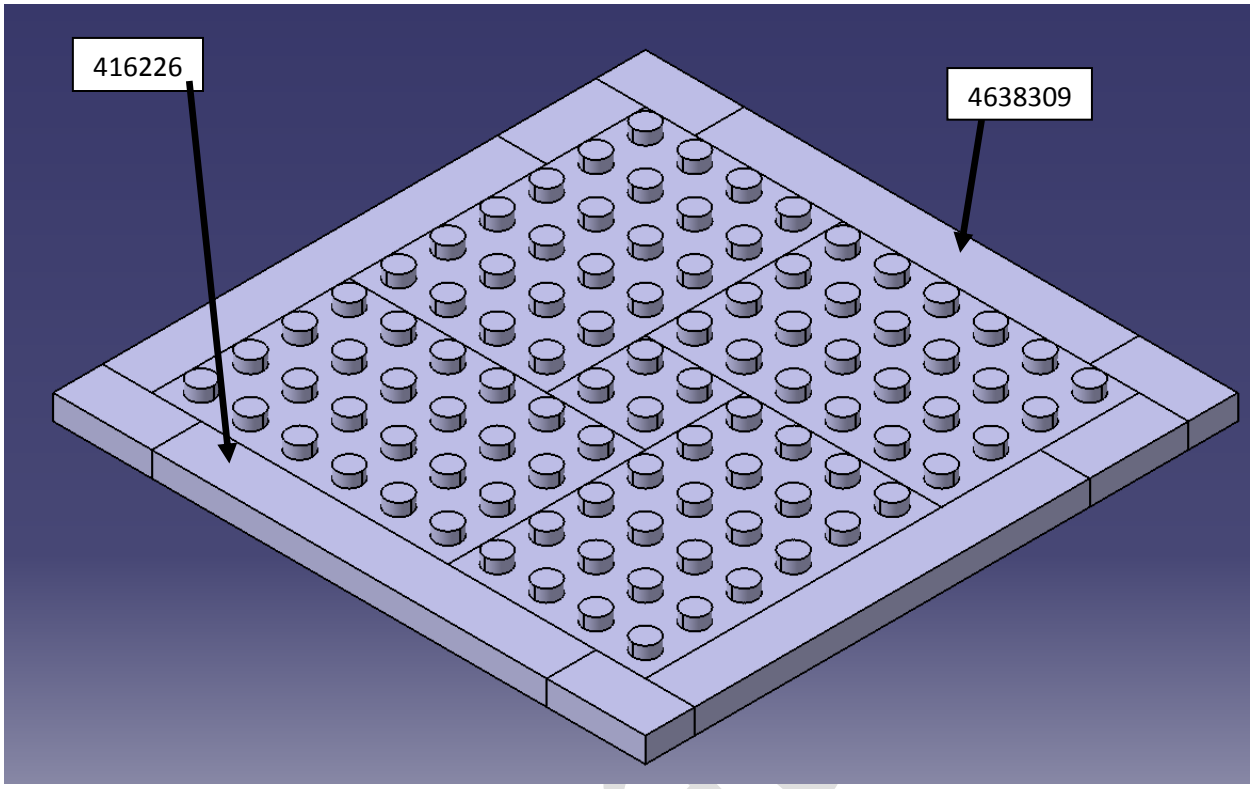


Fig.9 Ansamblul doi (2nd Floor)

Al treilea ansamblu (3rd Floor)

Ca si in cazul celui de-al doilea ansamblu, mai jos sunt desenele de executie ale pieselor ce formeaza cel de-a treilea ansamblu.

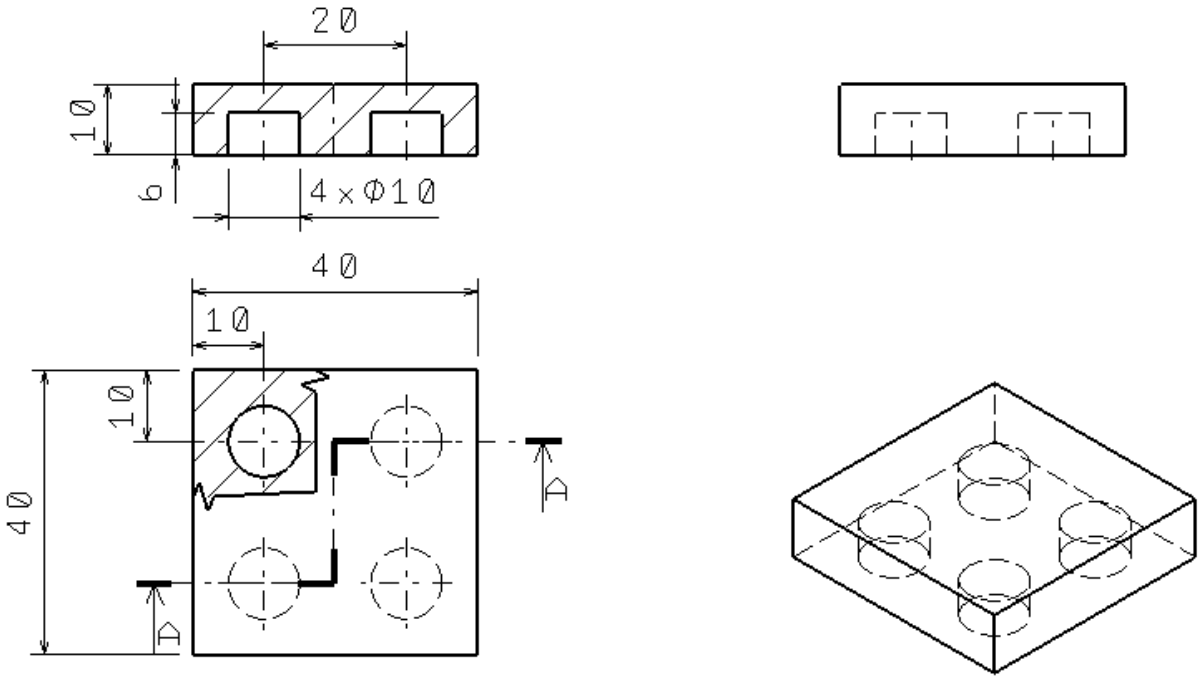


Fig. 10 Desen executie 4211413

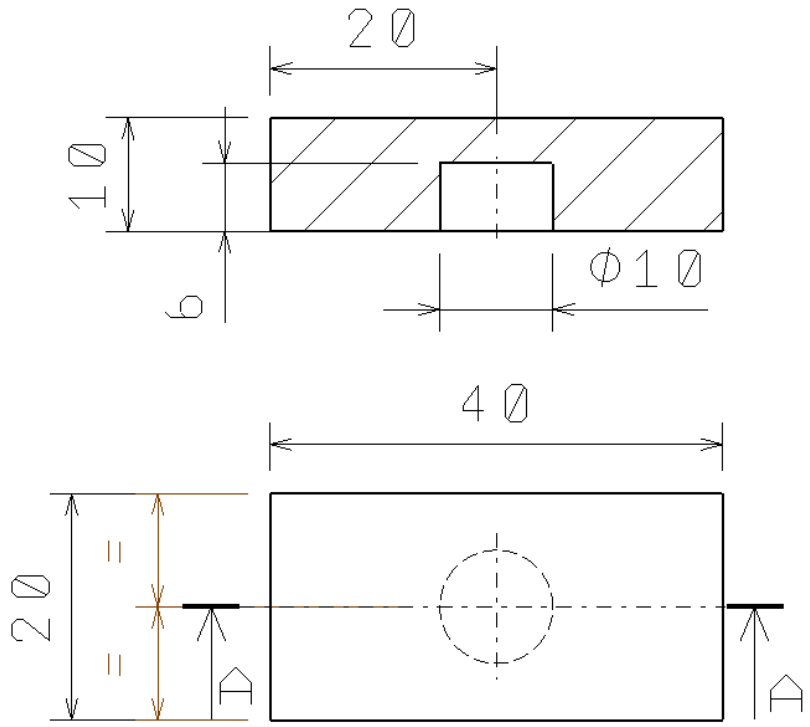


Fig. 11 Desen executie 4211414

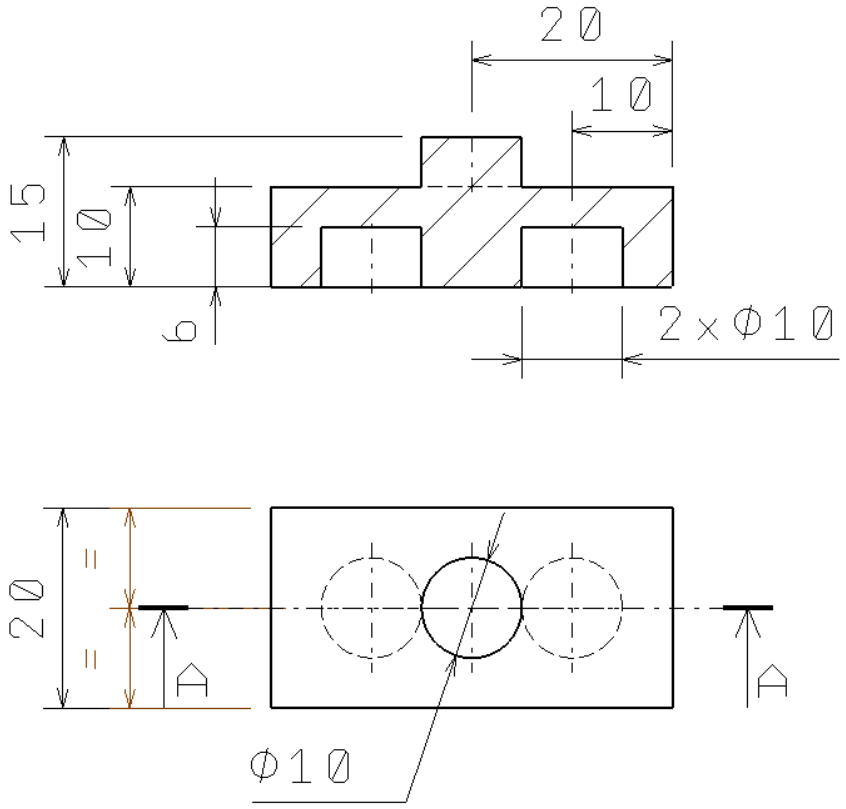


Fig. 12 Desen executie 4211451

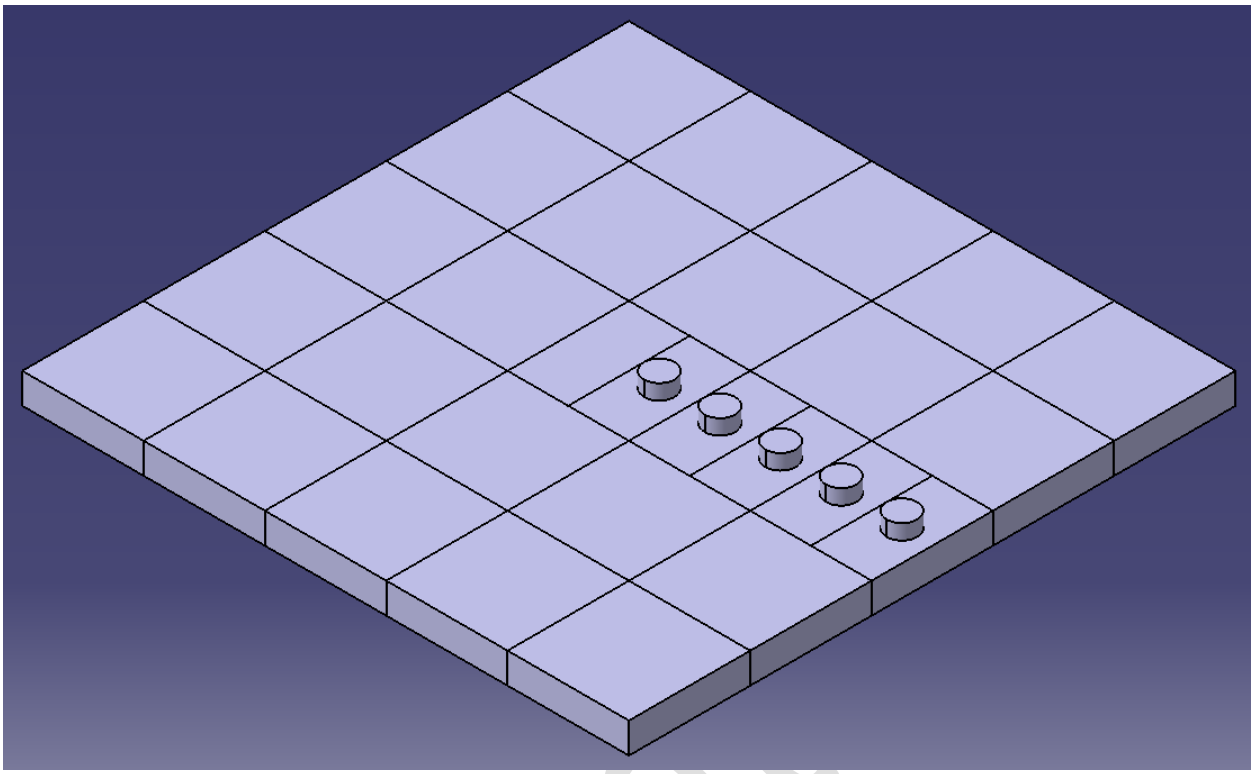


Fig. 13 Ansamblul trei (3rd Floor)

Al patrulea ansamblu (4th Floor)

Mai jos puteti gasi desenele de executie ale pieselor necesare construiri celui de-al patrulea ansamblu.

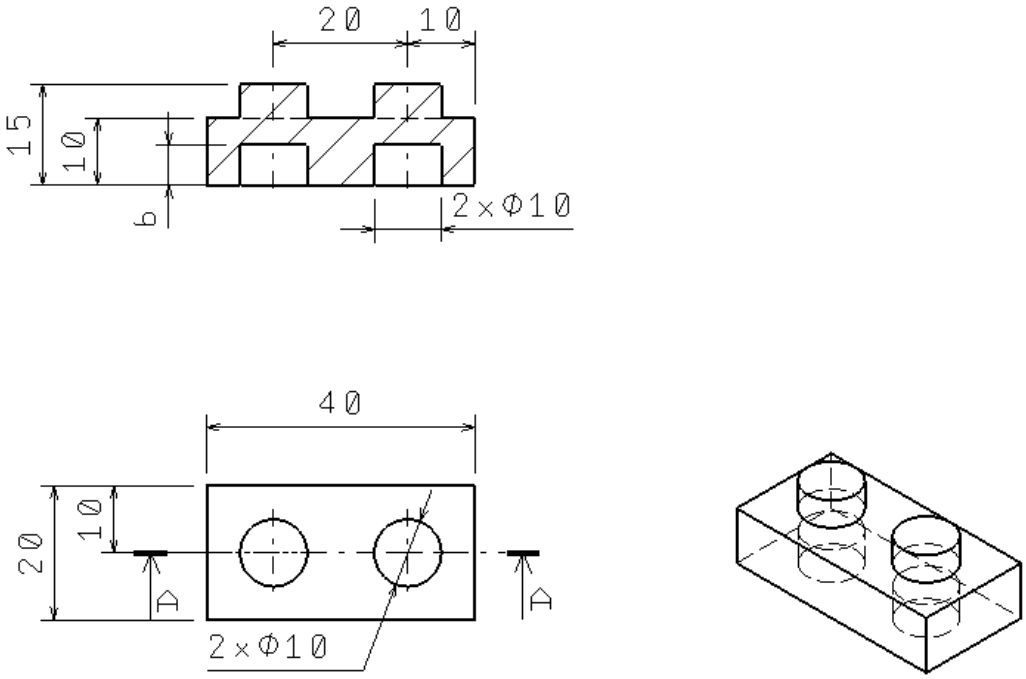


Fig. 14 Desen executie 4211398

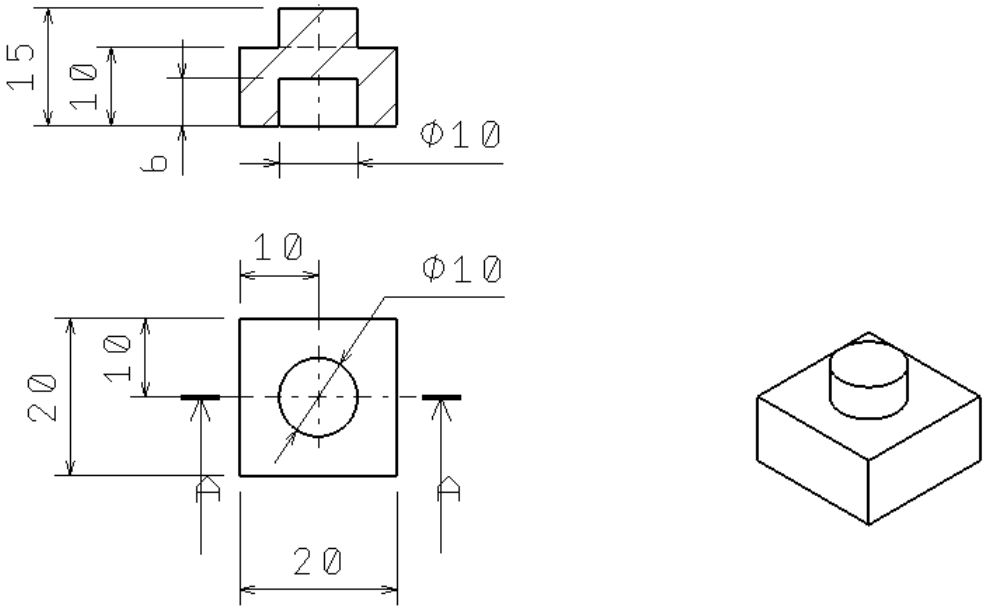


Fig. 15 Desen executie 4211399

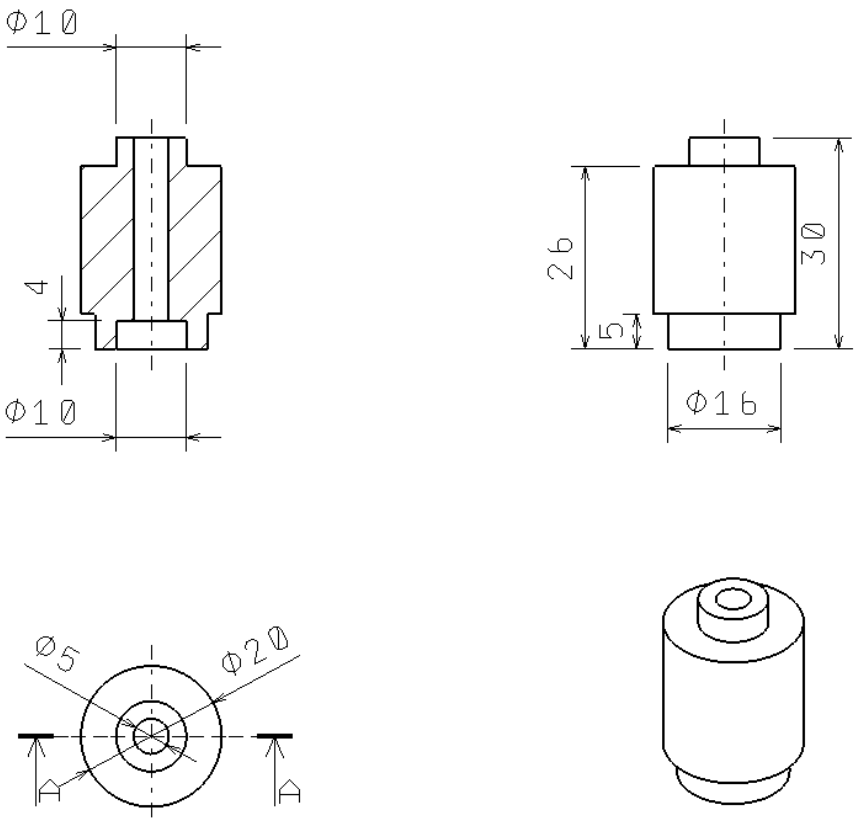


Fig. 16 Desen executie 4211412

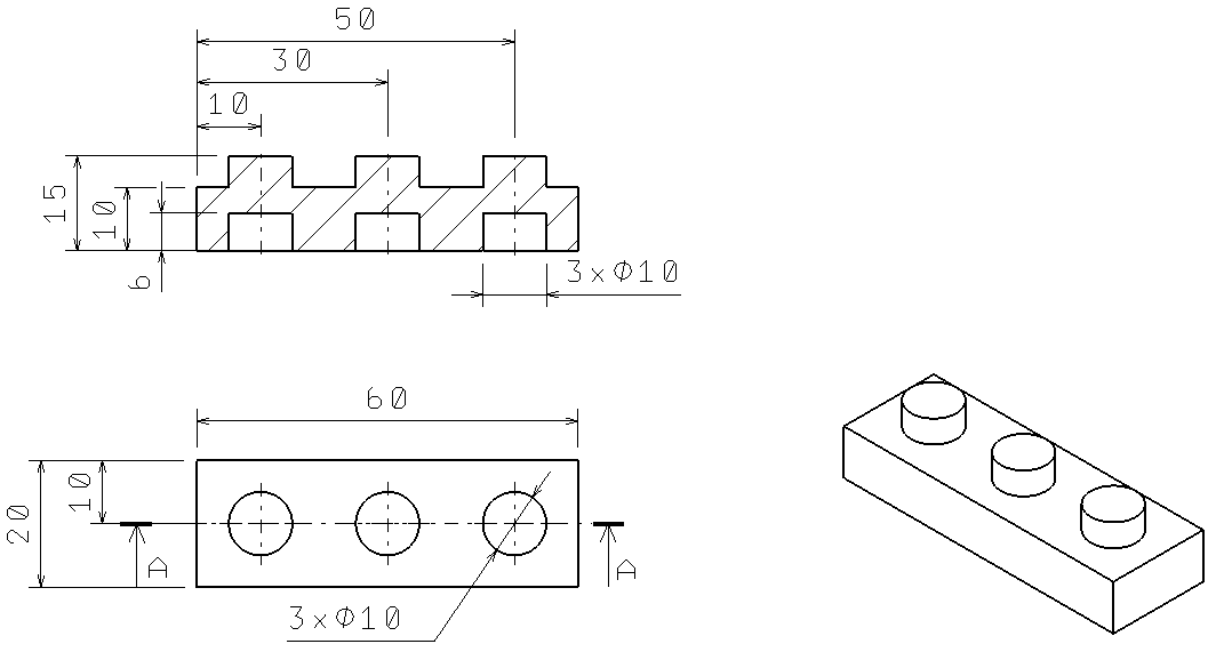


Fig. 17 Desen executie 4211429

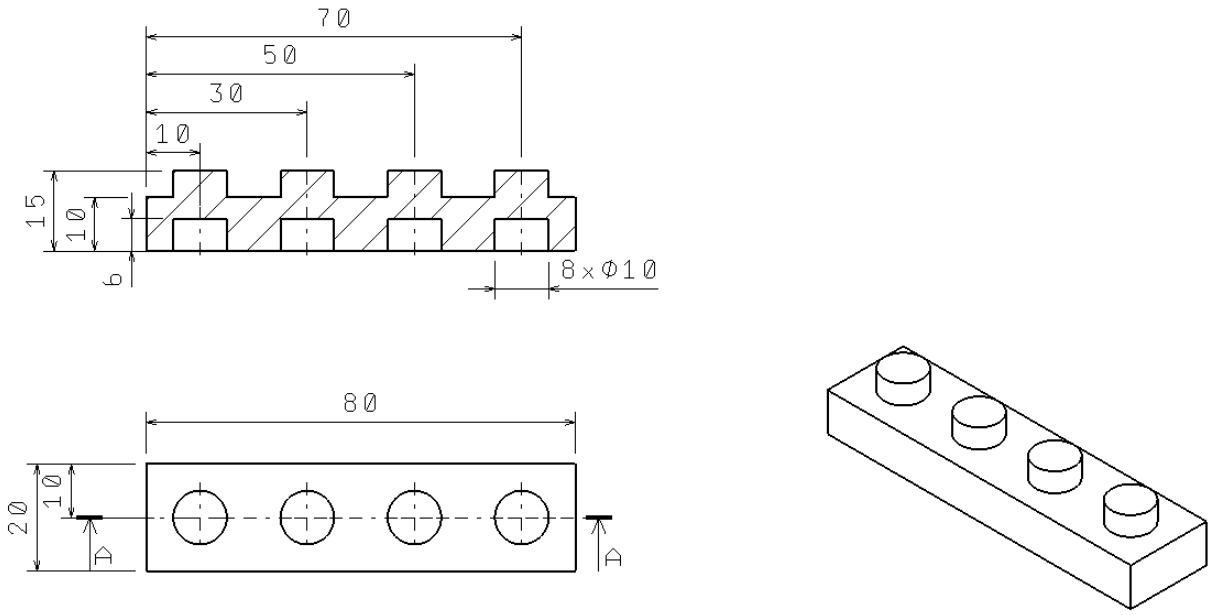


Fig. 18 Desen executie 4211445

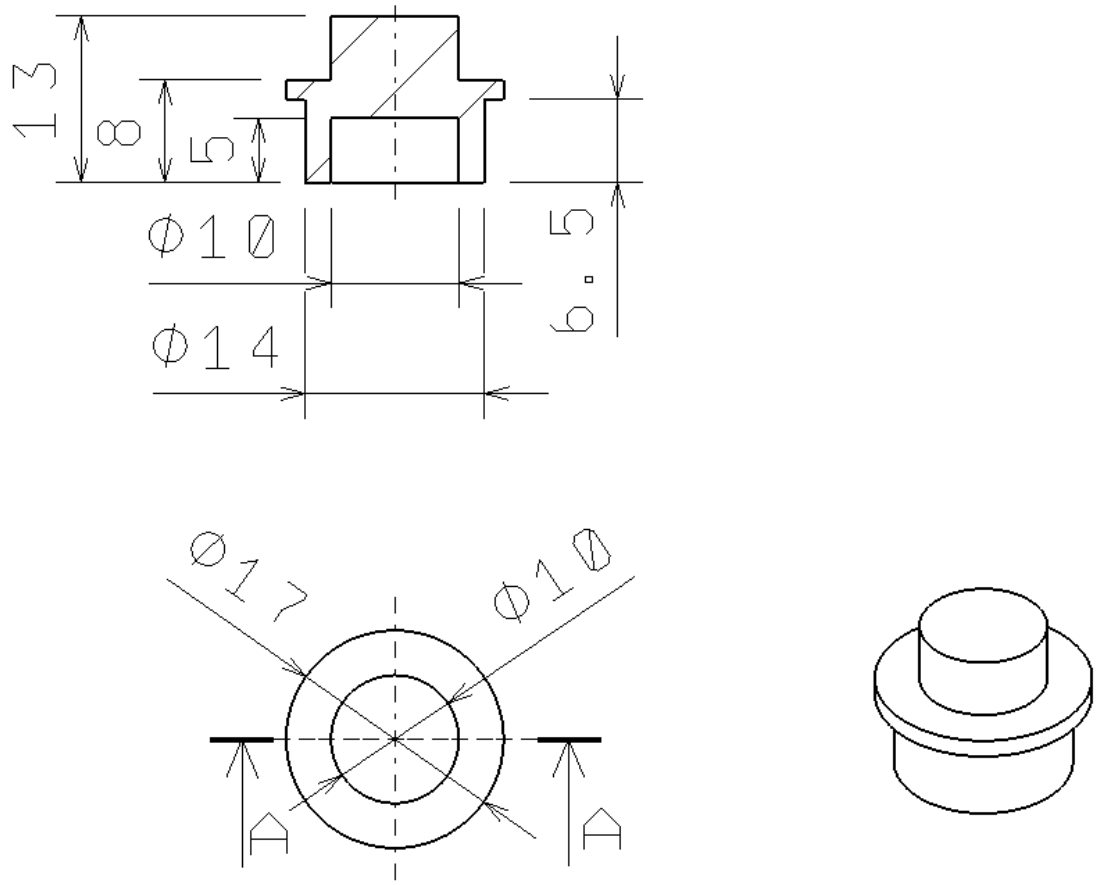


Fig. 19 Desen executie 4211525

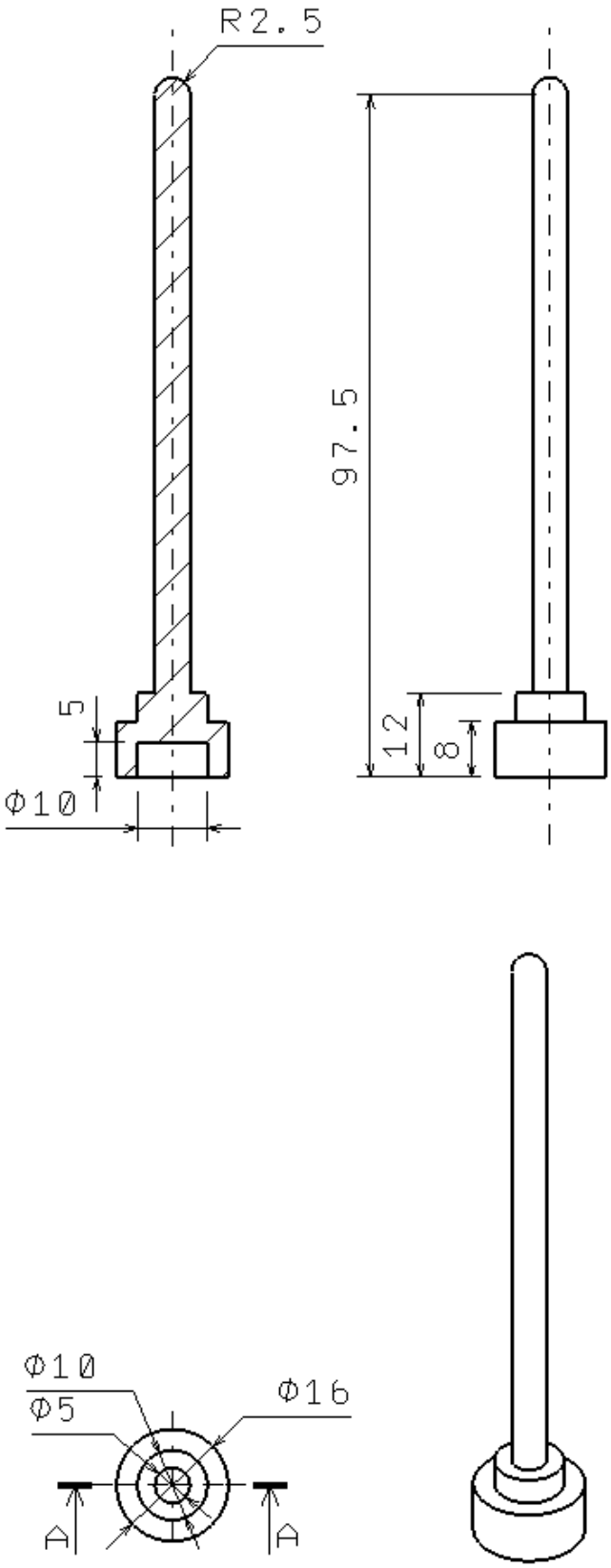


Fig. 20 Desen executie 4211473

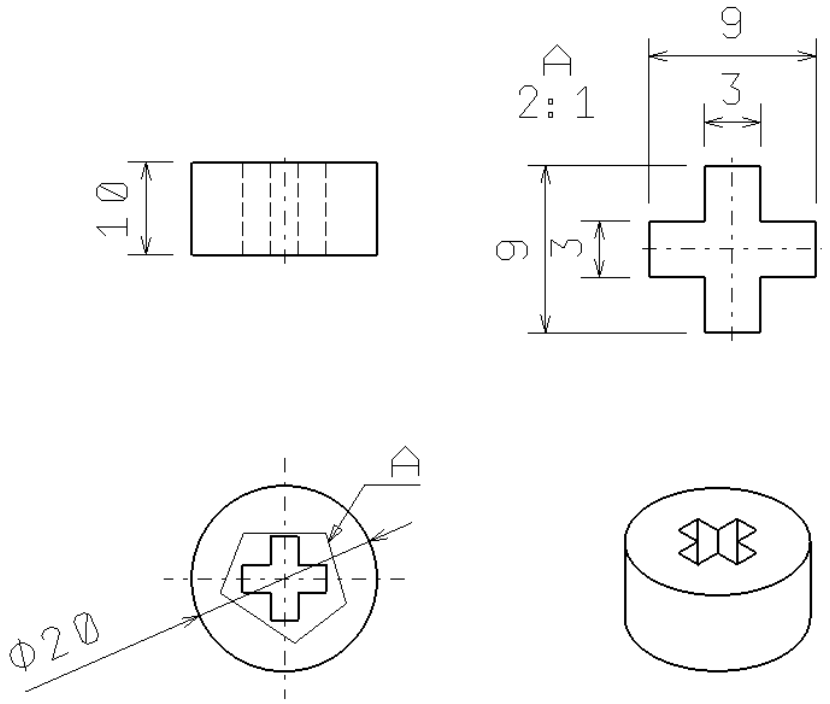


Fig. 21 Desen executie 422573

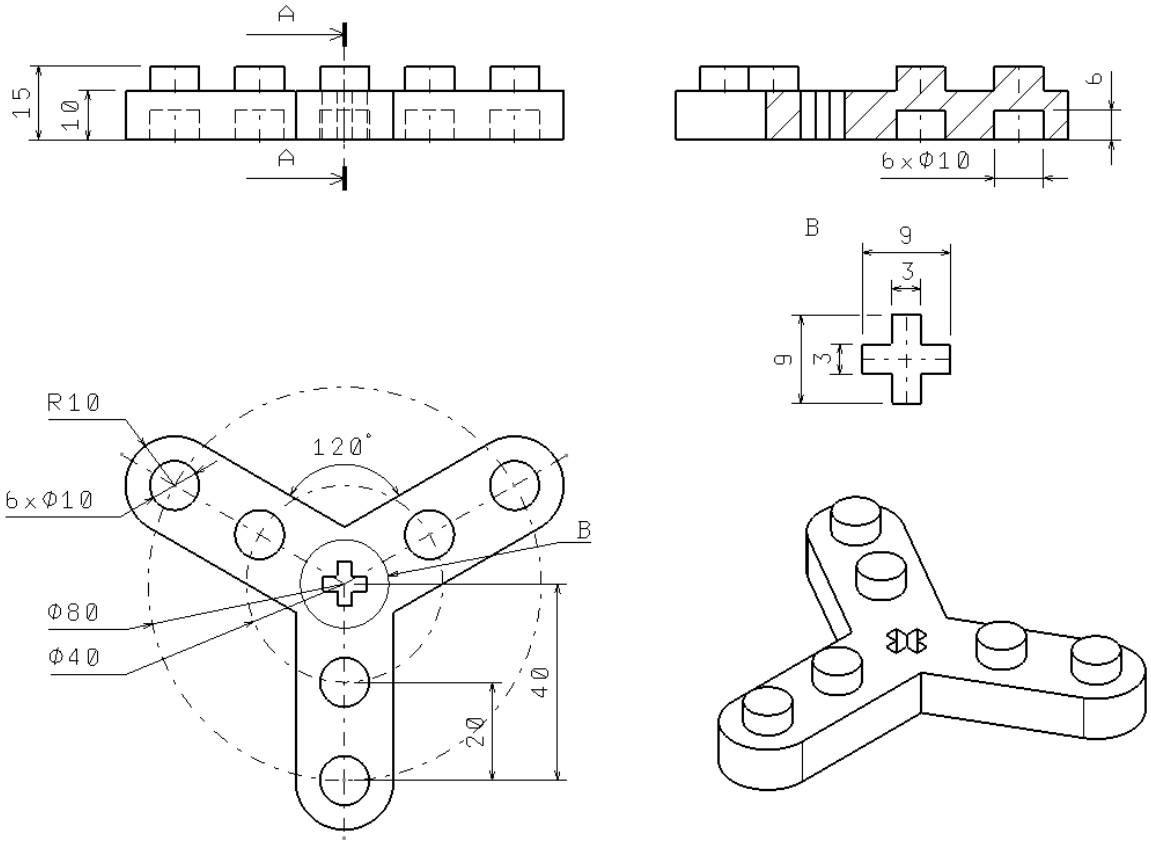


Fig. 22 Desen executie 4262978

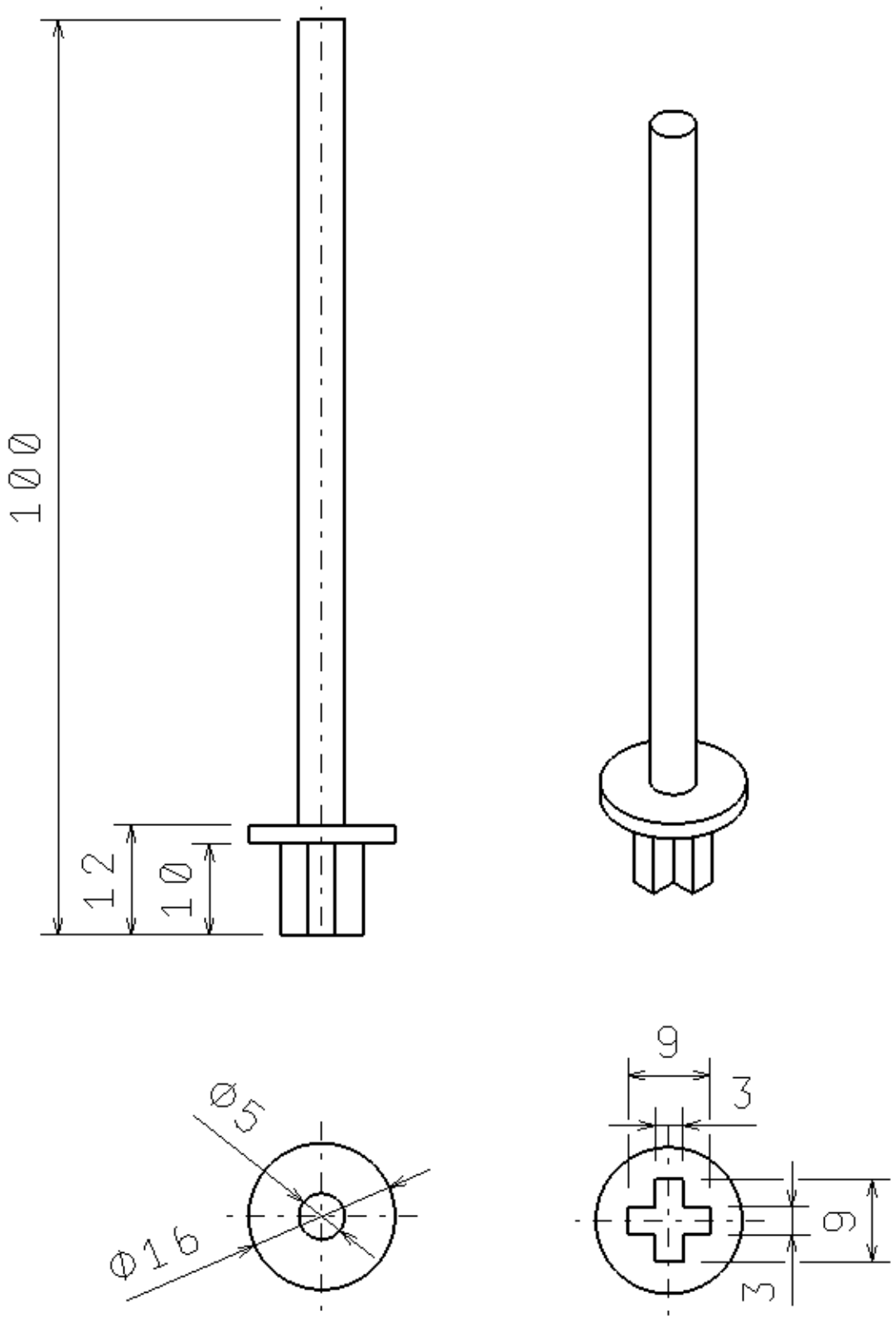


Fig. 23 Desen executie 4538098

In continuare va sunt prezentati pasi ce trebuiesc parcursi pentru a construi al patrulea ansamblu.

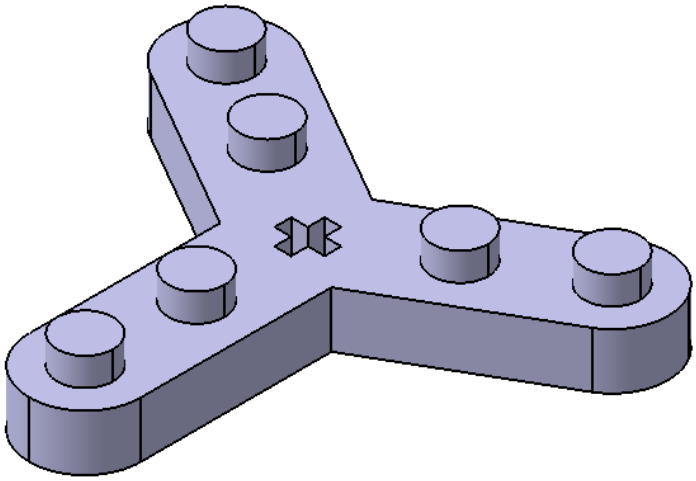


Fig. 24 Pas 1

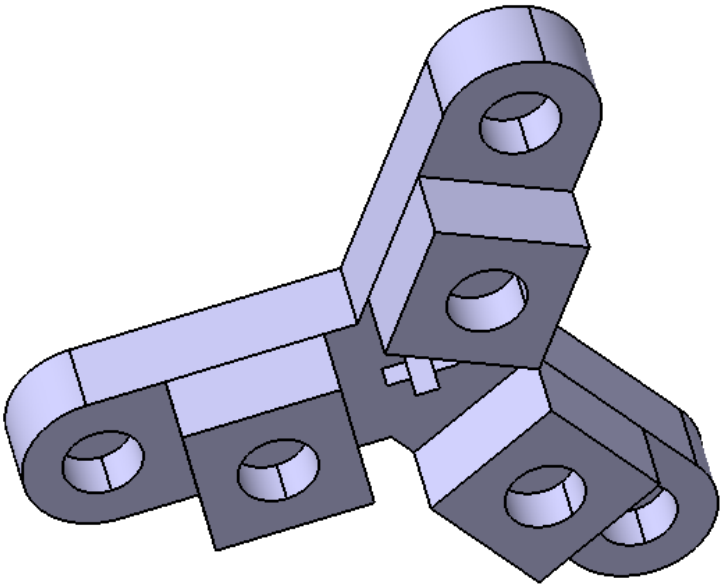


Fig. 25 Pas 2

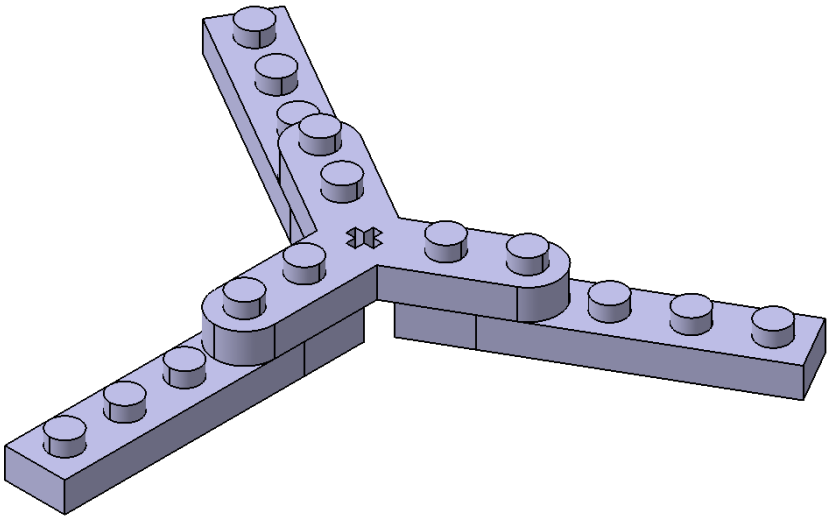


Fig. 26 Pas 3

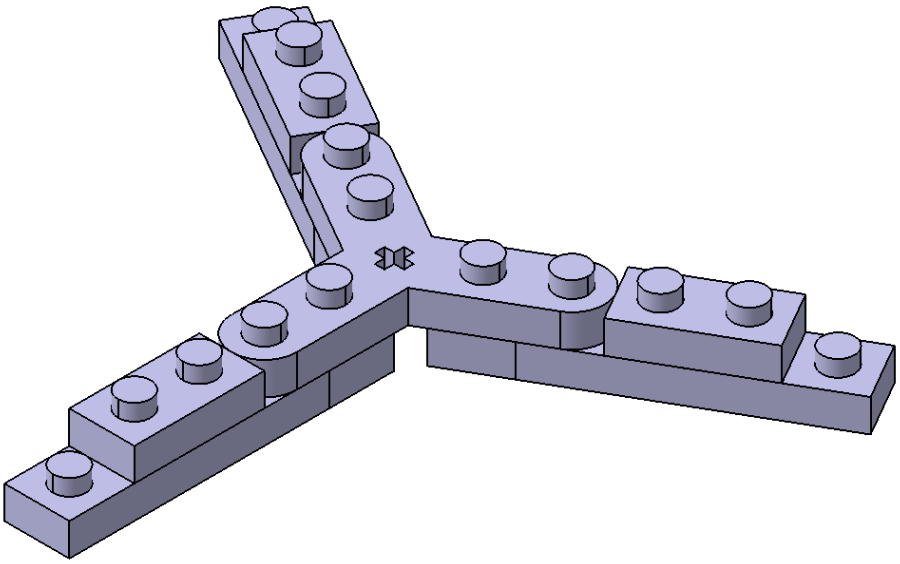


Fig. 27 Pas 4

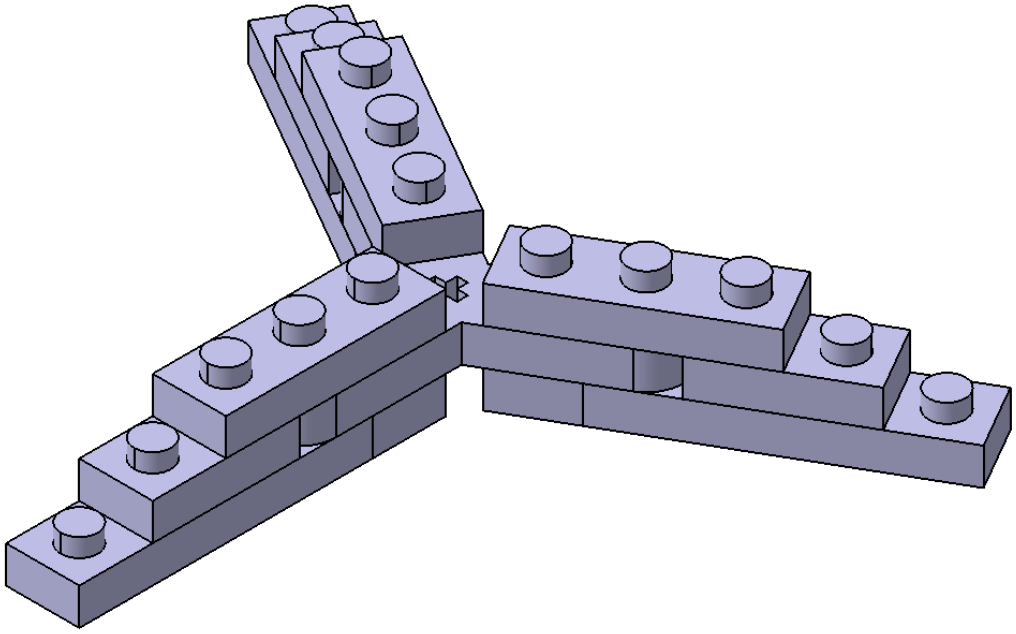


Fig. 28 Pas 5

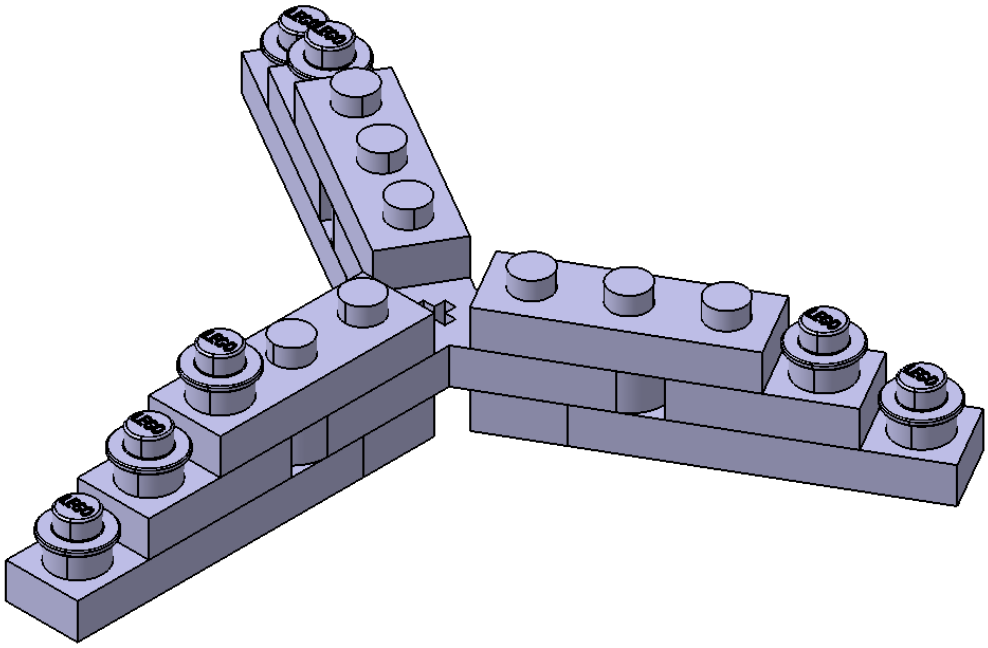


Fig. 29 Pas 6

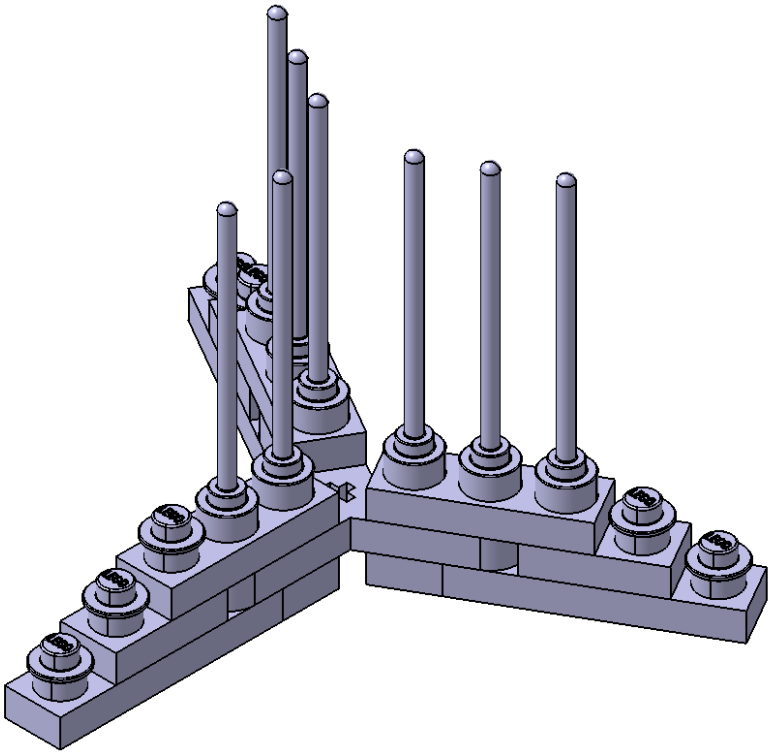


Fig.30 Pas 7

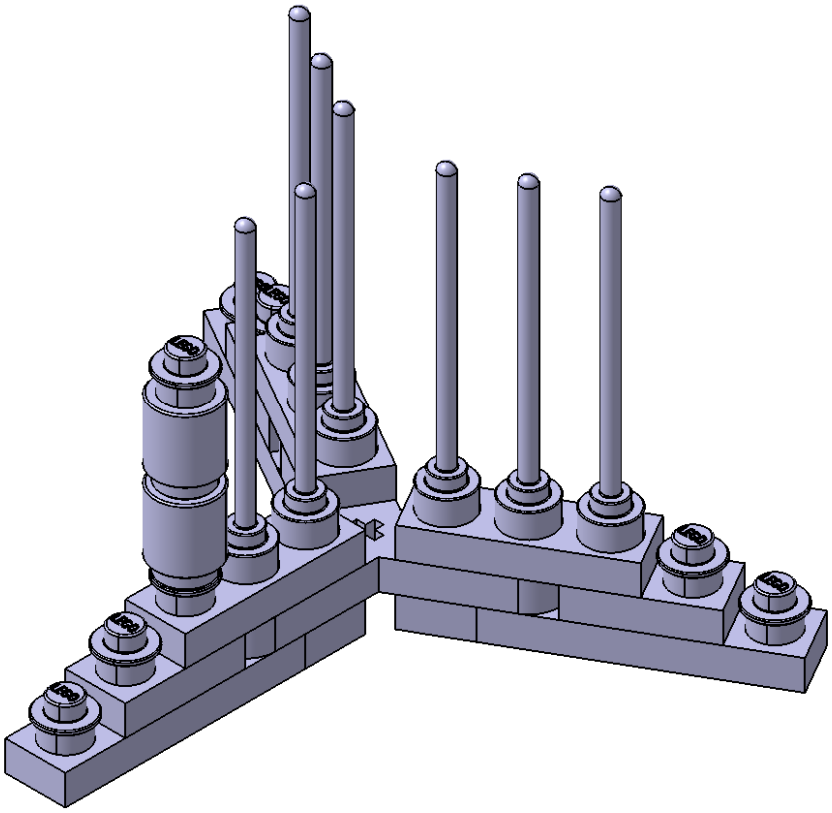


Fig. 31 Pas 8

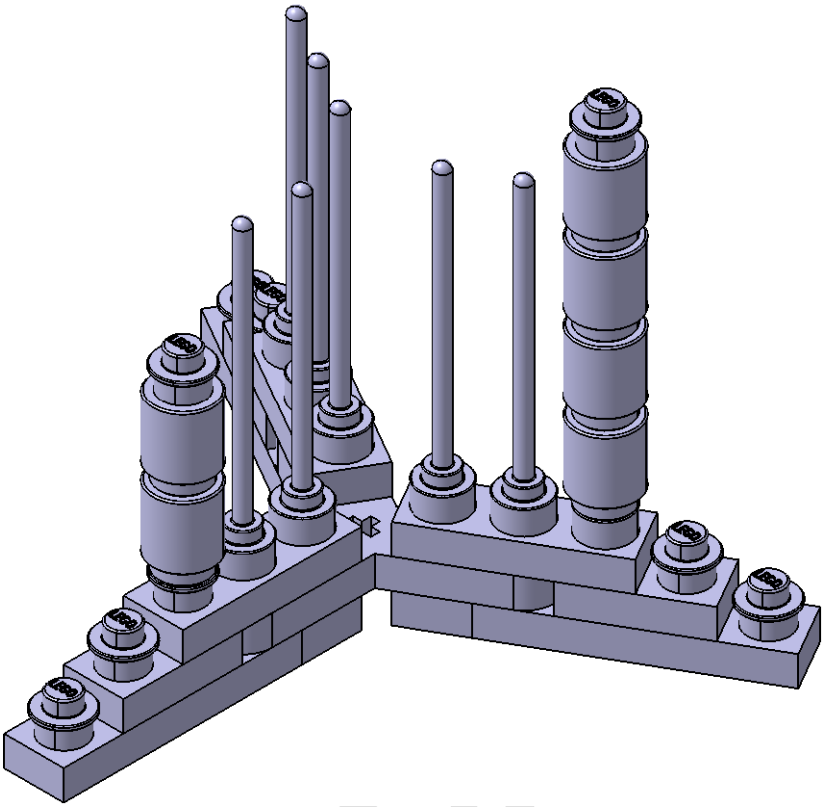


Fig. 32 Pas 9

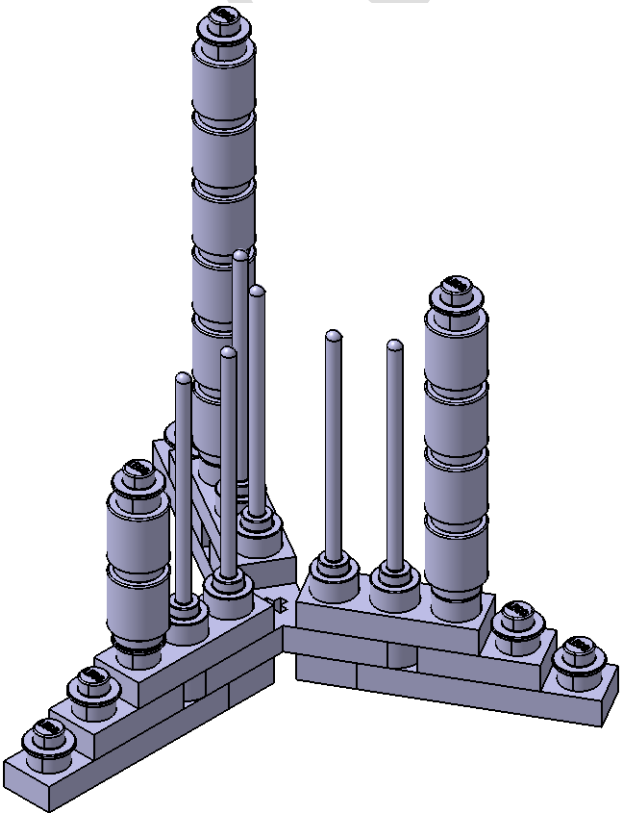


Fig. 33 Pas 10

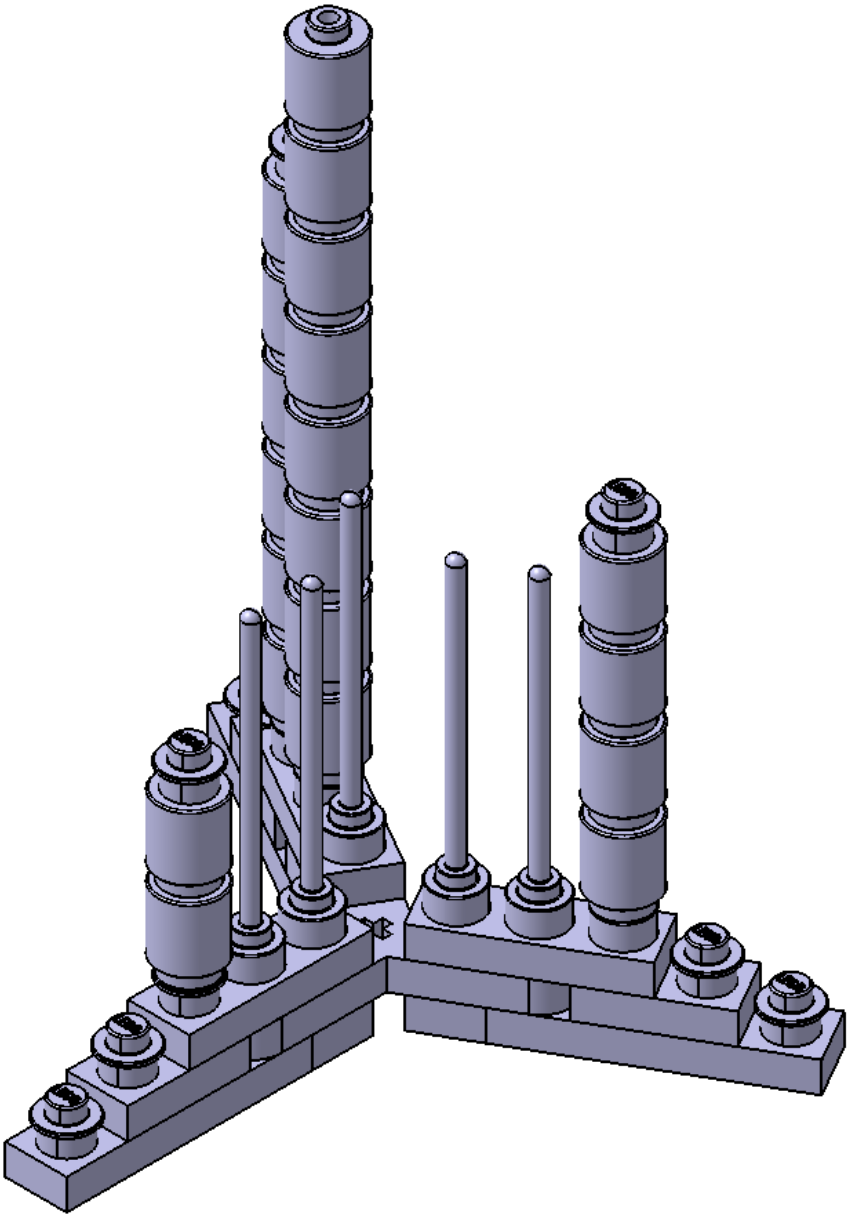


Fig. 34 Pas 11

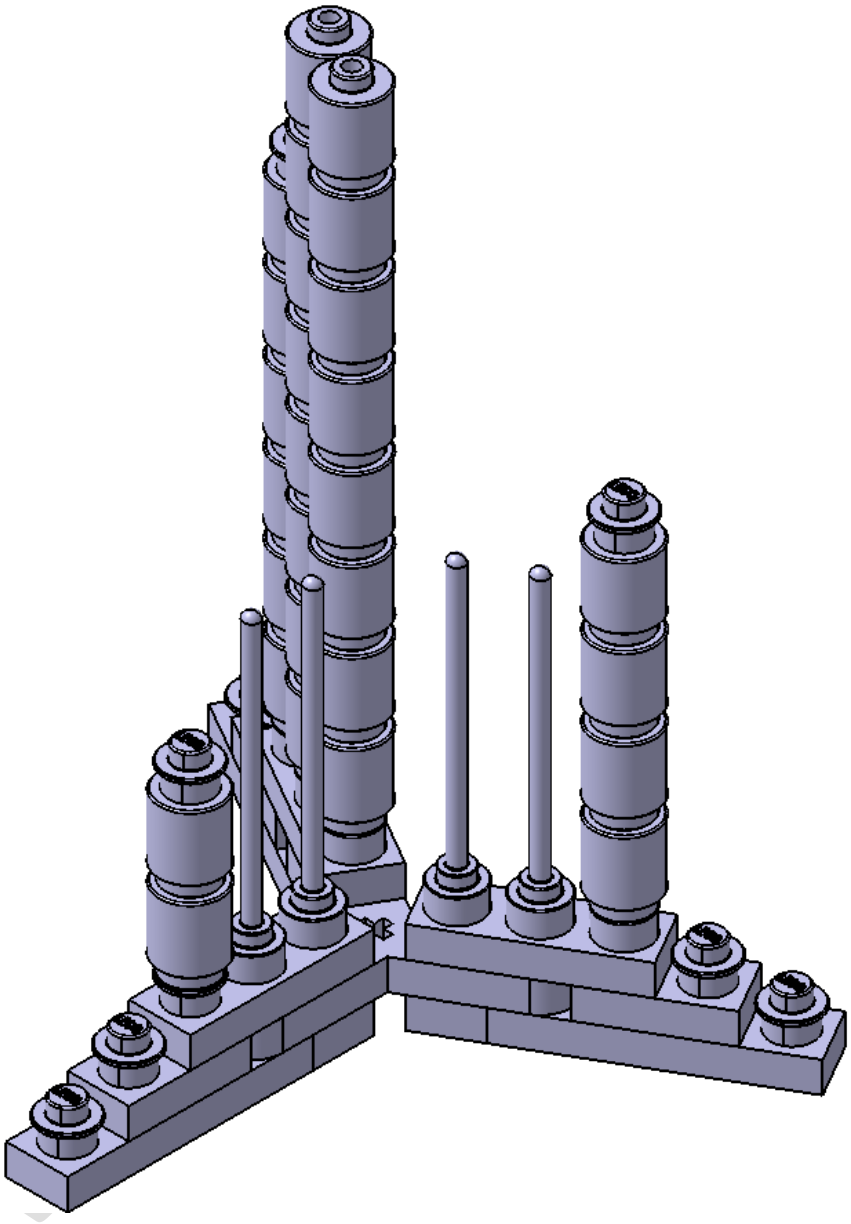


Fig. 35 Pas 12

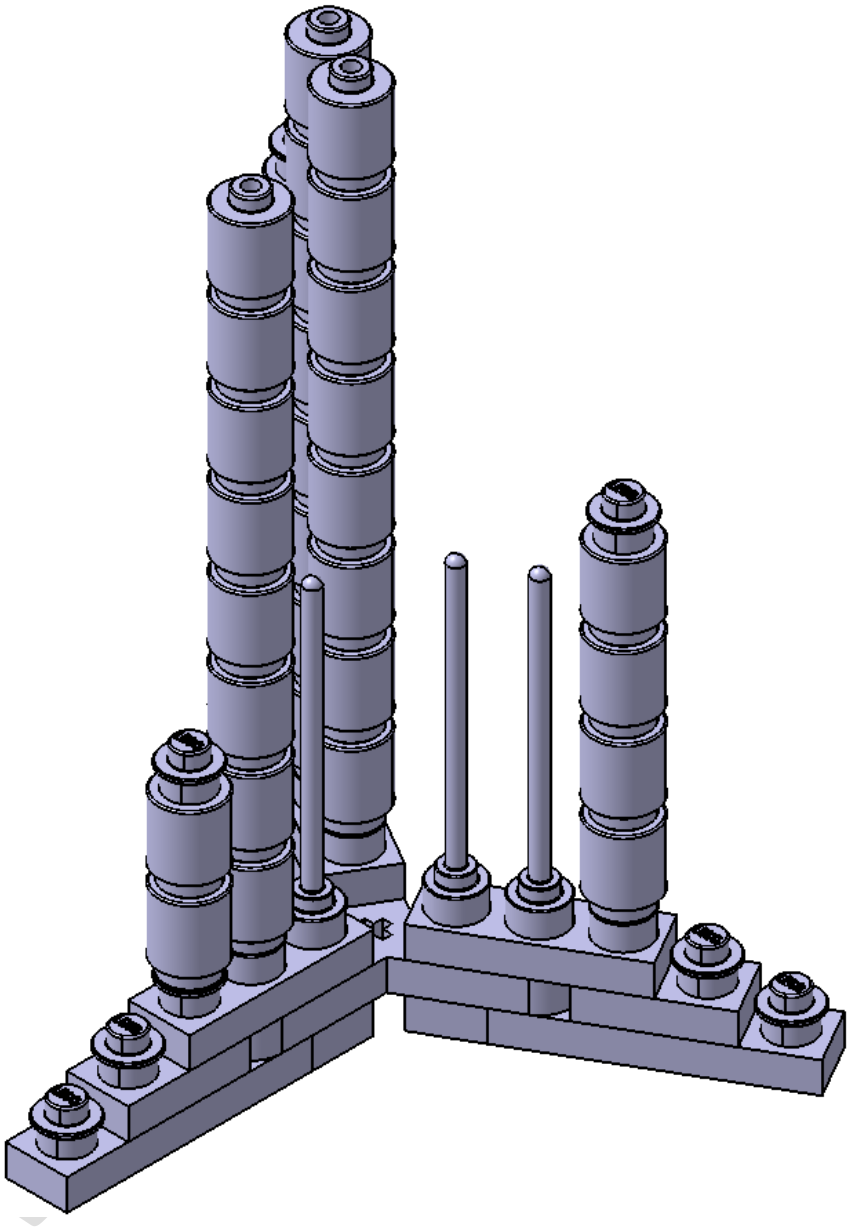


Fig. 36 Pas 13

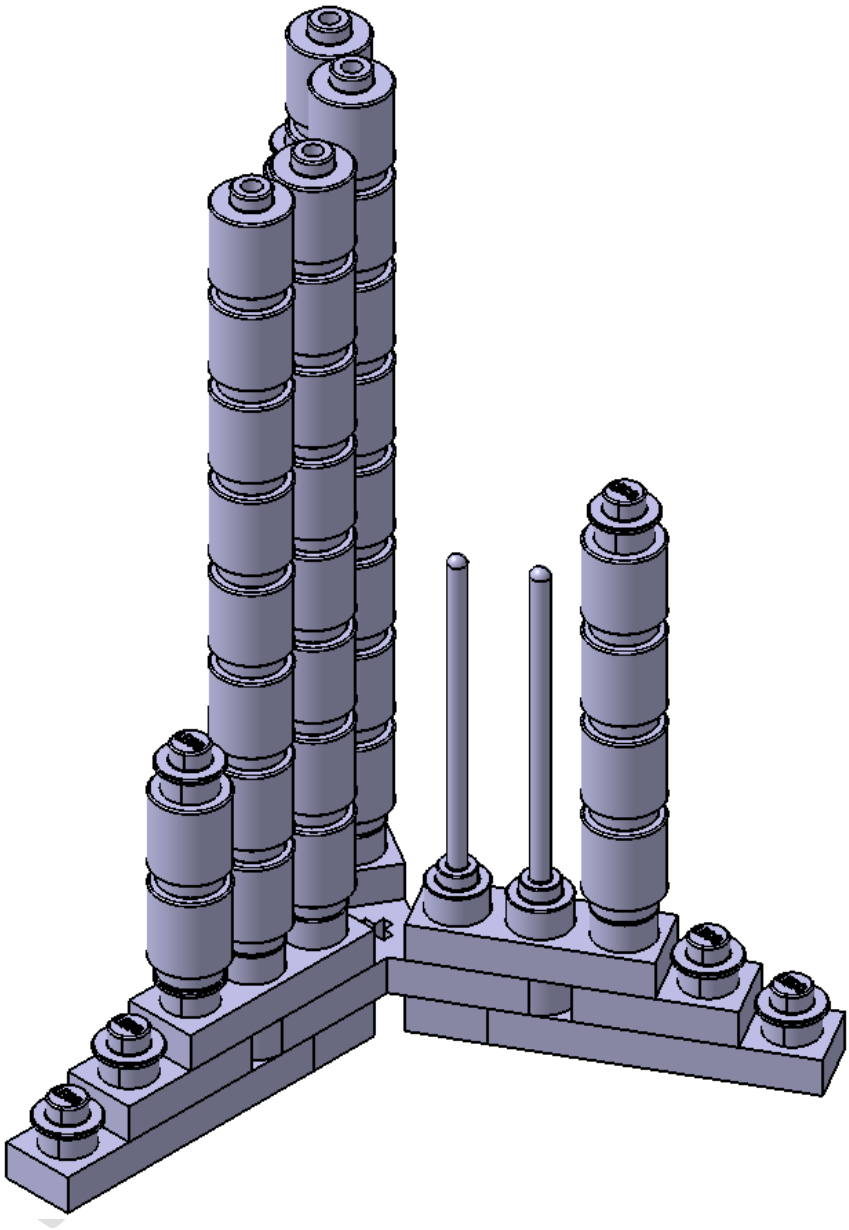


Fig. 37 Pas 14

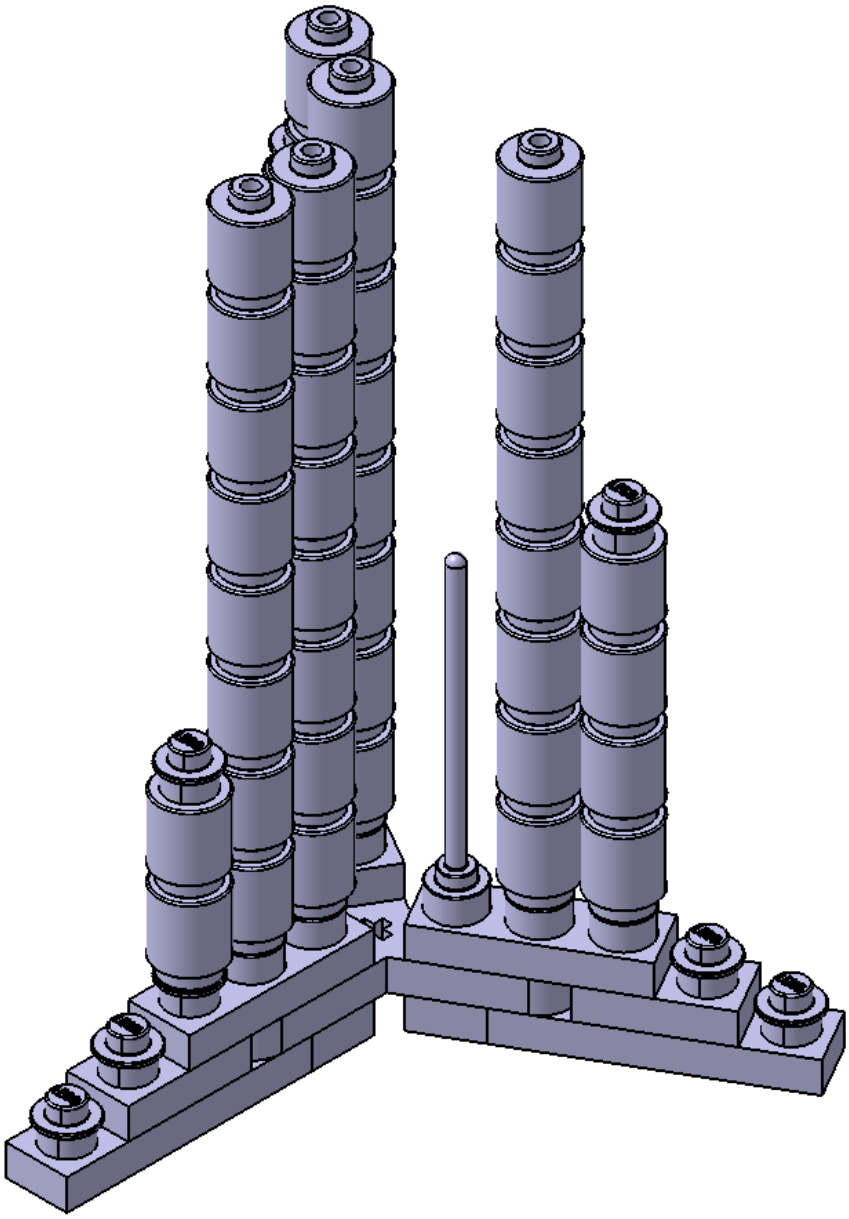


Fig. 38 Pas 15

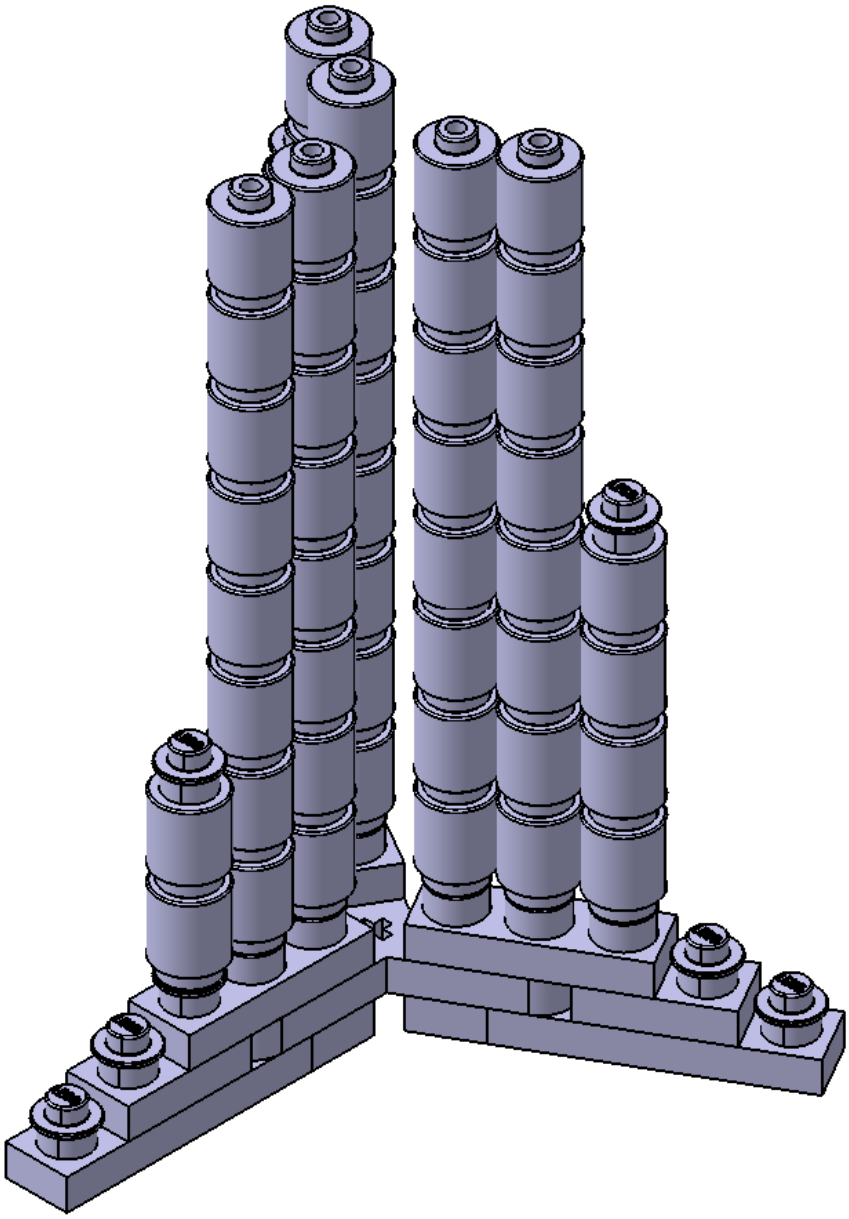


Fig. 39 Pas 16

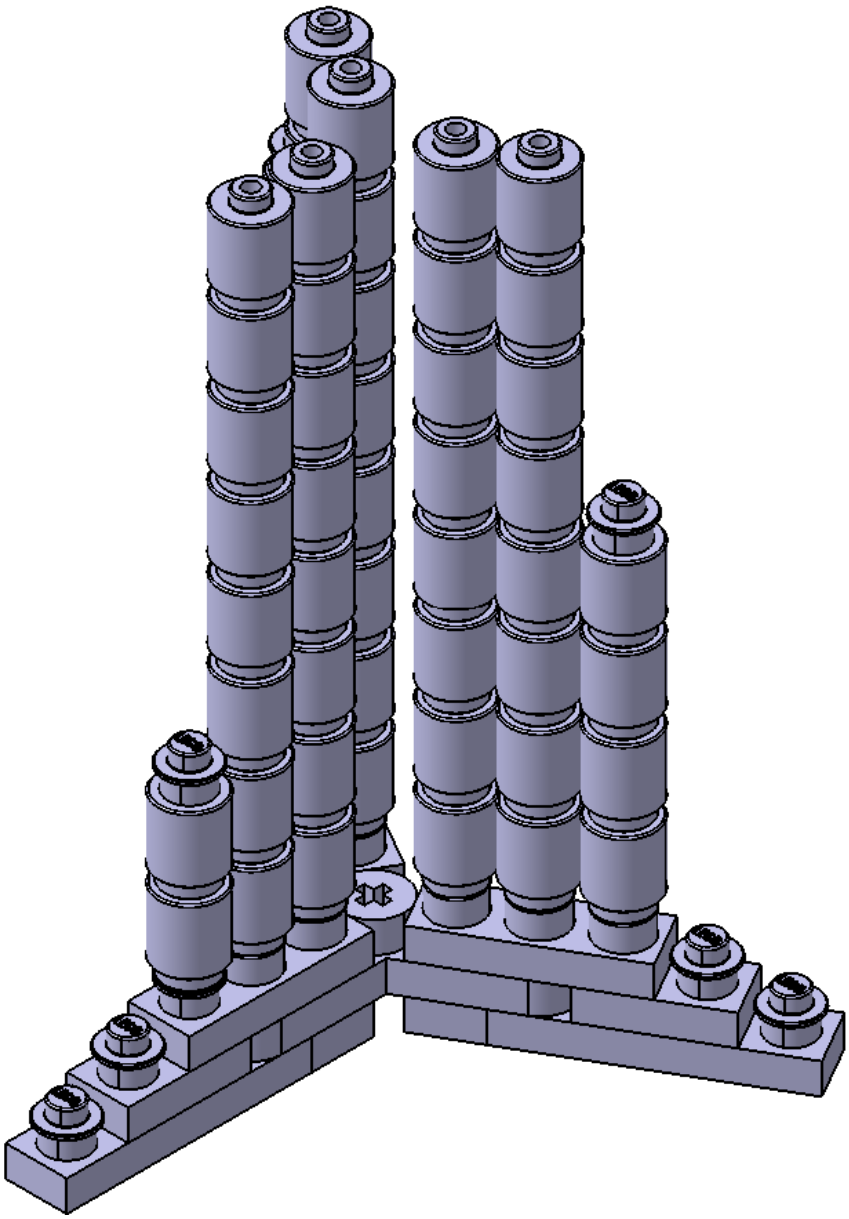


Fig. 40 Pas 17

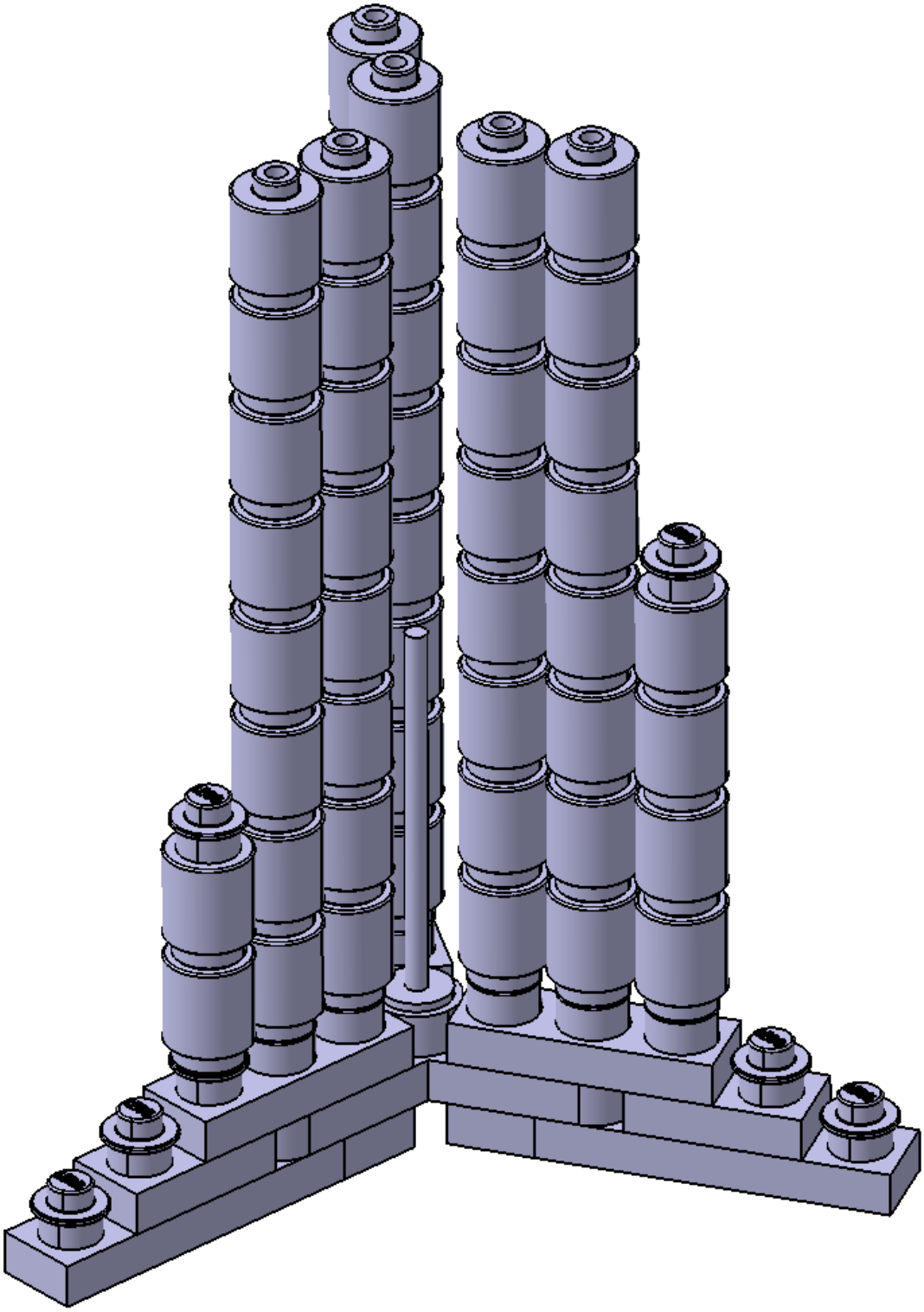


Fig. 41 Pas 18

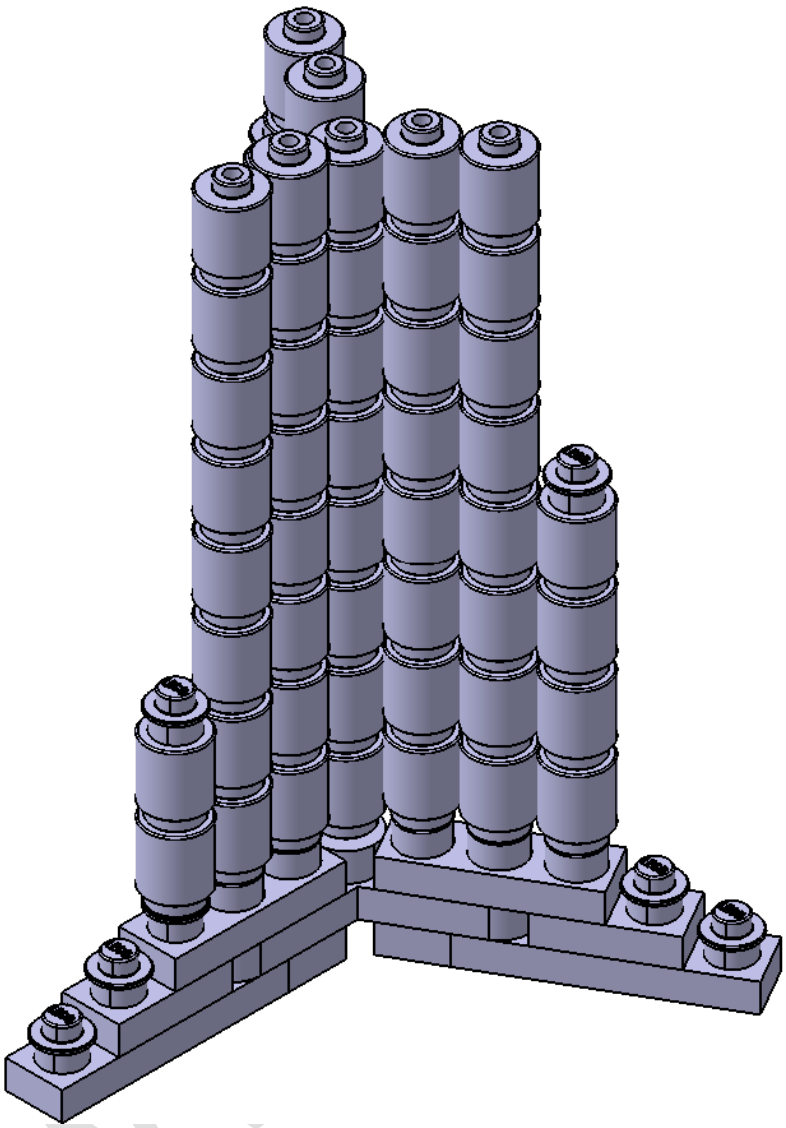


Fig. 42 Pas 19

In total pentru acest ansamblu aveti nevoie de urmatoarele piese :

1x 4262978
3x 4211399
3x 4211445
3x 4211398
3x 4211429
10x 4211525
8x 4211473
68x 4211412
1x 4211573
1x 4538098

Al cincilea ansamblu (5th Floor)

Mai jos va sunt prezentati doar pasi de constructie al ansamblului deoarece piesele necesare sunt deja construite.

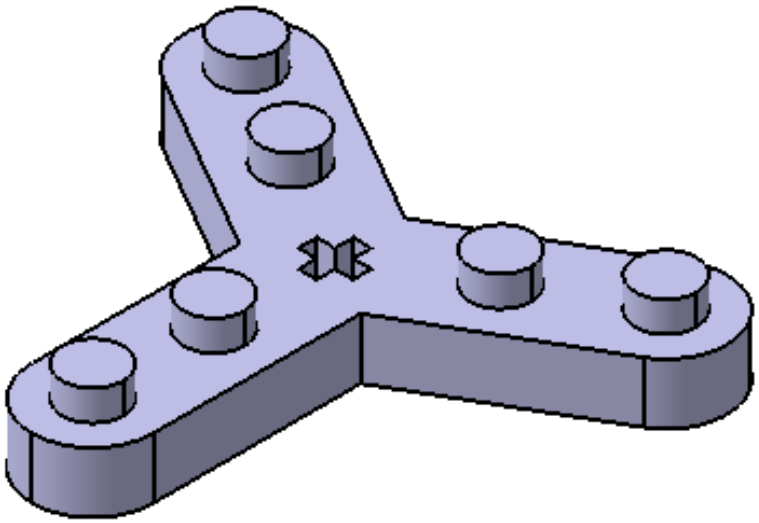


Fig. 43 Pas 1

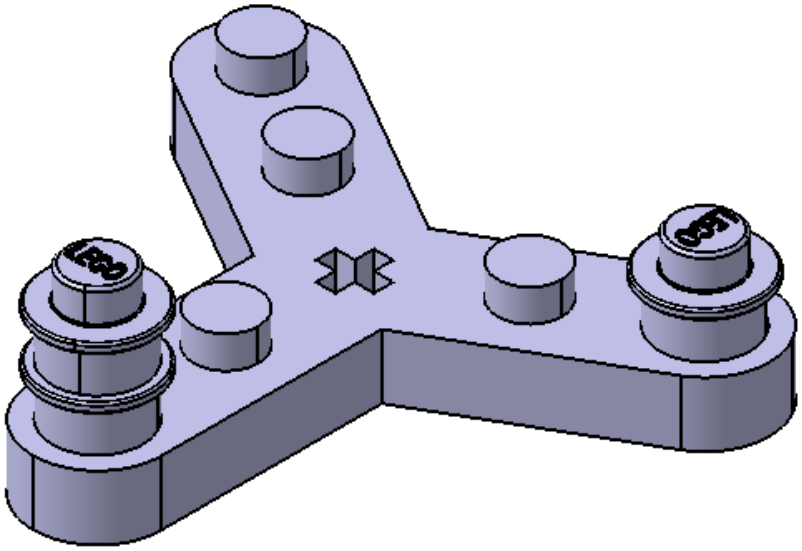


Fig. 44 Pas 2

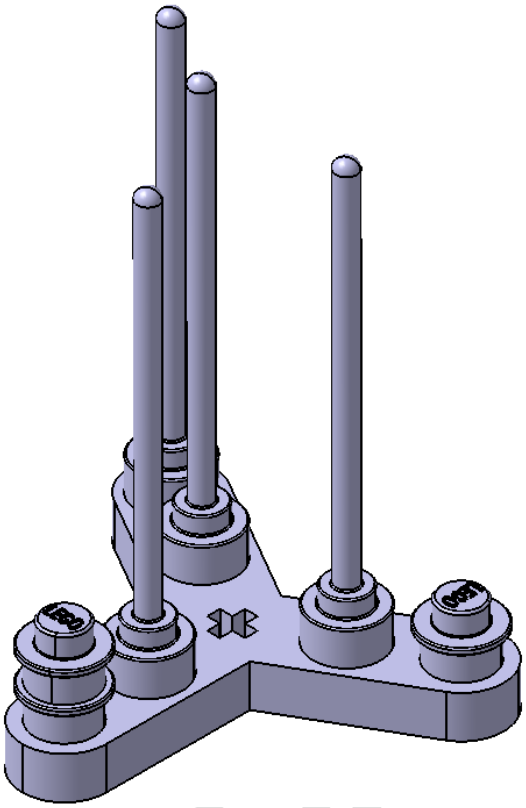


Fig. 45 Pas 3

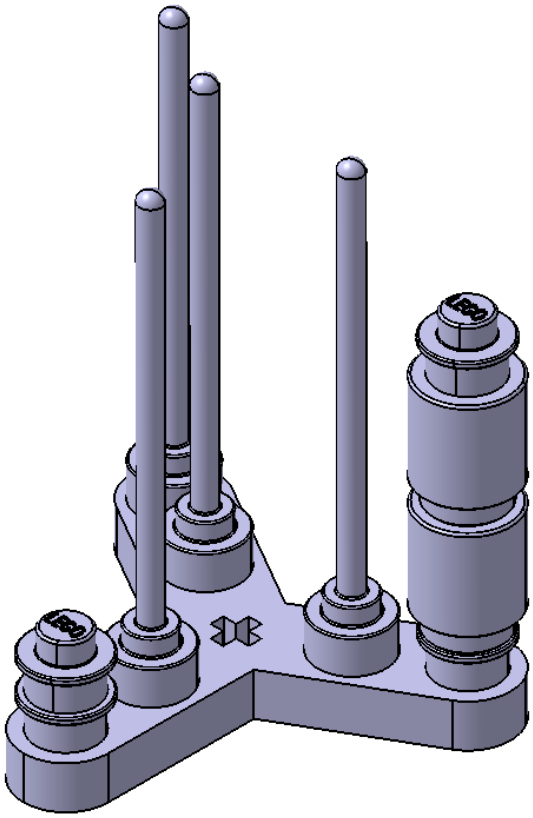


Fig. 46 Pas 4

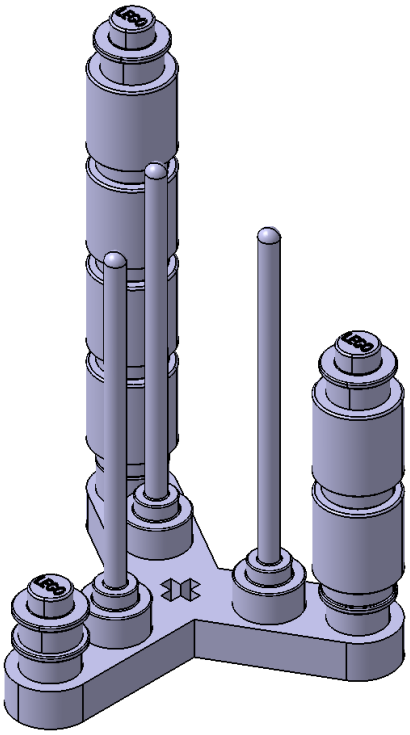


Fig. 47 Pas 5

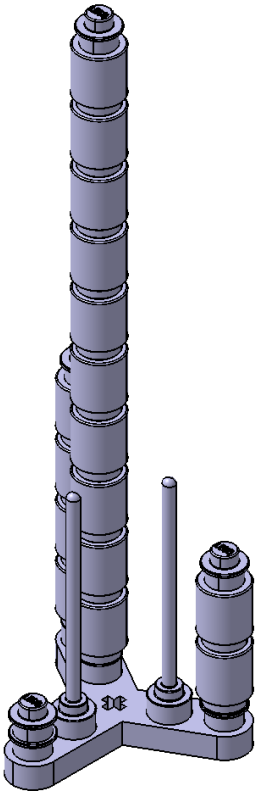


Fig. 48 Pas 6

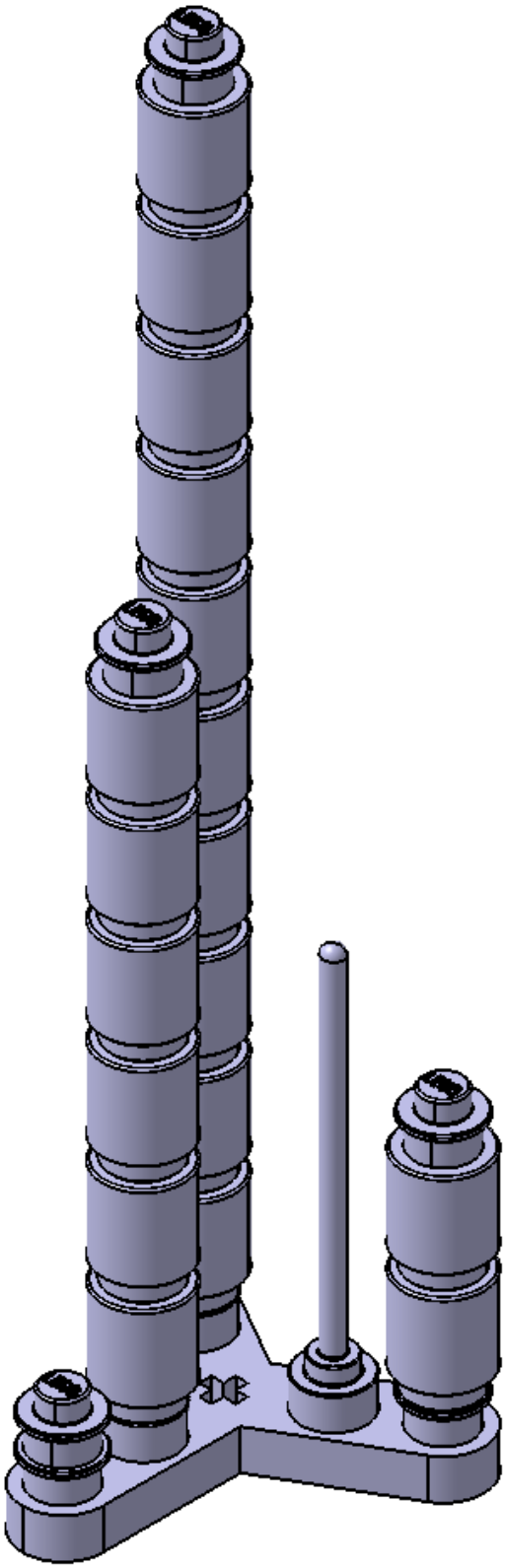


Fig. 49 Pas 7

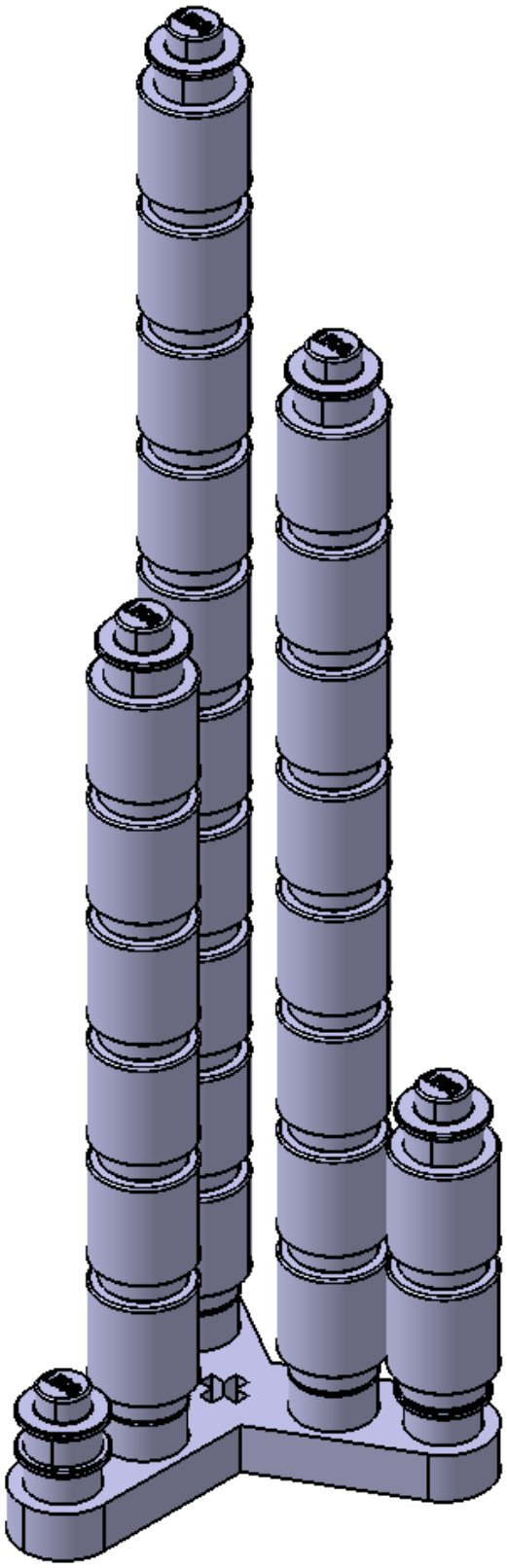


Fig. 50 Pas 8

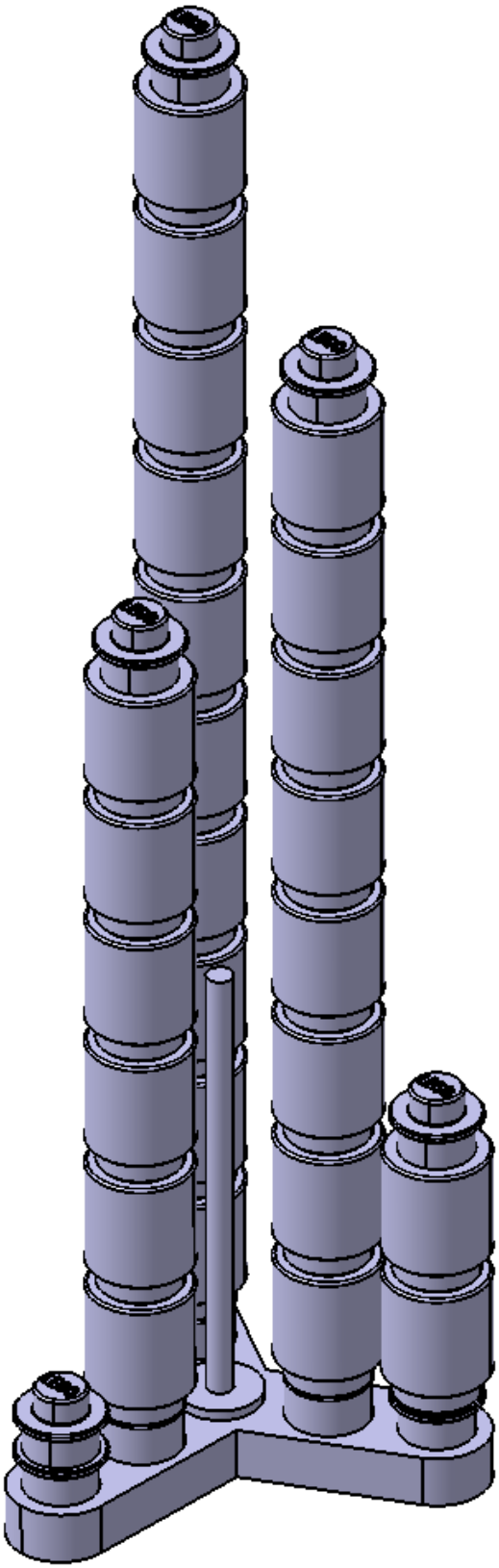


Fig. 51 Pas 9

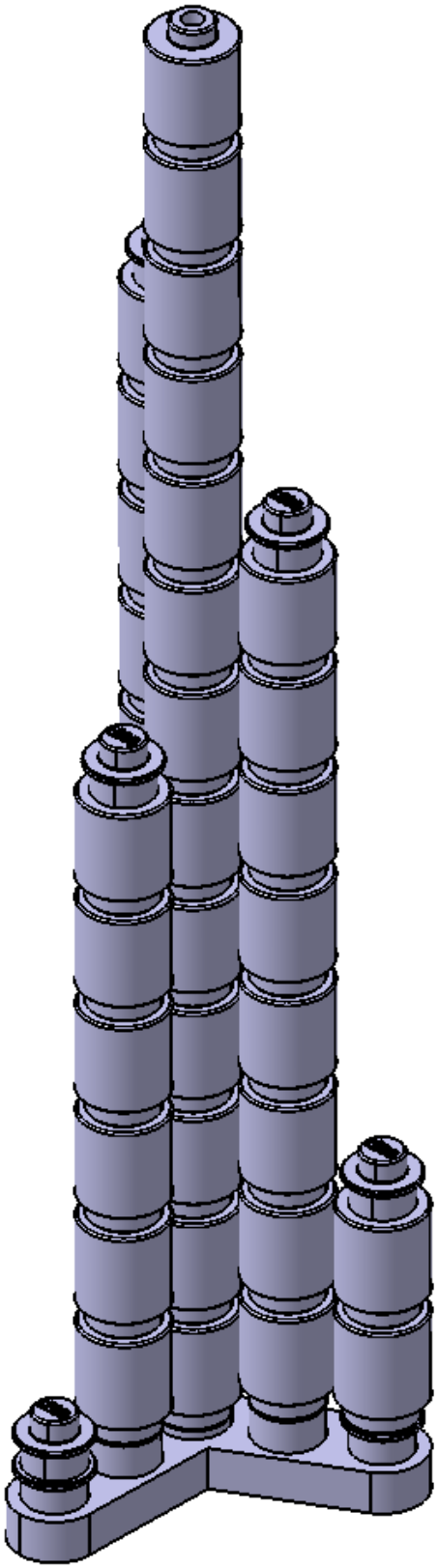


Fig. 52 Pas 10

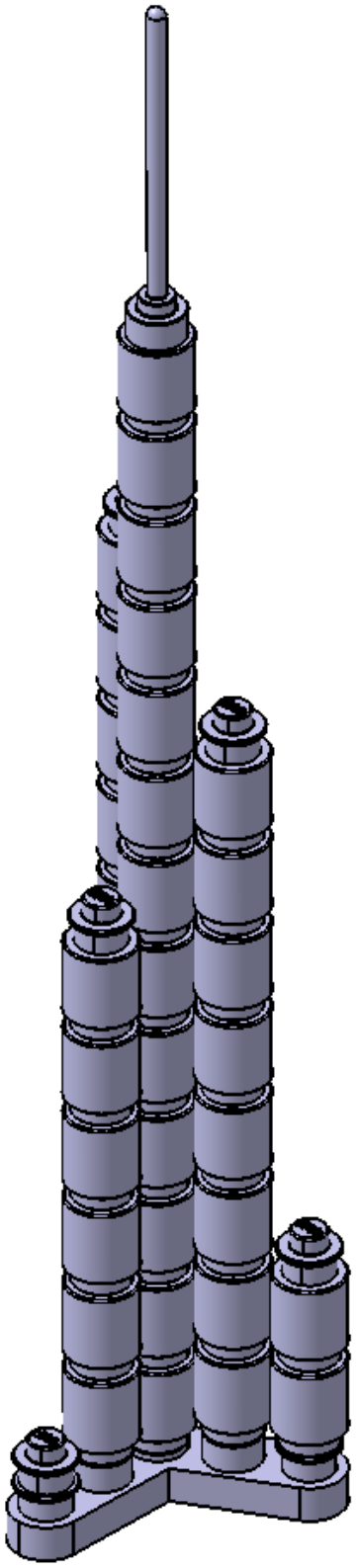


Fig. 53 Pas 11

Pentru constructia ansamblului final se va deschide un nou *"Assembly"*, si se vor insera cele 5 ansambluri in ordinea constructie lor si vor fi constranse ca in imaginile urmatoare.

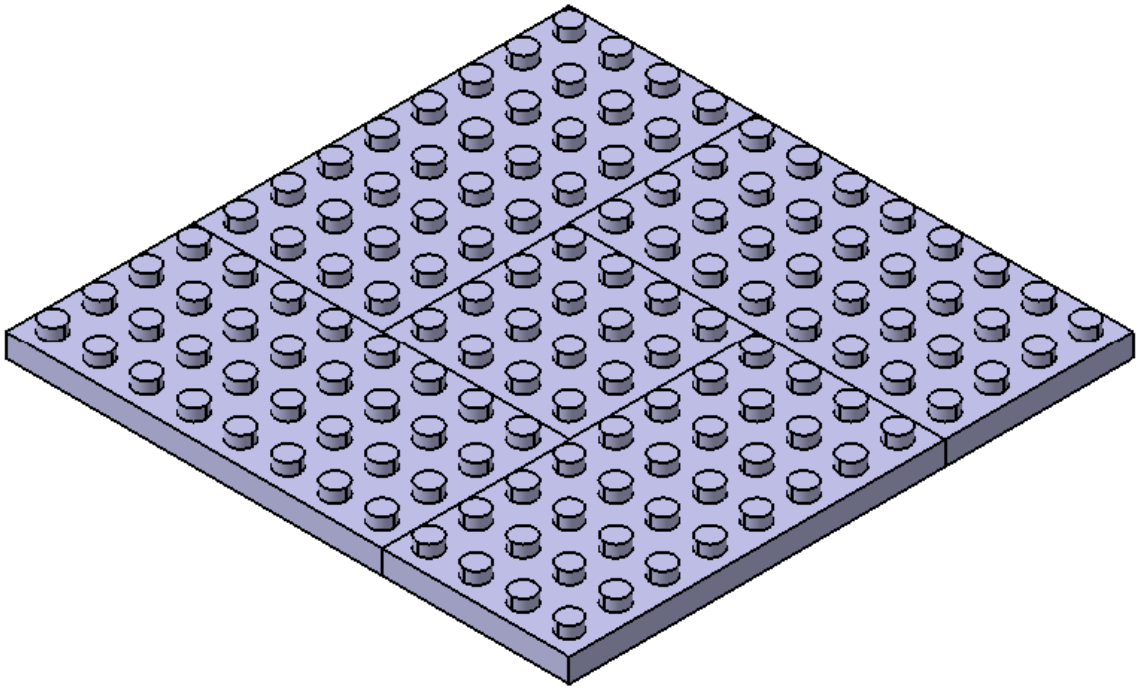


Fig. 54 1st Floor

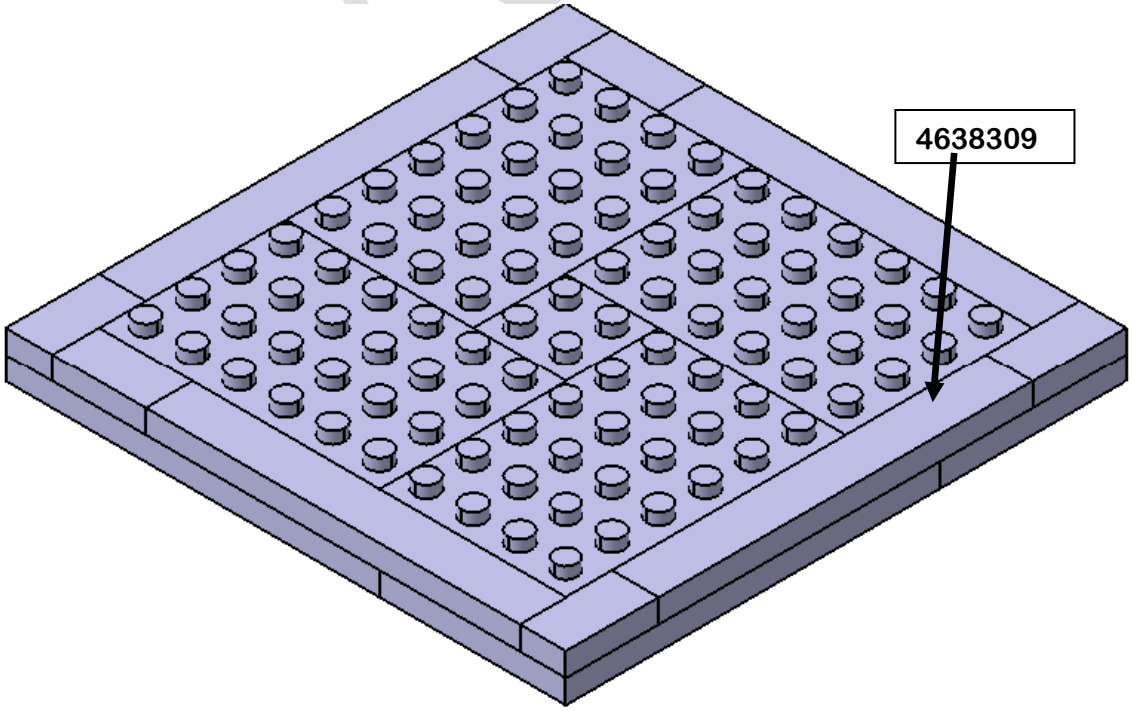


Fig. 55 2nd Floor

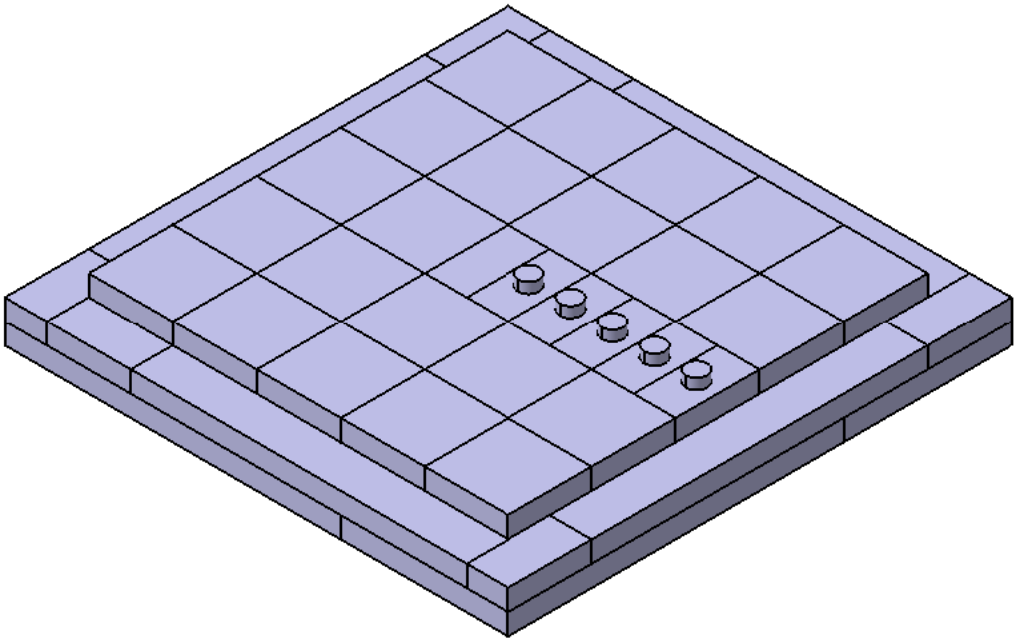


Fig. 56 3rd Floor

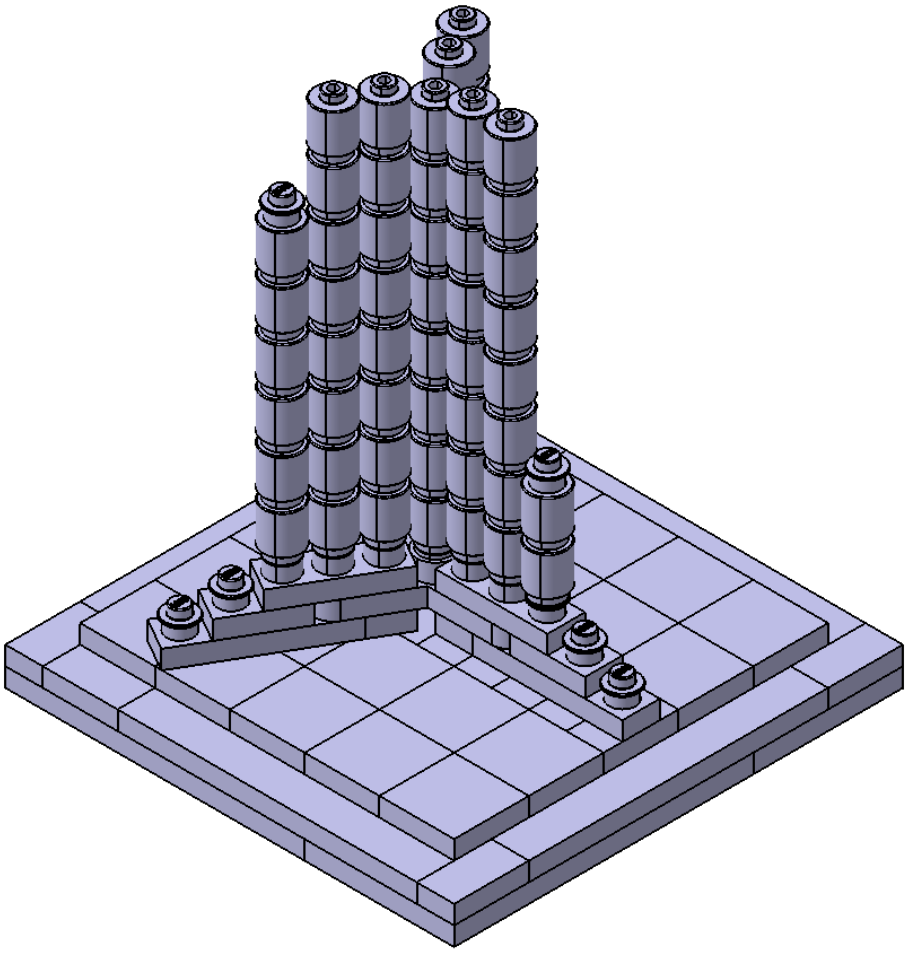


Fig. 57 4th Floor

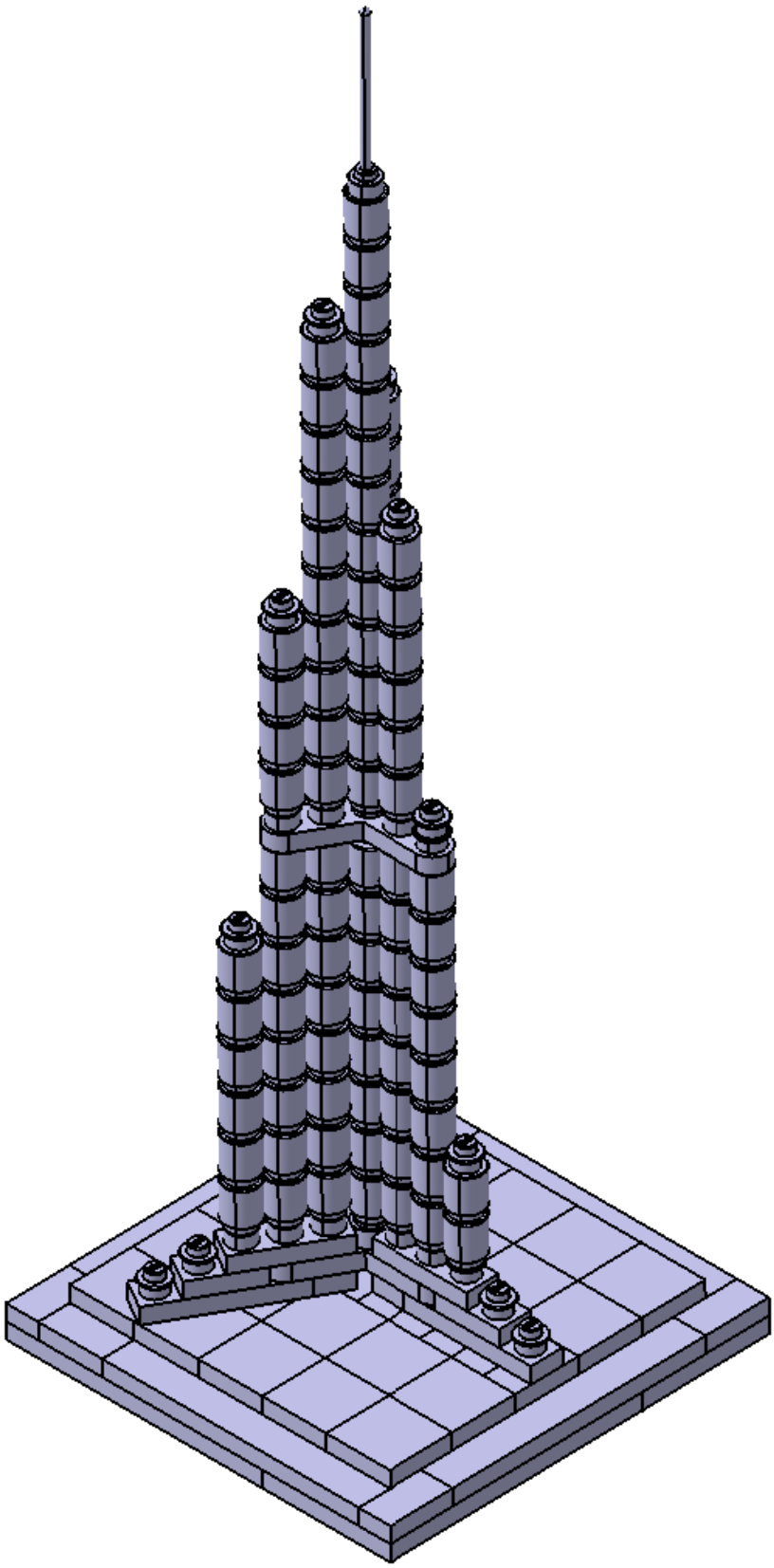
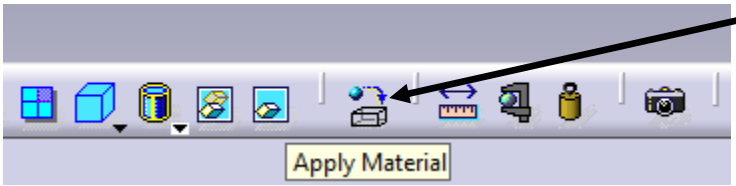


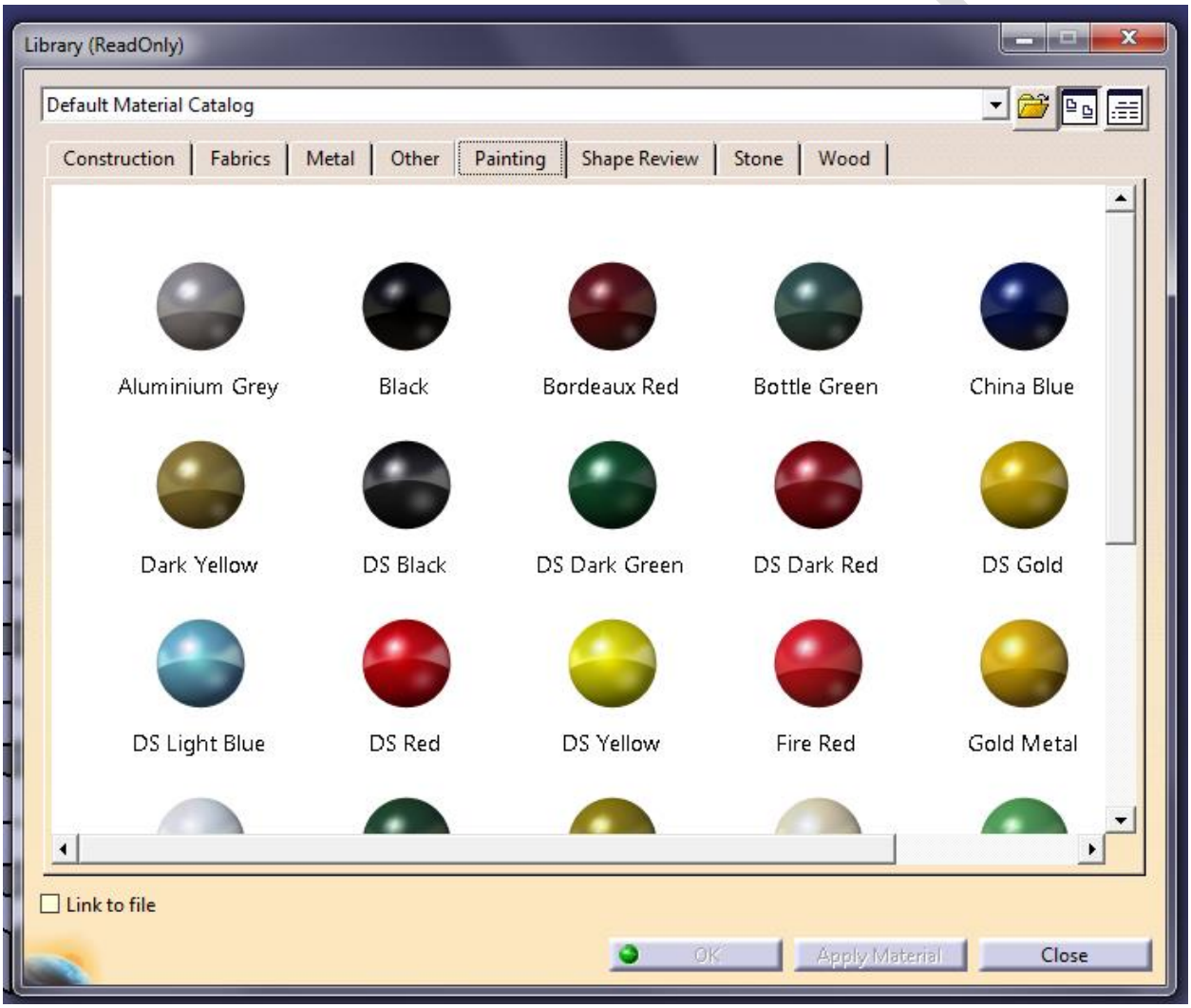
Fig. 58 5th Floor

In mod automat CATIA seteaza pentru orice piesa construita culoarea gri. Pentru a personaliza constructia vom aplica diferite materiale/culori pe piese.

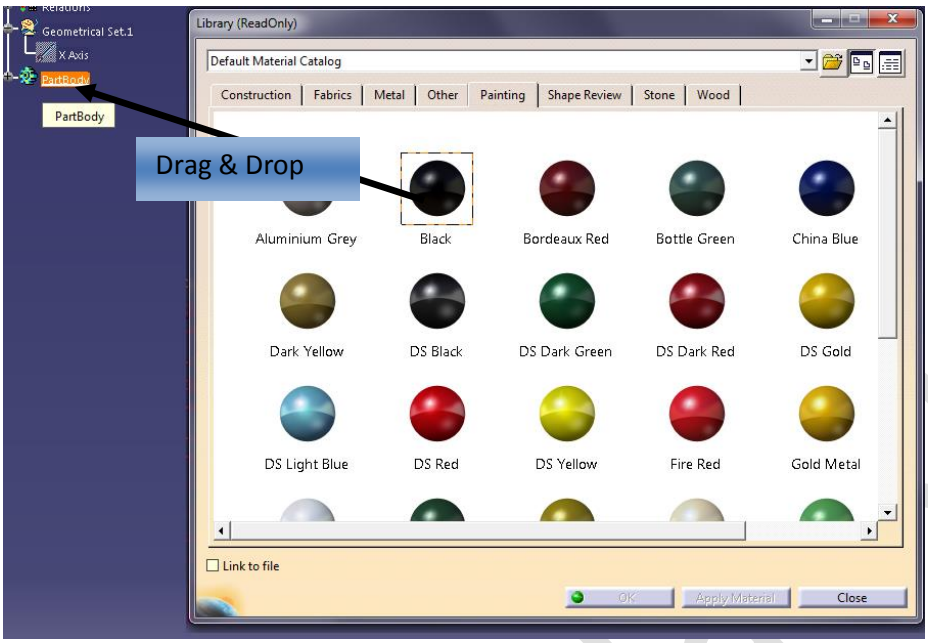
Pentru acest lucru vom deschide o piesa si dam click pe *"Apply Material".*



Din libraria de materiale, pentru piesele din primele doua ansambluri eu am ales din meniul *"Painting"* culoare neagra, mai putin pentru piesa 4638309 pe care vom aplica numele Burj Khalifa (gasiti explicatia mai jos).

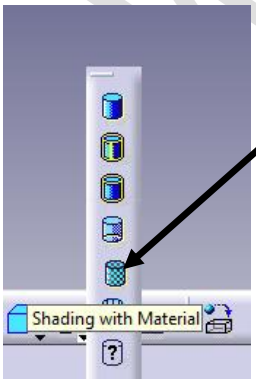


Acum vom face click pe culoare dorita si cu Drag & Drop vom da drumul la click doar in momentul in care suntem pe *"PartBody".*



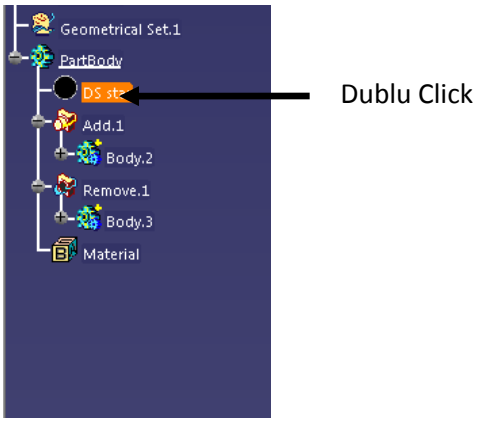
Desi inca nu se vede nici o diferenta vom vedea ca daca dam click pe *"+"-ul de la "PartBody"* a aparut inca o ramura care ne spune ce culoare am ales.

Pentru a modifica si aspectul piesei va trebui sa alegem din meniul *"Visualisation" -> "Shading with Material"*.

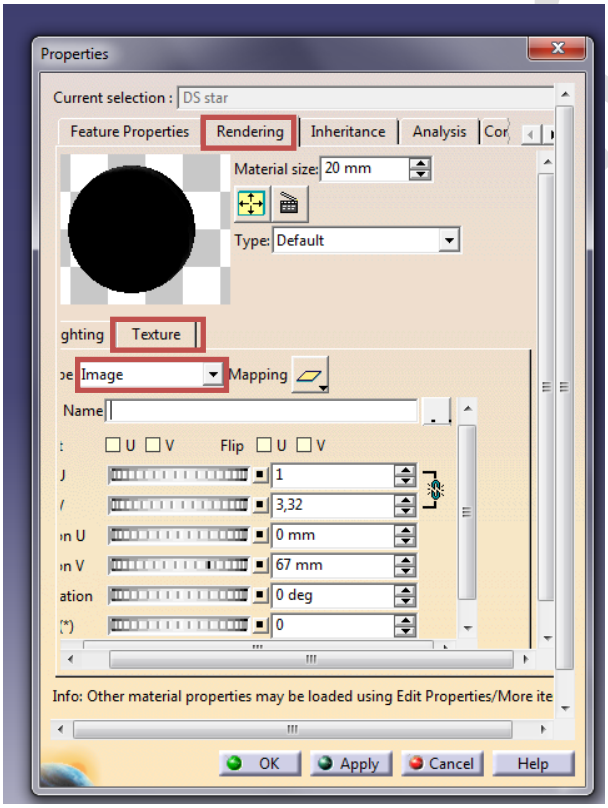


Pentru piesele din ansamblurile 3,4 si 5 vom alege culoarea *"Grey Blue"*.

Pentru a aplica scruisul pe piesa 4638309 prima data vom cauta o imagine in care apare doar *"Burj Khalifa"* si o salvam local. Apoi vom aplica culoarea *"Black"* ca si la celelalte piese insa vom face dublu click pe ramura care defineste culoarea si va aparea urmatoare fereastra.



Din tabul *"Rendering" -> "Texture" -> "Tipe"* se alege *"Image"*, se cauta poza in calculator iar apoi din optiunile de mai jos se pozitioneaza.



Dupa ce ati facut si acest lucru deschideti ansamblul final setati *"Shading with Material"* iar rezultatul final va fi urmatorul.