Industrial Design Project II

Innovative Application of Steel in Housing
Floor Slab

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(2013-15)

Guide
Prof. Vijay P Bapat

Co-Guide
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CEMENT

Concern About the Carbon Footprint

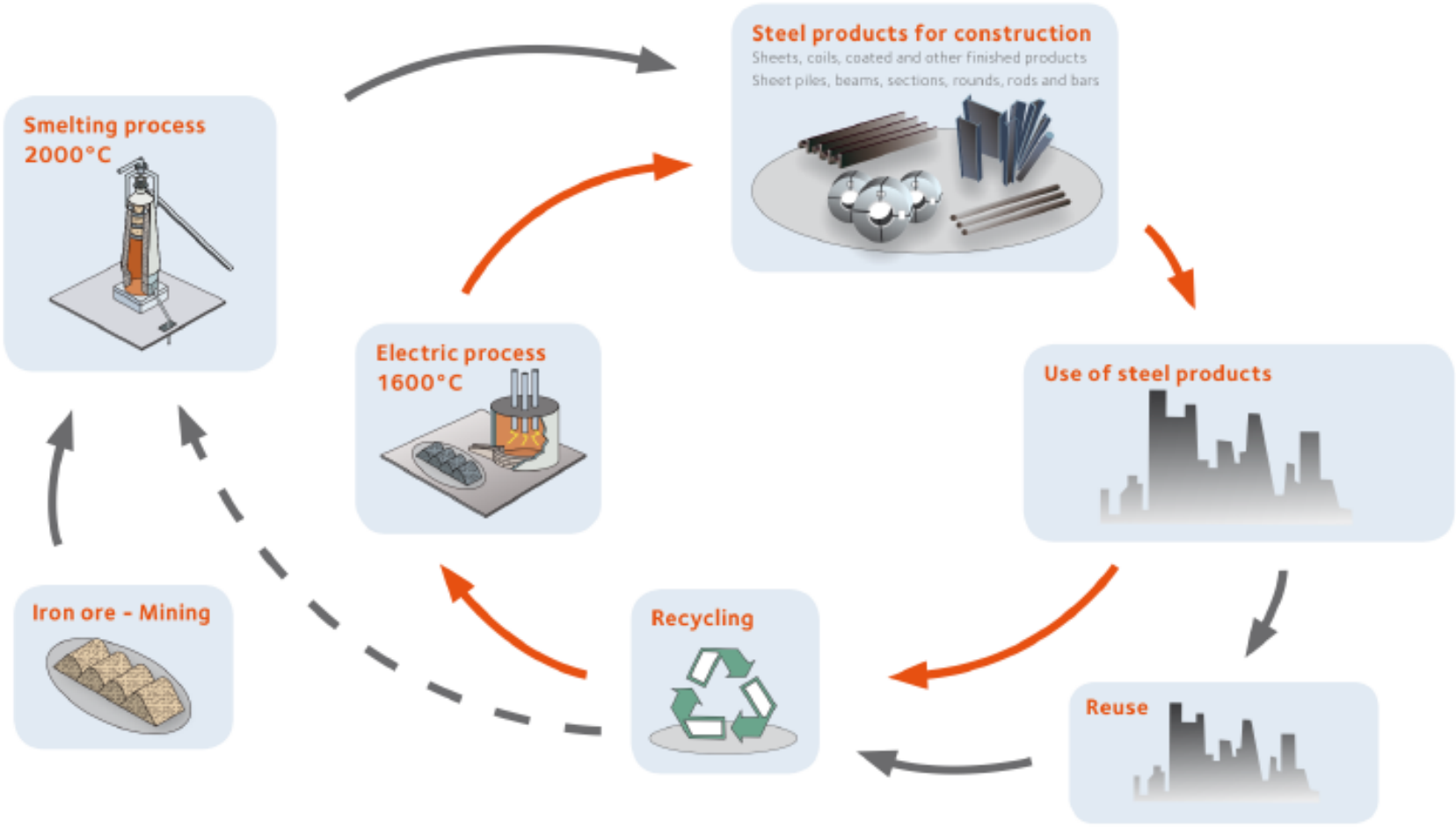
http://www.greenrationbook.org.uk/resources/footprints-concrete/ as seen on 13/11/2014

Concrete is most widely used material on earth apart from water

Almost 60% of total CO2 emission is from CM facility.

Ecological Concerns

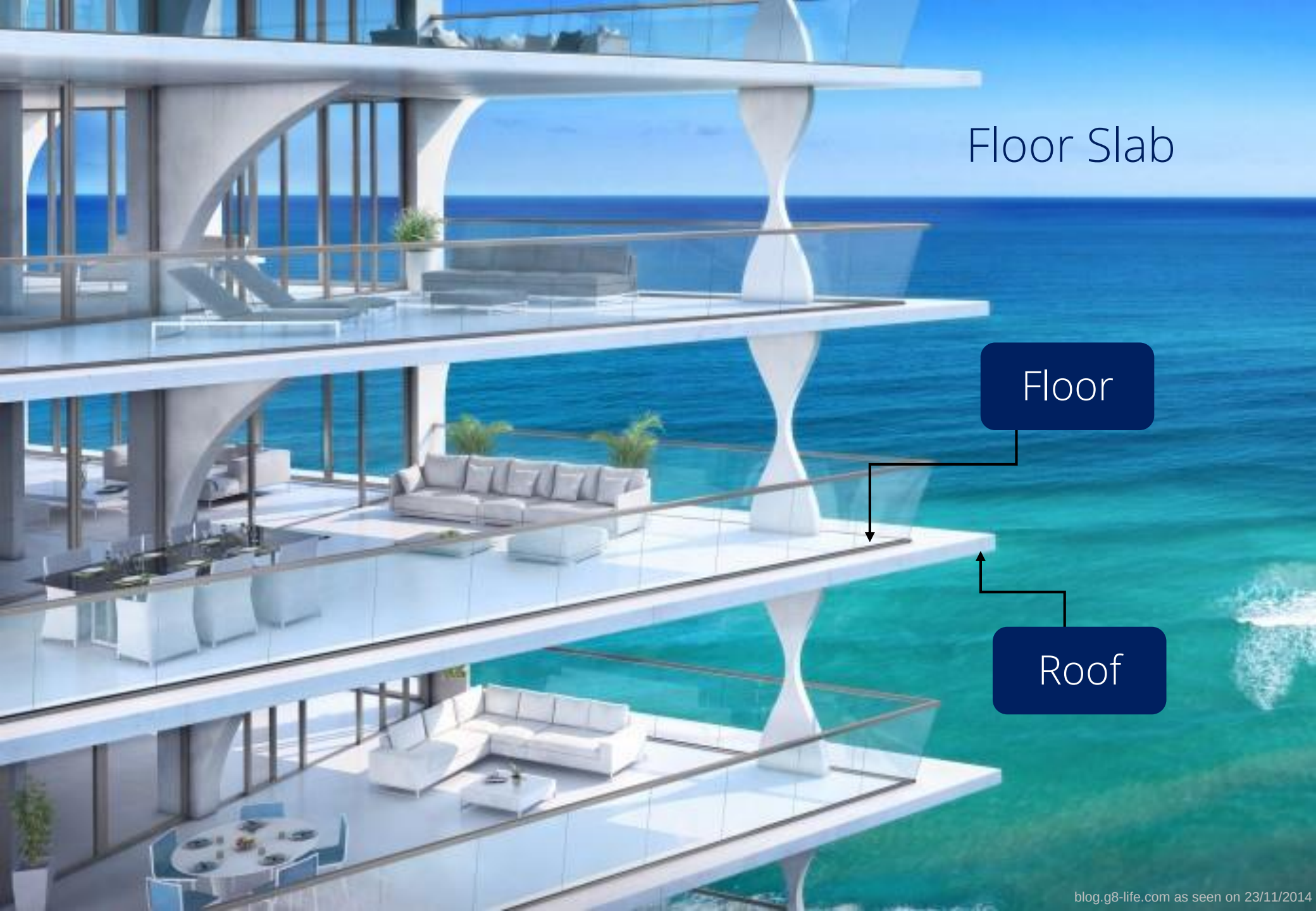
Concrete Vs Steel Housing



> "It's interesting to think of steel as a material that can be easily deconstructed and reused for another building, in another place."
>
> Sergio Baragaño, [baragaño], Spain

http://pcimplements.com/koenigins/wp-content/uploads/2014/03/home.jpg as seen on 23/11/2014

Set guidelines and intelligent techniques can help in speeding up the process of building a house, even by an unskilled worker.



blog.g8-life.com as seen on 23/11/2014

Steel Housing : A new Era in Rapid Construction

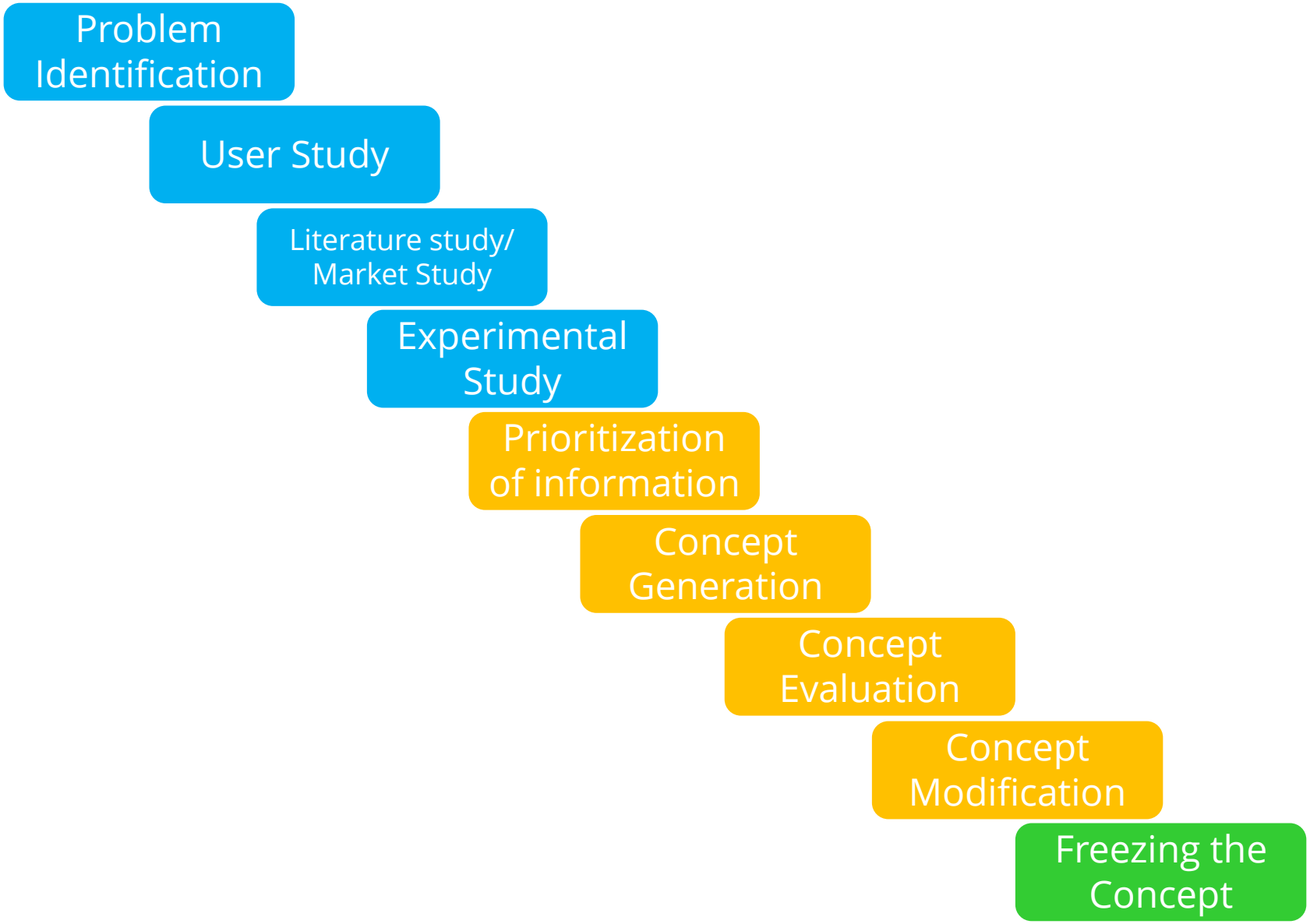
http://www.truecore.com.au/images/source/Steel-success-award-1-def.jpg as seen on 23/11/2014

http://juniorhockeynetwork.com/wp-content/uploads/2014/08/Why.jpg as seen on 23/11/2014

- Structurally sound and manufactured to strict specifications and tolerances.
- Easy to modify and offers design flexibility.
- Less maintenance, while offering improved safety and resistance.

http://lunar.thegamez.net/greenenergyimage/green-technology-product/green-products-green-product-logogif-787x787-filesize-7356-kb-787x787.jpg as seen on 21/11/2014

Design Approach



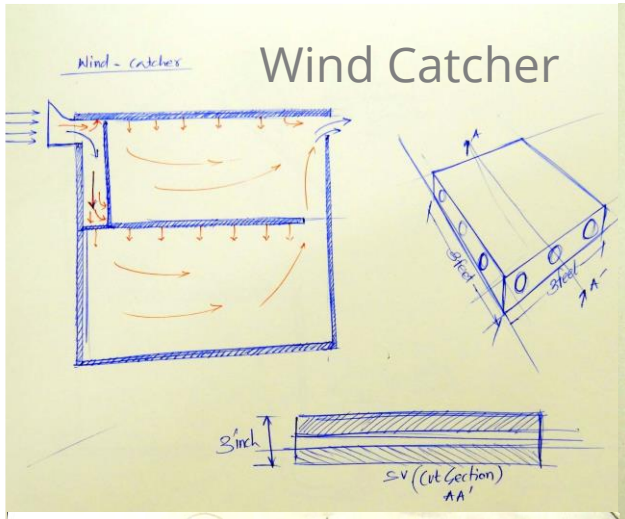
Design Brief

“To explore innovative application of steel in flooring and ceiling ,which may result in solving User centered issues like reduction in construction time, better design of joints, less involvement of skilled labor force and finally come up with a working prototype or scaled model of product.”

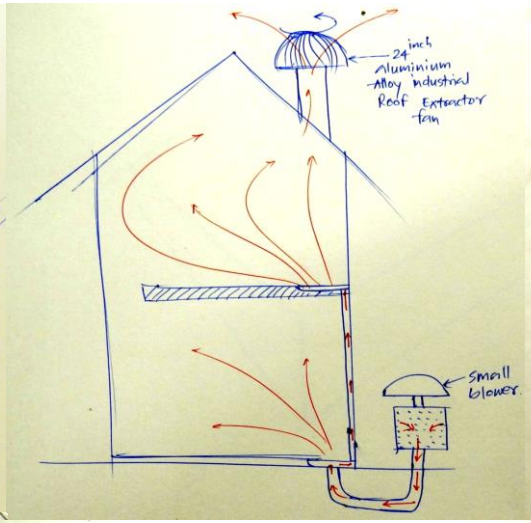

Stone
Wood
Metal
Floor covering
Load
Structure
Bamboo
Material
Cleaning
Support
Rigid
Floor Slab
Sub floor
Size
Insulation
Joints
Glass floor
Nightingale floor
Floor-structure
Floating floor
Raised floor
Balcony
Sprung floor

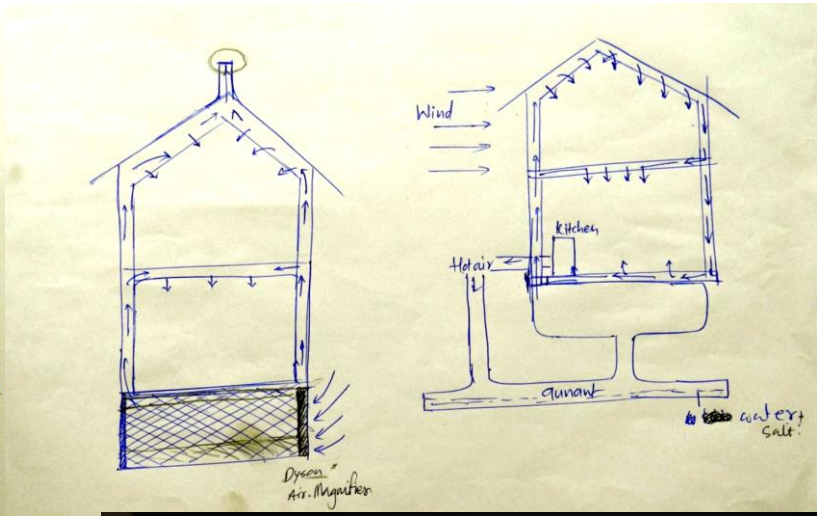
Some Initial Ideations (Stage 1)

Concept 1

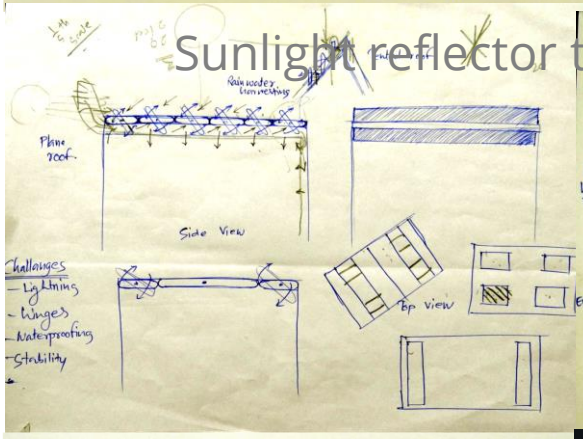


Wind Catcher

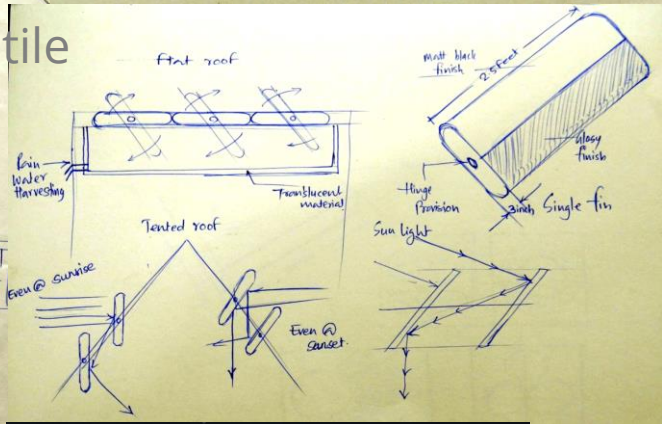


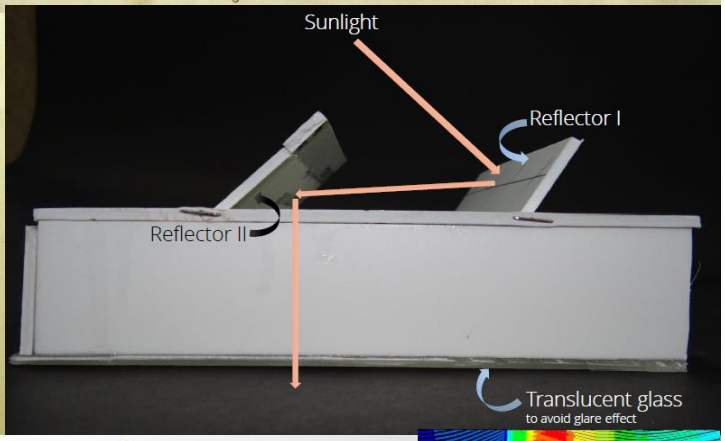


Concept 2

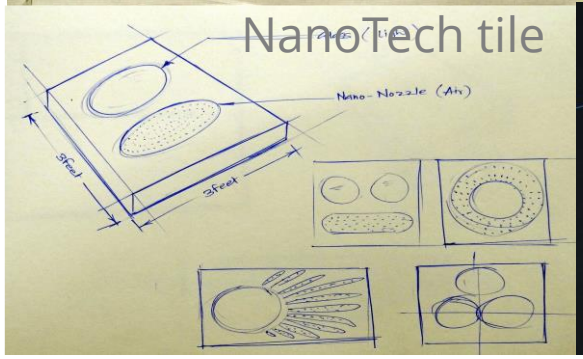


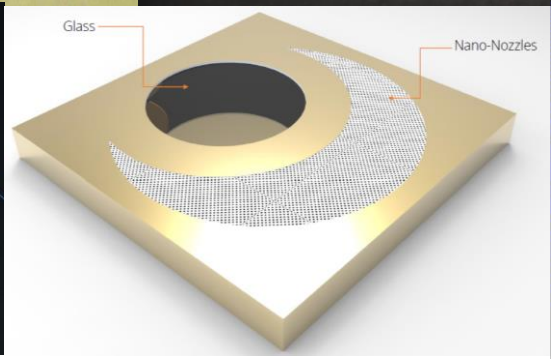
Sunlight reflector tile

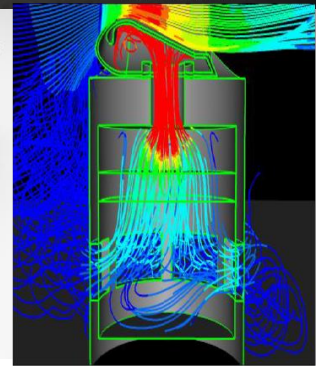




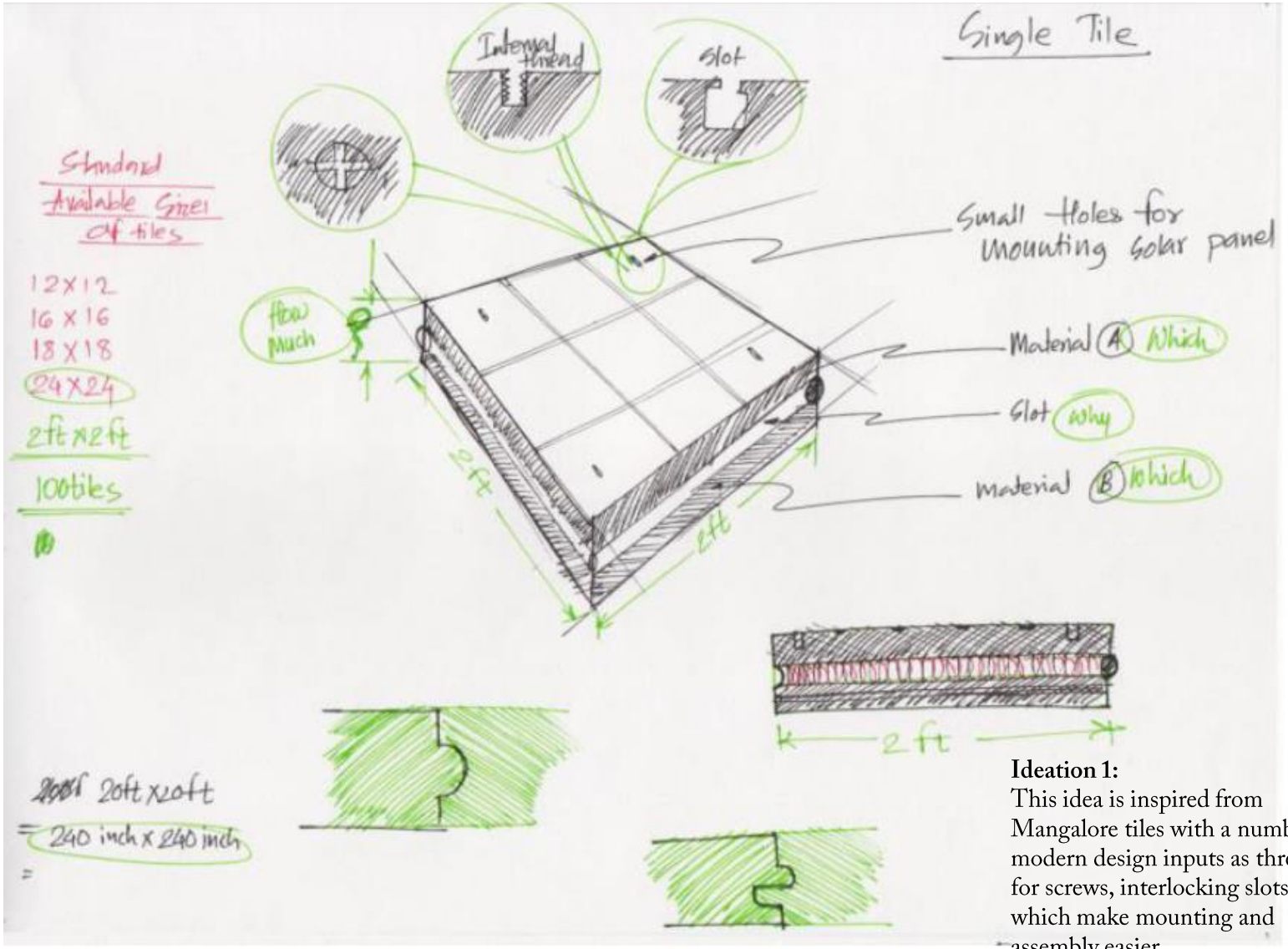
Concept 3





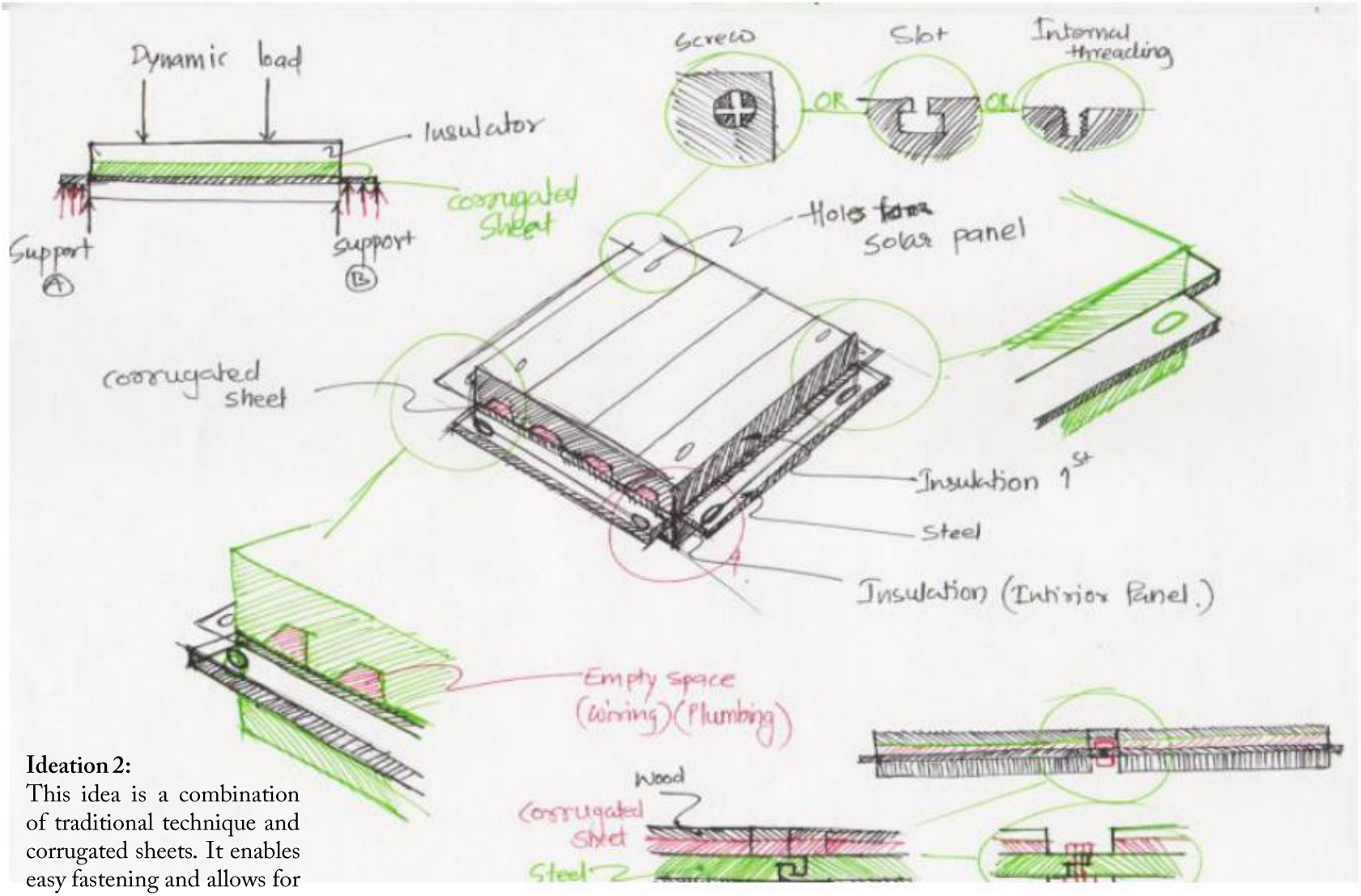


Some Initial Ideations (After Stage 1)



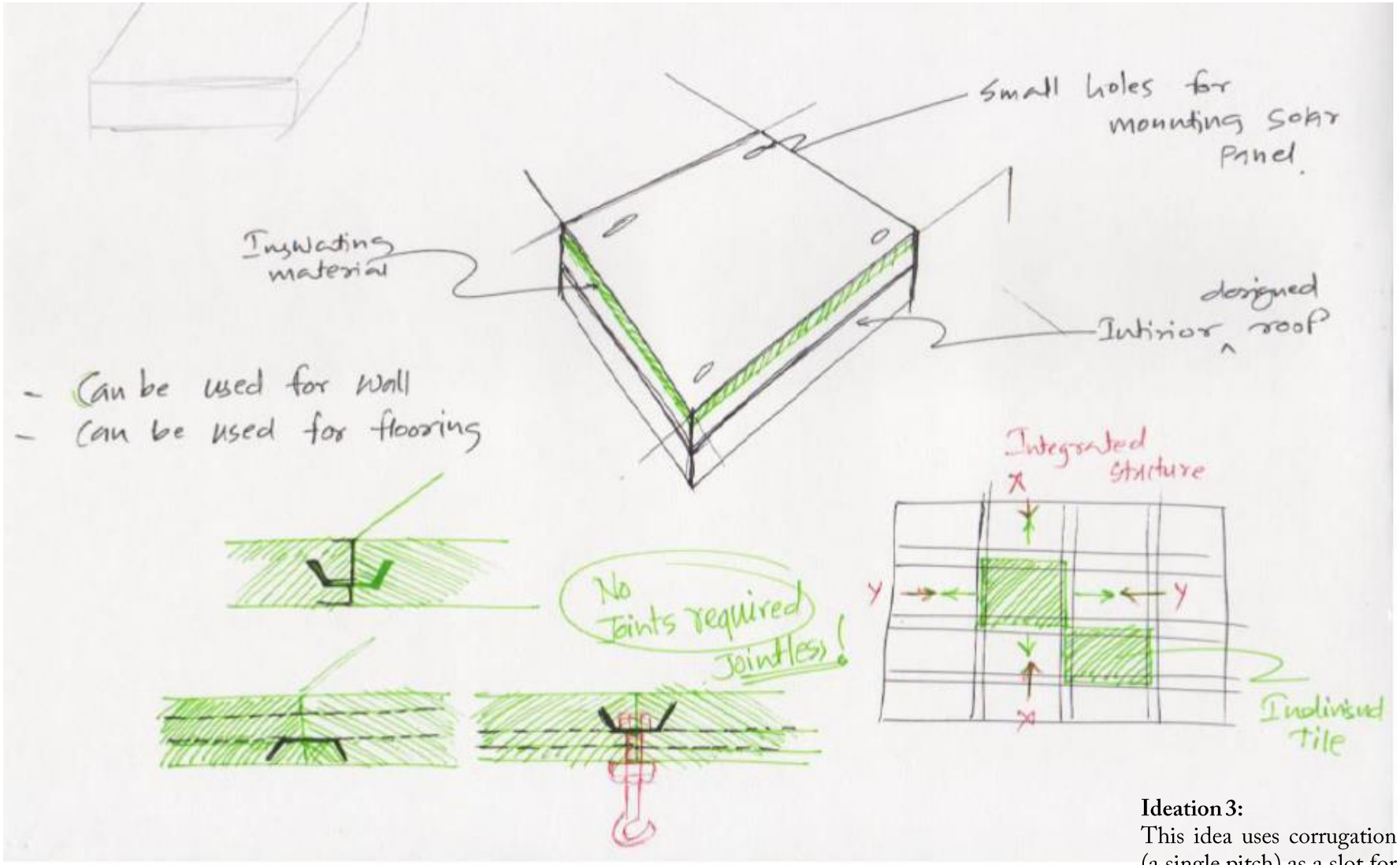
Ideation 1:
This idea is inspired from Mangalore tiles with a number of modern design inputs as threading for screws, interlocking slots, etc which make mounting and assembly easier.

Some Initial Ideations (After Stage 1)



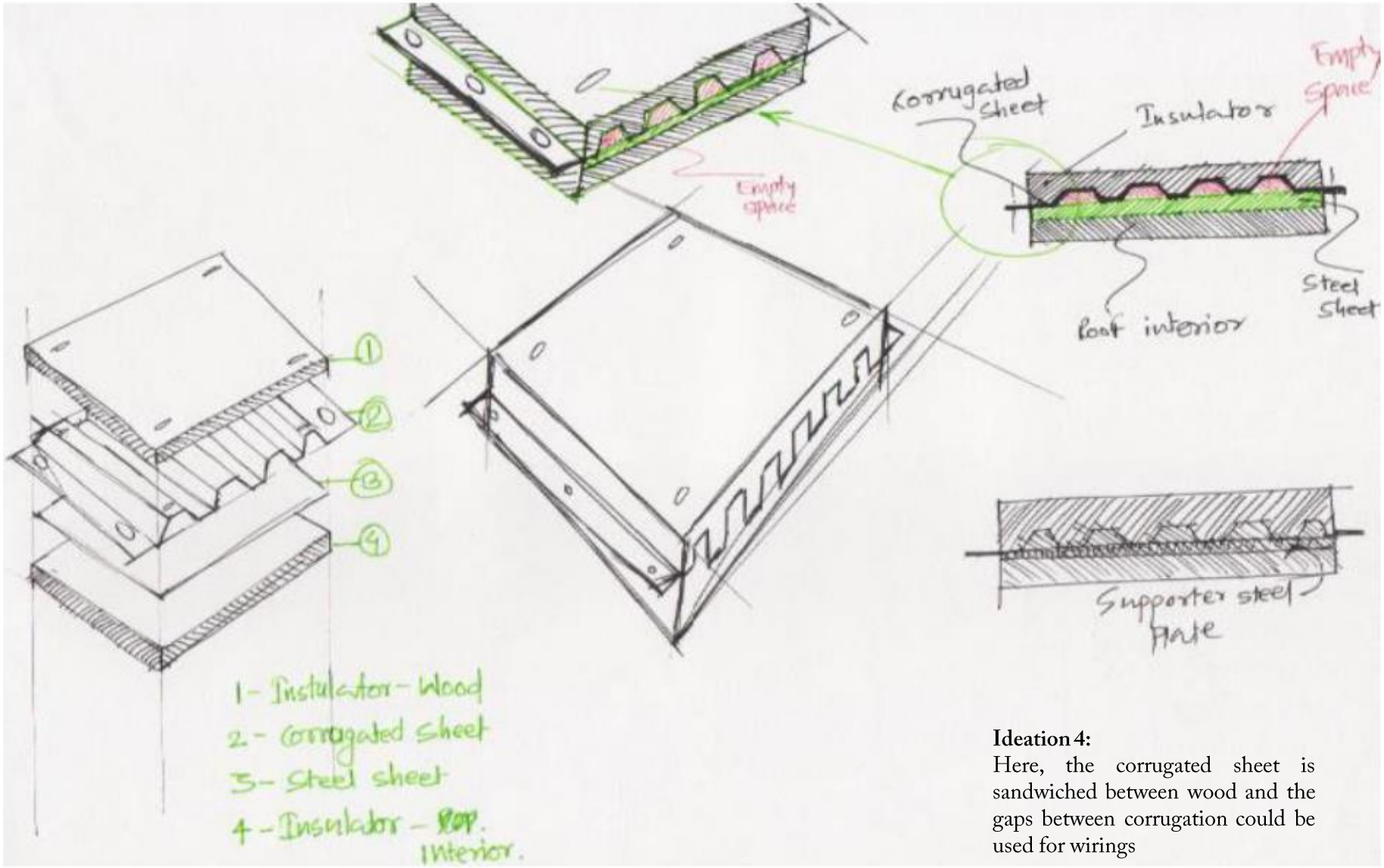
Ideation 2:
This idea is a combination of traditional technique and corrugated sheets. It enables easy fastening and allows for mounting of fixtures, etc.

Some Initial Ideations (After Stage 1)



Ideation 3:
This idea uses corrugation (a single pitch) as a slot for sliding and interlocking adjoining panels.

Some Initial Ideations (After Stage 1)



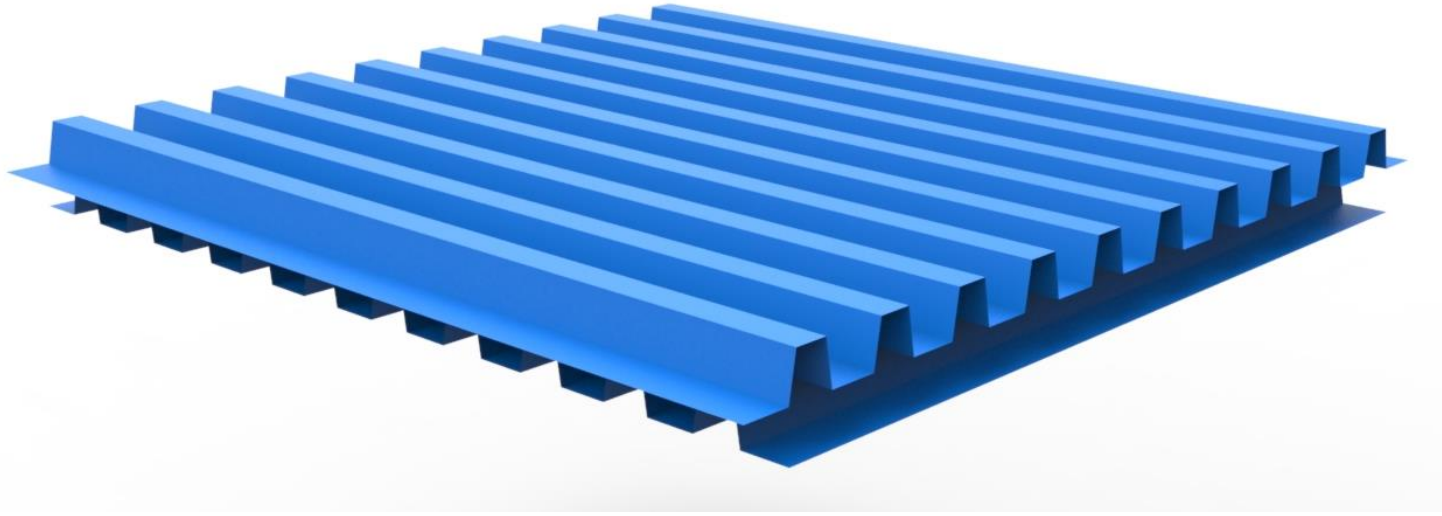
Ideation 4:
Here, the corrugated sheet is sandwiched between wood and the gaps between corrugation could be used for wirings

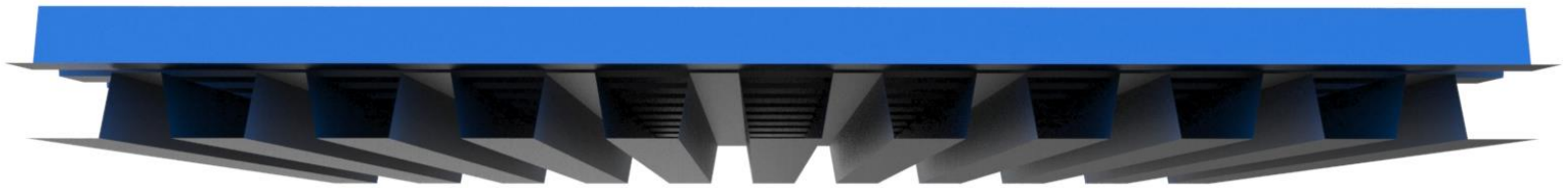
While working on this project specially in structure of a house, along with my guide and project met, we came up with very innovative idea of very strong structure and we named it as

“CRISS-CROSS CORRUGATION structure” (CCC structure)

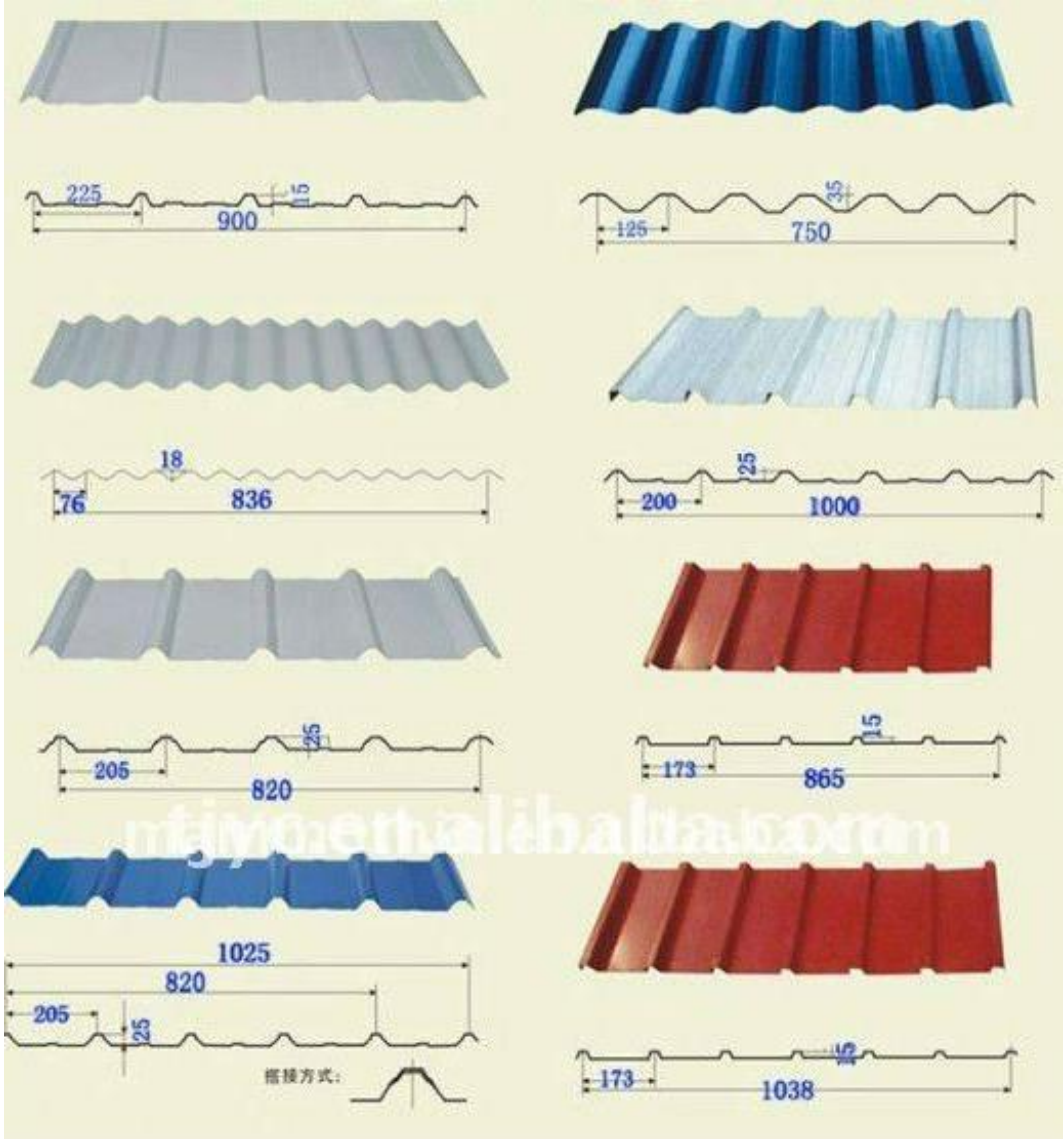
“CCC” , What is it?

It is a innovative concept where two corrugated sheets are joined together in criss cross manner.

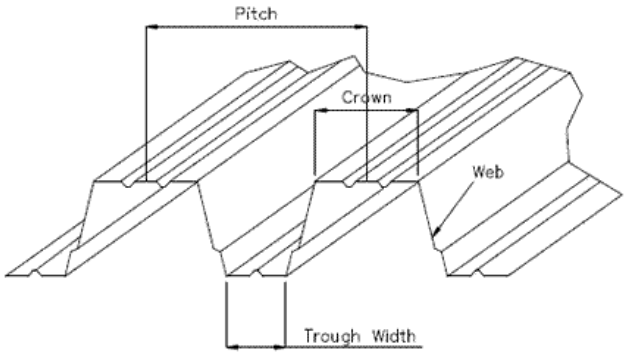




Research on Galvanized Corrugated Sheets



Typical types of corrugated sheets available in Indian market
http://i01.i.aliimg.com/img/pb/785/865/384/384865785_447.jpg as seen on 10/11/2014



http://www.slecladding.co.uk/comtrisomet2.jpg as seen on 10/11/2014

Joining of Corrugated Sheets

- ✓Adhesive bonding
- ✓Welding
- ✓Riveting
- ✓Clinching
- ✓Fastening (Nut-bolt)
- ✓Crimpling
- ✓Stamping
- ✓Magnet fixing
- ✓Stitching
- ✓Snap on
- ✓DST
- ✓Brazing
- ✓Eyelet

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Out of these fastening method is good because of easiness in assembling and disassembling corrugated sheets.

✓Adhesive bonding

Fig 24 (a) : Locktite adhesive bottles available in market http://www.loctite.com.au/loctite-tereson-products.htm as seen on 10/11/2014

HIGH TEMPTURE / CHEMICAL RESISTANCE

LOCTITE® H8600 HYSOL® STRUCTURAL ADHESIVE

Galvanized Bonder

Excellent impact and shear strength on steel and aluminium. Especially designed for severe environments.

Key characteristics of thread lockers

•Single-component

•Clean and easy to apply

•Resists vibration

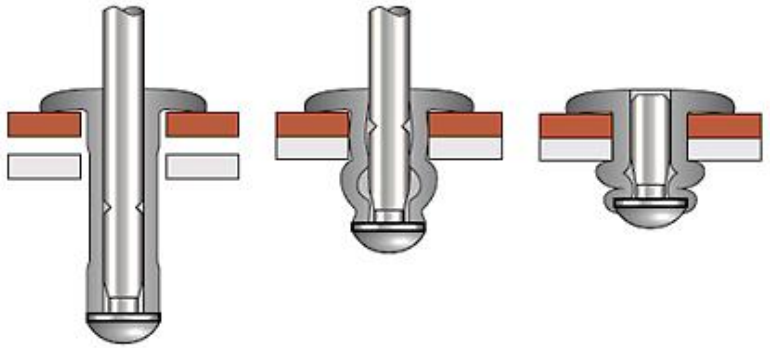
Disassemble??

✓Riveting

http://www.gbtoolhirecallington.com/wp-content/uploads/2012/05/lazy_tounge_pop_rivet.jpg as seen in 21/11/2014

Advantage

Makes a quick, permanent fastening when you can only reach one side of the material.



http://www.marshallsales.com/images/products/rivet_blind_art.jpg as seen on 26/11/2014

Disassemble??

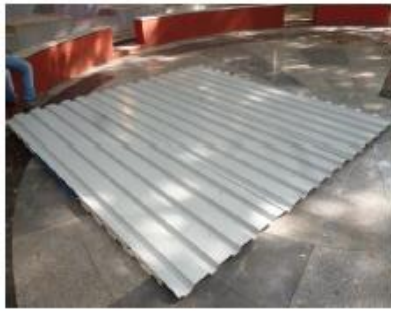
✓Fastening (Nut-bolt)

)https://d2t1xqejof9utc.cloudfront.net/screenshots/pics/4bf7782e2959a8065bc393d0cf649d9a/medium.png as seen on 12/11/2014

From the three mentioned techniques, fastening with nut bolts allows ease of assembly and disassembly. Considering our application, which has to enable easy, quick and reversible procedures, fastening is preferred over the other two techniques.

✓ Disassemble

10Feet * 10Feet Actual Model : Load Validation



Arranging

Overlapping

Marking

Punching

Drilling

Fastening

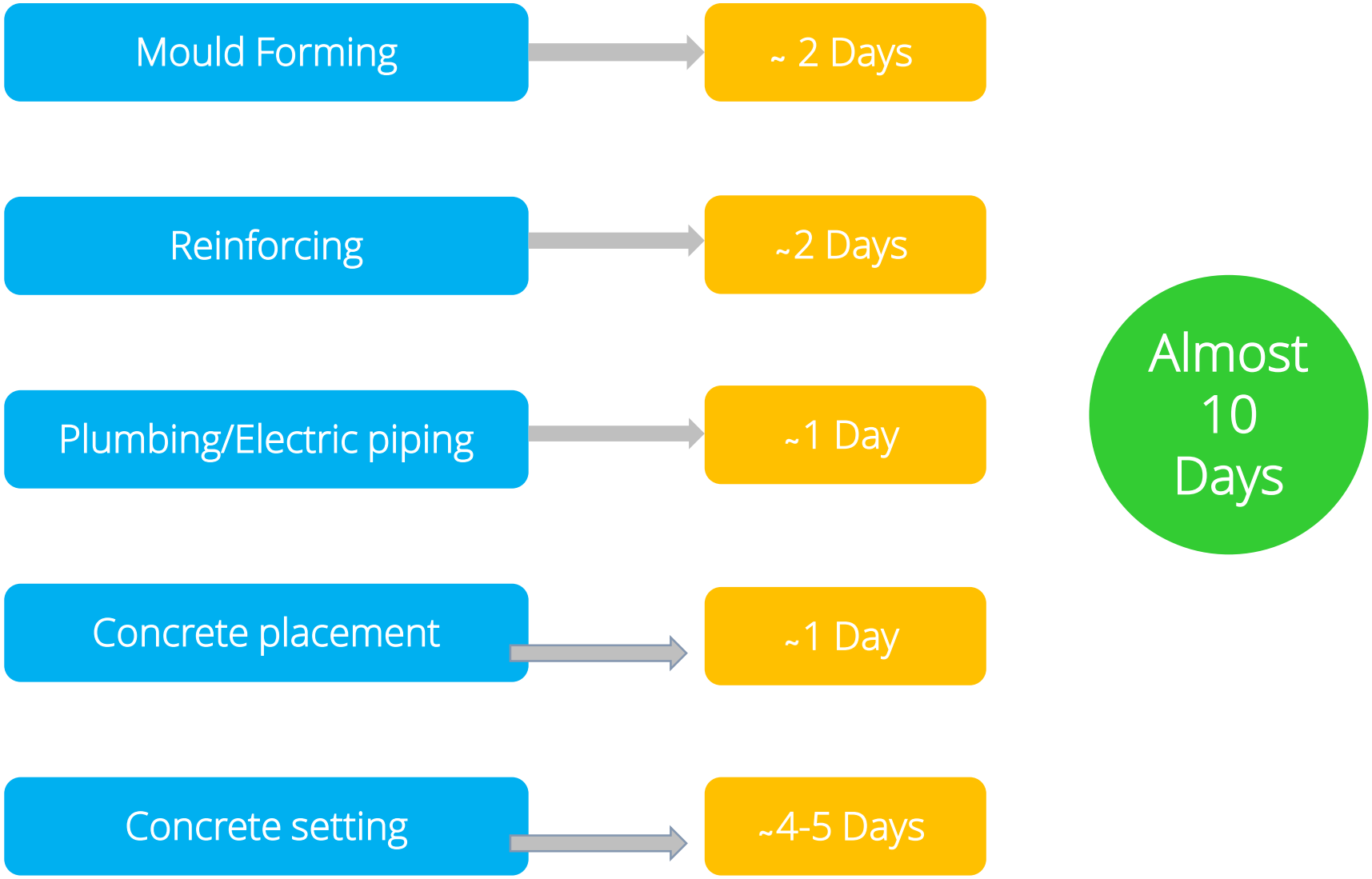
~60 Kg load test

~130 Kg load test

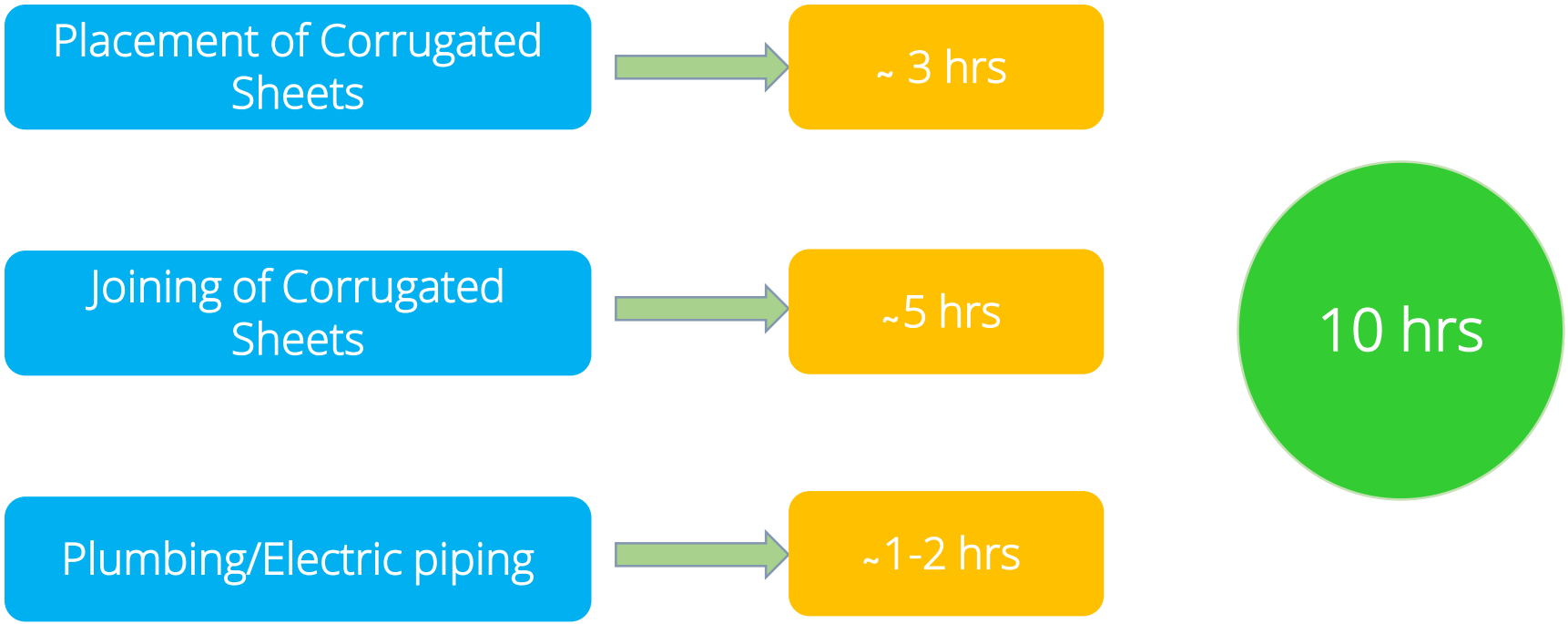
~300 Kg load test

Ponding Effect = ~5mm

Time Study of RCC Floor Slab (10'*10')



Time Study of Joining CCC Structure (10'*10')



Cost Estimation : RCC Vs CCC (10'*10' Area)

Concrete (M20)	₹ 8000 approx.
Rebar (0.4 cm)(48 meter)	₹ 2500 approx.
Rebar (0.8 cm)(48 meter)	₹ 2000 approx.
Labour, Equipment and Transportation	₹ 5000 approx.
15% Extra	₹ 2625 Approx.

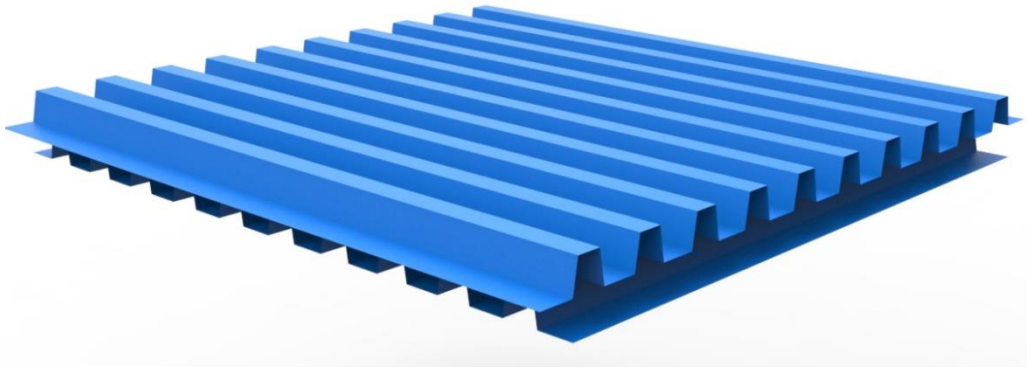
₹ 20,125/- approx.

Corrugated Sheets (6 sheets)	₹ 8000
Nut-Bolts	₹ 500 approx.
Equipment and Transportation	₹ 2000 approx.

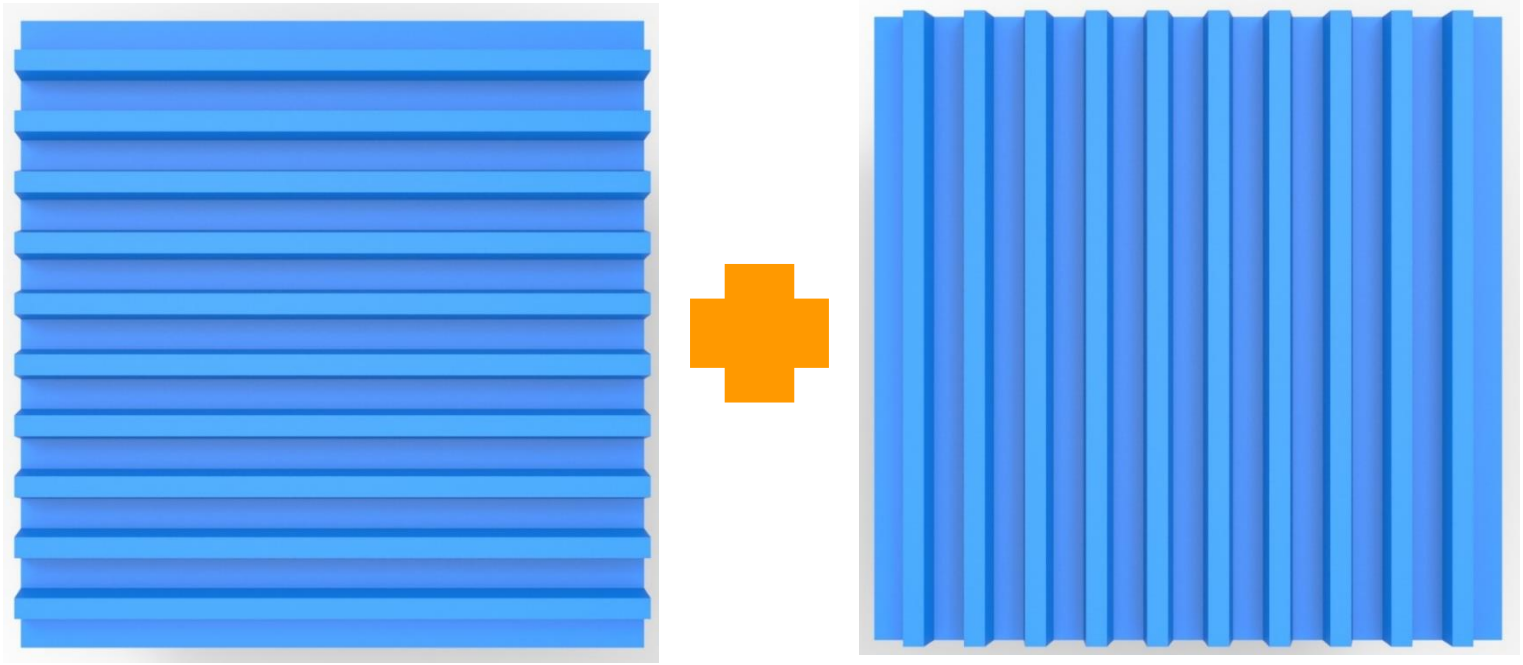
₹10500 /- approx.

Thus, from the cost analysis, it is clear that the proposed cross corrugation technique reduces the costs by almost **50%.**

Why Criss-Cross?



Single Sided = Stiffness in one direction
CCC = Stiffness in both direction

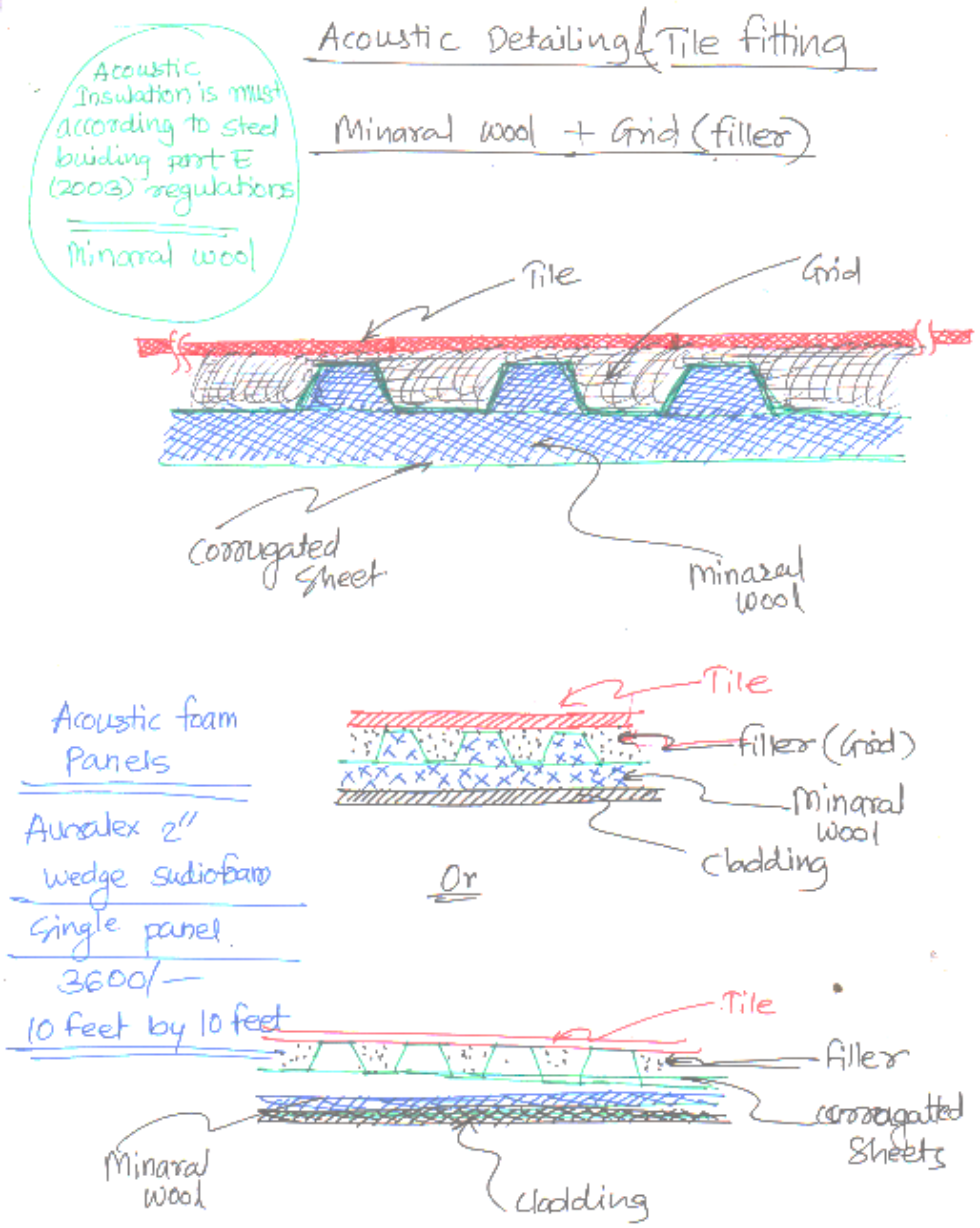


Where we can use this Structure?

https://c1.staticflickr.com/1/42/102017268_756ae32e41.jpg as seen on 10/11/2014

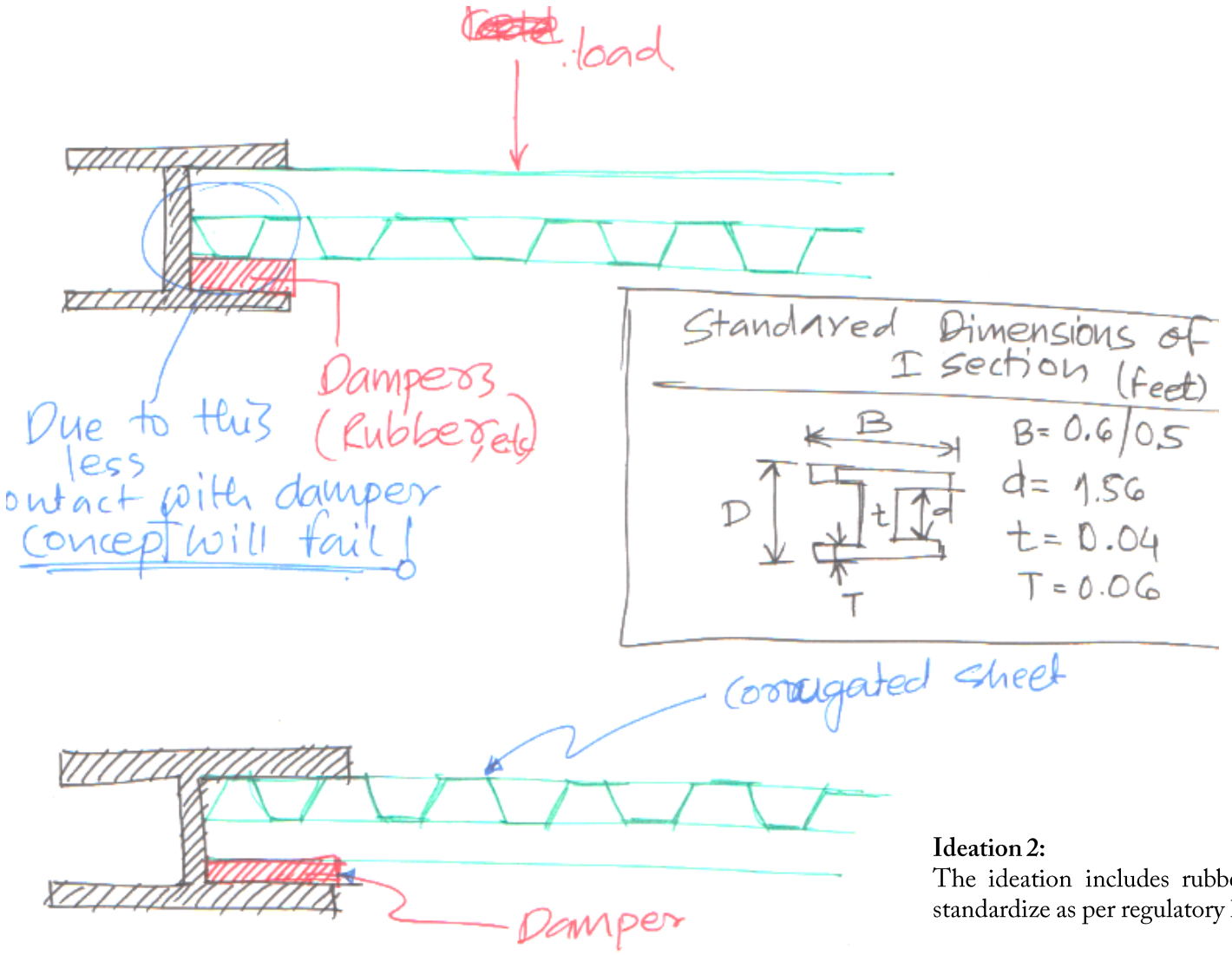
http://anchorite.org/blog/wp-content/uploads/2008/03/wiringmess.jpg as seen on 10/11/2014

Some Initial Ideations (After Stage 2)



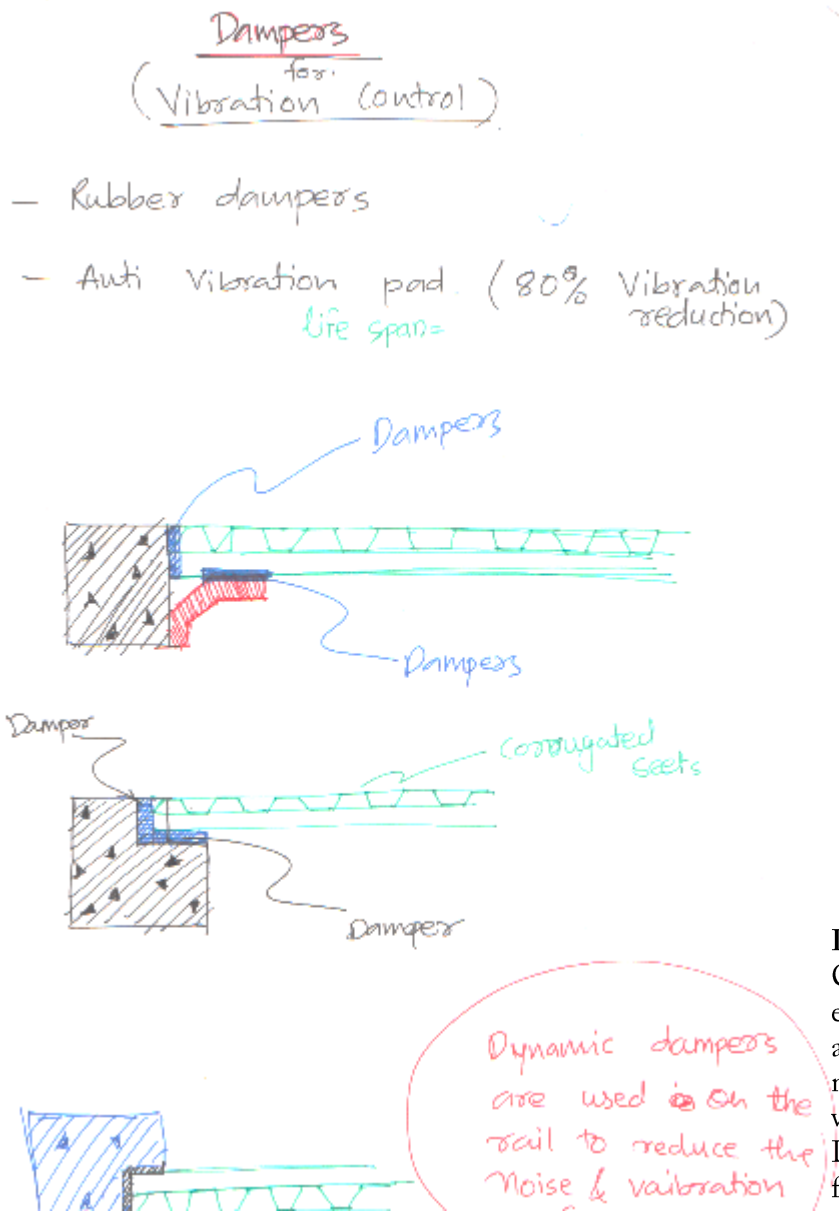
Ideation 1:
Insulation is a must as per laws laid down by construction authorities (Steel Building part-E, 2003). The ideation aims to include the same as a filler between the corrugation.

Some Initial Ideations (After Stage 2)



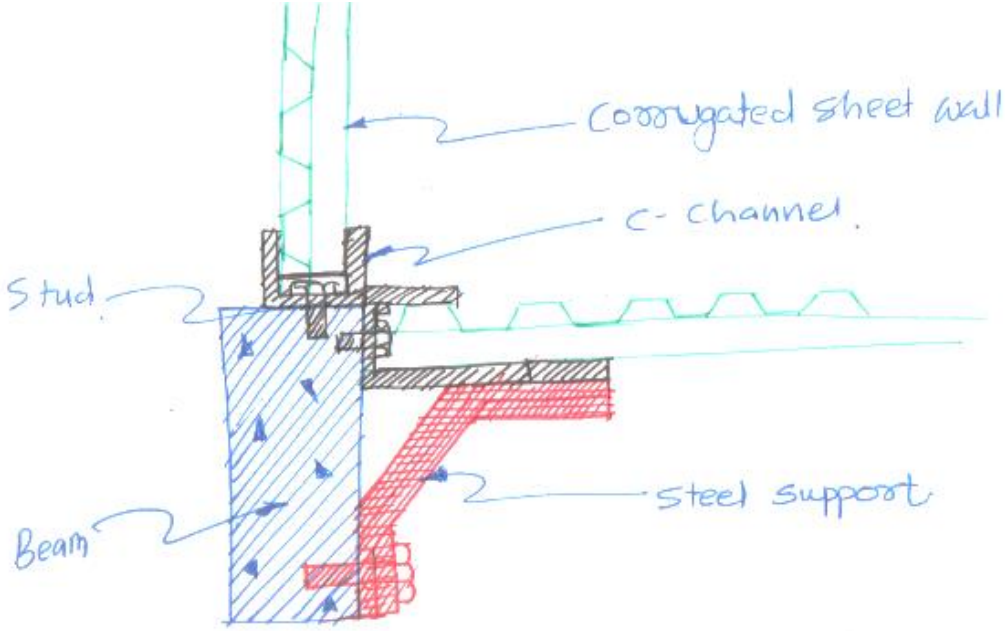
Ideation 2:
The ideation includes rubber dampers to standardize as per regulatory laws

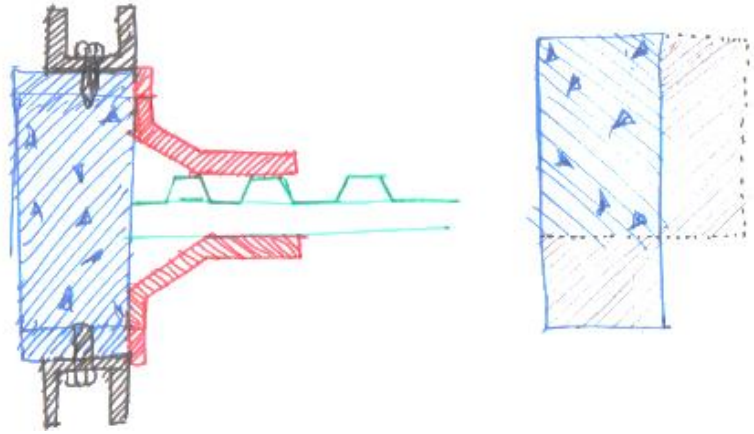
Some Initial Ideations (After Stage 2)



Ideation 3:
Considering analogies from vehicles and earlier ideations, here rubber dampers and anti-vibration pads have been used. This might lead to almost 80% reduction in vibrations.
Dynamic dampers can also be used for further stability.

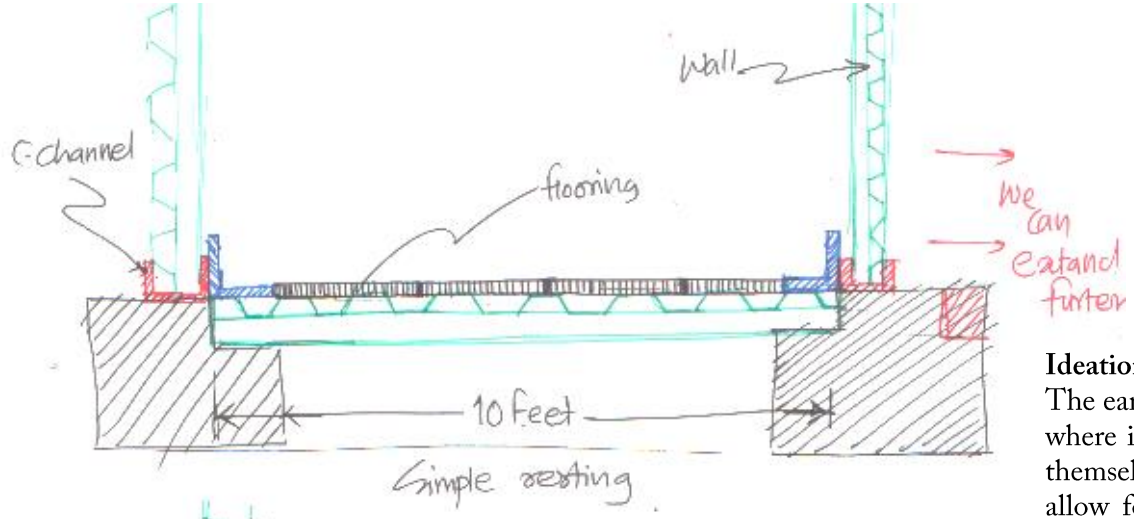
Some Initial Ideations (After Stage 2)



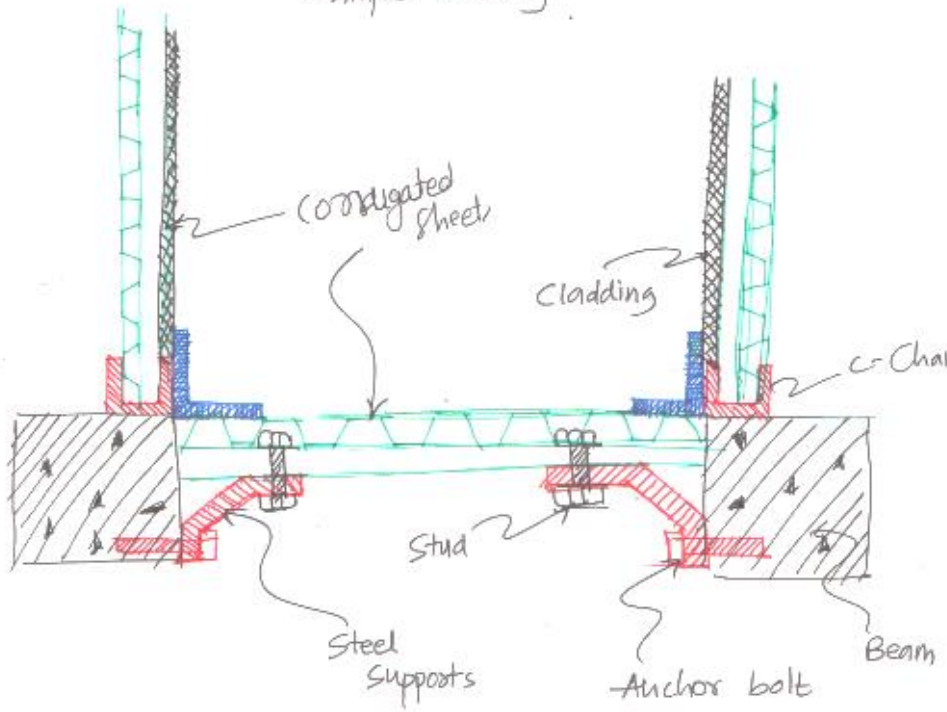


Ideation 4:
Here dedicated steel supports are bolted to concrete beams and the corrugated sheets are then held by these clamp-like supports. This allows for thermal expansion and a certain degree of freedom for movement.
(Bridges use such techniques)

Some Initial Ideations (After Stage 2)



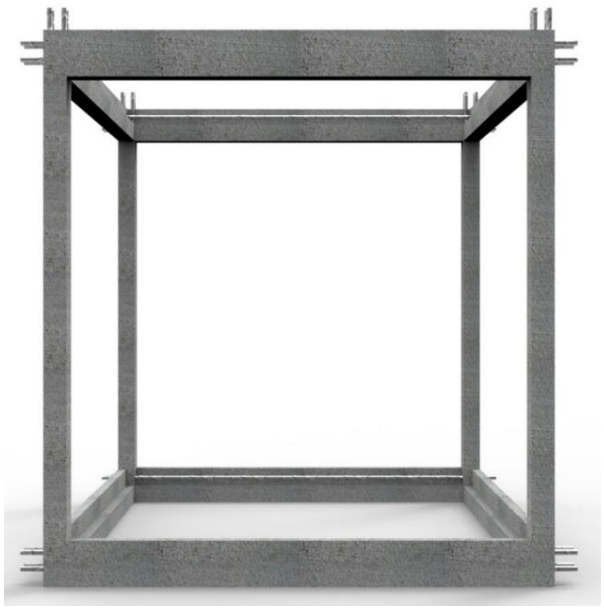
Ideation 5:
The earlier ideations have been modified, where it is proposed that the beams are themselves precast in such a manner to allow for easy resting of sheets without any external component.

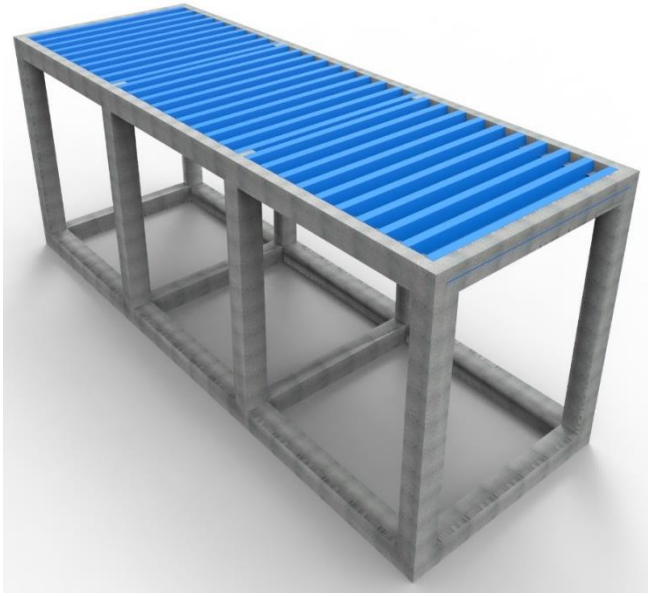


Ideation 6:
Here, the clamps are anchored to the beams as in earlier ideations, but the freedom of movement is restricted by bolting the corrugated sheets, thus improving upon the earlier design.

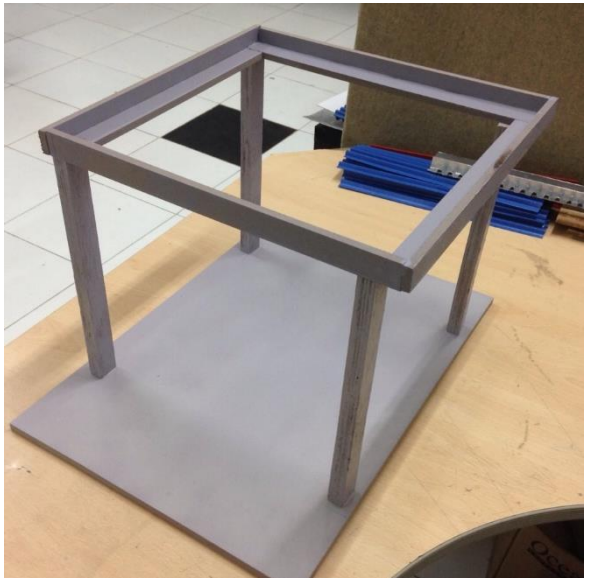
Construction details : How to use Criss-cross Corrugation Structure as a Floor Structure?

3D models of ideation

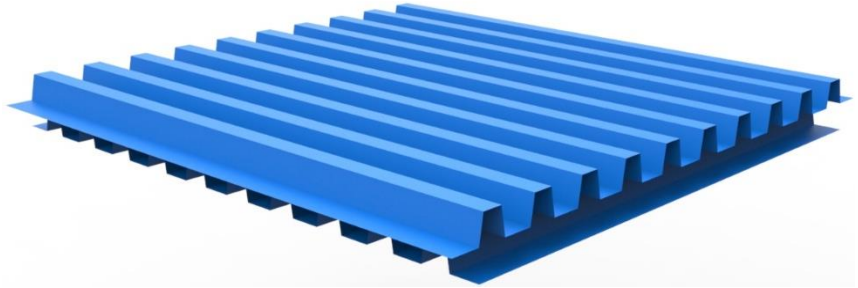




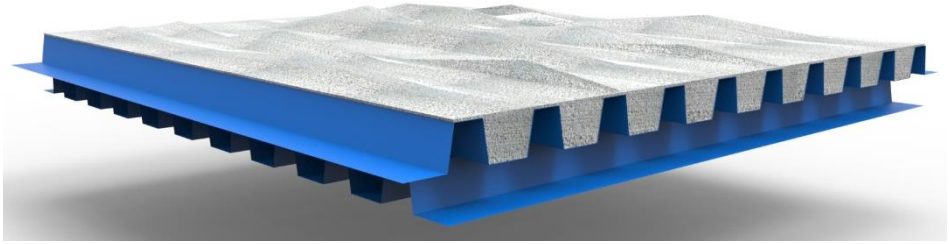
1:10 scale model



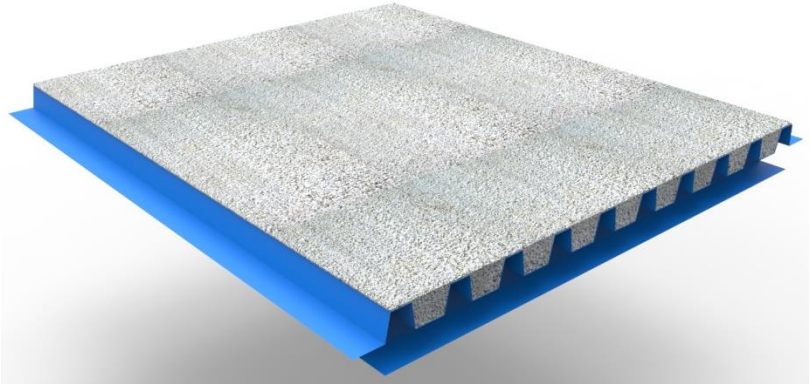
Step wise Procedure of using Criss Cross Corrugated Structure as a Floor Slab.



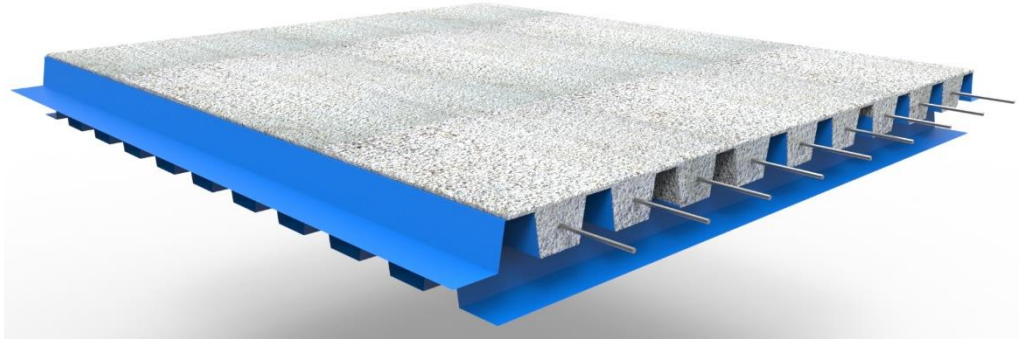
Step 1:
Two corrugated sheets are joined together by pop riveting in criss cross manner



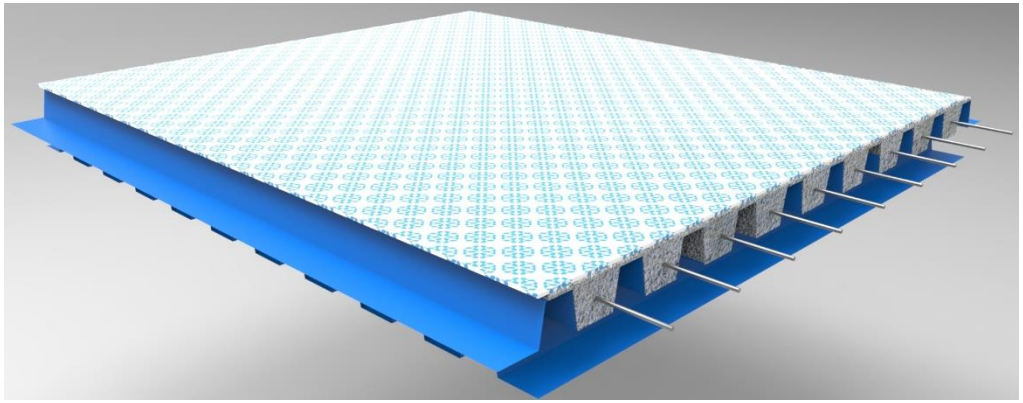
Step 2 :
Grid along with cement is placed above the structure as shown



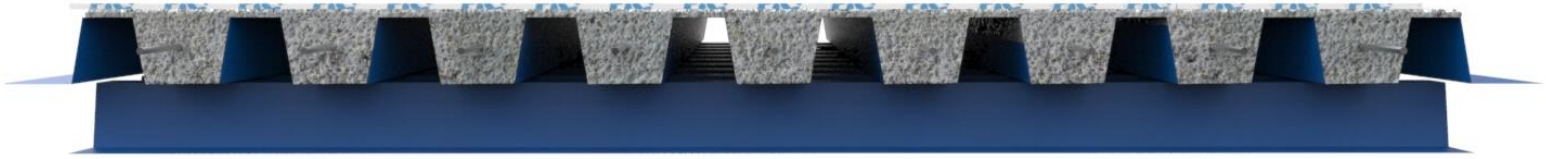
Step 3 :
By using any plane batten or a plane rod ,leaving of the grid + cement is done.



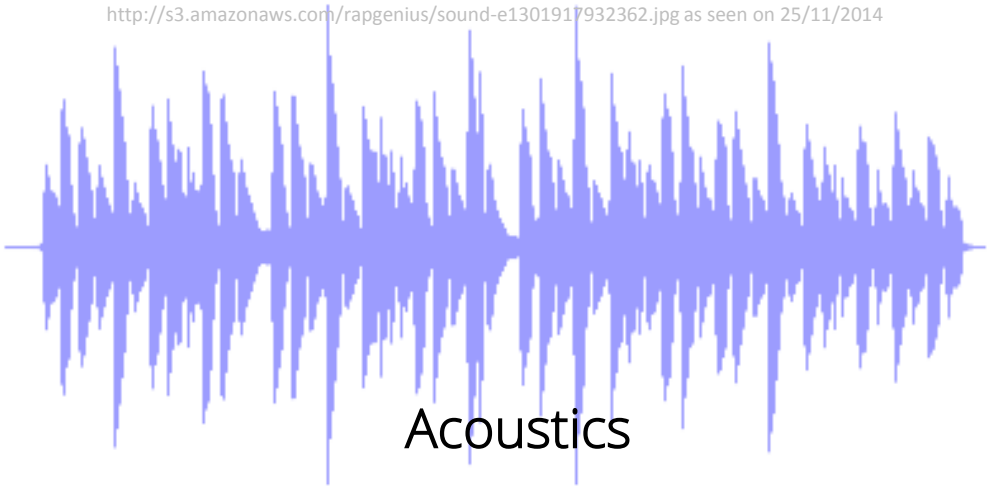
Step 4 :
Depending upon the area insert steel rod of having die 8mm inside the grid + cement.



Step 5:
As we are getting nice level of grid + cement just place the tiles above that. If needed use cement pest to settle the tile perfectly.

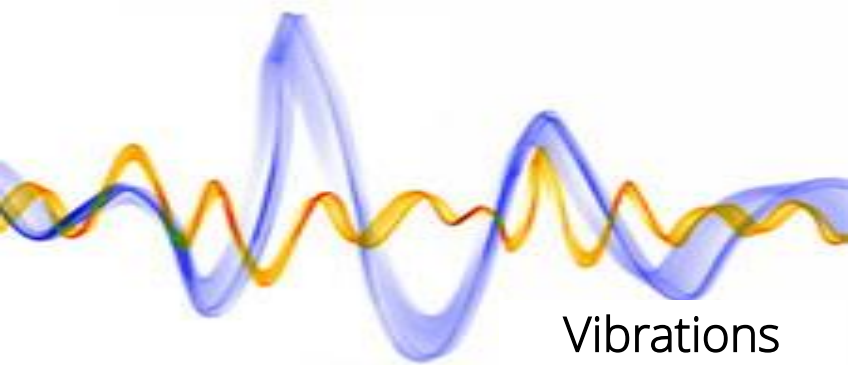


http://s3.amazonaws.com/rapgenius/sound-e1301917932362.jpg as seen on 25/11/2014



Acoustics

http://www.idacontrol.com/images/sup-Cautionary_warning_480_Caution.jpg As seen on 24/11/2014



Vibrations

http://www.sciencevideos.com/Images/vibration2.jpg as seen on 24/11/2014

Acoustics

http://www.firestopcaulking.com/store/images/mineral%20wool.JPG as seen on 10/11/2014

According to Steel Building Part E (2003) regulation use of mineral wool is must in order to decrease the acoustic effect arising from steel material.

Vibrations

http://img.directindustry.com/images_di/photo-g/rubber-dampers-28243-2793755.jpg as seen on 10/11/2014

http://image.made-in-china.com/2f0j00YCLafeltvBzK/ as seen on 10/11/2014

As we know dynamic dampers are used on the rail to reduce the noise and vibrations of steel railway bridge. Same kind of dampers are used here to control the vibrations. Following are two types of dampers selected

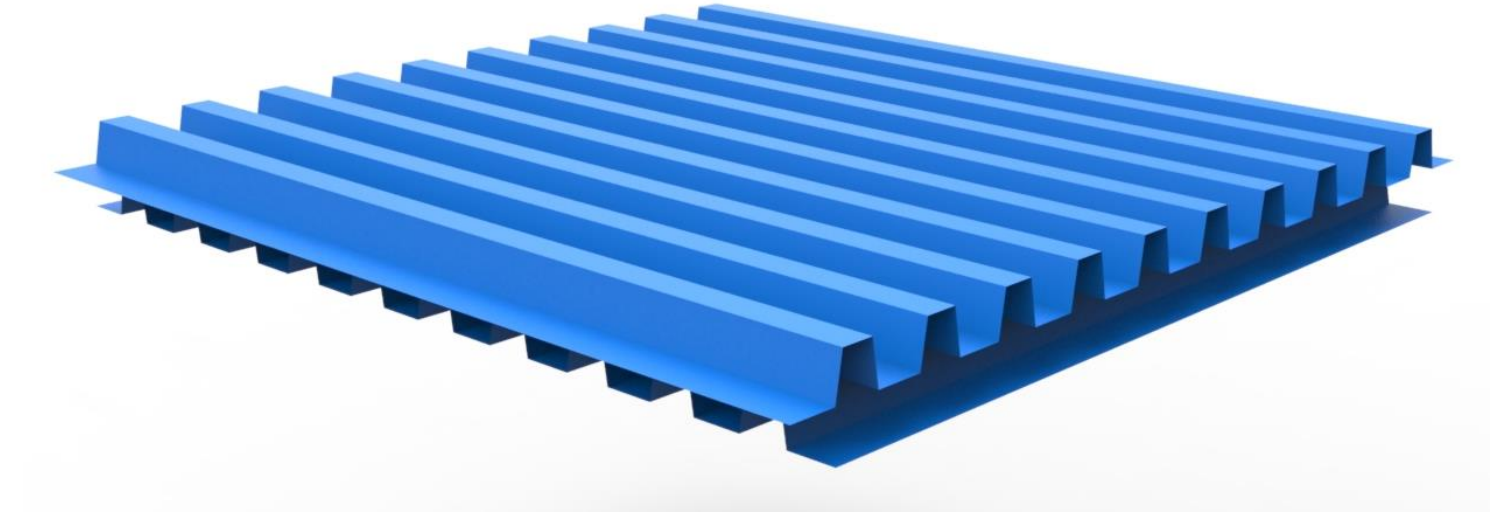
a. Rubber damper
b. Anti vibration pad

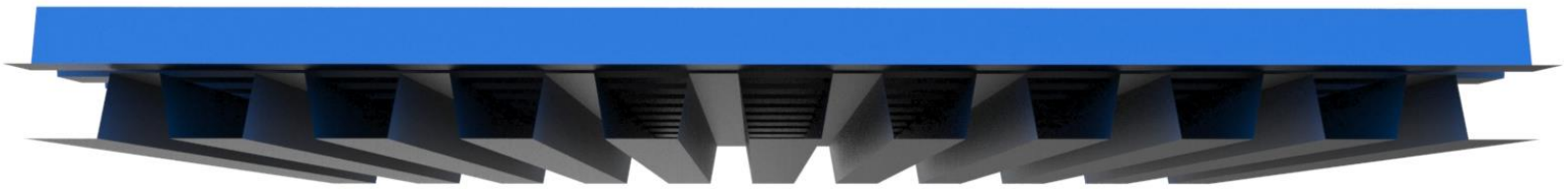
Anti vibration pad is cheap and durable as compared to the rubber dampers.

Scenarios

1. CCC Structure
2. CCC to CCC joinery
3. CCC to building joinery

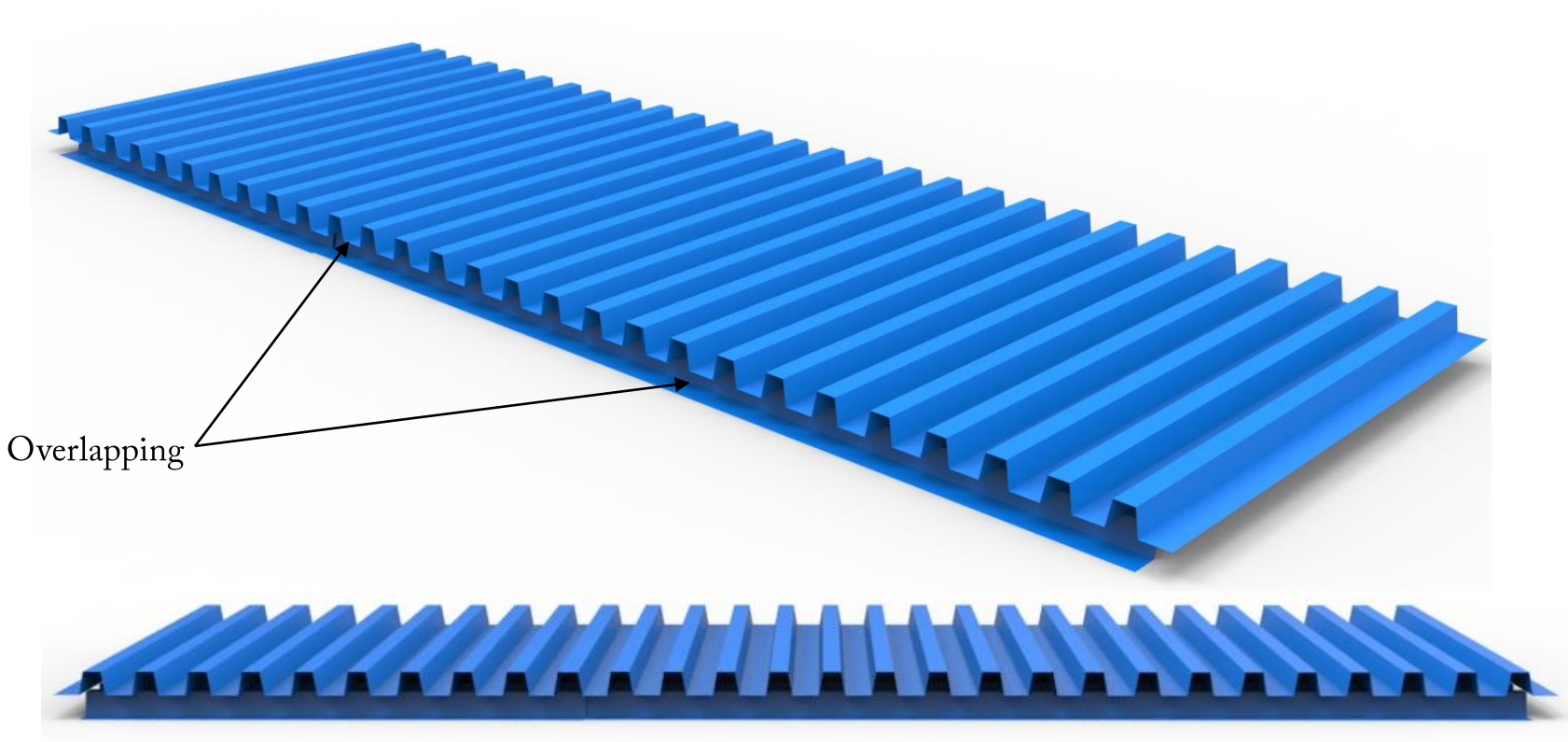
Scenario 1. CCC Structure





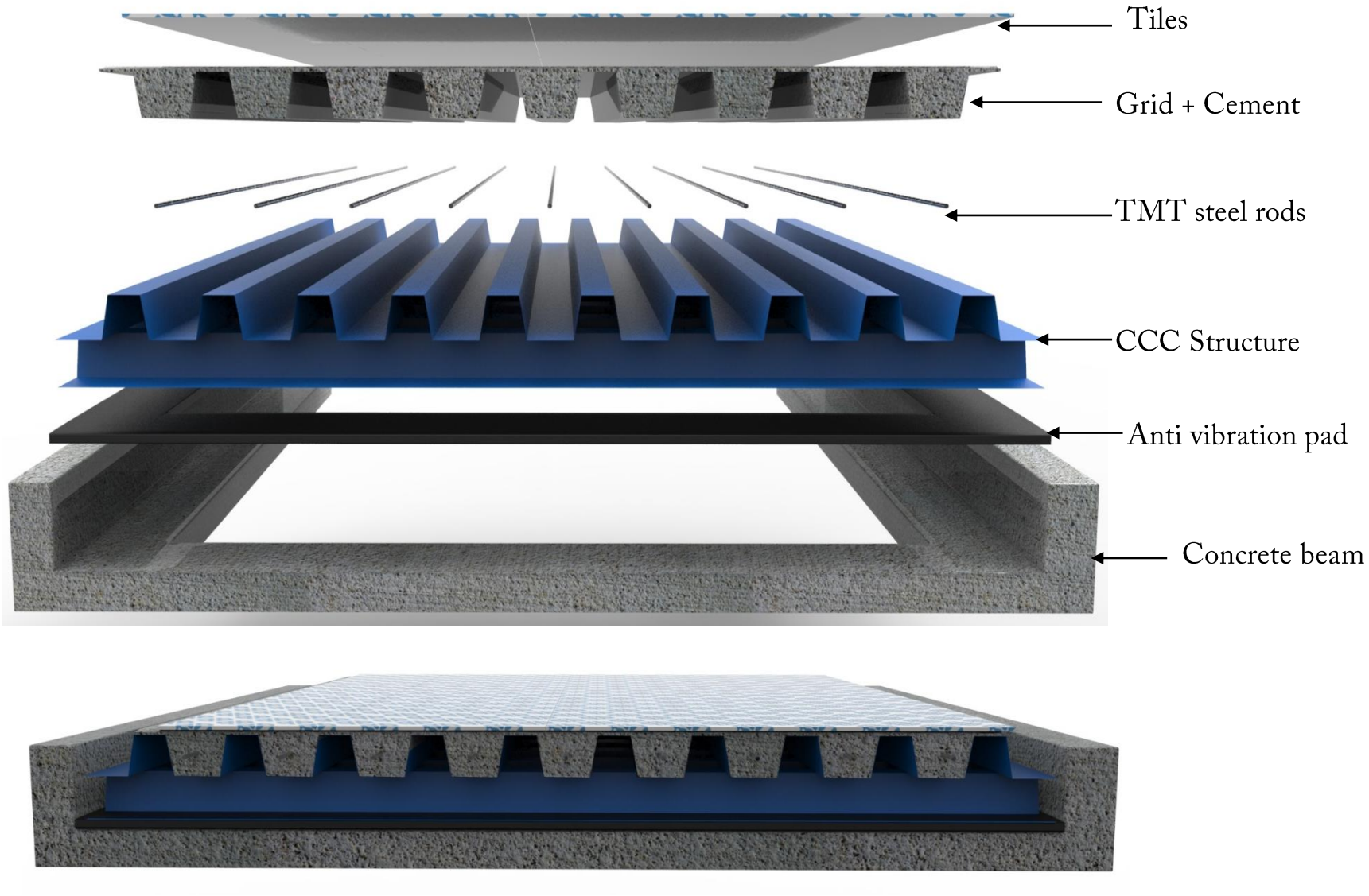
Total 6 corrugated sheets (3 above and 3 below) in a criss cross manner are used to made 1:1 size model. The arrangement provides gaps which can serve as ducts for number of piping, wiring, etc.

Scenario 2. CCC to CCC Joinery

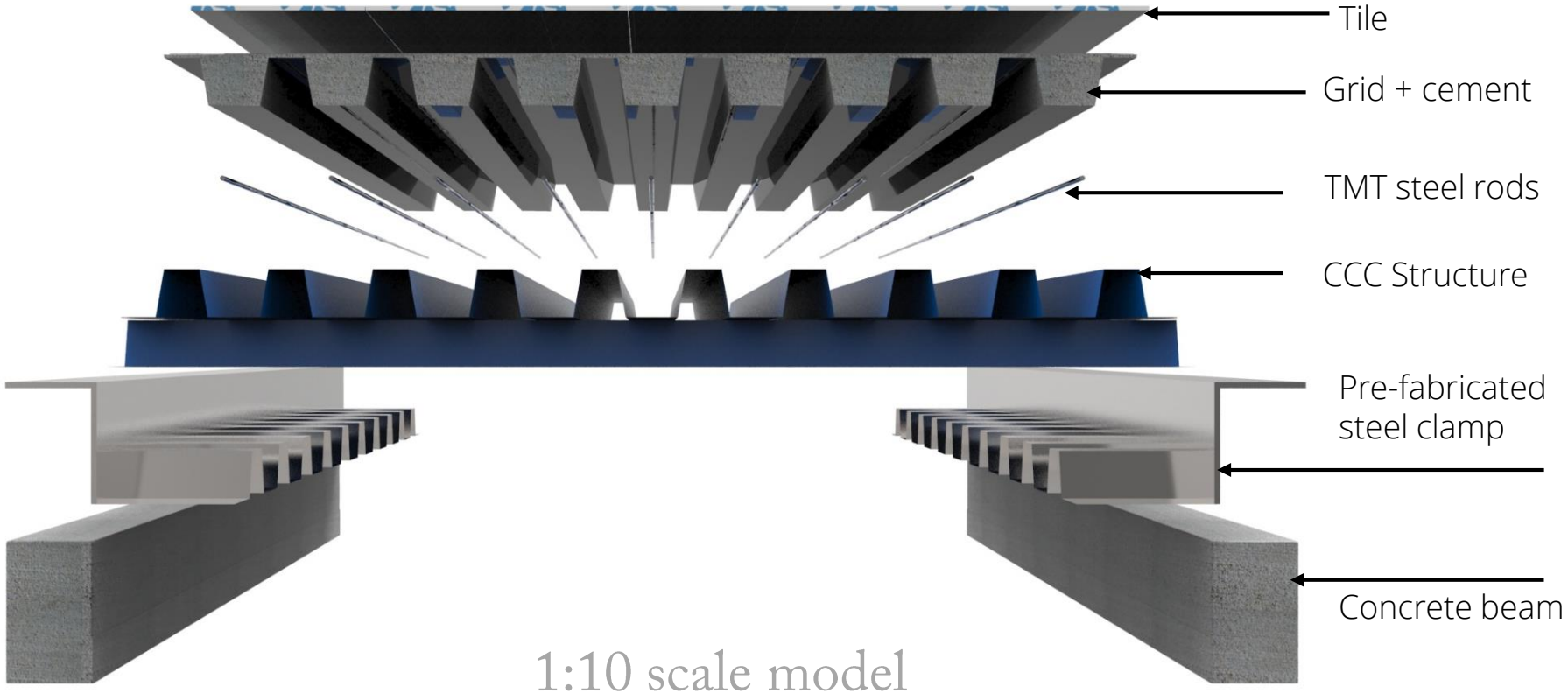


Scenario 3. CCC to building joinery

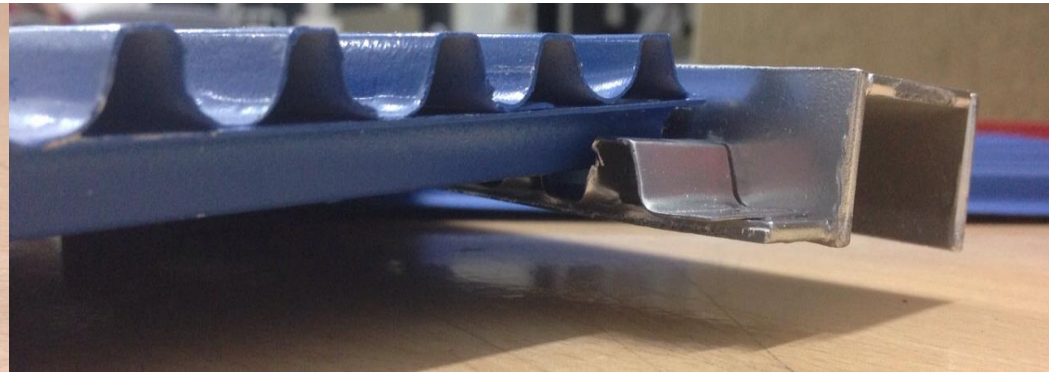
Concept 1's Exploded View



Concept 2's Exploded View

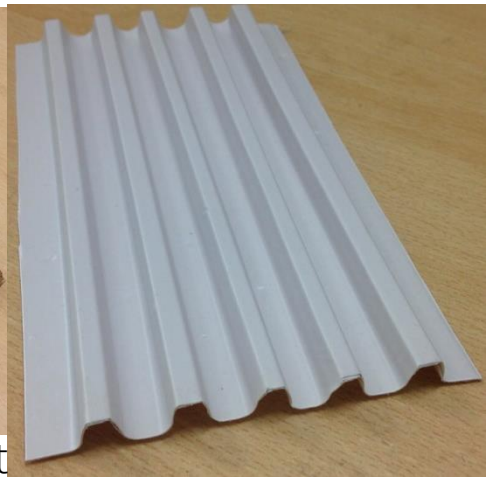


1:10 scale model

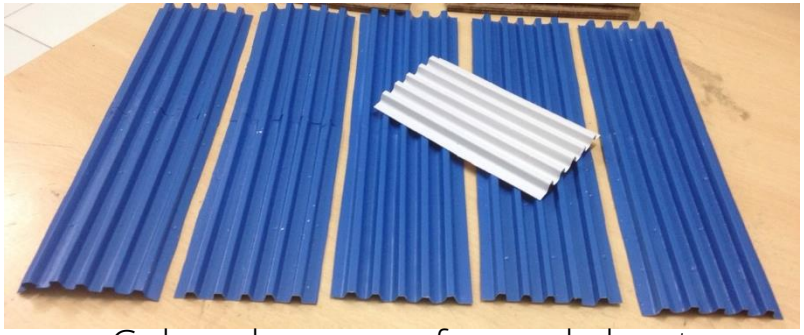


1:10 Scale model making

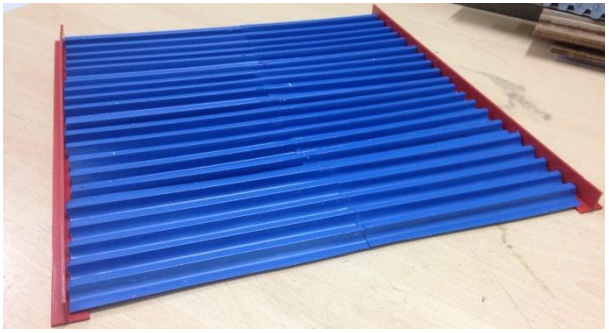
Mould



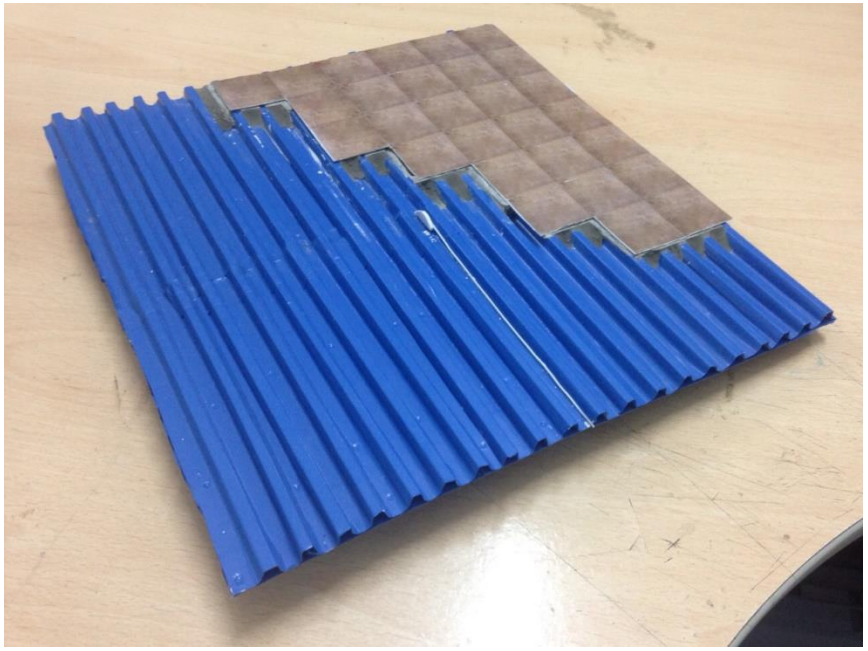
Mould with vacuum formed sheet



Colored vacuum formed sheet

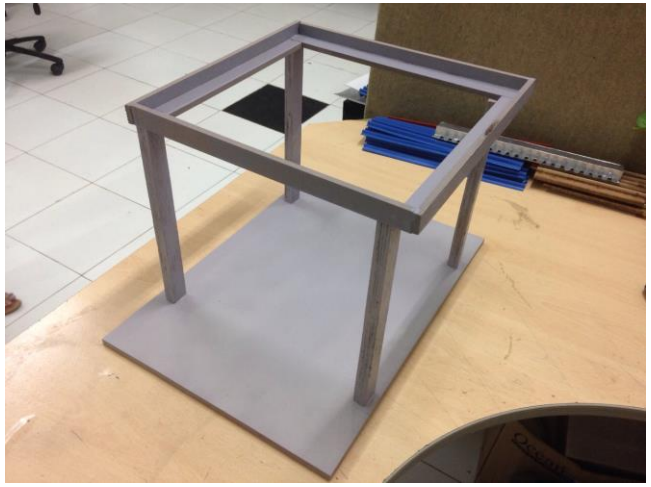


T section fixing details



CCC composite structure with details

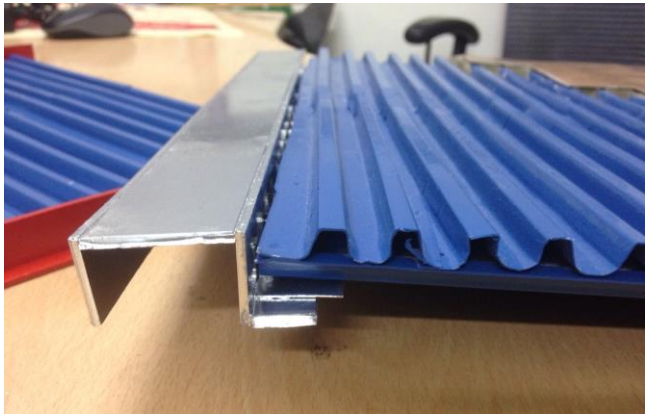
1:10 Scale model making



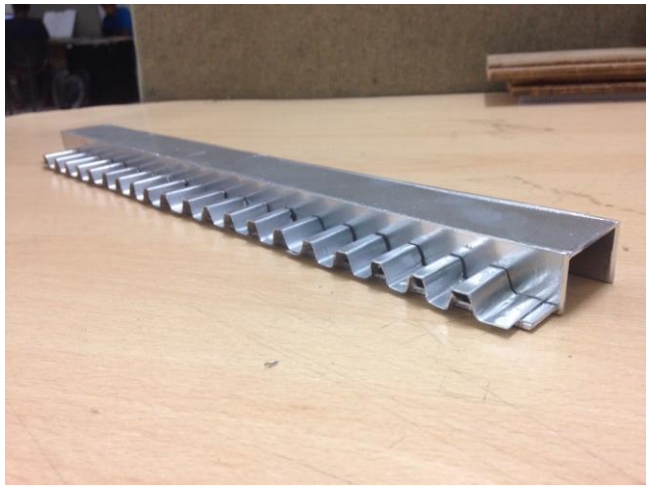
Concrete structure

Concrete structure with CCC

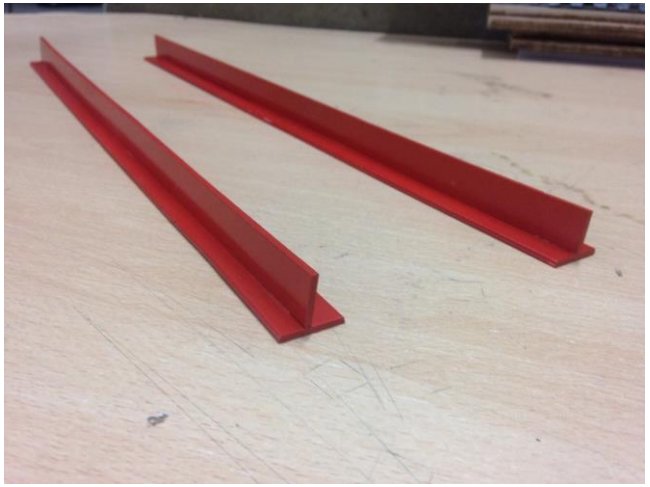
Fan hanging details



CCC beam support with CCC



CCC beam support



T Supports

Anchor

Thank You!!!