# Some Mechanics of Muon System

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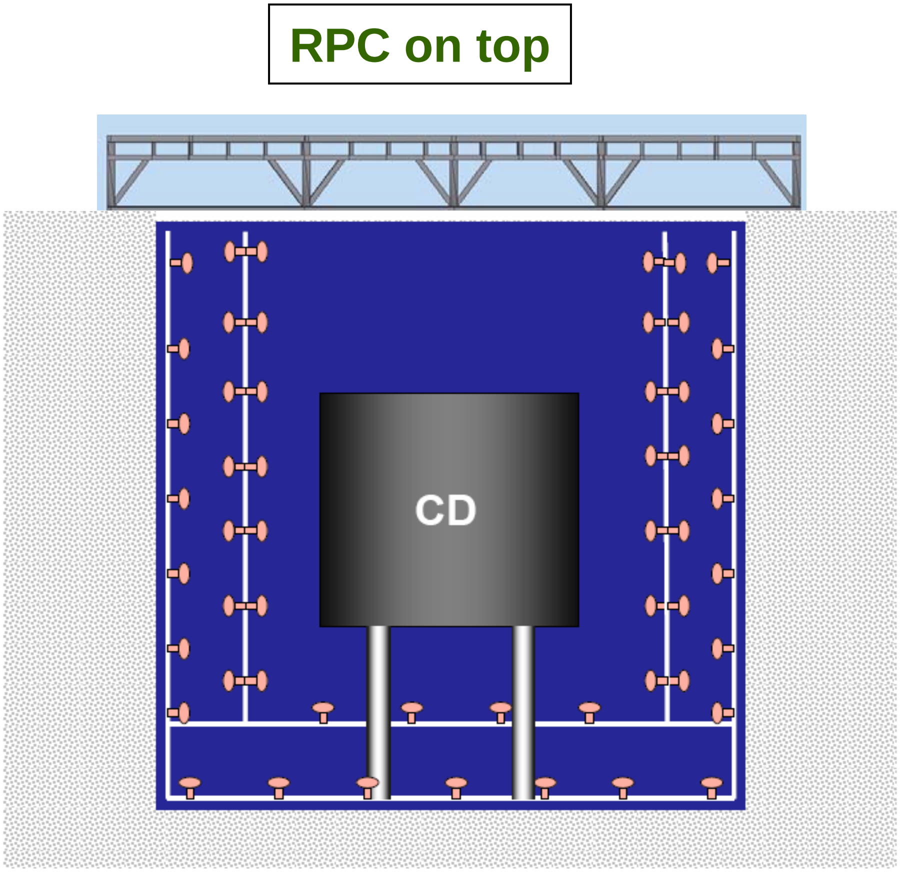
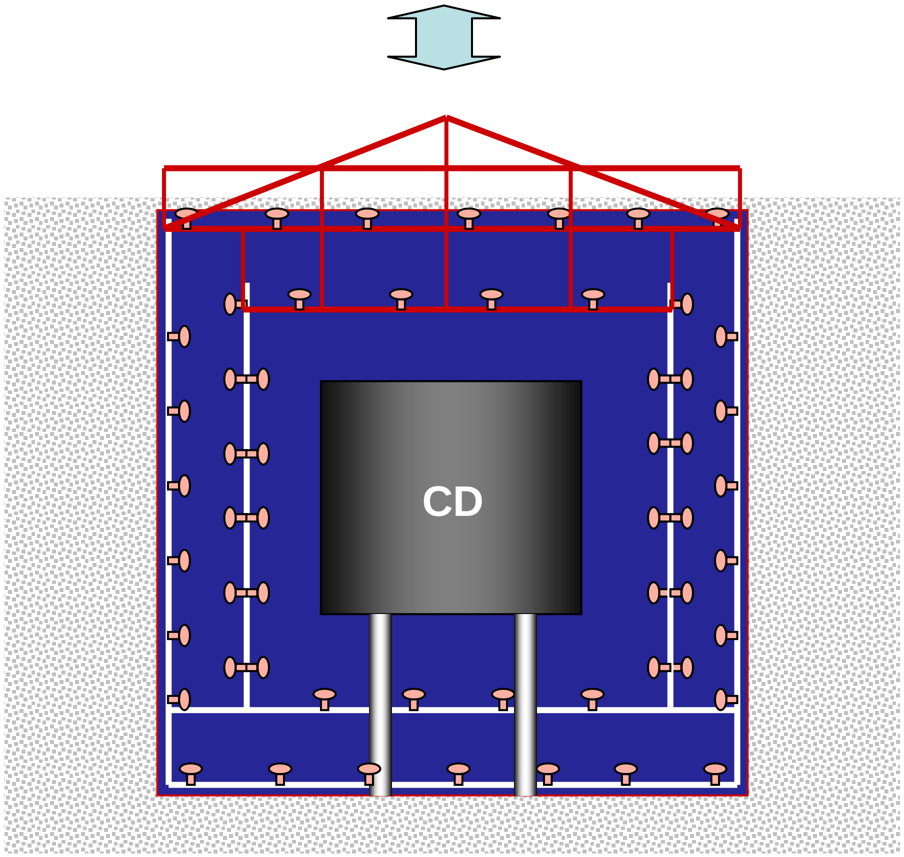
   Option 2: Water Cerenkov Based
4. Summary

C.G. Yang (IHEP)

HongKong, 13/1/2007

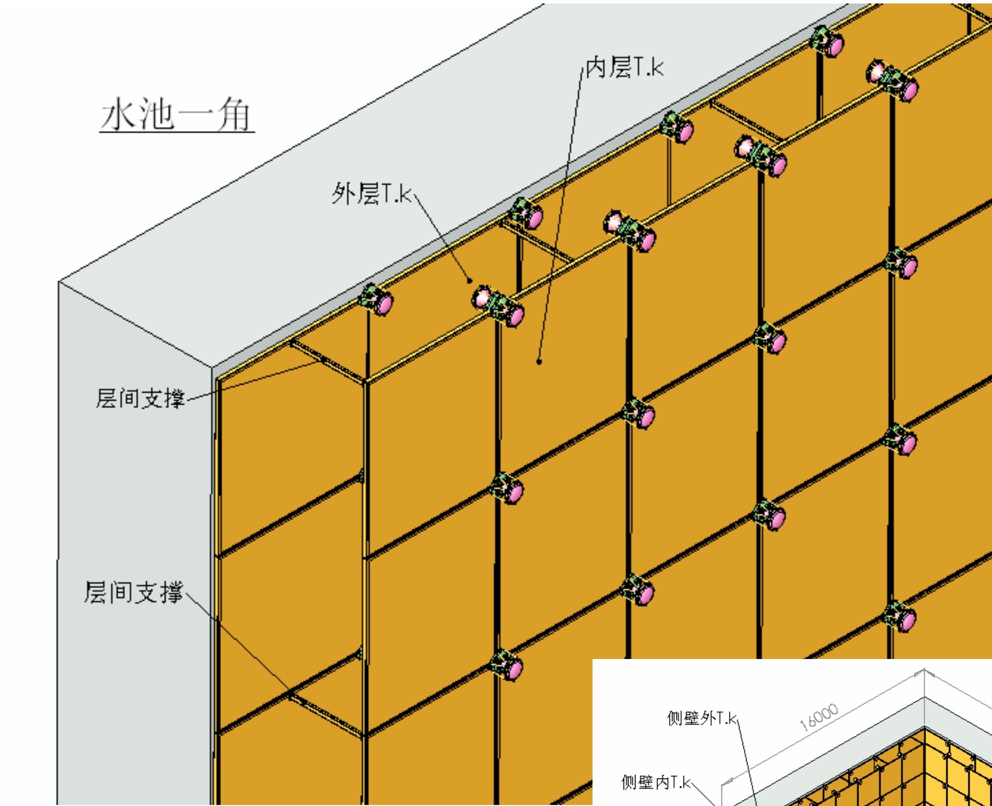
# 1. Introduction:
## - Muon System Mechanics

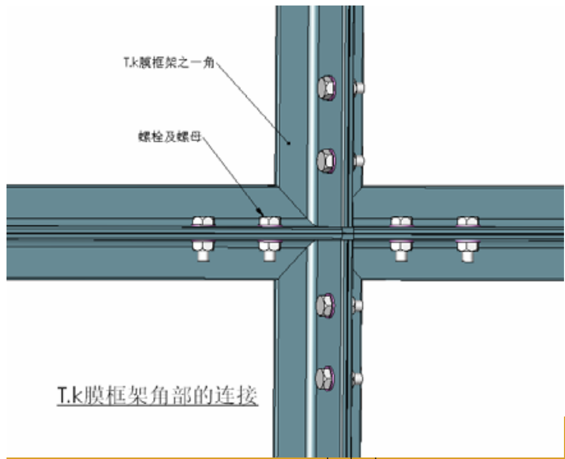


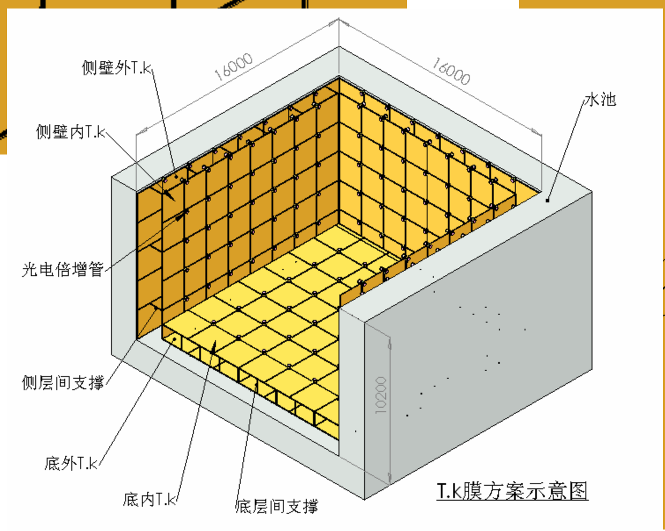



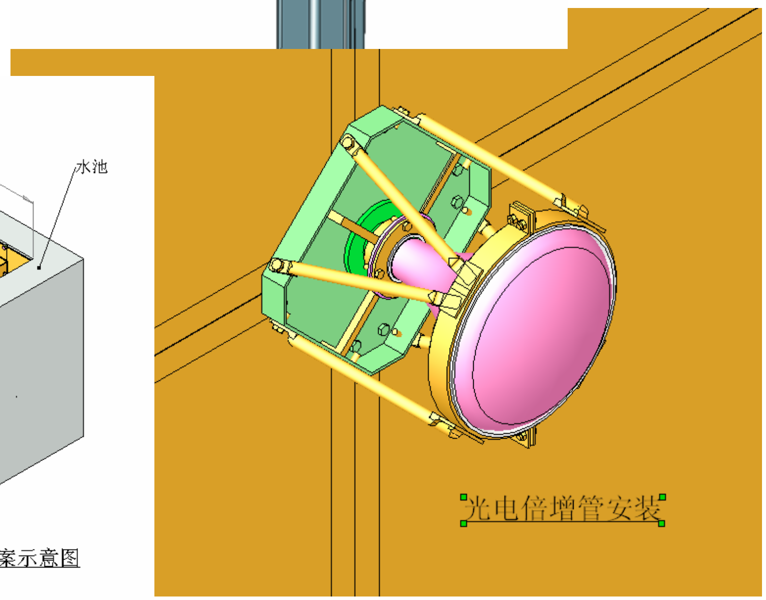
# 2. Support Structure In the Pool

## (4 side + bottom) (W.L. Wang)

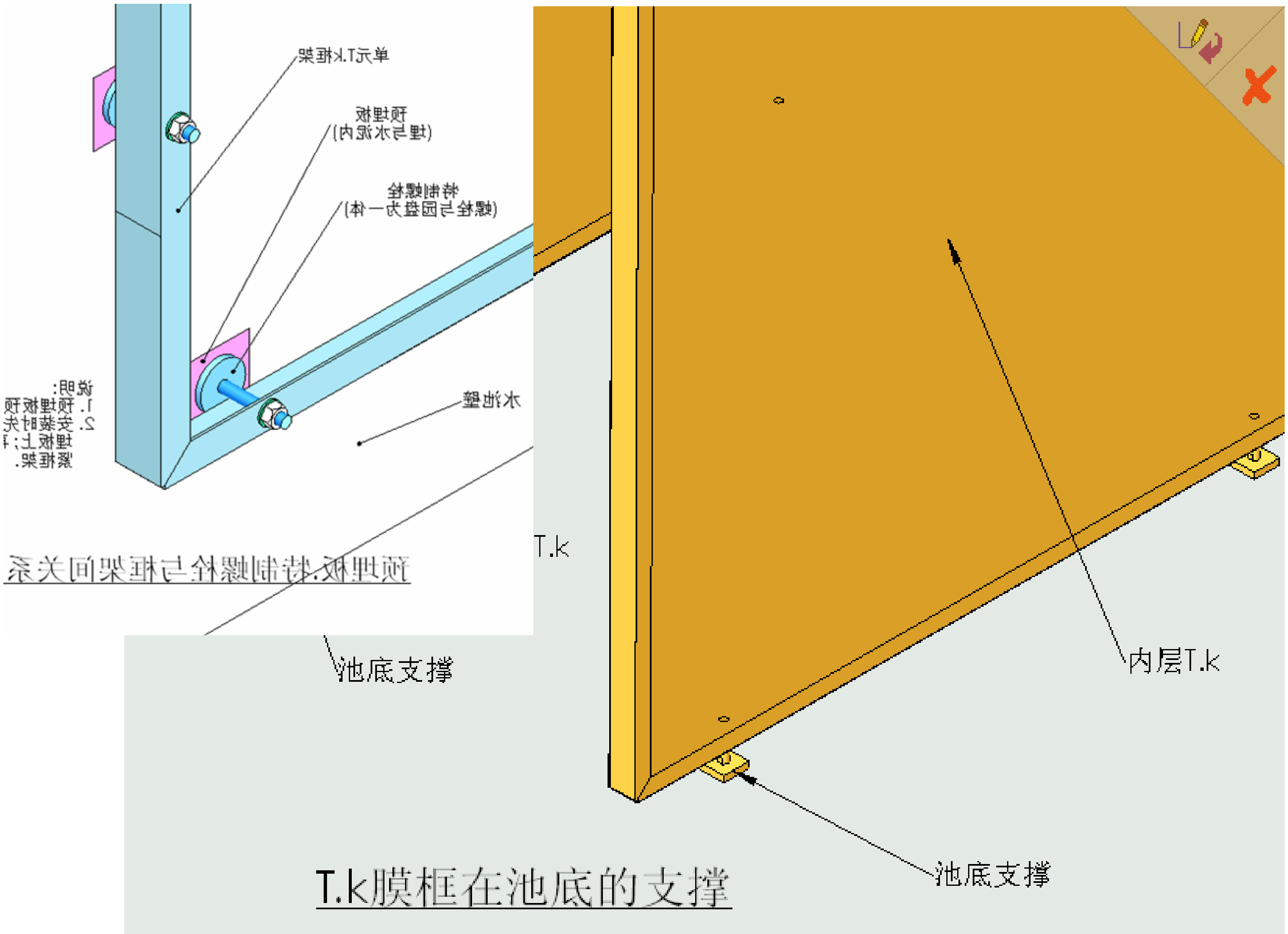


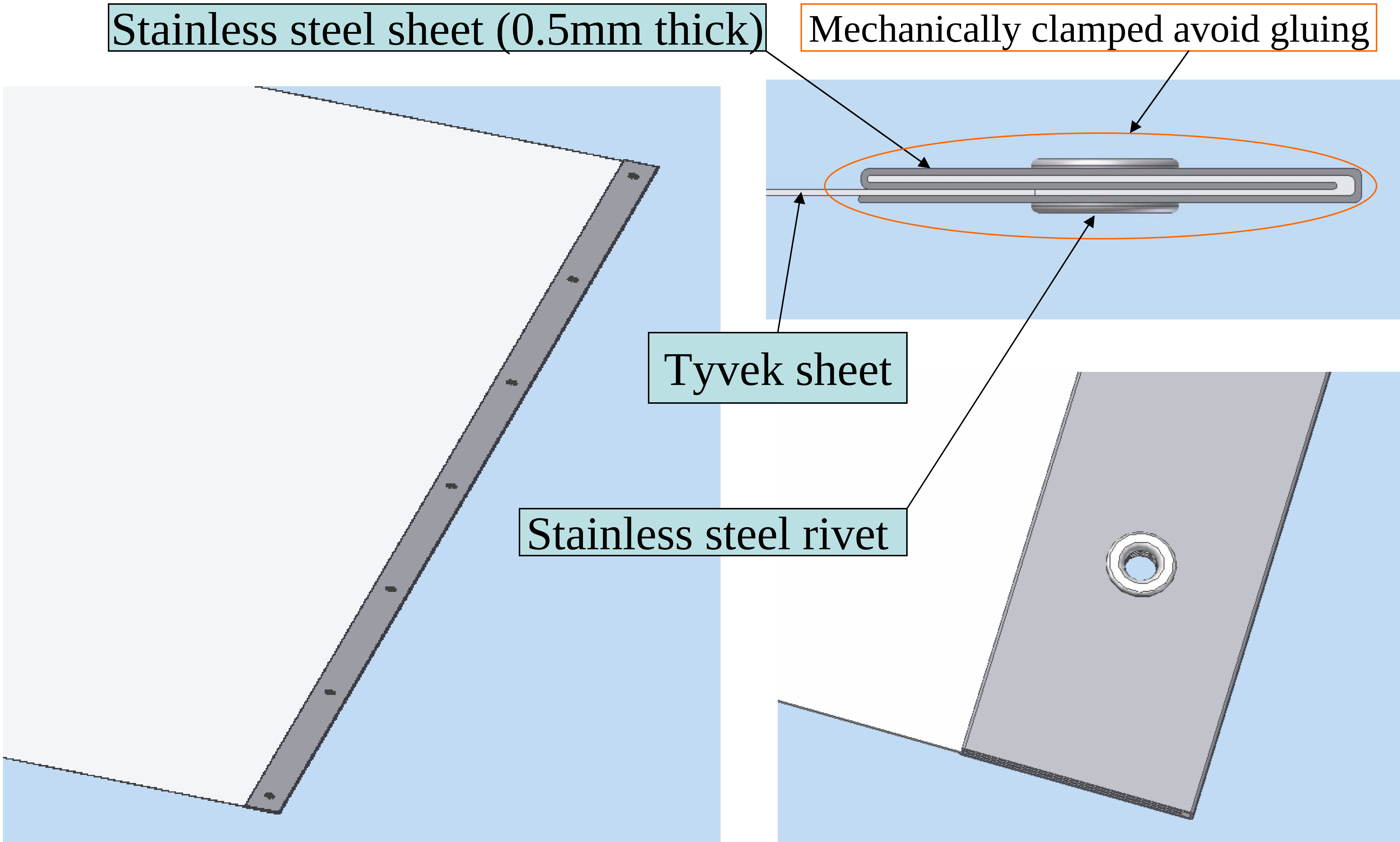



# Fixation of frame on the wall and floor

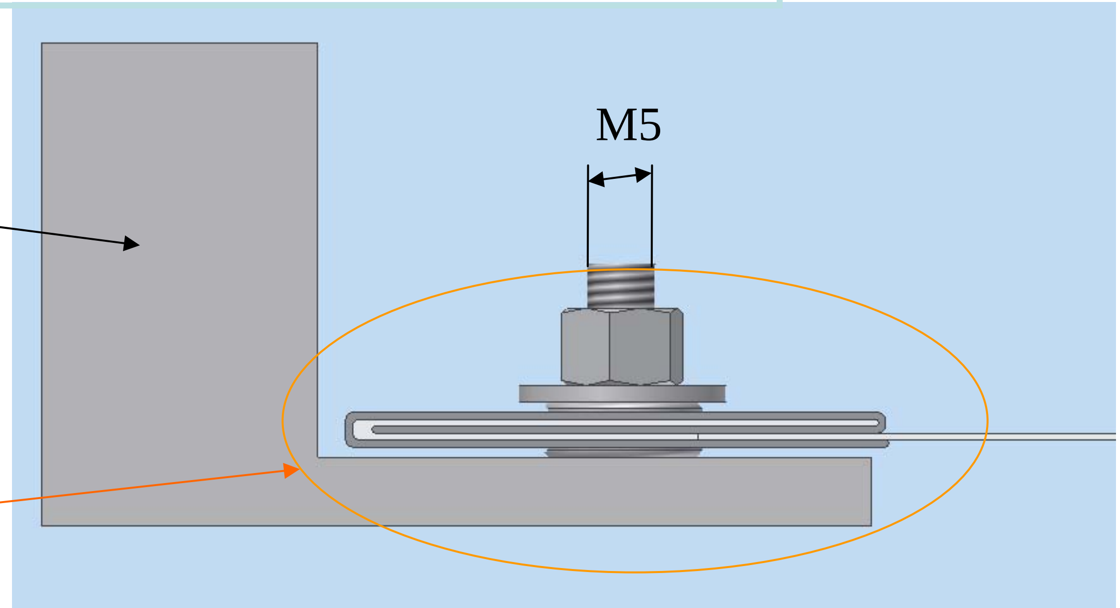


# Tyvek Assembly Unit (TAU)



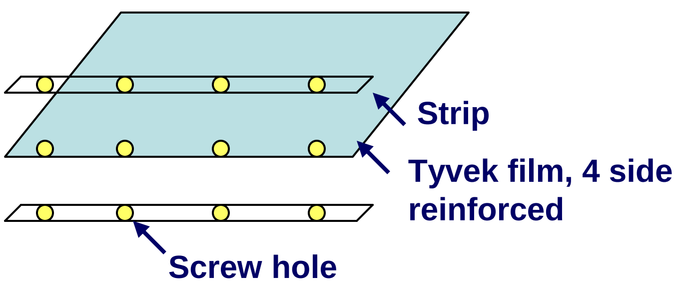
# One Option to Mount the TAU

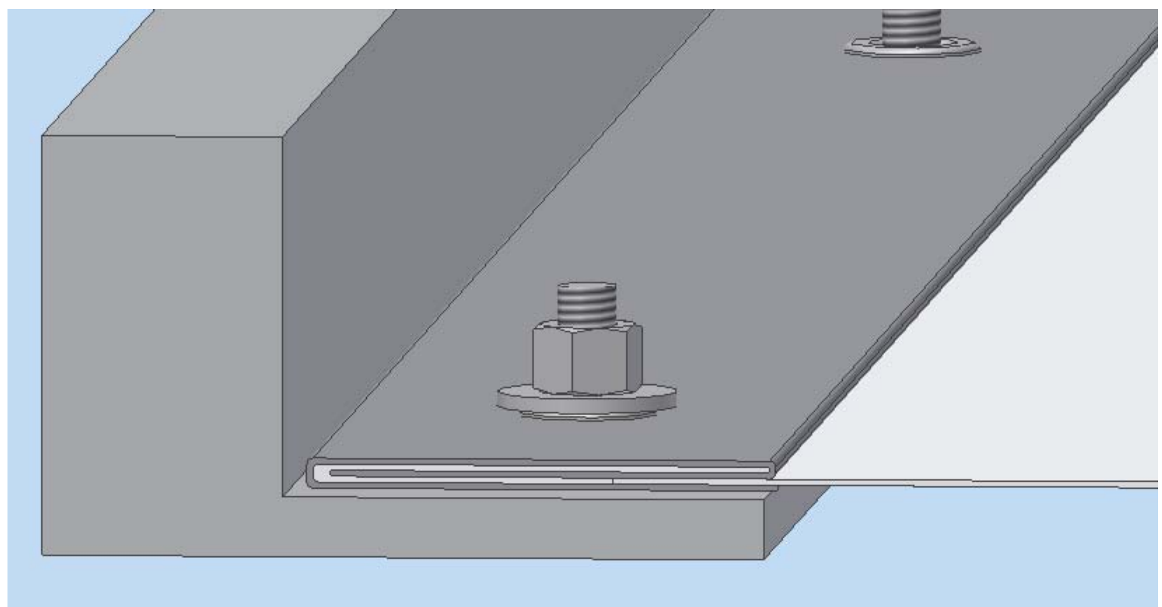
Main beam of the support structure



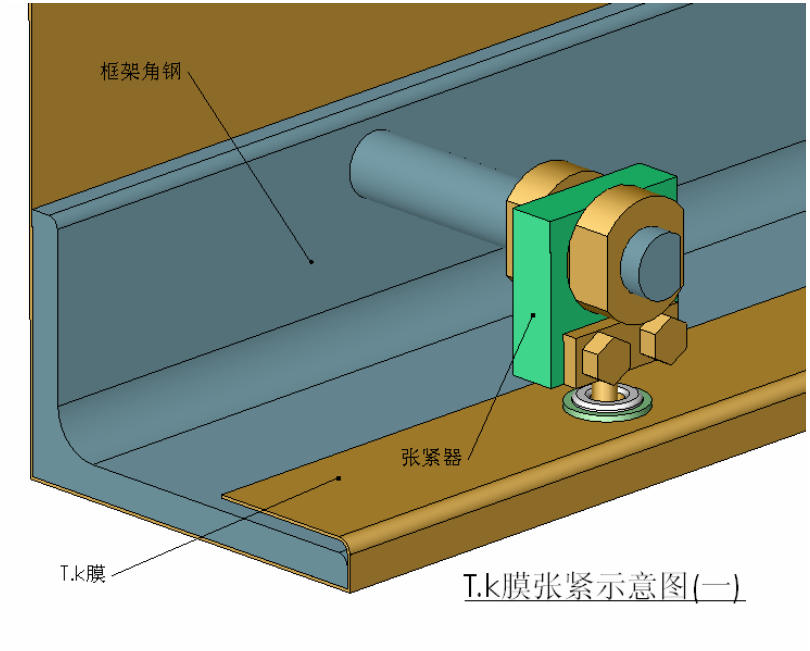

The TAU easy to be mounted and disassembled

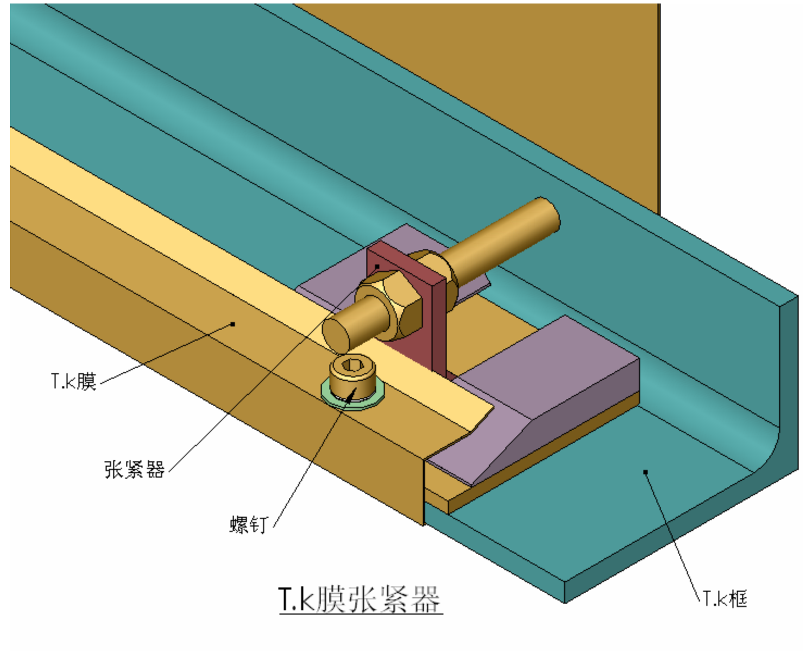
## Another option?



# Tyvek tighten unit

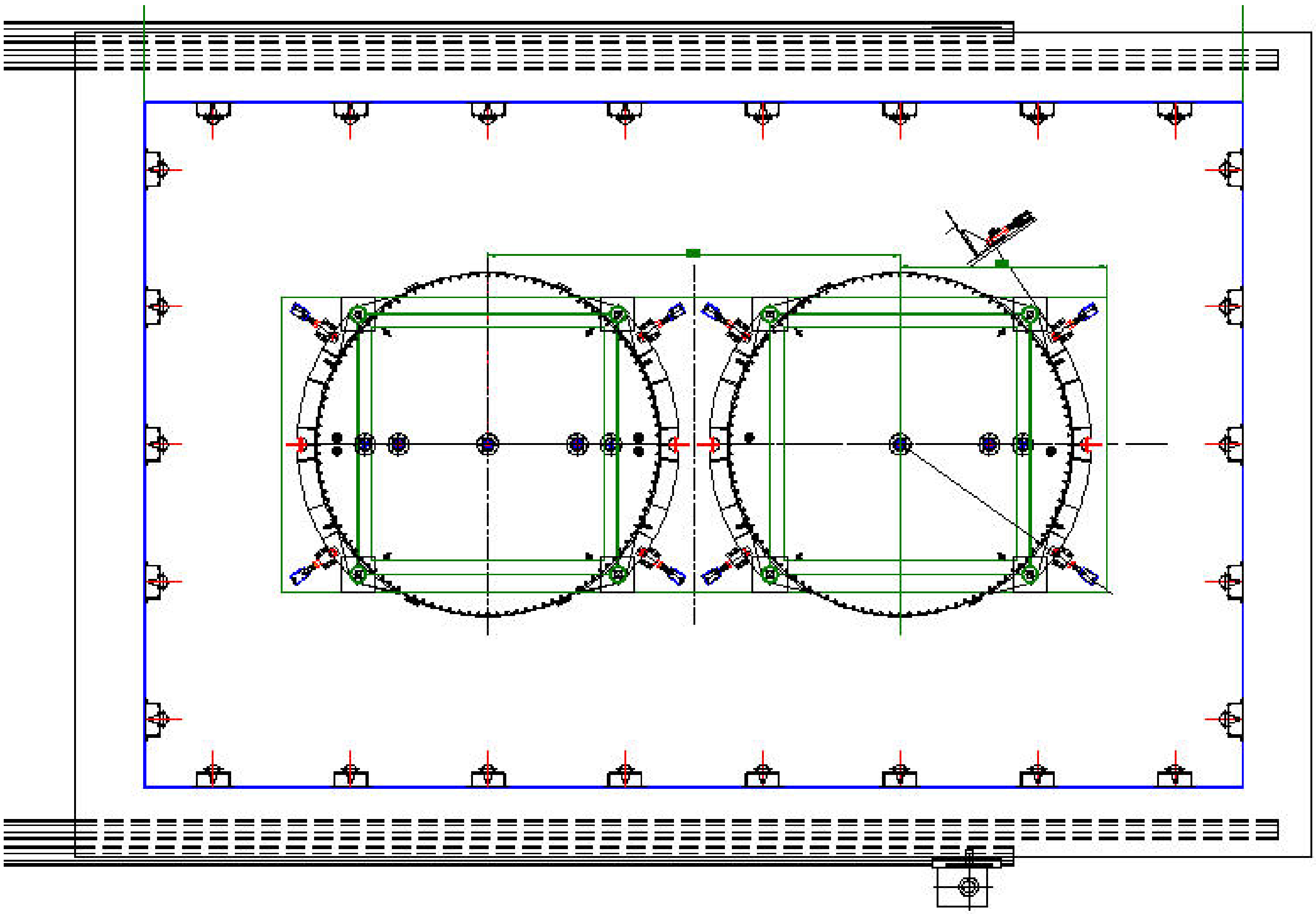


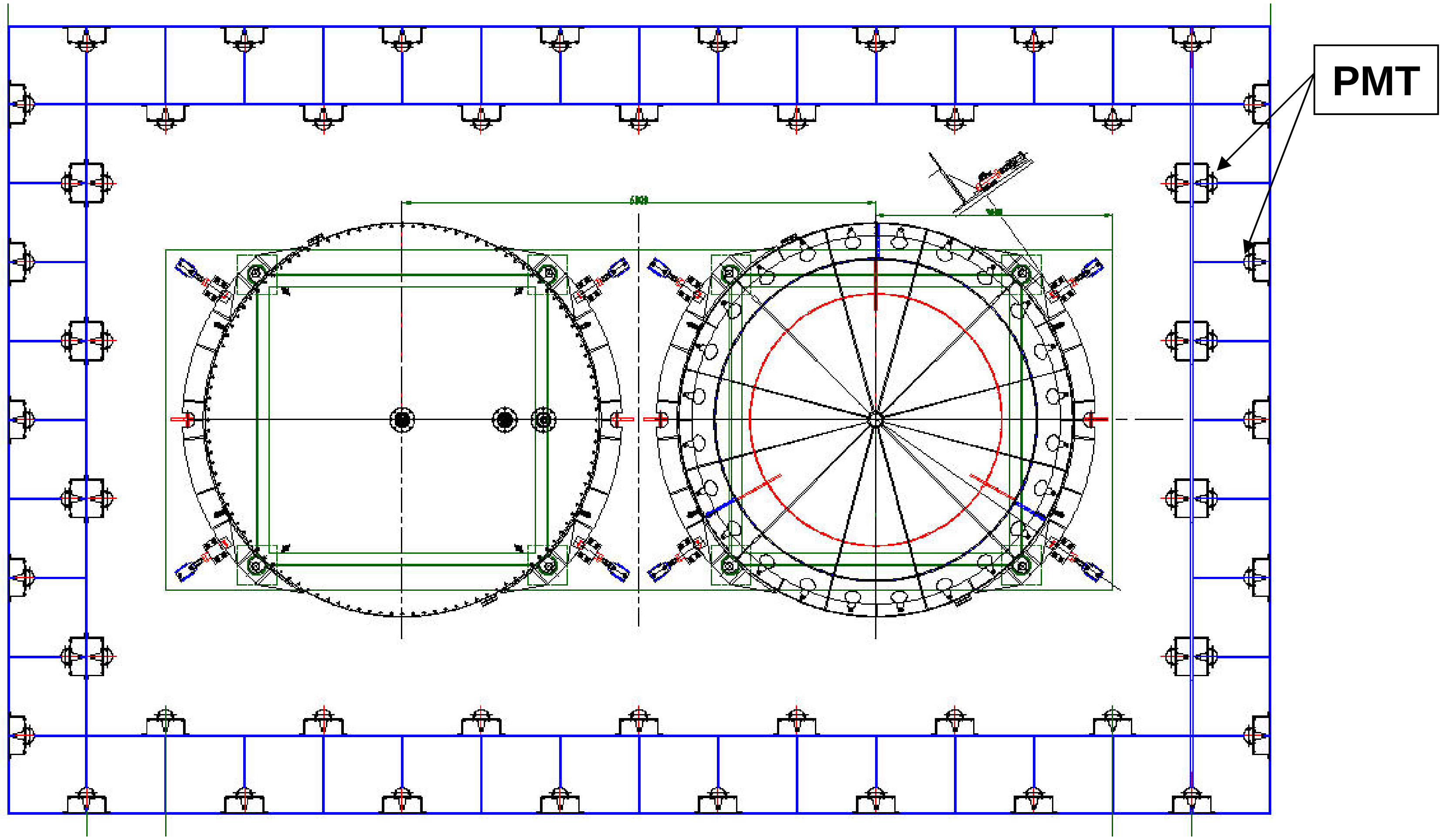

The "L" steel is 50mm x 32mm x 3mm. Other shape, like use 20 mm square steel (thickness 2mm), will save steel, but is it strong enough for the inner support structure?

# Support structure in pool (X. Liu)

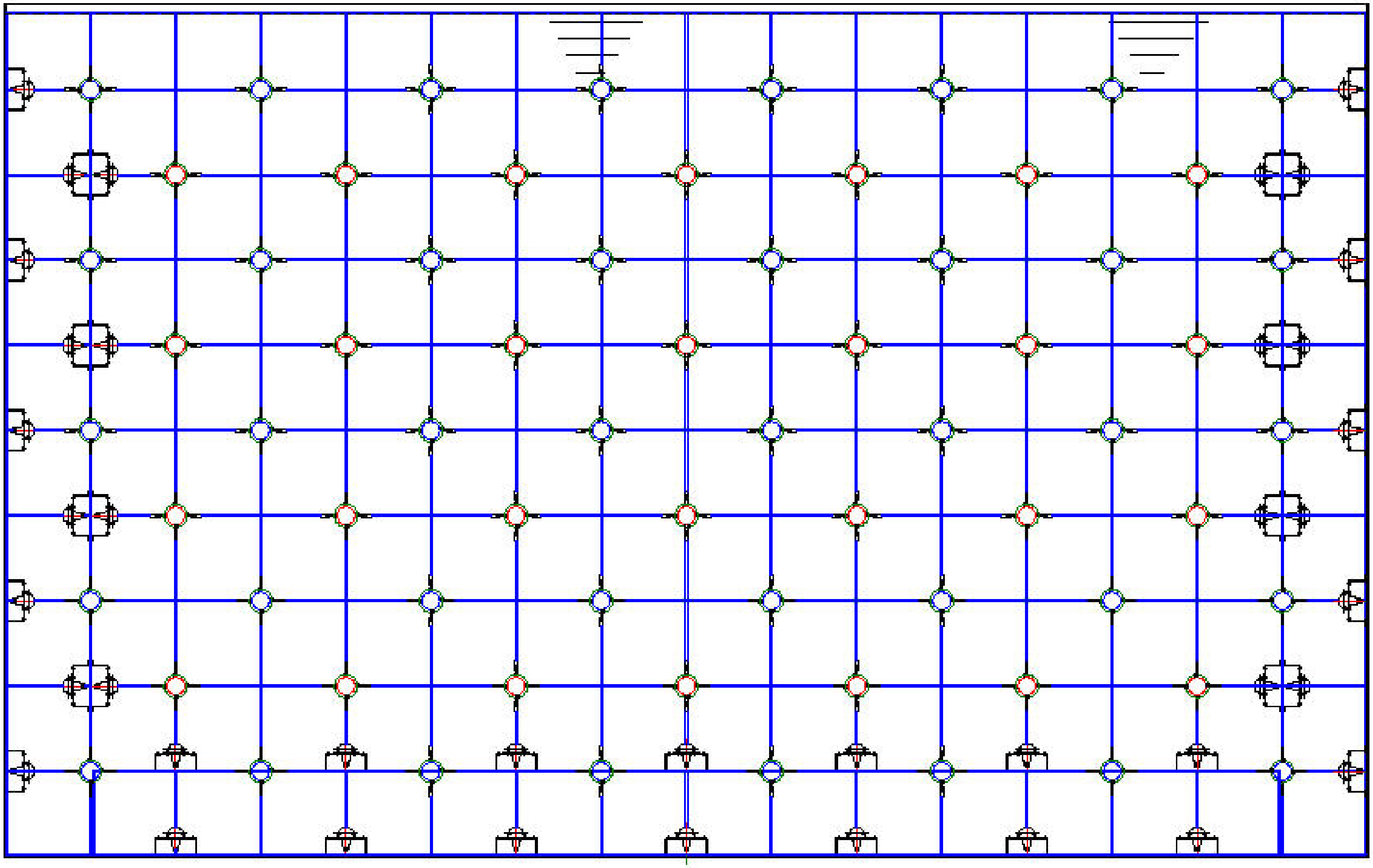
1. One layer of PMT



# 2. two layers of PMT



# PMT arrangement on side wall in pool



**Put PMT in a grid shape structure will be able to allow inner zone and outer zone have same density of PMTs**

# Mechanical Structure Cost in the Pool

## -- Structure frame only

## Estimation 1 (W.L. Wang, assemble in the pool):

**Outer zone: Square shape steel: 20X20X2 mm, Steel: 1.5 t, Cost: 67.5 ky, Production: 54 ky, Total: 121.5 ky**
**Inner zone: "L" Steel: 50X32X3 mm, Steel: 1.08 t, Cost: 48.6 ky, Production: 38 ky, Total: 86.6 ky**
**3 Pool: ~ 200 ky (near site) X 3.4 = 680 ky**

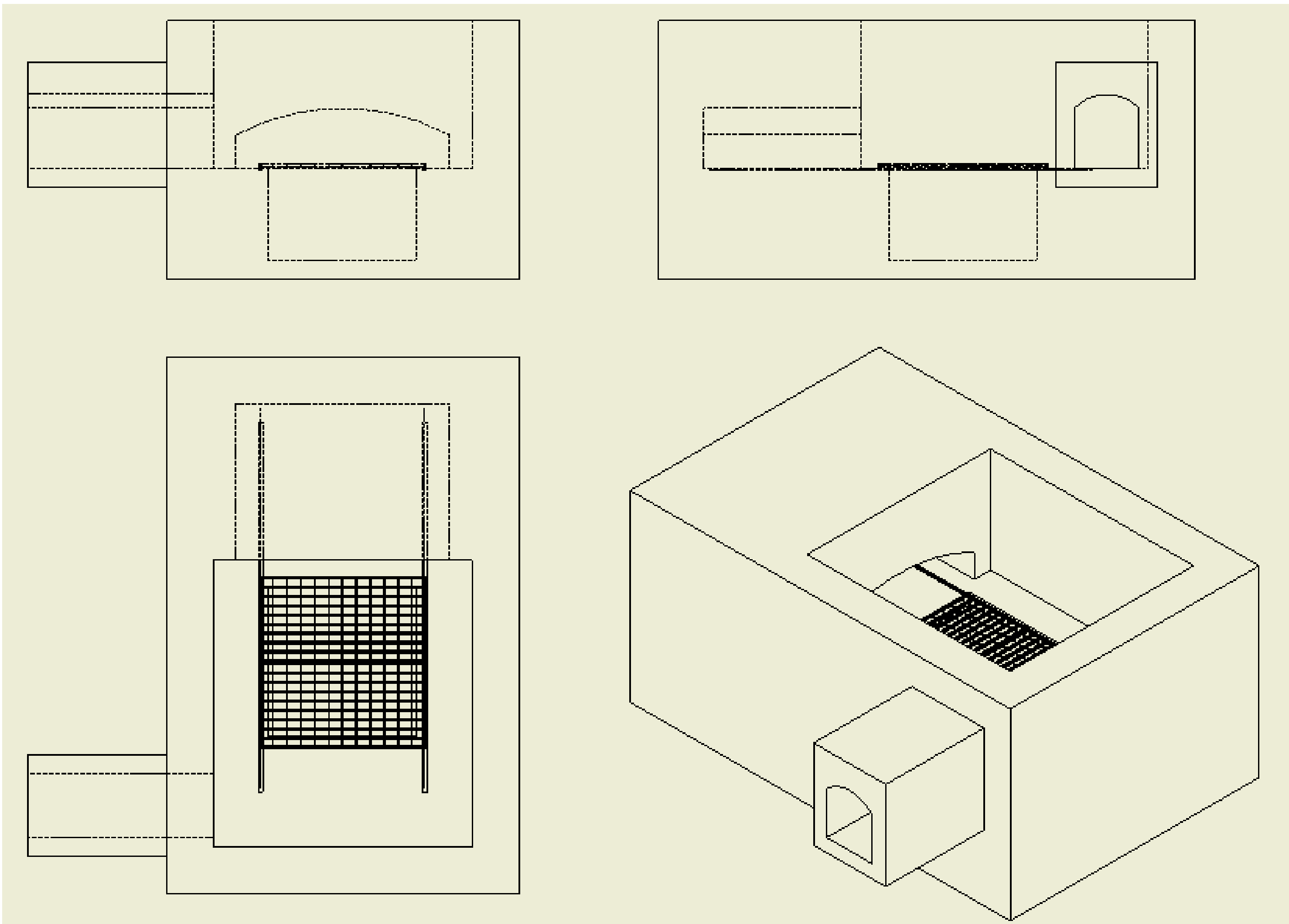
## Estimation 2 (X. Liu, soldering in the pool):

| | | Unit | 2 layer PMT | 1 layer PMT |
|---|---|---|---|---|
| | Steel length | m | 4074 | 958 |
| | Raw steel Cost | Ky | 136 | 32 |
| | Cost | ky | 273 | 64 |

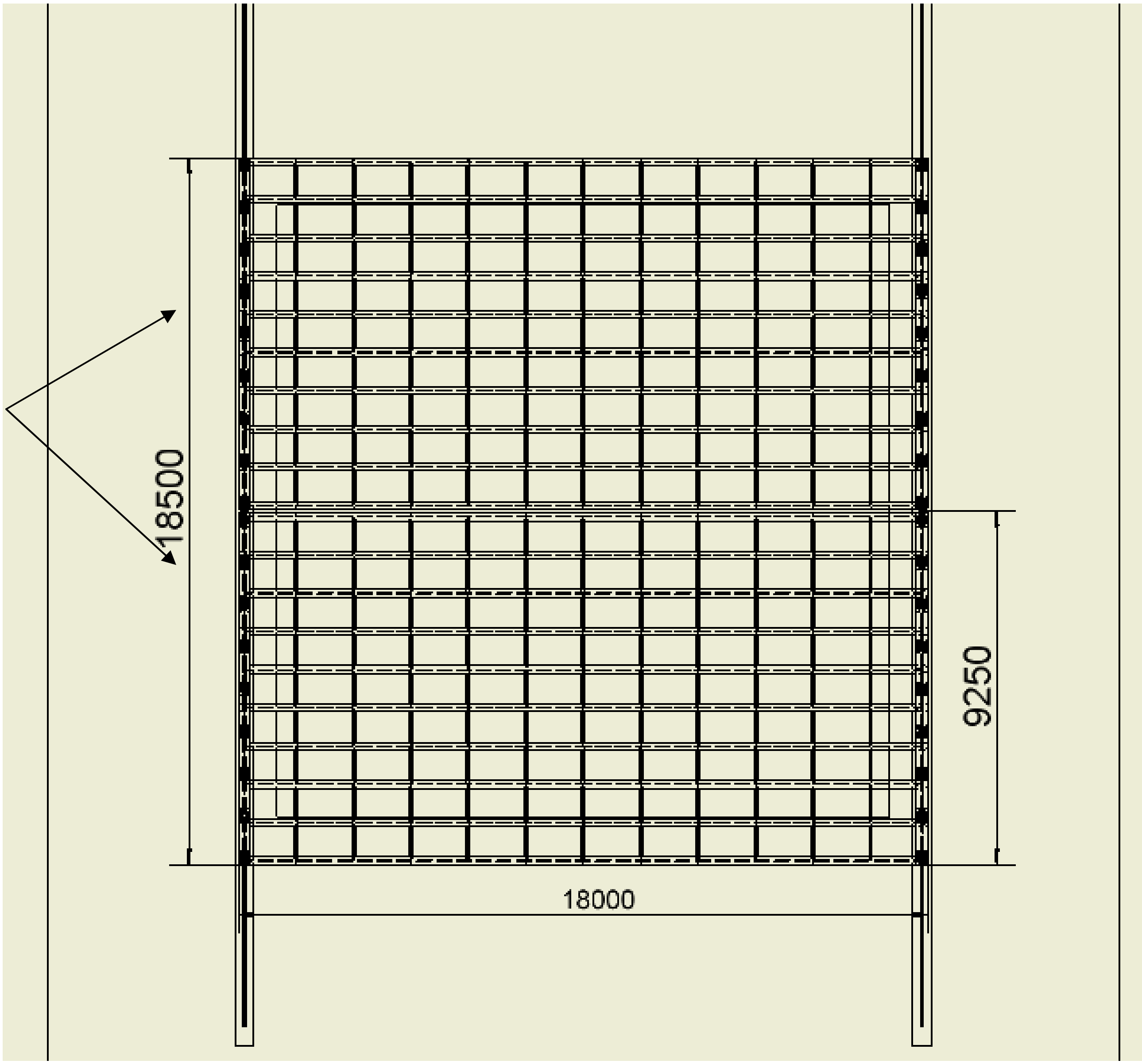
More investigations are needed. Fixation in the pool, Tyvek film fixation also have to include. We also need to balance how to transport? Where to assemble it? Soldering in factory or locally?

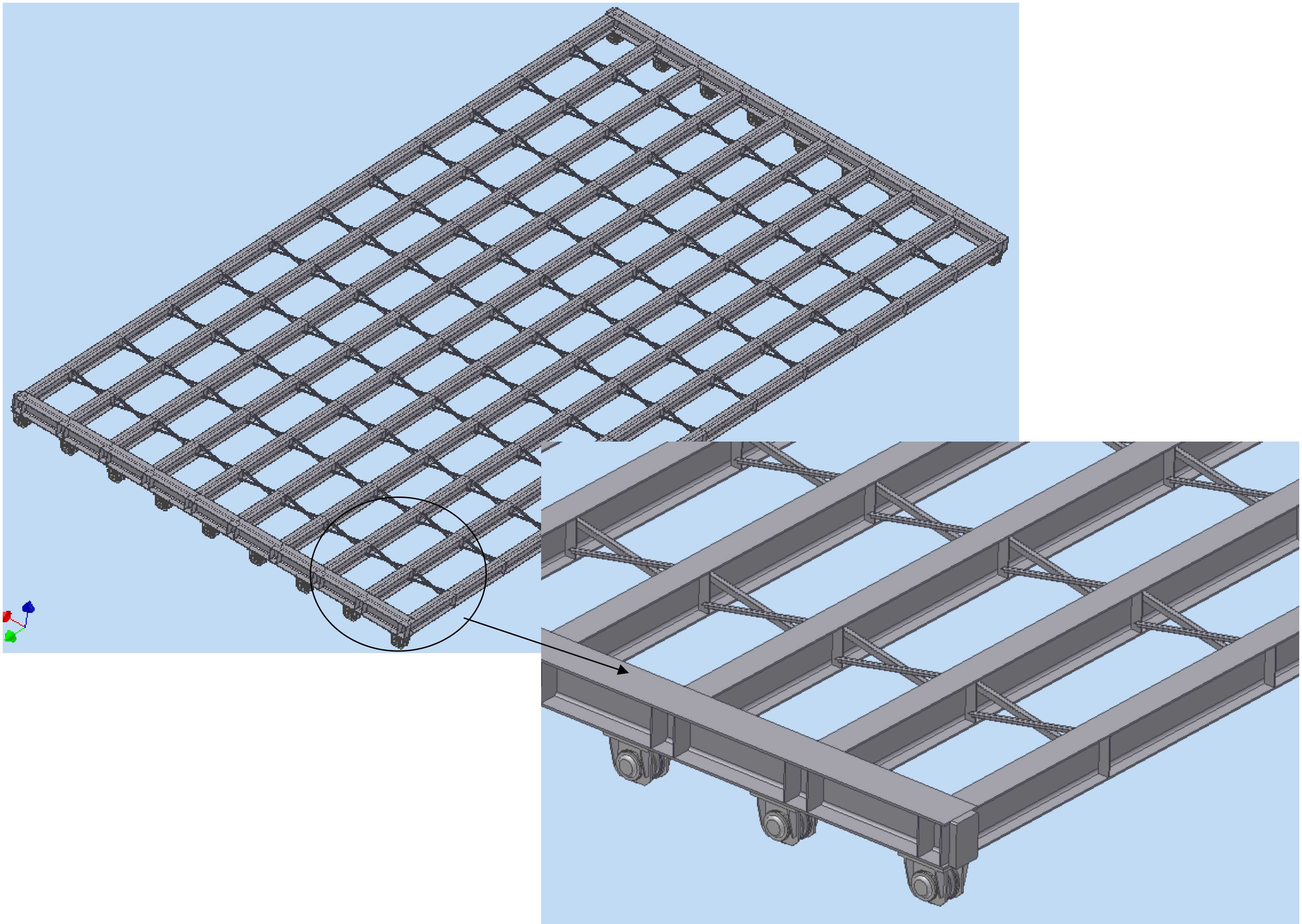
# 3. Support Structure on top

## - Option 1: RPC Support

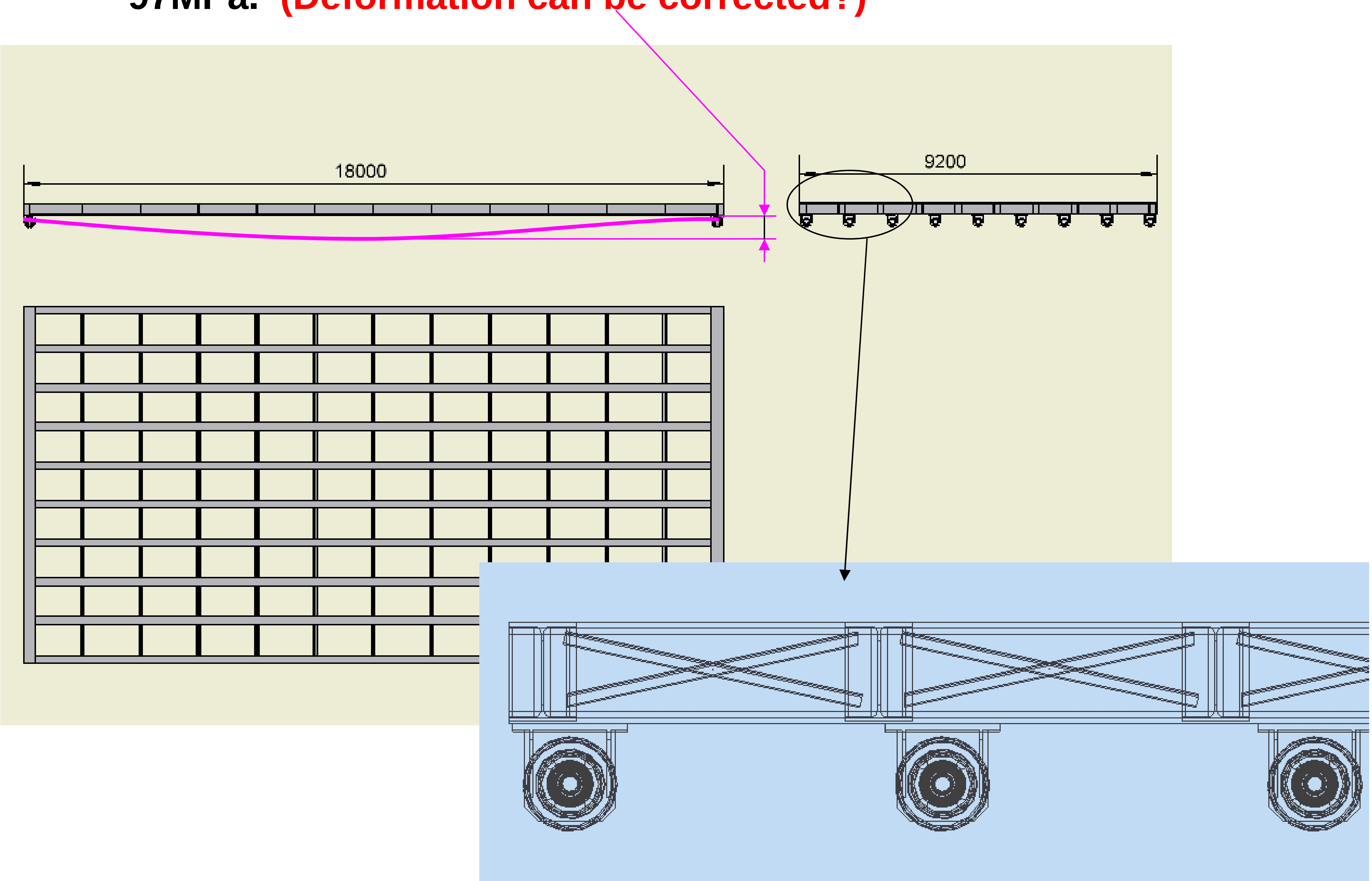


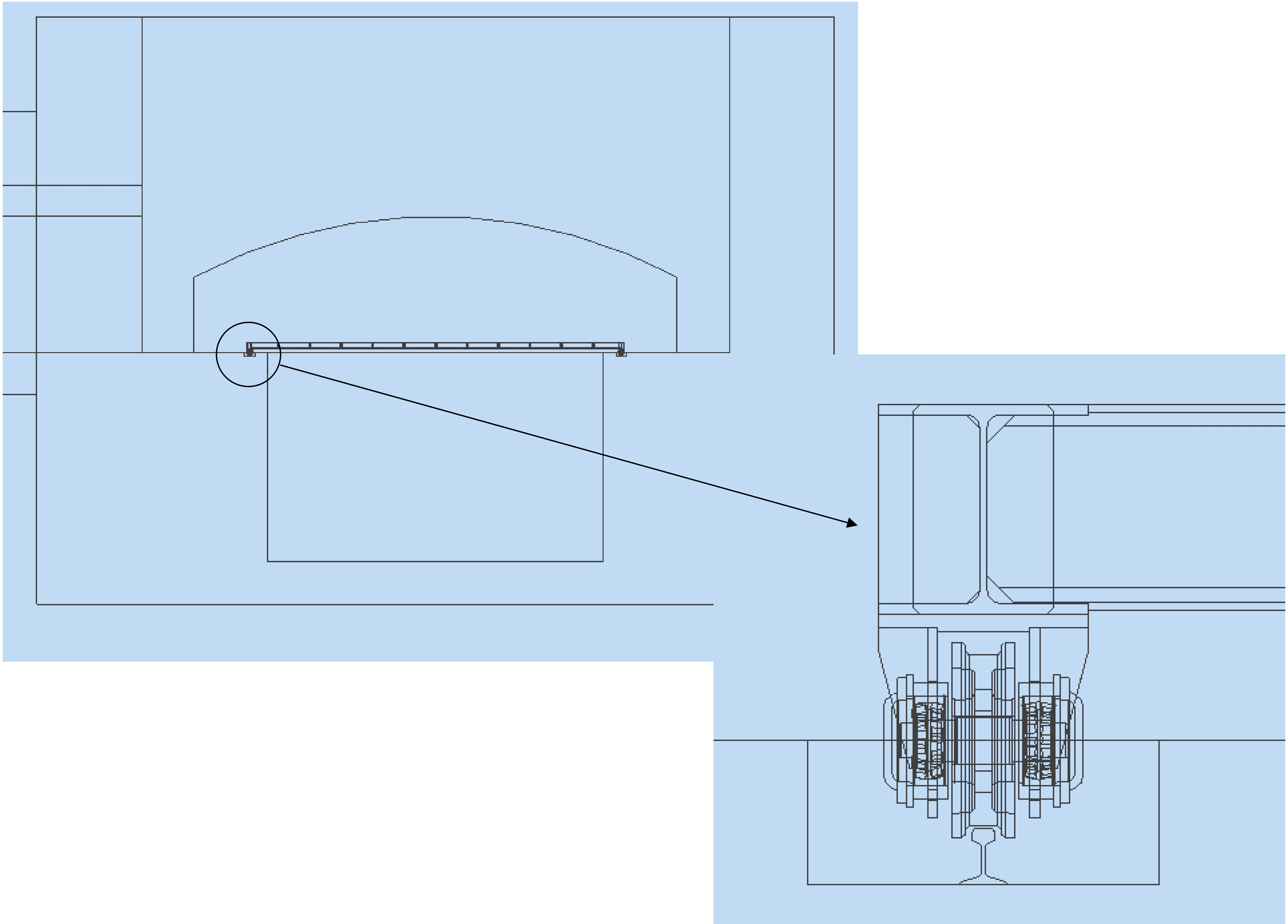
# Design A: Flat top

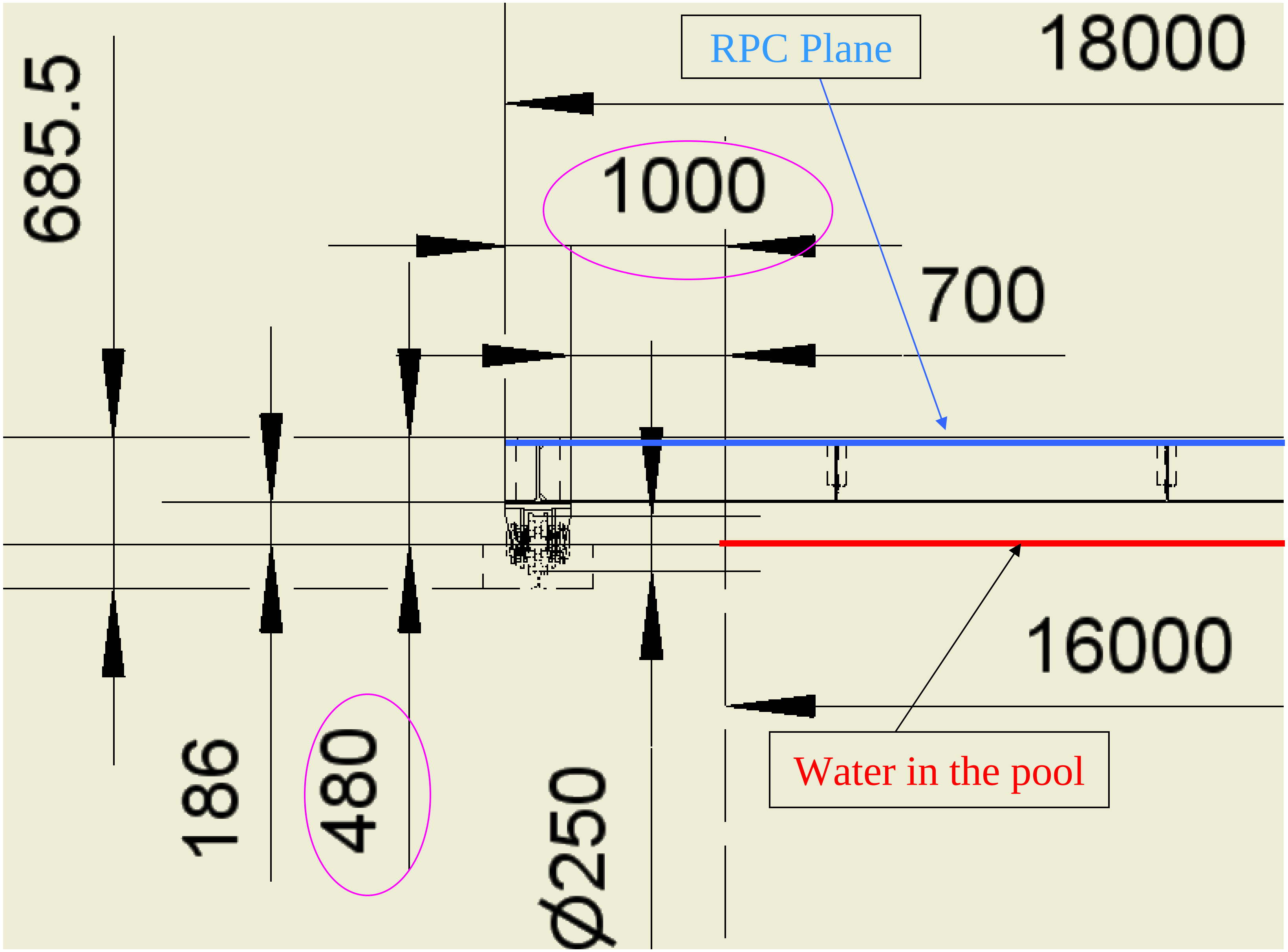




**Max. deformation under full loading :109mm. Max.Stress: 97MPa.** **(Deformation can be corrected?)**



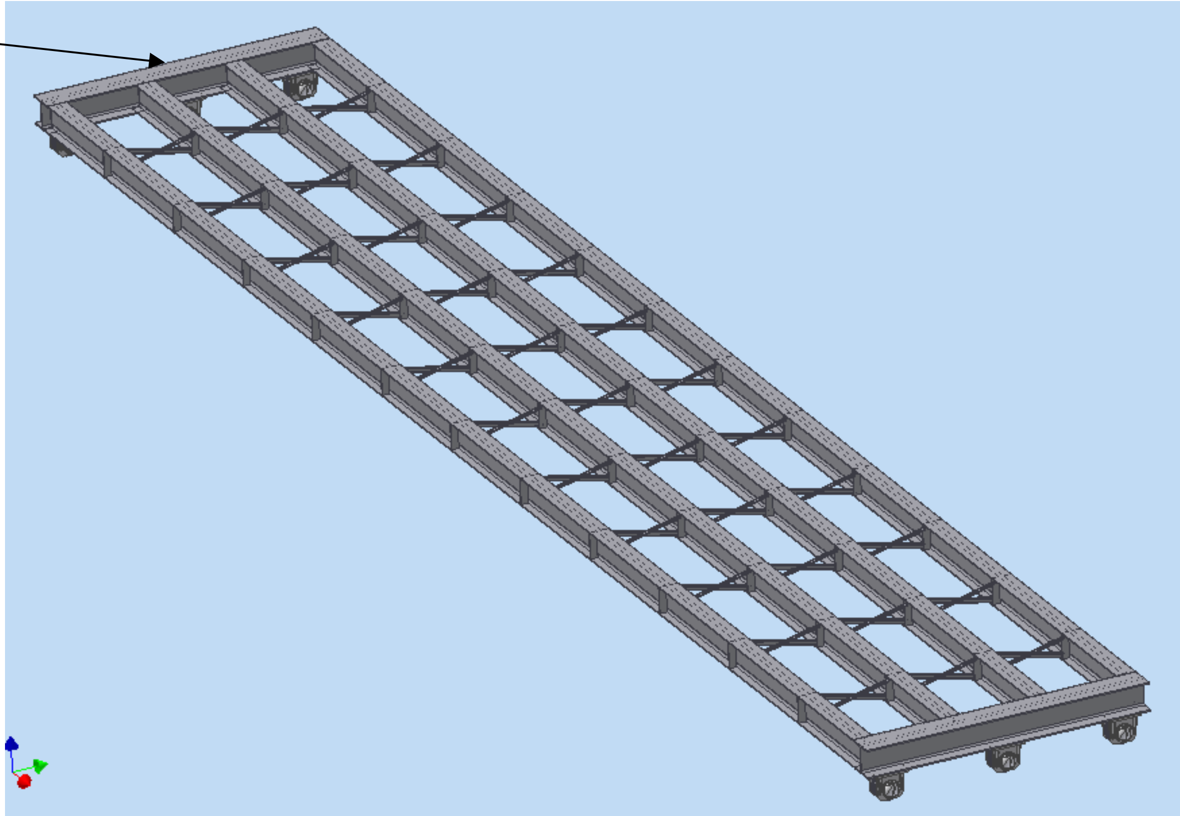




RPC Plane
18000
685.5
1000
700
16000
Water in the pool
186
480
Ø250

If large support structures can’t be welded in the hall due to the limitation of the space, it can be realized by cutting it in a few smaller parts as following :

Change width to :3-4m. Then connect them as a whole by welding or bolted joint.



# Basic Calculation and Selection of the structural steel – specs of I beams

Simple beam

span

Max. stress

Max.deformation

Volume of steel

两端简支梁

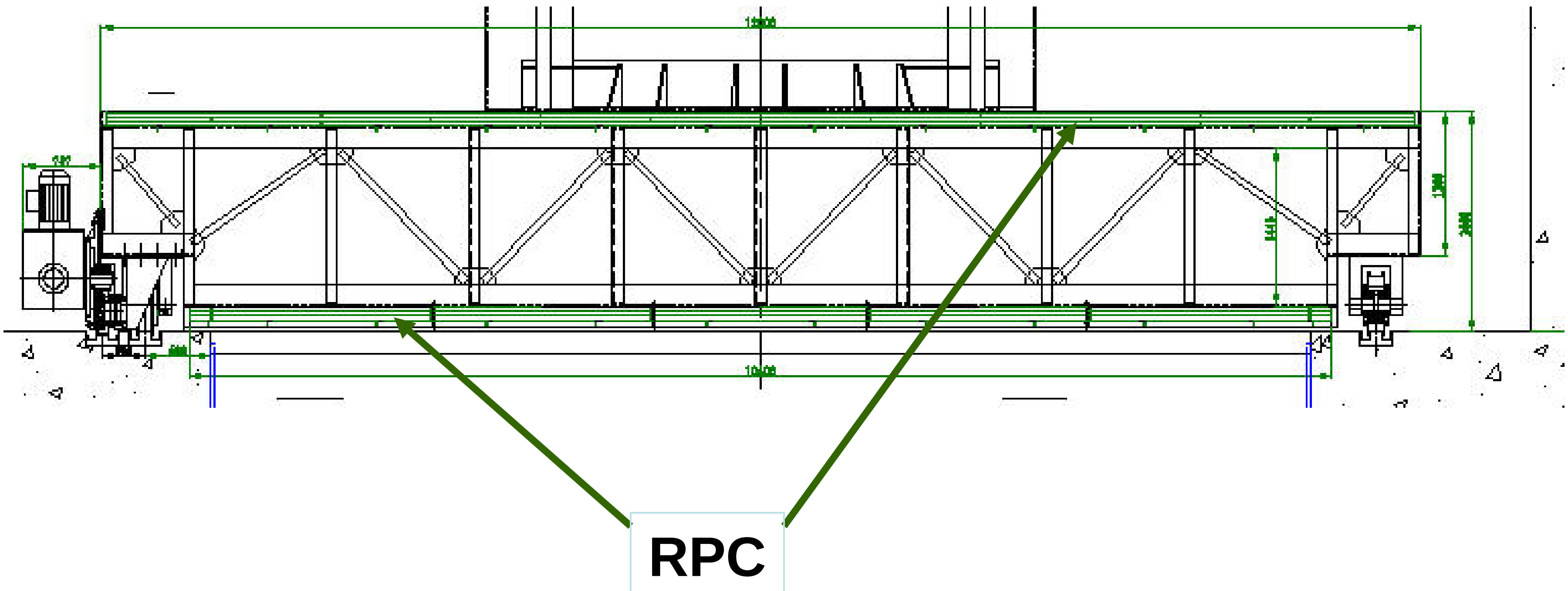
| 梁型号 | 梁长度（m） | 理论重量（N/m） | 单位长度载荷 (N/m) | 惯性矩（cm4) | 截面抗弯模量(cm3) | 弹性模量(Gpa) | 最大弯矩（N.m） | 最大应力(Mpa) | 最大挠度(mm) | 用钢量(ton)1m间距18m跨度 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| HM200x150 | 18 | 320 | 1300 | 2740 | 283 | 206 | 65610 | 231.837 | 392. 307 | 13. 824 | |
| HM250x175 | 18 | 450 | 1300 | 6120 | 502 | 206 | 70875 | 141.185 | 189. 735 | 19. 44 | |
| HM300X200 | 18 | 573 | 1300 | 11400 | 779 | 206 | 75856.5 | 97.3768 | 109. 017 | 24. 7536 | 采用 |
| HM350X250 | 18 | 797 | 1300 | 21700 | 1280 | 206 | 84928.5 | 66.3504 | 64. 121 | 34. 4304 | |
| HW200X200 | 18 | 505 | 1300 | 4770 | 477 | 206 | 73102.5 | 153.255 | 251. 085 | 21. 816 | |
| HW250X250 | 18 | 724 | 1300 | 10800 | 867 | 206 | 81972 | 94.5467 | 124. 351 | 31. 2768 | |
| HW300X300 | 18 | 945 | 1300 | 20500 | 1370 | 206 | 90922.5 | 66.3668 | 72. 6648 | 40. 824 | |

According to the comparison of the beams listed above, based on the calculation of stress, deformation and volume of material to be used. The I beam of spec HM300x200 looks to be good to fabricate the main structure in current design.

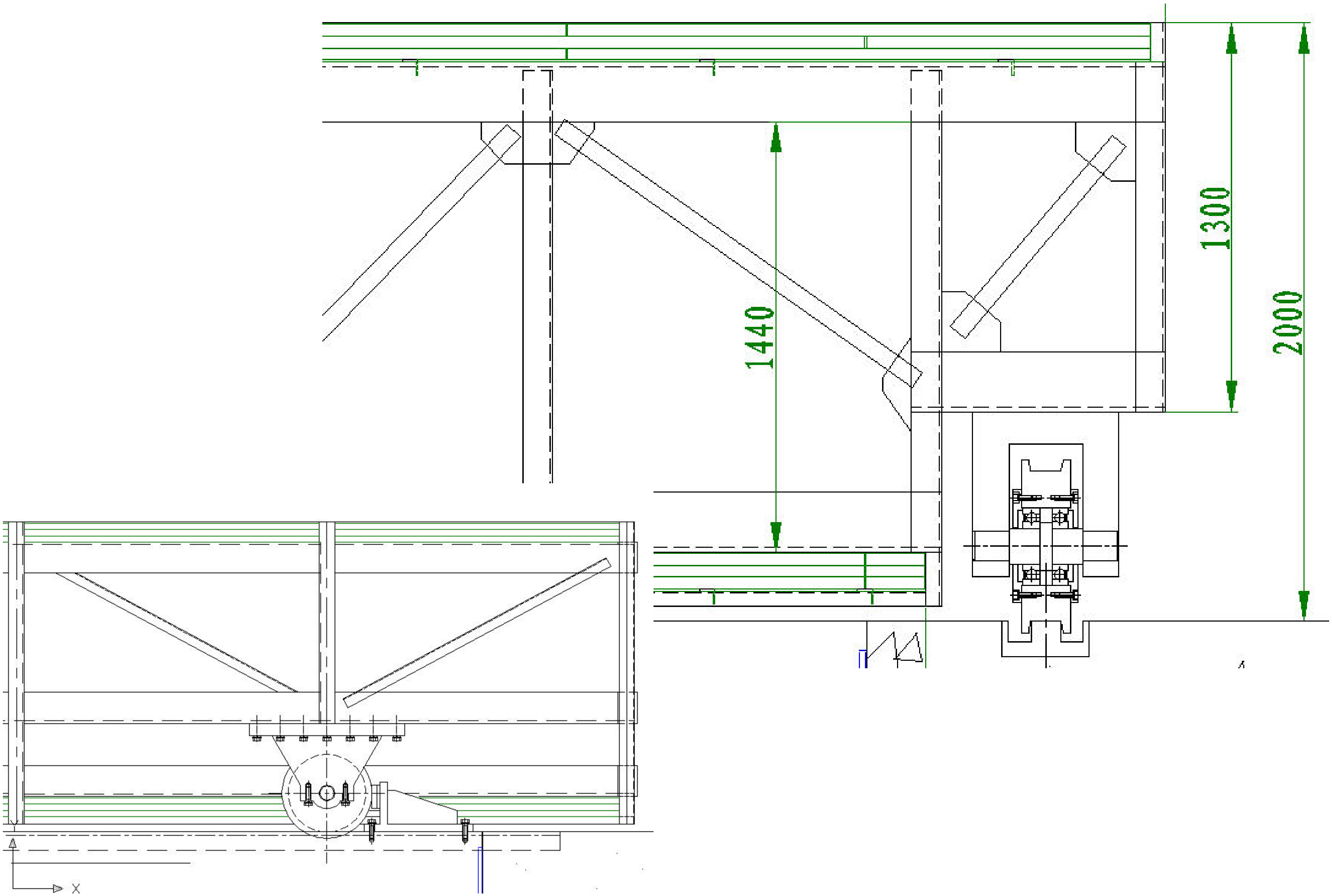
# Near Site can use smaller I-beam to reduce weight?

| Steel Type | Span(m) | Weight (N/m) | Loading (N/m) | Max. Stress(Mpa) | Max. Defor. (mm) | Weight(t) (1m space) |
|---|---|---|---|---|---|---|
| HM200x150 | 12 | 320 | 1300 | 103 | 77 | 15.104 |
| HM200x175 | 12 | 450 | 1300 | 63 | 38 | 21.24 |
| HM300X200 | 12 | 573 | 1300 | 43 | 22 | 27.0456 |
| HM350X250 | 12 | 797 | 1300 | 29 | 13 | 37.6184 |
| HW200X200 | 12 | 505 | 1300 | 68 | 50 | 23.836 |
| HW250X250 | 12 | 724 | 1300 | 42 | 25 | 34.1728 |
| HW300X300 | 12 | 945 | 1300 | 30 | 14 | 44.604 |

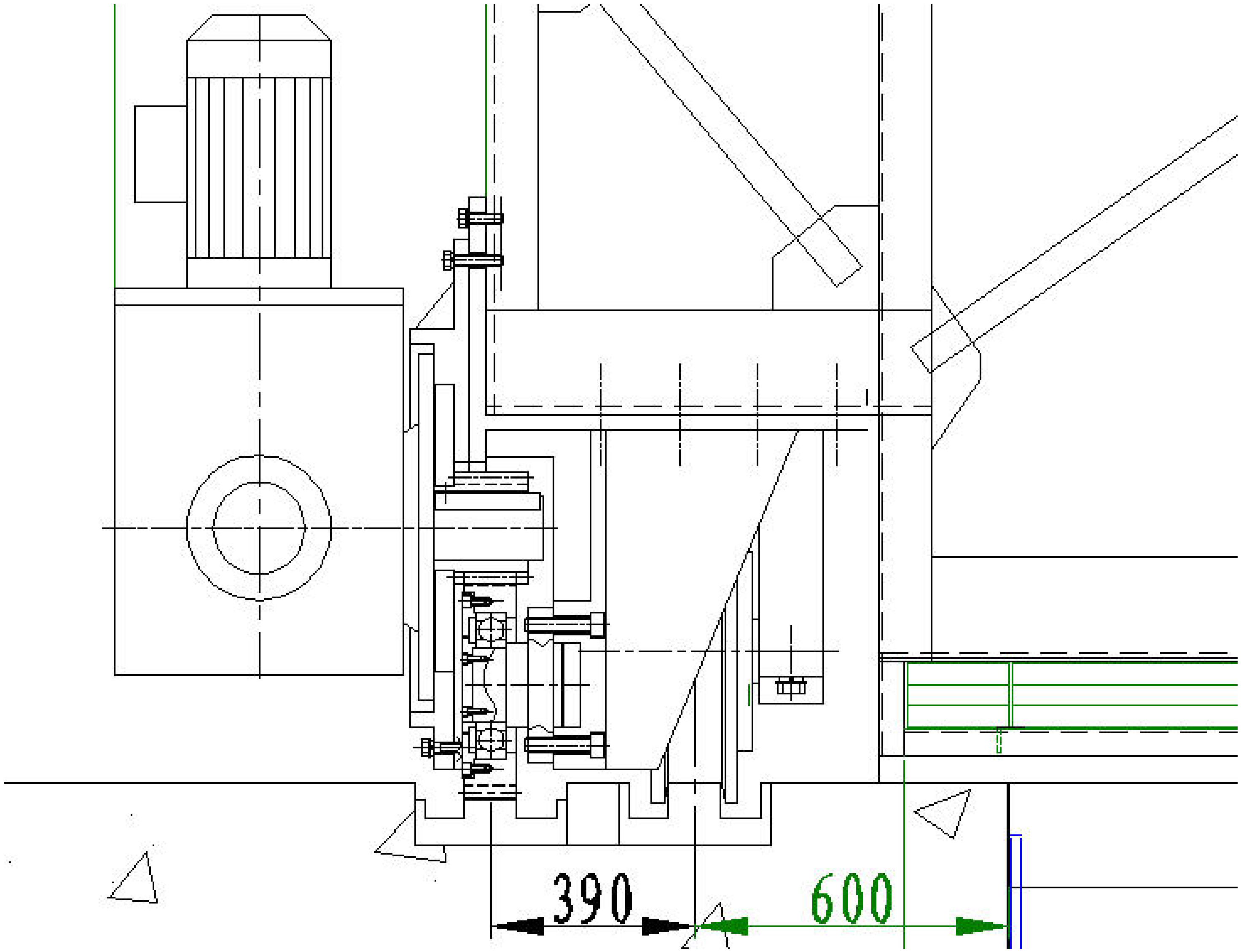
# Design B: Support bridge of top RPC



# The wheel



# The drive mechanism (can be a manual one?)



# RPC Support Note:

Material: Common Structural carbon steel (Q235 or Q345),

Design A: Gross weight: 14x2= 28 ton –far hall,

cost: 28 x 2.4(2 near + far) x 12kyuan/t = 806 kyuan

- just main structure, other accessories, e.g., specific parts for mounting of RPC,wheels,rails,etc are not included.

Flat top (No dead space), deformation is big (deformation can be corrected?), weight is a little more

Design B: Gross weight: 17 t (estimation) –near hall,

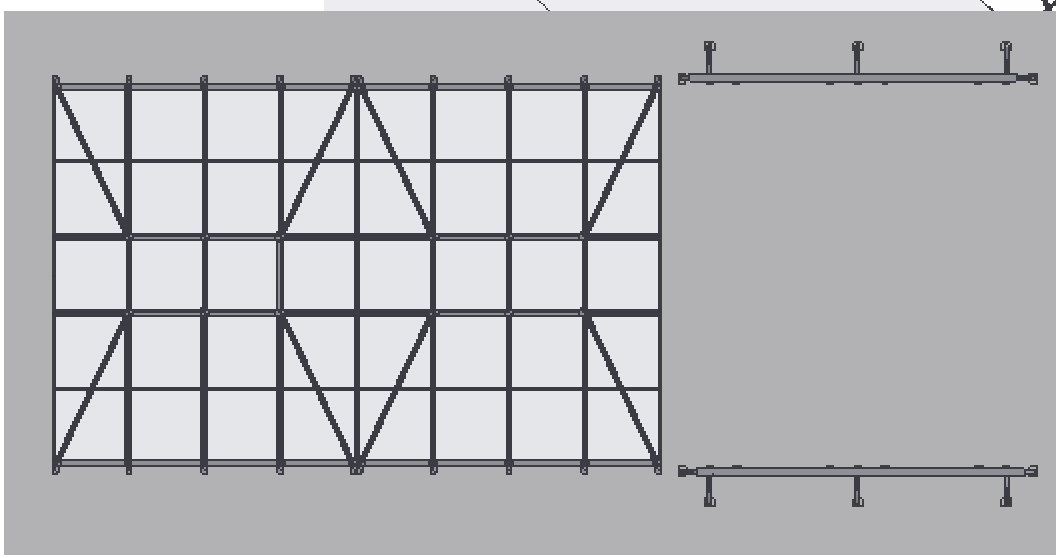
cost: 17 x 3.4(2 near + far) x 12kyuan/t = 694 kyuan

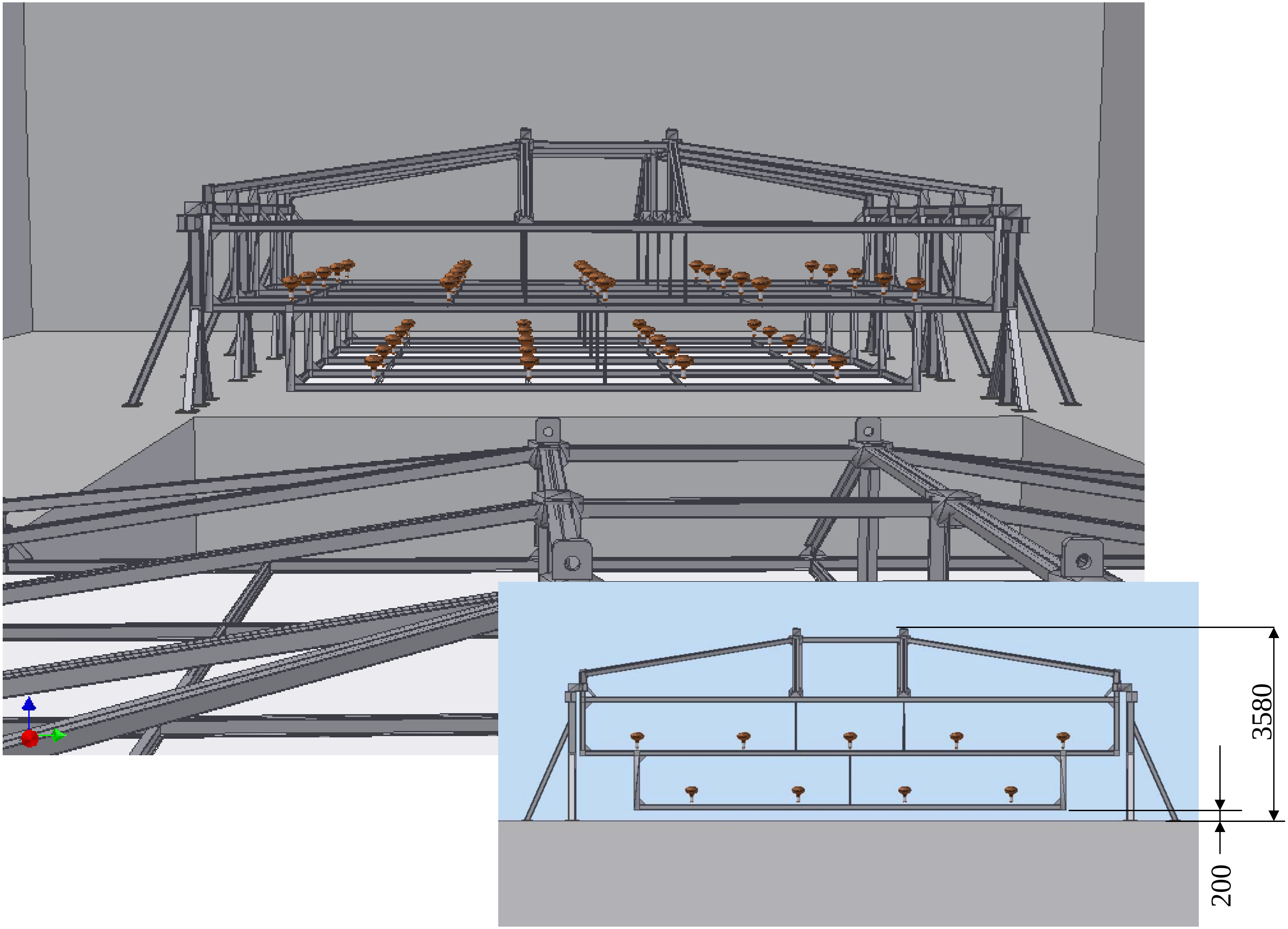
With some dead space, deformation is small (a few mm), weight is less

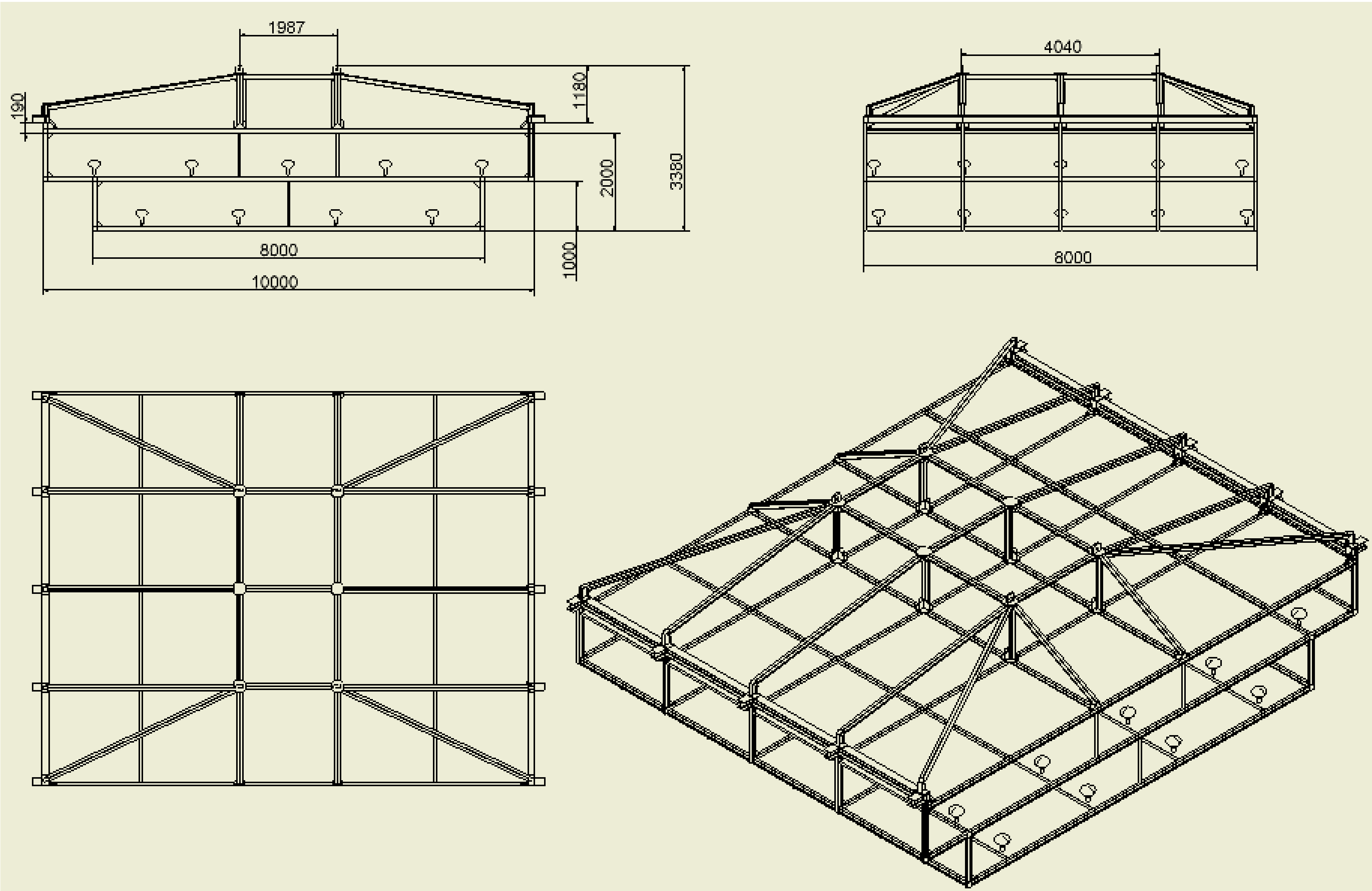
-In addition, FEA analysis is needed and to be finished in next step if it is decided that such a structure is really feasible to the experiment. Based on that, the detailed and optimized structure with more accurate cost estimate will be available.

# 3. Support Structure on top

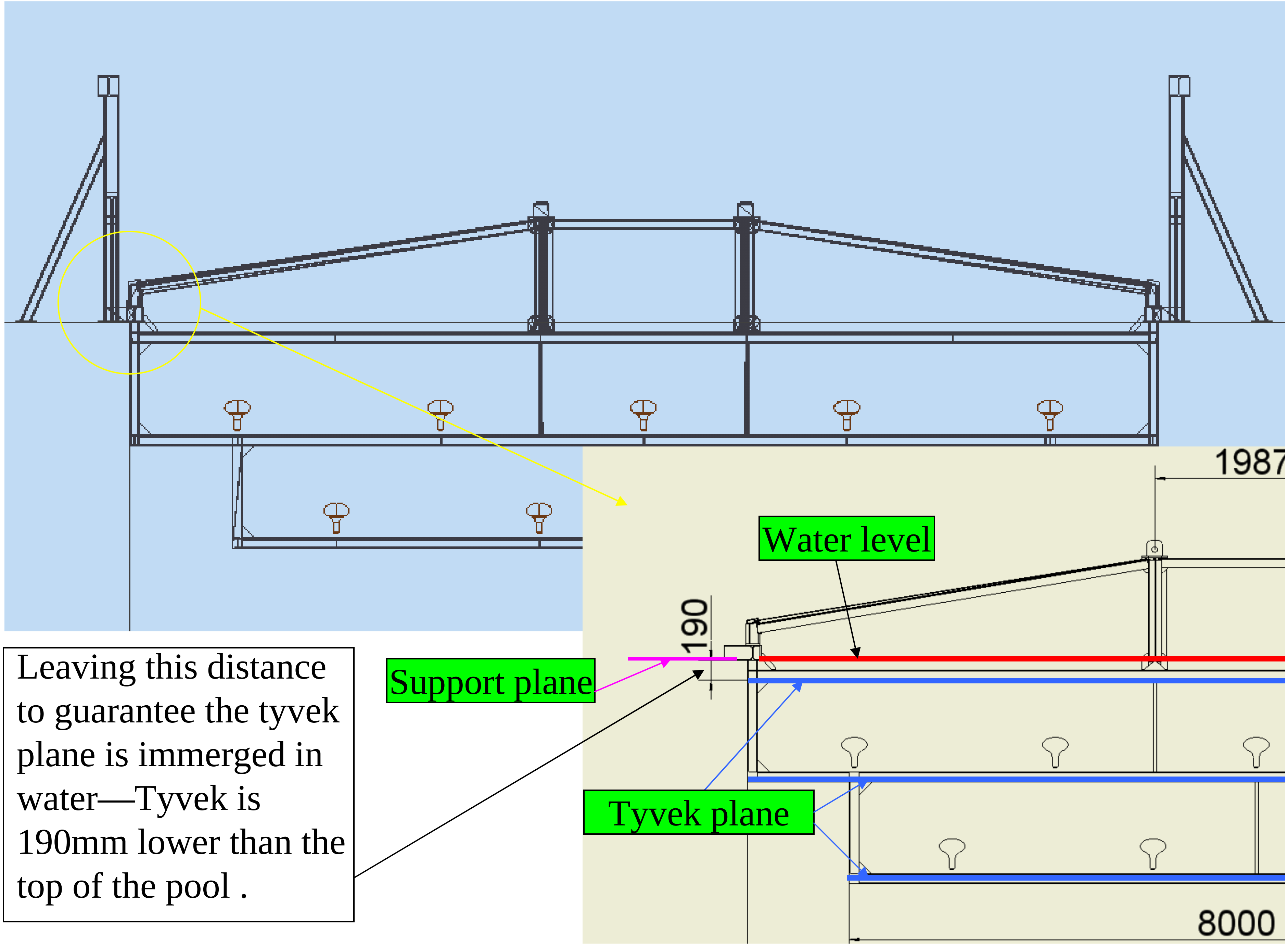
## - Option 2: Water Cerenkov based

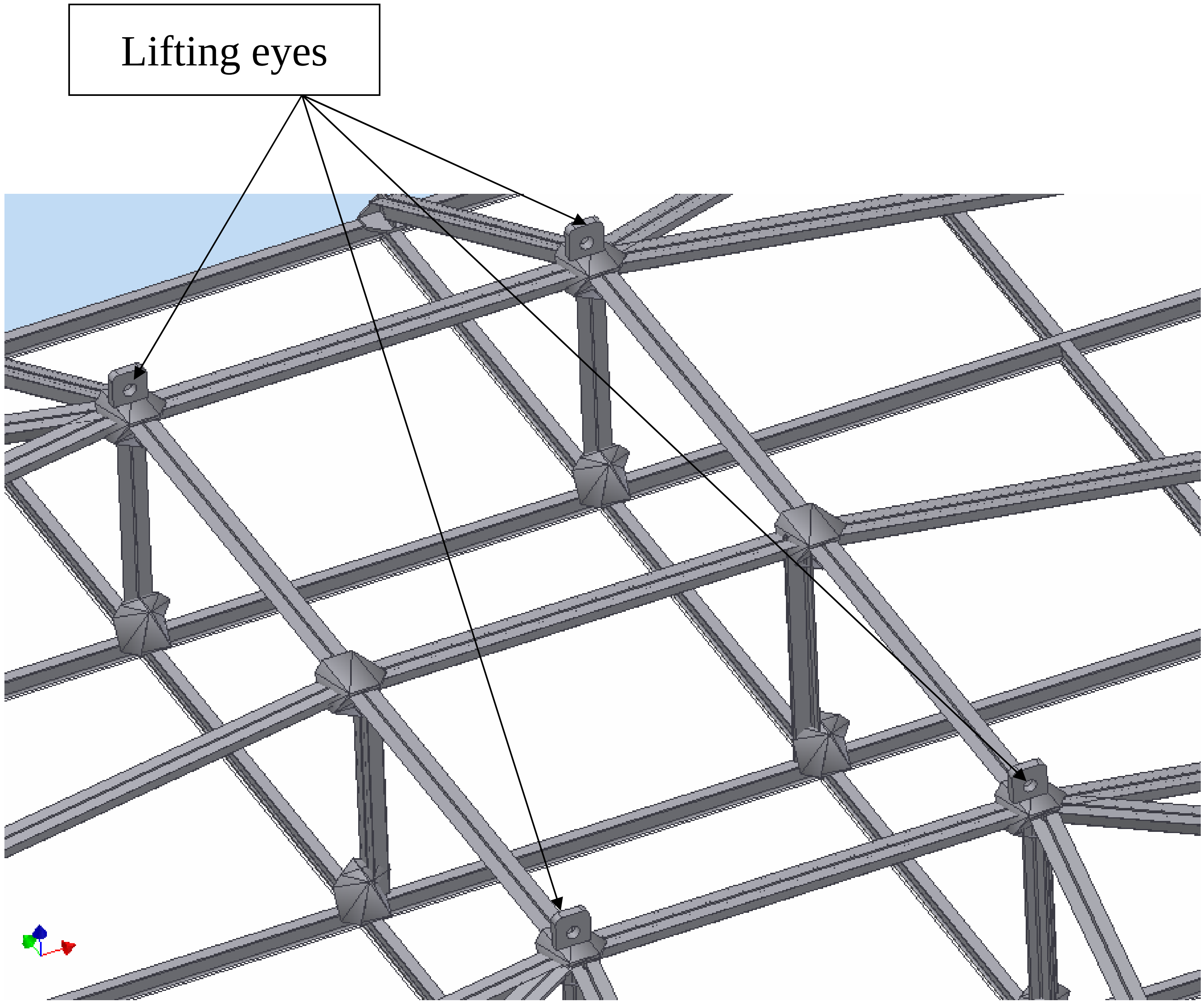



3580
200



1987
190
1180
2000
3380
8000
1000
10000
4040
8000


1987
Water level
190
Support plane
Tyvek plane
8000
Leaving this distance to guarantee the tyvek plane is immerged in water—Tyvek is 190mm lower than the top of the pool .


Lifting eyes

# Supporting structure for PMT and Tyvek

## -for near hall with the pool:10mx16mx10m

Basic Calculation and comparison of different specs of structural steel-I beams

Simple beam

| 两端简支梁<br>梁型号 | span<br>梁长度（m） | 理论重量（N/m) | 单位长度载荷 (N/m) | 惯性矩（cm4) | 截面抗弯模量(cm3) | 弹性模量(Gpa) | 最大弯矩（N.m） | Stress<br>最大应力(Mpa) | Defor.<br>最大挠度(mm) |
|---|---|---|---|---|---|---|---|---|---|
| HW100X100 | 10 | 172 | 300 | 383 | 76. 5 | 206 | 5900 | 77.1242 | 77. 8959 |
| HW125X125 | 10 | 238 | 300 | 847 | 136 | 206 | 6725 | 49.4485 | 40. 1486 |
| HM150X100 | 10 | 214 | 300 | 1040 | 140 | 206 | 6425 | 45.8929 | 31. 2393 |
| HN100x50 | 10 | 95. 4 | 100 | 192 | 38. 5 | 200 | 2442.5 | 63.4416 | 66. 2571 |
| HN125x60 | 10 | 133 | 100 | 417 | 66. 8 | 200 | 2912.5 | 43.6003 | 36. 3771 |
| HN150x75 | 10 | 143 | 100 | 679 | 90. 6 | 200 | 3037.5 | 33.5265 | 23. 2994 |

Use as the main beam of the frame structure.

# Note:

**Material** :stainless steel 304

**Weight:** 4.6-5.5 ton/one half – near hall

One near hall 5.5x2=11 ton

**Cost estimate :** 770 kyuan (just for frame structure without any accessories), for 3 site: $770 \div 0.7 + 770 \times 2 = 2{,}640$ KYuan

-In this design, the main frame structure is more likely to be welded as a whole body in the hall, if that is difficult, we can think instead of 2 halves we can have 4 pieces so that can be moved in through tunnel. (but still how to move from factory to DYB?).

-For detailed and optimized structure with more accurate cost estimate, FEA analysis is necessary. Still rooms to reduce the weight?

# 4. Summary

- We have the idea what the support structure in the pool, optimization of the detail are needed, detail technique design are needed;
- Flat top RPC support looks good for RPC support, the weight is not very much different, cost saving room is not significant. Deformation can be pre-corrected? Can we use manual driving system?
- Water Cerenkov based top support design looks good, still rooms to reduce weight?
- Next step, combine the design and production with one contract?