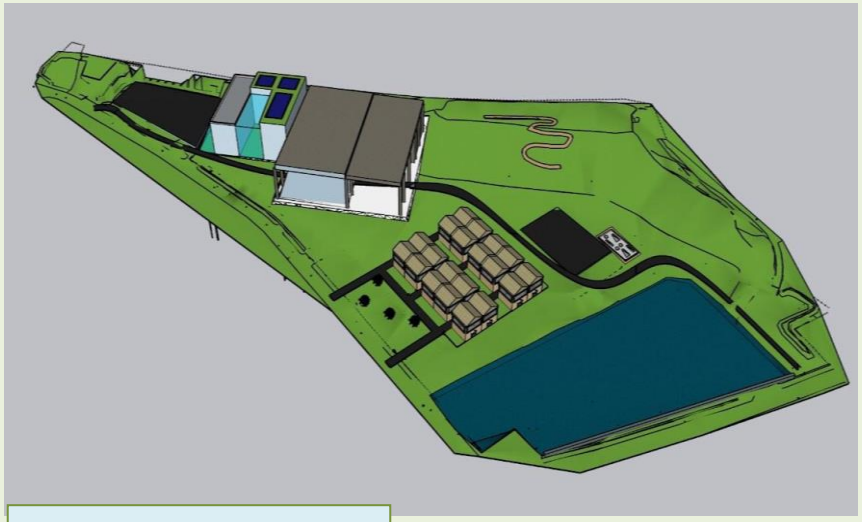
# Appendix 3: Portfolio

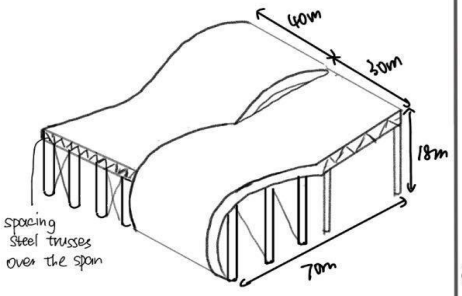
## 1. Introduction

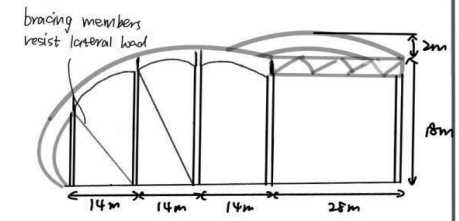
This portfolio is an overview of the key steps in the Integrated Design Project (IDP) part 1 design. The Sheffield City Council (SCC) are planning to redevelop the Neepsend Gas Works. There are several elements in the design requirements. I dedicated myself to doing the long-span structure design including a ski slope and a long-span roof. The portfolio provides evidence for the Institution of Civil Engineers (ICE) Member Attribute that I mentioned in Appendix 2 above.



3D Site layout

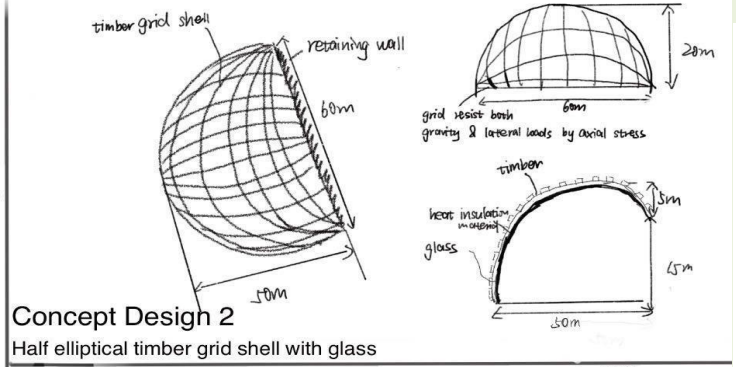
**Initial ideas and drawings**



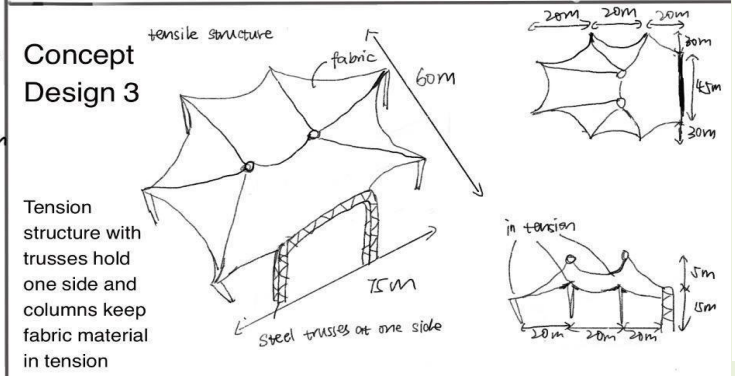

Concept Design1

Spacing steel frames with polycarbonate material as cover



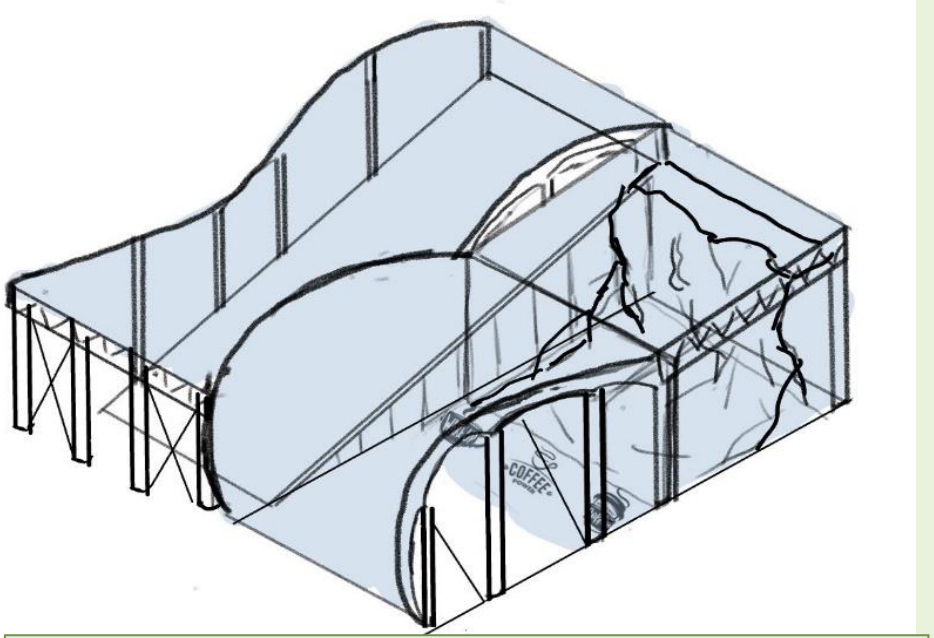

Concept Design 2

Half elliptical timber grid shell with glass




Concept Design 3

Tension structure with trusses hold one side and columns keep fabric material in tension



The finished hand sketch of the building, utilising lightweight steel frames and ETFE sustainable covering material. A pathway goes down underneath the ski slope and go through the whole building.

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## 2. Design Calculation

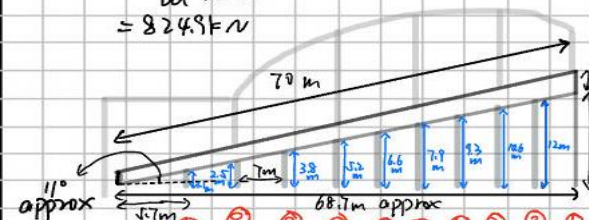
There are essential hand calculation parts that are conducted to figure out the size of columns and beams. I also conducted some spreadsheets to do analysis.

**Calculations**

$N_{Ed}' = N_{Ed} + 2B_{net} + Y_{net}$

$= N_{Ed} + 0 + 0$

$= 824.9\,kN$




using Ranking-Gorson formula

| | | | |
|---|---|---|---|
| ① | Lcr = 17.4m | 305×305×137 S275 UC mass per metre 136.9 kg/m | 309.4×320.5 |
| ② | Lcr = 12m | 305×305×118 S275 UC | 307.4×314 |
| ③ | Lcr = 10.6m | 305×305×97 S275 UC | 305.2×307.9 |
| ④ | Lcr = 9.3m | 254×254×107 S275 UC | 258.8×266.7 |
| ⑤ | Lcr = 7.9 m | 254×254×73 S275 UC | 254.6×254.1 |
| ⑥ | Lcr = 6.6m | 203×203×86 S275 UC | 208.1×222.2 |
| ⑦ | Lcr = 5.2m | 203×203×71 S275 UC | 206.4×215.8 |
| ⑧ | Lcr = 3.8m | 203×203×46 S275 UC | 203.6×203.2 |
| ⑨ | Lcr = 2.5m | 152×152×37 S275 UC | 154.4×161.8 |
| ⑩ | Lcr = 1.1m | 152×152×30 S275 UC | 152.9×157.6 |

**University of Sheffield, Department of Civil & Structural Engineering**

The University Of Sheffield.

Calculation Sheet for Integrated Design Project

Calculation Title: Long Span Structure Design — Calculation by: Chelsea

Sheet No. — Checked by:

| References | Calculations | Output |
|---|---|---|

**Preliminary sizing of roof columns**

The roof is being designed with CHS column. Sizing columns using Ranking-Gordon formula (P.168 IStructE Concept Design of Building Structure)

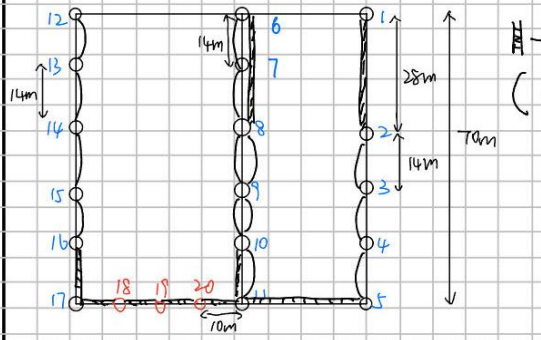
IStructE Concept Design of Buildings.

$$N_{b,Rd} = \left(\frac{1}{N_{G,Rd}} + \frac{1}{N_{cr,Rd}}\right)^{-1}$$

$$N_{G,Rd} = A f_y$$

$$N_{cr,Rd} = \frac{\pi^2 EI}{L_{cr}^2}$$

In order to use the above equation, we need to know the axial load of column. The following diagram shows the load type for each roof column




Take column number 5 as an example, the axial load on there is load of 30m span trusses +load of 14m span arch, which is calculated below.


$d = \frac{30}{15} = 2m$

try trusses @ 7.5m centre along length of building

Calculate member forces

Dead Load = 1.5 kN/m² (gk) > assume

Imposed Load = 0.6 kN/m² (qk)

$F_d = (1.35 \times 1.5 + 1.5 \times 0.6) \times 7.5 = 22\,kN/m$ (Axial force on colu

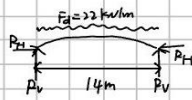
(1.35 for factors)

Reaction at the end of horizontal truss = $\frac{wL}{2} = 330\,kN$

**Calculations**

Parabolic arch – uniform loading

$H = \frac{Span}{7} = \frac{14}{7} = 2\,m$




$P_V = \frac{F_d L}{2} = \frac{22 \times 14}{2} = 154\,kN$ $P_H = \frac{F_d L^2}{8h} = \frac{22 \times 14^2}{8 \times 2} = 269.5\,kN$

Hence load on col 5=154 kN+ 330kN=484 kN
Then we can use the Ranking-Gordon formula

Try 273.0×8 CHS S355 from online Blue Book

$N_{b,Rd} = 629\,kN$ ($L_{cr}$=13m) → Lcr in this case is the length of cols =13m

$A = 66.6\,cm^2$

$I = 5850\,cm^4$

$E = 210\,kN/mm^2$

$f_y = 355\,N/mm^2$

calcuate resistance using Ranking-Gorson formula (P.168 IStructE Conceptual Design of Buloting Structures)

$N_{b,Rd} = \left(\frac{1}{N_{G,Rd}} + \frac{1}{N_{cr,Rd}}\right)^{-1}$

$N_{G,Rd} = A f_y = 66.6 \times 10^2 \times 355 = 2364\,kN$

$N_{cr,Rd} = \frac{\pi^2 EI}{L_{cr}^2} = \frac{\pi^2 \times 210 \times 5850 \times 10^4}{13000^2} = 717.4\,kN$

$N_{b,Rd} = \left(\frac{1}{N_{G,Rd}} + \frac{1}{N_{cr,Rd}}\right)^{-1}$

$= \left(\frac{1}{2364} + \frac{1}{717.4}\right)^{-1}$

$= 550\,kN > 484\,kN$ ∴ OK

The calculation step is the same for each column annotated above. The whole calculation could be found in the excel

The calculation process:

1). Determine the load of different spans of trusses and arches.

2). Superposition the load for columns

3). Sizing circular hollow columns using the Ranking-Gordon formula

| load | | | | | | |
|---|---|---|---|---|---|---|
| snow | 1.56 | KN/m2 | dead load without roof | 6.86 | KN/m2 | dl for column in part 1 316.008 KN |
| skiier+equipment | 2.5 | KN/m2 | factored dl | 9.261 | KN/m2 | dl for column in part 2 518.616 KN |
| slab | 3.3 | KN/m2 | | | | dl for column in part3 372.708 KN |
| cladding | 1 | KN/m2 | imposed load without rc | 3.5 | KN/m2 | |
| wind | 1 | KN/m2 | factored il | 5.25 | KN/m2 | il for part 1 172.2 KN |
| | | | | | | il for part 2 294 KN |
| roof load | | | | | | il for part3 197.4 KN |
| dead load | 1.5 | KN/m2 | | | | |
| imposed load | | | | | | |
| | | | | | | total load for column in part 1 488.208 KN |
| self load of beams | | | | | | total load for column in part 2 812.616 KN |
| self load of column | | | | | | total load for column in part 3 570.108 KN |

Part of calculation spreadsheet

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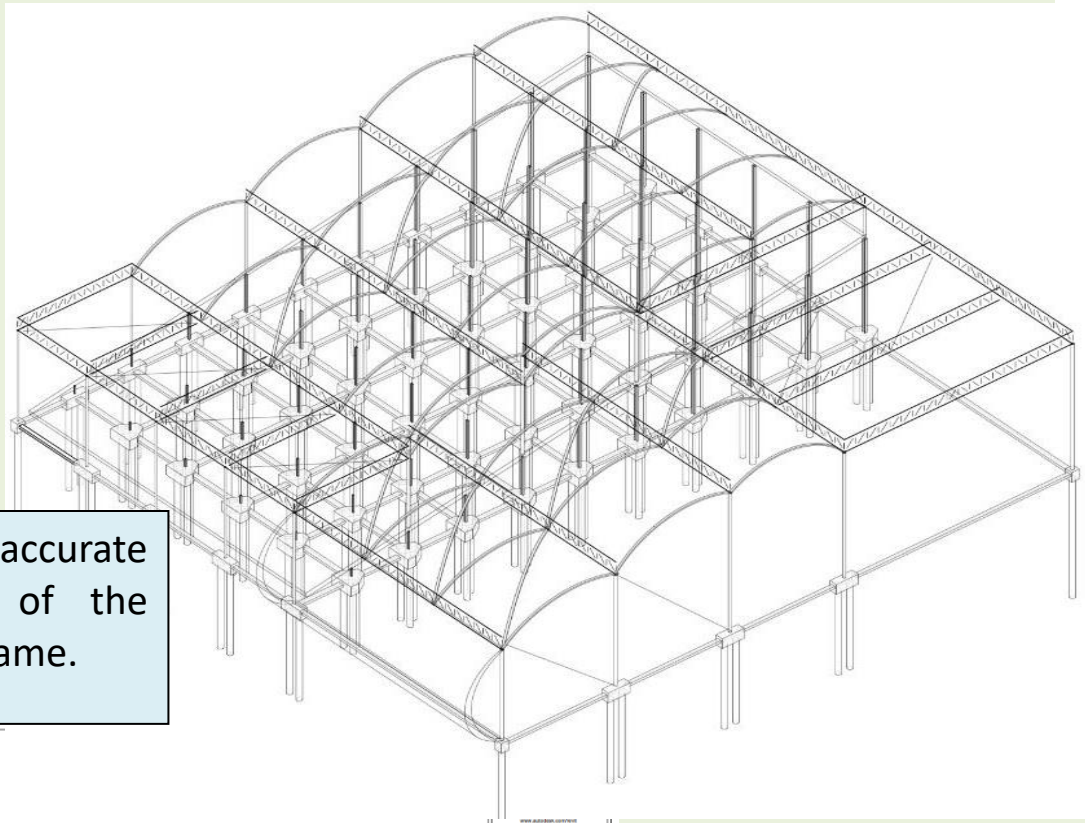
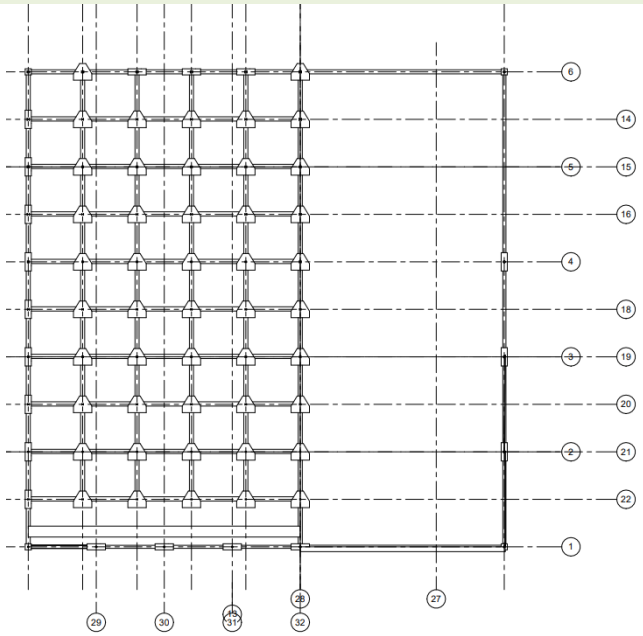
## 3. Revit Model

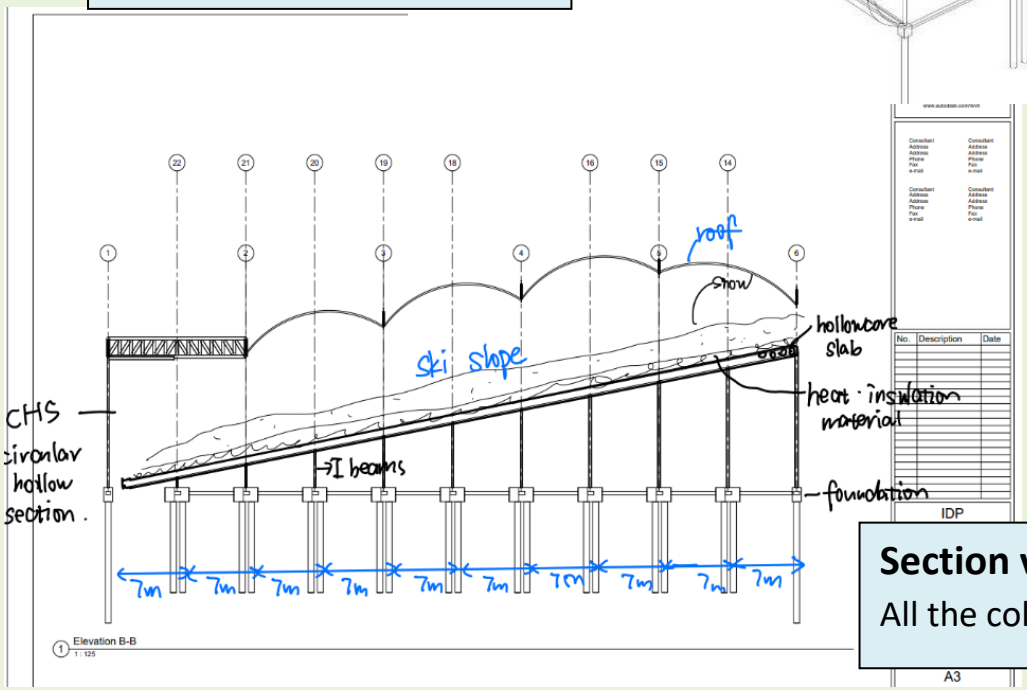


The visual and accurate isometric view of the steel structure frame.



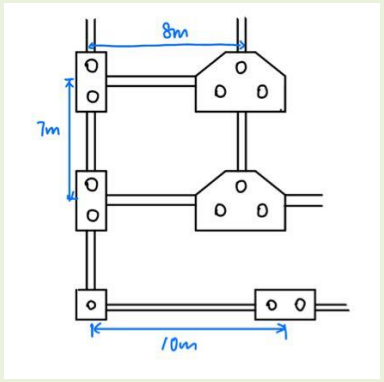
**Foundation Strategy:**

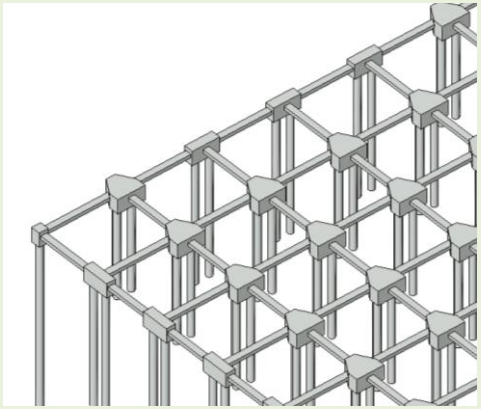
Single pile foundation in the corner linked by a 2-pile arrangement and 3-pile arrangement pile cap.




**Section view of the structure:**

All the columns align with the concrete pads.



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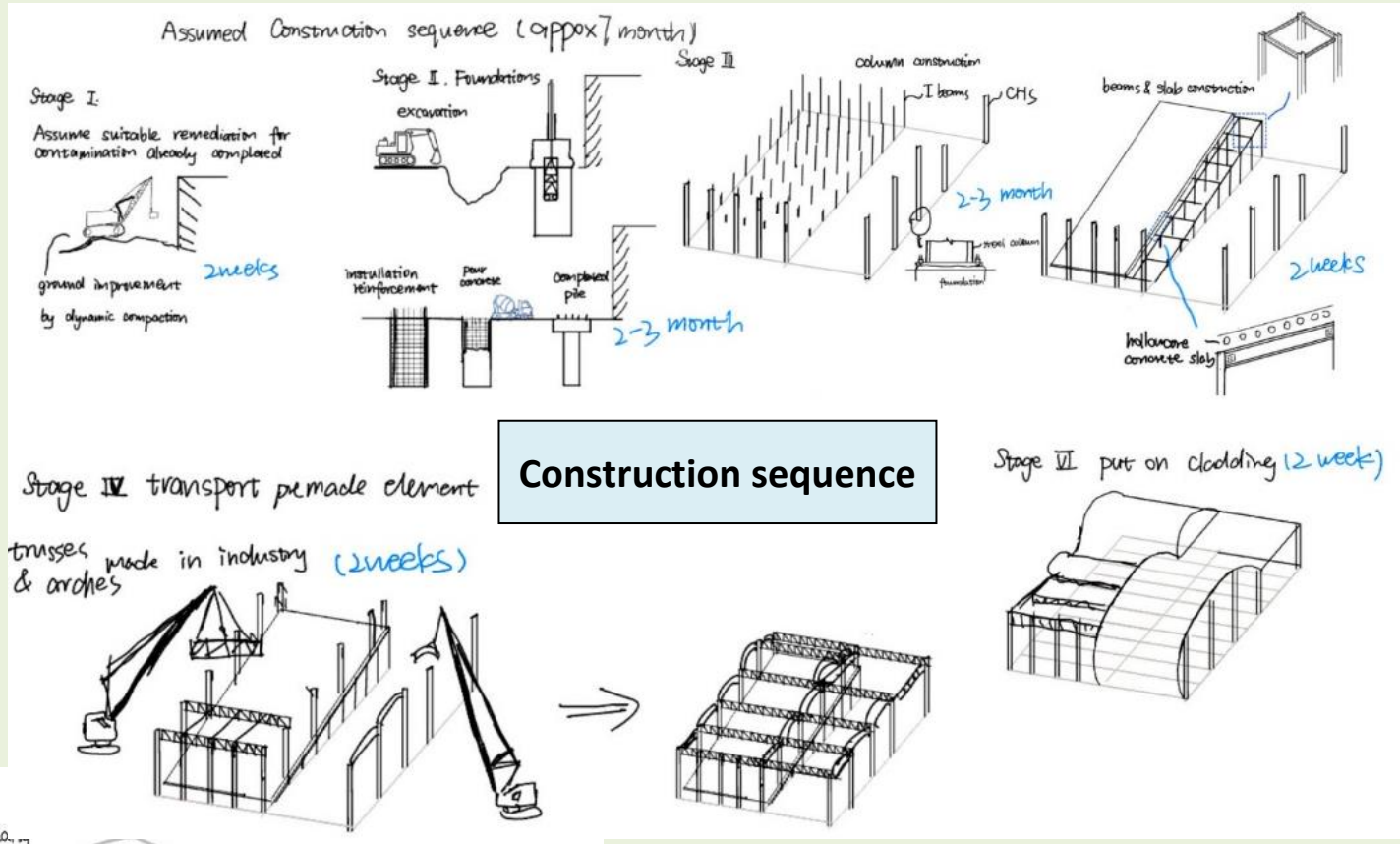
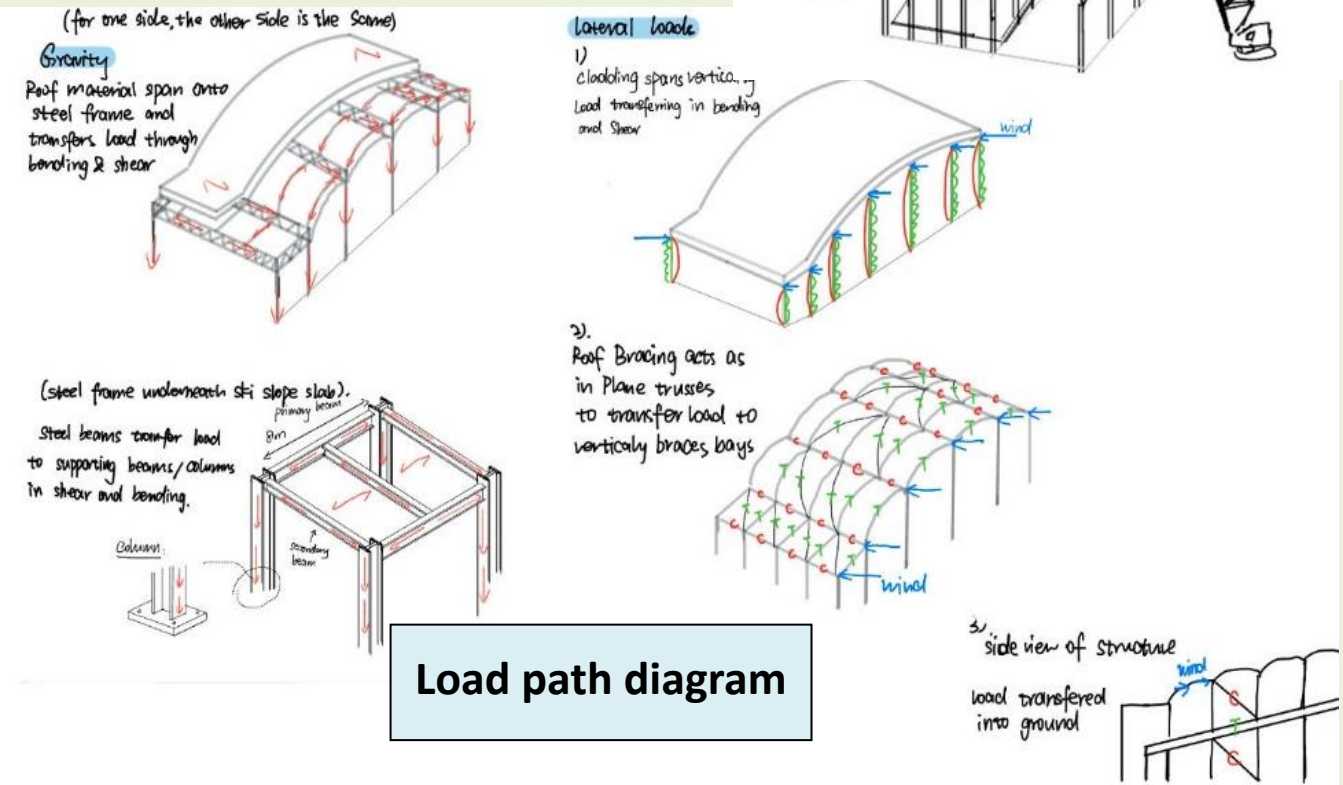
## 4. Hand Sketches

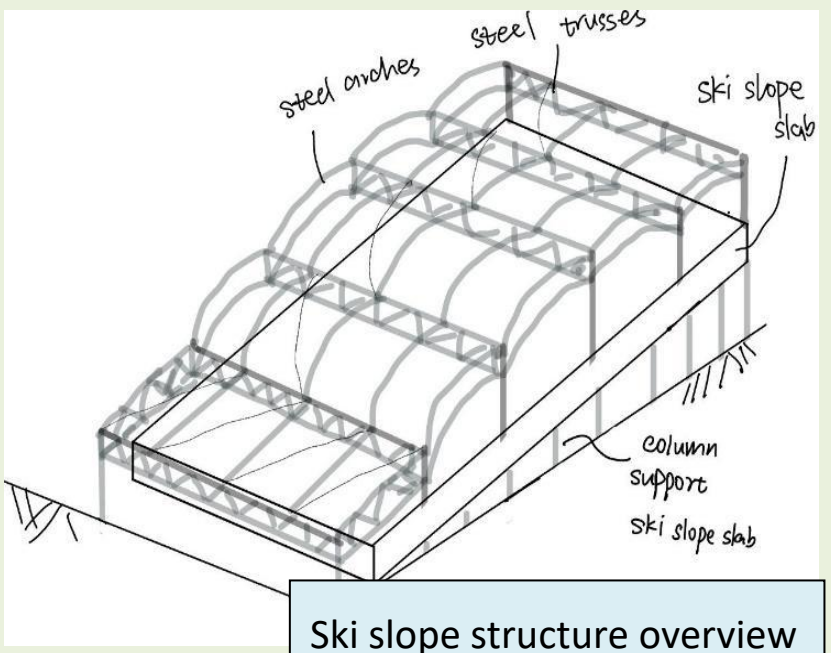
To visualise my design for clients, I produced a few hand drawings such as the load path diagram and construction sequence.




**Construction sequence**




**Load path diagram**




Ski slope structure overview

# Appendix 3: Portfolio

## 5. Communication

This section includes graphs for oral and written communication graphs. The visual outputs are in the sketch section above.

**Project review presentation**

### Meeting notes

| Date | Agenda | Key takeaways | Important tasks left to do |
|---|---|---|---|
| 07/02/2024<br>14:00 - 15:30<br>(tutorial) | Assign team members to each section | Refer to 'Assignment of topics' | |
| 08/02/2024<br>14:00 - 17:00<br>(tutorial) | -Finish and finalise site constraints, checking with lecturers<br>-Collectively come up with an initial design | Group discussion that let to a rough group idea of layout that will be used to derive each member's initial ideas | |
| 12/02/2024<br>11:00 - 13:00<br>(Optional meeting) | -Discuss Initial plans and decide which one to take forward<br>-Critic everyones design | -probably have to move the pipe to accommodate lake size<br>-Importance of scaling<br>-Aspects of each design to take forward<br>-Flood prevention methods needs to looked at | -Need to ask whether building bottom right is part of the site<br>Could try and negotiate CPO compulsory Purchase order<br>-If the ski slope is curved how would we calculate the long span structure<br>Inside curve at 70m, outside curve >70m, think of worse case - outlining columns (long metre centres)<br>-Could change the route of gas pipe, do not worry about cost.<br>-Need to ask whether cafe area can be under the ski slope<br>Can put underneath - can be seen as cost effective approach |
| 12/02/2024<br>14:00 - 17:00<br>(tutorial) | Cement an initial layout that may only change depending on research made in each field | 2 layouts made, the difference between the 2 is the main road within and the lake/pipe rerouting | Talk about hazards when rerouting gas pipes. (Include that in risk assessment and site plan)<br>Think about construction equipment in site and minimizing downtime. Minimize required length of rerouting. |
| 14/02/2024<br>14:00-17:00<br>(Geo workshop & short meeting) | Understand Geo section | | For structure part:<br>Need to do at least 3 concept designs for both longspan structure and bridge. |
| 15/02/2024<br>14:00-16:00<br>(tutorial) | | Geo:<br>Realised all tasks to do to complete the section | |
| 16/02/2024<br>14:30 -<br>(optional meeting) | Discuss Plan and timings, what needs to be done per section and how it may be done | Structure:<br>-Working on actual Design of pedestrian Bridge | Waiting on Final Layout:<br>-Drainage (Sara)<br>-Contamination<br>-CAD (Abdul) |

## Political

**Overview**
Baotou is the largest urban population city in inner Mongolia. Inner Mongolia is an autonomous region of China which is the third-largest Chinese administrative subdivision. It borders with two other countries: Mongolia and Russia.

**International relationship**
On October 18, 2023, China and Mongolia held the 23rd Round of consular consultations (Ministry of Foreign Affairs of the People's Republic of China, 2023) and made an effort to take the China-Mongolia comprehensive strategic partnership to a new level. In the same month, China held regular meetings with Russia (Ministry of Foreign Affairs of the People's Republic of China, 2023) and drew up a new blueprint to deepen strategic collaborative partnerships. These stable and harmonious international relationships and political stability with neighbouring countries support to design and propose the Neepsend project in this city.

**Policy of China and Autonomous Region**
China introduced a "FINL+pre-entry national treatment" (GOV.UK) to govern foreign investment. As the mechanism stated: treat foreign businesses equally with Chinese domestic firms. Moreover, the government of the Inner Mongolia autonomous region encourage technological exchange and project cooperation by offering a convenient investment policy support for Foreign direct investment (FDI). Such policies and mechanisms provide opportunities to carry out a foreign design and construction project.

**The policy of Baotou City**
During the 14th Five-Year Plan period (2021-25) (innermongolia.chinadaily.com.cn, n.d.) the autonomous region will continue to promote the process of Baotou City's modernisation. However, the attention will be on the construction of a new-type materials industrial base, a modern energy industrial base, a modern equipment manufacturing industrial base and an agricultural and livestock food that will have a national impact. Moreover, the State Council approved the overall urban planning (2011-2020) for Baotou City(www.gov.cn, n.d.). In the plan, the autonomous region aims to transform Baotou City into a thriving and livable modern city with distinctive qualities and a well-maintained ecological system and distinct features. However, the state council rigorously controls newly added construction land and makes efforts to improve the land usage rate and protect basic farmlands. It will be challenging to occupy new land to carry out new projects but it depends on our approach and strategy.

**Recommendation**
According to the policies and strategies above, it is feasible and encouraged by the government to carry out the project in Baotou City. The site plan includes transport and water infrastructure projects. The material chosen and construction methods satisfy circular economy and sustainability. All these features meet the Inner Mongolia government's infrastructure construction standard. However, there are still some challenges and potential changes that need to be taken into consideration:
Firstly, it should ensure that the site's land usage rate is high enough so that the state council allows the construction of land.

Secondly, since Baotou is one of the biggest industrial cities in the country, the figure below is one of the industrial bases in Baotou City. it is suggested to combine the Neepsend project with an industry base, which meets Baotou's overall urban planning and government's expectations.

*Figure 2. Industrial base in Baotou City*

International Report on Baotou City
(Political Analysis)

*Figure 1. Baotou Iconic Landmarks "Deer Monument"*