Introduction

The following document has been produced by the Examinations Panel as part of the continual effort to provide candidates with as much material as possible to help with preparations for the exam.

The fully critiqued answer script contained within the document is intended to show candidates a general idea of how their answers should be structured. It is not intended to be used as a ‘model’ answer and it should not be replicated in part or full as an answer to any future questions.

The critique features comments by Jon Bird, the Chief Examiner for the question, that show where marks were gained and where the candidate could have improved their answer to secure higher marks. The actual marks awarded are not shown in this document.

This answer has been taken from the February 2023 Chartered Member Exam. Candidates preparing for January 2024 onwards should note the changes to the exam as detailed in the Exam Preparation Guidance document for further examples. Candidates are advised to continue to engage with their Regional Group with exam preparation activities. They should also download and review all other guidance material supplied by the Institution, which is available on the website.

Michael Lewis

Examination and PRI Manager
8th FLOOR TO ROOF

1st to 7th FLOOR

GROUND FLOOR

ELEVATION

NOTE: All dimensions are in metres

FIGURE Q2
Q2. Office Building

Client’s requirements

1. An 8-storey office block is to be constructed. See Figure Q2.
2. All elevations are to be glazed. No bracing is permitted in glazed facades.
3. Minimum column spacing is 6m. Only 2 internal columns are permitted at ground floor level. No columns are permitted outside the perimeter of the building.
4. The first floor is to be 5m above the ground floor level. Other floors are to have a 3.5m floor to floor height.
5. On the 8th floor the façade is to be set back 2m from the lower floors. See Figure Q2.

Imposed loading

6. Roof 4 kN/m²
7. Floors 10 kN/m² on ground floor and 4kN/m² on other floors

Site conditions

8. The site is in the centre of a large city. Basic wind speed is 40.0m/s based on a 3 second gust; the equivalent mean hourly wind speed is 20.0m/s.
9. The ground conditions are as follows:
   - Ground level – 5m  Heavily contaminated made ground N=2
   - -5m –to -10m  Firm clay C=50kN/m²
   - Below -10m  Mudstone C= 150 kN/m²
   No water was discovered.

Omit from consideration

10. Design of the lifts/elevators and stairs.

SECTION 1 (50 marks)

a) Prepare a design appraisal with appropriate sketches indicating two distinct and viable solutions for the proposed structure including the foundations. Indicate clearly the functional framing, load transfer, serviceability, and stability aspects of each scheme. Review and critically appraise the schemes, and identify the solution you recommend, giving reasons for your choice. (40 marks)

b) After the scheme is complete, the client advises you that they wish to add an additional storey. Write a letter to the client explaining the implications on your design and the construction. (10 marks)

SECTION 2 (50 marks)

For the solution recommended in Section 1(a):

c) Prepare sufficient design calculations to establish the form and size of all the principal structural elements including the foundations. (20 marks)
d) Prepare general arrangement drawings, which may include plans, sections and elevations to show the dimensions, layout and disposition of the structural elements and critical details for estimating purposes. (20 marks)
e) Prepare a detailed method statement for the safe construction of the works and an outline construction programme to include consideration of any temporary works that may be required. (10 marks)
1. All answers are to be given on the A3 and A4 paper provided. This includes all rough working and preparatory sketches.

2. The number of sides of A3 and A4 paper used during the examination should be recorded at the top of this cover sheet. You should record your initials above in block capitals. All papers should be secured to this front cover sheet with the treasury tag provided.

3. Your full candidate number should be written in the section above and the last five digits of your candidate number on each answer sheet. A3 graph paper will be moved to the back of the pack for scanning – please number these D1, D2 etc. so that the whole answer pack remains in number order.

4. Your answer sheets and question paper, unless previously given up, will be collected by the invigilator at the end of the examination. Question papers may not be taken out of the examination room.

5. You may not bring any wireless-capable electronic devices into the examination room.

6. If you are found using a mobile phone at any time during the exam, including lunch time, the matter will be reported to the Examination Panel with the recommendation that you are disqualified from the examination.

Martin Powell
Chief Executive

A reminder on codes of practice

Any design code or standard may be used to answer the questions in the paper as long as the codes or standards used are clearly stated and reference to those codes or standards is consistent throughout.
Office Building

The client would like a new 8-storied office block within a city centre.

Key Design Requirements and Other Structural Observations
- All elevations are to be glazed - assume all 6 glazed
- No bracing is permitted in the glazed facades
- Minimise deflections
- 7.5m triangular setback at ground floor
- Container structure required since no external columns are permitted
- Minimum column spacing = 6m C/C
- Only 2 internal columns permitted at ground floor
- Central core - assume 7.5 x 7.5m since no dimensions shown
- Since no external bracing is allowed, core must be used for stability
- \[ H = 33m, \ H/7 = 4.7m \] bracing required each direction
- Consider openings for access into core
- 8th floor has 2m setback
- Additional transfer structure may be required
- Assume 2H fire resistance since \( H > 30m \)

Robustness - office 4 but < 15 stories so class 2B

* to reduce the risk of progressive collapse horizontal + vertical ties to be detailed
The use of sketches here is an effective way of showing your thought process to the examiners. Contaminated land recognised as an issue and discussed.

**Structural Design**

**Ground Floor**

- 2.2 m max
- 0.7 m

2.6 m min clear

**Level 1+**

- 0.7 m max struct zone
- 0.2 m service zone
- 3.8 m min clear

Concrete could be coordinated with steel beam penetrations if needed

**Ground Conditions**

- 0
- -5
- -10

- Heavily contaminated made ground
  - N = 2, ABP = 10 N = 20 kPa
  - PM Clay C = 50 kPa
  - ABP = 2Cu = 100 kPa
  - Mudstone C = 150 kPa
  - ABP = 300 kPa

No groundwater encountered

Heavily contaminated ground → assumption

Is assessment would be undertaken to determine specific contaminants and associated risk

Is remediation could be:
  - excavate + reconstruct clean fill material
  - blending with clean material to reduce concentration is difficult to implement + consider adjacent sites?
  - physical treatment
  - isolation - sheet pile around site to prevent contaminants moving
Scheme 1

Scheme 1 uses a concrete framed structure braced using RC shear walls founded on piled foundations.

The building uses a 7.5 x 7.5m grid.

Typical floor construction is concrete flat slabs 230mm thick.

To span the setbacks at ground floor, 2.2m deep enganier beams are used.

Minimum dimensions have been selected to achieve one 2H fire rating.
Effective and clear sketches. Use of colour and key helps to keep sketches clear and simple to understand. Key transfer structures shown.

Functional Framing

Plan L2

Plan L1

Transfer beams

Ground floor footprint

Column above only

L7 footprint

L5 footprint

Peel slab 55 measured

Column below

Level 8 Pano Plan

Elevation A-A

Preliminary Sizing:

RC flat slab without drops, span = 7.5m, S/d = 33 → d = 0.227m

5 min for 2H fire = 125mm so use 230mm

300mm thick RC shear wall - openings assumed for access

Continuous edge beams to limit glazing movement

Span = 7.5m, S/d = 15 → d = 0.5m

Level 8 transfer beams - only carrying 1 floor

700mm structural depth = S/d = 10.7 so ON - detail checks later
transfer beam is not suitable

Level 1 Transfer Beam ⇒ Tray 7.2m deep
\[ d = 2.10 \text{ m} \quad b = 0.50 \]
\[ P = 8 \text{ floors} \quad DL = 0.23 \times 7.5 = 5.75 \text{ kPa} \]
\[ LL = 0.1 \times 7.5 = 0.75 \text{ kPa} \]
\[ SPL = 1.25 \text{ kPa} \]

Tensile area = \( 7.5 \times 3.5 = 26 \text{ m}^2 \)
\[ \therefore P = 8 \times (1.35 \times (575+185) + 154) \times 26 \]
\[ = 3.38 \times 10^6 \text{ kN} \Rightarrow \text{very big} \]
\[ \Rightarrow \text{c40/50 conc} \]

\[ M = PL = 3.38 \times 7.5 = 25.36 \text{ kN m} \]

\[ u = \frac{M}{bd^2 f_{cu}} = \frac{2.536 \times 10^6}{0.85 \times 2000 \times 2000} = 0.15 \% \lesssim 0.16 \% \Rightarrow \text{no compression necessary} \]

\[ z = 0.85 \times d \]

\[ As, Req = \frac{M}{0.87 f_y z} = \frac{2.536 \times 10^6}{0.27 \times 500 \times 0.85 \times 2000} = 3.26 \text{ mm}^2 \]

2 layers = 16.33 mm² per layer

\[ \text{max in 800 for 900 width = only 1.823 mm²} \]

\[ \Rightarrow \text{make 1200 mm wide} \]

Conclusion: working hard but feasible

is detailed shear and deflection checks to be carried out in detail design

= 2.2 x 1.2 m beam

Sizing calculations for key members is important, and candidate has correctly recognised that a span/depth check would not be sufficient for this member.
Internal column: 7.5 x 7.5 = 56 m² total area

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*Assume suspended ground floor as upper level
*No partitions at roof and no ceilings at all
*EC load factors 1.35 DL + 1.5 IL for ULS

Columns use 8121 UN ULS → 27.27 m² so use 620 x 620 mm square

Foundations: For bearing onto firm clay (assume will replaced) area required = \( \sqrt{6777 / 100 \text{ kN/m}^2} \) = 8.22 m² square
Therefore > 7.5 m grid → use piled foundations

Assume 4 pile caps → 1694 UN per pile (else foundations to be 2 pile caps)
Approx 9000 piles 30 m long
Horizontal load path
- see elevation A-A on previous page

Vertical loads from gravitational effects are supported on 2-way spanning floor slabs

These loads are transferred through bending and shear to the slabs' column strips

Columns act in compression to transfer loads to foundations

Piles provide friction and end bearing to transfer loads to ground

At transfer locations, deeper transfer beams take the loads to the columns through bending and shear

Simple and clear description, referring back to a clear sketch
Horizontal loads arising from wind and geometric imperfections are distributed to the floor levels by the cladding.

Significant in-plane stiffness of floor plate distributes to stiff core walls by diaphragm action.

Floorplate resolves the eccentricity from the building geometry.

Horizontal forces at each floor resisted by the core walls which act as horizontal continuity whereas resisted at the base as push pull action by the foundations.

Piles transfer resisting forces to the ground.
Scheme 2 uses a steel framed structure braced using steel braced bays founded on piled foundations.

The grid is 7.5 x 7.5 m.

Typical floor construction is 130 mm composite slabs supported on secondary beams at typically 2.5 m c/c, which span onto primary beams.

To span the 7.5m setback @ at ground floor a steel concreteen transfer truss is used.

Fire protection will be provided by intumescent paint, the slabs have been sized based on the live line rating.

Simple clear description again.

Looking at distinctness:
Frame - distinct framing, but could maybe add comments along lines of "clear spans give more flexibility for future use changes".
Could also maybe discuss any alternatives considered for locations of transfer structure.
Foundations - not distinct for the 2 schemes. It is acceptable to have piled solutions to both schemes, as long as alternatives are discussed and ruled out as unviable. This discussion has not been done by this candidate.
Candidate recognised an issue with their scheme on upper floor and dealt with this clearly.

Functional Framing

Level 2+ Plan

Level 1 Plan

Section A-A

Preliminary Sizing

- Primary beam: 700mm deep, span = 7.5m max, S/d = 11 so OK
- Secondary beam: 700mm deep, span = 15m max, S/d = 21 so OK since composite

- 130mm common SI slab (1mm gauge) max 7.5m span typically

- 9 storeys total so UC354

- See back roof structure aligns with SI structure - beams designed to take point loads - stiffeners may be needed at PL locations
Transverse truss - remove UDL from floor loads for now

\[ P = 8 \text{ (kN/m)} \]

\[ DL = 0.13 \times 25 + 1 = 0.75 \]

\[ SDL = 1.85 \]

\[ L = 4 \]

Total area = 7.5 \times 3.5 = 26 \text{ m}^2

\[ P_e = 8 \times 26 \times (1.75 \times (4.25 + 1.85) + 1.5 \times 4) \]

\[ = 2460 \text{ kN} \]

\[ M = PL = 7.5 \times 2460 \]

\[ = 22207 \text{ kNm} \]

Say 2m deep truss

Top/Bottom chord 
\[ N_{ed} = \frac{M}{h} < \frac{22207}{2} = 11103 \text{ kN} \]

\[ A = \frac{N \times 1.15}{f_y} = \frac{11103 \times 1.15}{0.355} \]

\[ = 35967 \text{ mm}^2 \]

\[ = 359 \text{ cm}^2 \]

\[ U = 356 \times 406 \times 287 = 366 \text{ cm}^2 \]

Feasible - full check to be done in detail design.
Foundations

3rd - typical edge col

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Ground floor as Scheme 1 = 5.75 kPa PL underestimated but provide span capacity

For beam: \[ \frac{\sqrt{592}}{100} = 7.74 > 7.5 \text{ m} \]

Piles needed & contaminated fill replaced

4 pile caps = 1498 kN/pile

So 900 & piles 25 m long

Ground slabs = suspended \Rightarrow replaced fill = low bearing capacity

15 m span \rightarrow 2-way continuous slab

\( \frac{s}{d} = 39 \)
\[ d = 15 / 39 = 0.38 \text{ m} \]

\( \Rightarrow \) use 400 mm thick
Horizontal load path
- see section A-A

Horizontal loads from wind + CHF distributed to floors by cladding
\[ \downarrow \]
Significant floorplate stiffness distributes to braced bays by diaphragm action (similar to pt 1)
\[ \downarrow \]
Resulting bracing forces transferred to foundations by push-pull action in the column pair, and resisted by piles
\[ \text{[simple steel connection]} \]

Vertical load path
- see transfer matrix page also

Vertical loads from gravitational effects are supported on 1-way spanning composite slabs
\[ \downarrow \]
Slabs span onto secondary beams which acts compositely with the slab
\[ \downarrow \]
Secondaries span onto primaries which take loads in bending and shear to supporting columns
\[ \downarrow \]
Columns act in compression to frame loads to foundations
\[ \text{piles friction + end bearing to soil} \]
Scheme comparison

Key considerations for the building:
- City centre site - limited storage / access
- Limited working hours due to noise
- Glazed façade - aesthetics and column spacing
- Efficient structure

Scheme 1: Concrete
- Heavy due to concrete
- Many wet trades, H&S - slow on site due to construction and striking times
- Easier delivery to site
- Aesthetics: Which concrete columns
- Material efficiency: Heavy structure, 7.5m concrete transfer pushing limits of concrete

Scheme 2: Steel
- Precast but less so
- Quicker and cheaper
- Long lead in + delivery of long sections may be difficult
- Easy to erect on site - less disruption to neighbours
- Better quality on site
- Services can travel through penetrations but must be coordinated
- No internal columns - greater flexibility
- "Passionable" exposed steel possible
- Lightweight structure

Pullout: expand to explain advantage of clear zone
Future flexibility

1. Concrete
   - less easy to adapt once built

2. Steel
   - easier to extend/reconstruct once built
   - better future proofing
   - assessment needed
   - cost of provision

Booze schemes fit the client's brief, however, considering the above, scheme 2 (steel) has been chosen since it best fits the client's key requirements. The more efficient structure will be quicker to construct on the city centre site, and because the column foundations have less impact on the contaminated ground. There are no internal columns so the use of the space would be much more appealing to the client.

Other issues that could be considered:
- Sustainability
- Propping/pre-camber long spans?
- Discussion on differences of the key transfers
Dear client,

RE: OFFICE BUILDING

Thank you for your correspondence concerning adding another storey to the building. This would increase the lettable floor area to one office in the prime city centre location so we can see why you are keen to consider this option. Since we are at the stage where the scheme is complete but the project has not started on site, this change is possible however it raises the structural concerns below:

1. We assume the additional floor will increase the height of the building, to avoid compromising the clear floor heights currently provided. The vertical loads will therefore increase due to the weight of this additional floor. The foundations and columns will need to be re-checked for these new loads and their site may increase. The 41 transfer trusses will now be taking an extra floor so would need to increase in depth.

Alternatively, if the requirement of no external bracing could be released, the 1-2 floor height could be used for this truss, increasing the clear height at ground floor. Aesthetically pleasing sections could be chosen here to retain the intended aesthetic façade.
Due to the increased height of the building, the building will see a greater wind load. These increased lateral loads will mean that the braced stability system will need to be re-checked and the sections may increase in size. The foundations will also need to be checked for this increased lateral load.

We recommend any revisions to the design are submitted to the project quantity surveyor to assess the estimated cost of this change. For example, cladding and column splice costs will have now increased since these are more.

We also suggest that the main contractor is contacted to assess the impact on the draft construction programme. The project would now take marginally longer on site because of the increased amount to construct.

Furthermore, the additional floor will need to be assessed by the MEP engineer. Service provision may need to increase which could affect the riser layouts. If the risers or plant space is insufficient, increasing could result in legs of drainage systems due to increased voids or increased loads due to greater plant space. Also, the increased risk should be reviewed by the planning council.

We look forward to hearing from you, please get in touch if you have any further questions.

Yours sincerely,

[Signature]

Engineer
2c calculations

The calculations shown in this section are in accordance with Eurocode (EC) guidance as listed below.

(1) Design Standards and Sources of Information
   BS EN 1991-EC1- Actions on Structures
   " 2-EC2- Design of Concrete Structures
   " 3-EC3- Design of Steel Structures
   " 7-EC7- Geotechnical Design

(2) Loading
   DL = 3.125 kPa, composite slab + 1kPa for steelwork
   SDL = 1.85 kPa (see part 1)
   LL = Ground 10kPa, elsewhere 4kPa
   Wind = see next page

(3) Performance Requirements
   Movement - total deflection = span/250
   Glazed areas = span/500
   Buildings sway = H/500
   Durability - external cover = 75mm
   - 50 year design life
   - internal steelwork = C1 (very low risk) = I1 or I2 paint
   - external = C3 (medium risk) = E1 paint

Fine - all steelwork to be insinacene painted to achieve 2H fine rating
Materials
- all concrete C30/37 UNO
- all steelwork S355 UNO
- all reinforcing grade 500B

Calculation schedule - key elements
- Bracing system
- Transfer truss
- Secondary beam
- Column
- Foundation

all other elements sized using engineering judgement
Wind load calculations

Basic wind speed

\[ V_b = \frac{c_e}{\alpha_d} \times c_a \times v \times \text{cut off} \times V_{100} \]

\[ = \frac{1}{x} \times \frac{1}{x} \times 1 \times 1.06 \times \text{mean velocity} \]

\[ V_b = 1.06 \times 20 = 21.2 \text{ m/s} \]

Basic pressure

\[ q_b = \frac{1}{2} \rho V_b^2 = \frac{1}{2} \times 1.226 \times 21.2^2 = 0.276 \text{ kPa} \]

Recur velocity pressure

\[ q_{vp} = c_c(z) \times c_e(z) \times C_{pr} \times q_b \]

\[ = 1 \times 3.1 \times 1 \times 0.276 = 0.823 \text{ kPa} \]

Net pressure - Check for

\[ H_{rd} = 1.1 \]

\[ c_{pela} \text{ face } D = 0.8 \]

\[ c_{pela} \text{ face } E = -0.5 \]

\[ \text{(windward pressure)} \]

\[ \text{(leeward suction)} \]

\[ : \text{ Net pressure } = (0.8 - (-0.5)) \times 0.823 \]

\[ = 1.0699 \text{ kPa} \]

\[ \text{Use 1.1 kPa} \]

Since this calculation is conservative, assume this value accounts for end stress to geometric imperfections.
Steel Braced Bay

Critical case: max overturning

\[ 1.001 + 15 \text{ wind} \]

i.e. no IL contribution

Assume wind is split between the 5 braced bays proportionally, 7.5m bay:

\[ \omega = 1.1 \times 30 \times \frac{7.5}{7.5 + 7.5 + 7.5 + 7.5 + 7.5} = 19.8 \frac{\text{kN}}{\text{m}} \]

\[ \text{max overturning} = \frac{\omega H^2}{2} = \frac{19.8 \times 33^2}{2} = 10781 \text{ kN/m} \]

\[ \text{Push/Pull} = m/6 = \frac{10781}{7.5} = 1437 \text{ kN} \rightarrow \text{check columns for this} \]

Base shear = \( V = \omega H = 19.8 \times 33 = 653 \text{ kN} \)

Bracing axial force = \( V \sin \phi = \frac{653}{7.5} \sin 56 = 78.8 \text{ kN} = f_y \)

\[ \text{AS, req (ULS)} = \frac{1.5 f_y}{0.355/1.15} = 1.5 \times 77.8 = 3780 \text{ mm}^2 \]

Therefore use 40 x 100 mm flat plate
Braced bay deflection

\[ S = \frac{60 \times L \times L^3}{8 \times E} \]

\[ = \frac{10.8 \times 3.3 \times 33000^3}{8 \times 205 \times 1.03 \times 10^{12}} \]

\[ = 13.9 \text{ mm} \]

\[ S \text{ lim} = \frac{14}{500} = \frac{33000}{500} = 66 \text{ mm so OK} \]

Acceptable, but should consider eccentricity effect to increase forces in braced bay.
Transfer Truss

\[ V = P + \omega L \]
\[ V = 2960 + 105 \times 7.5 \]
\[ V = 2971 \text{ kN} \]

Diagonals - end ways max shear
\[ f_t = \frac{V}{\sin \phi} = \frac{2971}{\sin 47^\circ} = 4062 \text{ kN} \]

Area
\[ A_{eq} = \frac{4062 \times 1.15}{0.355} = 131 \text{ cm}^2 \]
\[ b = 2.54 \times 2.54 \times 107 \text{ kN} = 136 \text{ cm}^2 \]

Top/Bottom chord
\[ N_{ed} = \frac{M}{W} = \frac{12577}{125.77} \text{ kN} \]
\[ A_s = \frac{12577 \times 1.15}{0.355} = 407 \text{ cm}^2 \]
\[ 2.56 \times 40.6 \times 540 \text{ UC} = 433 \text{ cm}^2 \]

Deflection
\[ S = \frac{wL^4}{8EI} + \frac{PL^3}{3EI} \]
\[ S = \left( \frac{105 \times 7.5 \times 7500^3}{3 \times 2.05 \times 8.66 \times 10^6} + \frac{2960 \times 7500^3}{3 \times 205 \times 8.66 \times 10^6} \right) \times 14 \text{ mm} \]
\[ S = 2.58/1.4 = 18.4 \text{ mm} \]

\[ S_{um} = \frac{7500}{500} = 15 \text{ mm} \]

From point 1, \( P = 2960 \text{ kN} \) (ULS)
\[ W = 7.5 \times [1.85 \times (4.125 + 1.85) + 1.5 \times 4] \]
\[ = 105 \text{ kN/m} \] (ULS)

\[ M_{max} = PL + \frac{WL^2}{2} \]
\[ = 2960 \times 7.5 + \frac{105 \times 7.5^2}{2} \]

1.875
\[ 2m \]

\[ \phi < \tan^{-1} \left( \frac{2}{1.875} \right) \]
\[ = 47^\circ \]

\[ b = 2.54 \times 2.54 \times 107 \text{ kN} = 136 \text{ cm}^2 \]

Mention restraints to bottom chord.
Secondary Beam \rightarrow 2.5m
c
assume full lateral restrain from slab

Try UB 650 x 250 x 170

loading
\[
\begin{align*}
\Delta E &= 3.125 \text{ kN/m} \\
SDL &= 1.8 \text{ kN/m} \\
LL &= 4 \text{ kN/m}
\end{align*}
\]

\[
\begin{align*}
\Sigma SL &= 8.975 \text{ kN/m} = 2.24 \text{ MN/m} \\
\Sigma UL &= 12.7 \text{ kN/m} = 31.8 \text{ MN/m}
\end{align*}
\]

\[
\text{Max BM} = \frac{\omega L^2}{8} = \frac{31.8 \times 15^2}{8} = 89.4 \text{ MN/m}
\]

Composite behaviour allows for 1.4 times increase on steel section capacity

Bending
\[
M_{Ed} = 1.4 \times \text{Wk} \times f_y = 1.4 \times 5630 \times 10^3 \times 355 = 1 \times 10^6
\]

\[
= 2789 \text{ kN/m} \text{ : ON 32\% utilised}
\]

Shear
\[
\begin{align*}
\text{V}_{Ed} &= 0.577 \text{ Av} \times f_y = 0.577 \times 355 \\
&= 0.577 \times 14.5 \times 355 \times 8 \times 10^3 \\
&= 20.58 \text{ kN}
\end{align*}
\]

\[
\text{V}_{Ed} = \omega L = 31.8 \times 15 \times 2 = 234 \text{ kN} \text{ : ON 12\% utilised}
\]

Deflection
\[
\begin{align*}
S &= \frac{5WL^4}{384EI} \\
&= \frac{5 \times 22.4 \times 15 \times 15000^2}{384 \times 205 \times 170000 \times 10^4} \\
&= 42.4 \text{ mm}
\end{align*}
\]

\[
SL = \frac{span}{250} = 60 \text{ mm}
\]

Attacted
Column Try (256x406x287UC)

Out of balance moments from secondary end shear (primary balance)

$N_{ed} = (509 + 4525) \times 1.4 = 7048 \text{ kN ULS}$

$M_{yy} = 0$

$M_{zz} = 239 \text{ kN m} \times \left( \frac{399}{2} + 100 \right) \div 1000 = 72 \text{ kNm}$

end shear

worse case buckling length < 5m

\[
\frac{N}{M_{ord}} + \frac{M_{yy}}{M_{ord}} + \frac{1.5 M_{zz}}{W_{zEy}} \leq 1
\]

\[
\frac{7048}{9719} + 0 + \frac{1.5 \times 72}{1017}
\]

$0.725 + 0 + 0.106 = 0.831 < 1 \text{ OK}$
Foundation

4 pile cap - 2.5m long 900Ø piles

Depth = 2.3Ø to limit punching

\[ d = 2.2m \]

\[ a = 2200 - 75mm coner \rightarrow \text{say} 2100 \text{mm} \]

Using Stiff + Tie Truss analogy

Tension force between piles

\[ T = \frac{N \cdot L}{4 \cdot d} \]

\[ N = 5992 \text{ kN from part 1} \]

\[ T = \frac{5992 \times 1350}{4 \times 2100} = 963 \text{ kN} \]

\[ A_s, \text{req} = \frac{963 \times 10^3}{0.87 \times 500} = 2214 \text{ mm}^2 \]

\[ \text{Provide } B25 @ 200 = 2454 \text{ mm}^2 \]

\[ \text{each direction} \]

Punching

at col base \[ v = \frac{N}{\pi \cdot d} = \frac{5992 \times 10^3}{2(356 + 4x)} \times 2100 = 1.87 \text{ kN/mm}^2 \]

\[ v_{rd, c} = 3.64 \text{ kN/mm}^2 \text{ so OK} \]

\[ d \text{ from col base is outside pile cap - punching OK} \]


**Pile Design**

- Assume no moment
- $N_{ed} = 1498 \text{ kN} / \text{pile}$ (from Table 1)

\[
N_{ed} = \frac{1498 \times 10^3}{900^2 \times 30} = 0.062
\]

Therefore use min steel $0.06 \% \rightarrow 254 \text{ kN/mm}^2 = 6.825

Soil capacity not checked
METHOD STATEMENT

1. PRELIMINARIES
   - clear site and erect perimeter hoarding
   - carry out further site investigation to identify type, extent and concentration of contaminants within the ground
   - also identify any below ground services or obstructions - city centre site so limited
   - relocate underground services if necessary + install temp services to site
   - Induct staff - site specific risk assessment highlighting key H&S areas (e.g. contaminated land, transfer semester)
   - develop traffic management + delivery strategy for city centre site so may need single lane closure
   - access in elements > 12m long to allow normal vehicle without an escort

2. OFF SITE CONSTRUCTION
   - Order Steel: 12 week lead time + 110 bolts
   - Reinforcement: 6 week lead time but can begin coordination of detail drawings

3. SUBSTRUCTURE
   - contaminated land to be removed and suitably disposed of
   - replaced with compacted fill
   - level site and set out piles - construct piles

Replacing this volume of material is expensive. Is it required? Alternatives should be considered.
- cut off piles at connect (length ensuring sufficient projection into pile cap
- install any below ground drainage
- excavate pile caps, trim sides, blind base
- construct rebar + place in excavations
- locate HD bolts for baseplates
- prepare crane base

Tower crane placed external to building with room to prevent needing to leave bay or slab within building vacant

- concrete cast to underside of ground slab
  - ground slab rebar Rage laid
  - ground floor + tops of pile caps cast as one

4. **STABILITY SYSTEM**
   - erection of steel to start in a braced bay in order to be self supporting
   - enir stable and self supporting bay can then be used to support subsequently erected steel
   - temporary stability to be maintained throughout construction

5. **SUPERSTRUCTURE** - continue erecting steel frame
   - safe access to and from working areas to always be provided
   - transfer beams - temporary prepping must be provided until fully constructed inc. backspan

Good to make key stability items during construction clear
* Composite decking - consider orientation and volume of material being stowed to prevent overloading
* Install edge protection
* Maximum amount of protective steel paint applied in workshop to be made good only after erection damage has been inspected
* Install shear studs

6) SLABS
   * Lay reinforcement onto decking
   * Ensure all cast-in cladding brackets and reinforcement are installed
   * Pour concrete
   * Ensure any areas where beam propping is identified are propped
   * Appropriate finishes to slab to be applied

7) ROOF - as shown plus membrane

8) CLADDING

9) MEP + Finishes → handover to client
   * Stand when 2 coats of primer have been completed for non-sensitive items
   * Once cladding complete (water-tight building)
   * Commissioning + installation of services finished
CONSTRUCTION PERIOD = WEKS

4 8 12 16 20 24 32 36 40 44 48 52 56 60 64 68 72 76

SITE SET UP
REMOVAL CONTAMINATED LAND
SUBSTRUCTURE
PILING
PILE CAPS
DRAINAGE
GROUND SLAB
SUPERSTRUCTURE
STABILITY SYSTEM
TRUSS
FLOORS INC. STUD + DECK
CAST SLABS
ROOF STRUCTURE
CLADDING
MEP + FINISHES

ORDER REBAR
ORDER STEEL

STURCTURE COMPLETE
MILESTONE
MILESTONE - BUILDING IS WATERPROOF

3960 m² or 330 m³/week
typical for office

MILESTONE - PRACTICAL COMPLETION - HANDOVER TO
CLIENT /

76 weeks
(19 masts) total
(typical office 15-18 months)

(30 x 30 - 15²) x 9 floors = 5075 m² total
Clear and well thought out drawings. Notes clear.
NOTES

REFER TO DRAWING 01 FOR DETAILS

This detail should be drawn as a critical detail.