The Institution of
StructuralEngineers

Energy question appendix

Chartered Membership Exam preparation guidance

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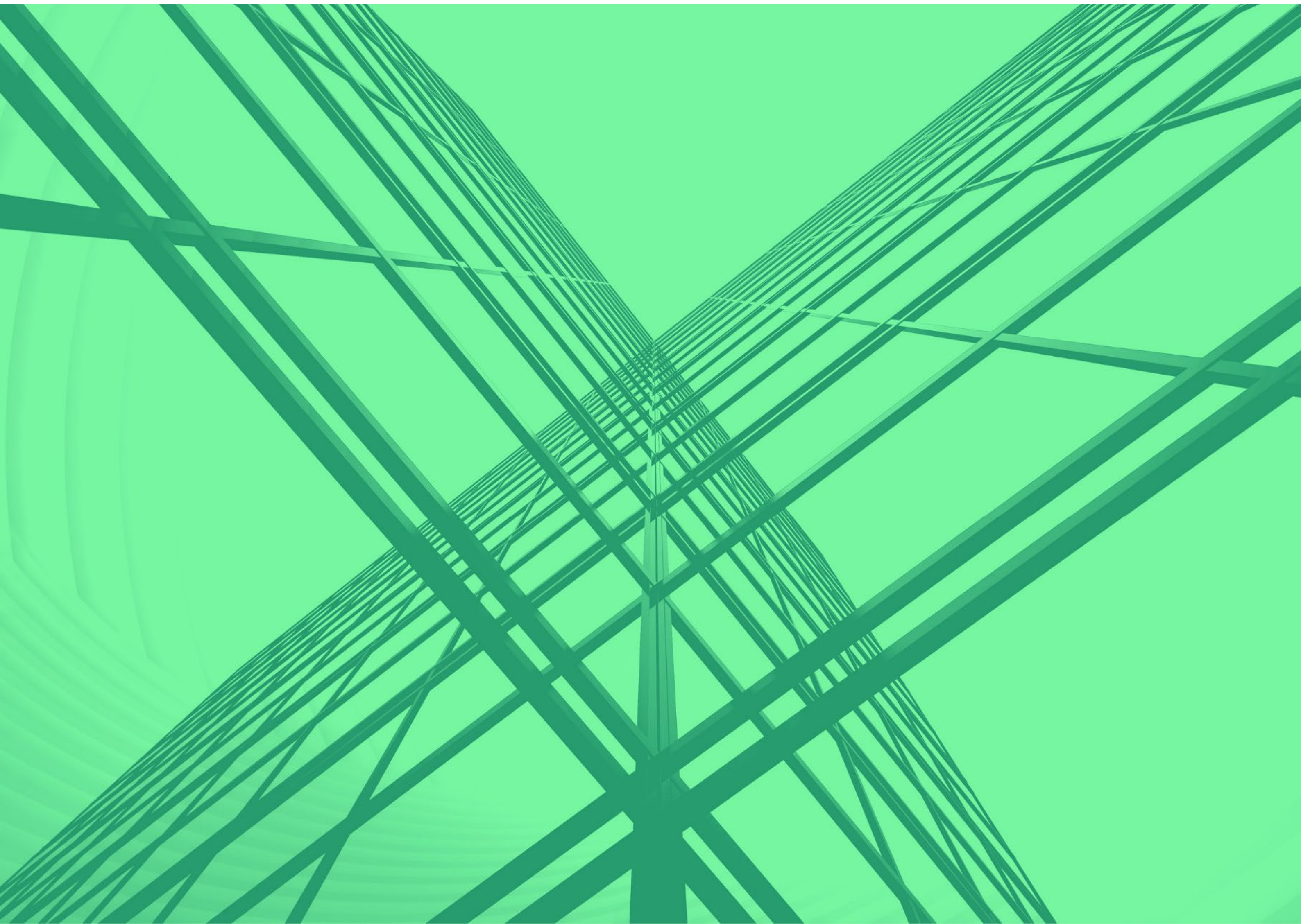


Contents

Introduction

From January 2026, the Institution will be reintroducing a question into the Chartered Membership Exam aimed at engineers who work predominantly on energy related structures for the renewables, oil and gas and nuclear industries, including offshore structures. This question will be included as a 6th option and will not be replacing one of the existing question types.

This new guidance appendix has been produced by the Examinations Panel and must be read in conjunction with the main Chartered Membership Exam Preparation Guidance. The information contained in this appendix is not a complete guide and focuses specifically on the additional requirements and considerations for those attempting this category of question.

Sample questions are also included to show how some previous offshore energy questions could be adapted to the new criteria introduced in 2024.

For ease of reference, the same titles and subtitles have been included in this appendix, as well as references to the associated main guidance page numbers.

General tips

In addition to the comprehensive range of examples of things that candidates should be mindful of, or where marks could be lost *(page 4)*, the following list would be specific to the energy question:

- Lacking in suitable demonstration of preventative measures to combat destabilising loading (wind / wave / blast / impact etc)
- Poor demonstration of load transferral between sections and main load carrying components (lift points / joints / bracing / primary members etc.)
- Highlighting of principal load bearing members (description of functional framing)
- Failure to demonstrate or account for load-out / load-in / transportation / lifting / installation / accidental load cases and construction methods.
- Highlighting the importance of weight management
- Demonstrate understanding of structural redundancy / efficiency and constructability methods

Providing distinct, viable and sustainable solutions

When considering the ways that a candidate can produce two schemes in their answer *(pages 6-7)*, recognition must also be given to external load combinations such as extreme environmental / ship impact / load-out / load-in / transportation / accidental loading from blast, swinging, dropped objects, and construction methods.

Adding to the list of significant differences between the two schemes, candidates should consider:

- Functional framing – principal load bearing members and end fixity assumptions
- Installation / transportation / accidental conditions

Each scheme should be distinct, viable and a valued discussion provided as to the salient differences and merits. It is important to acknowledge that all load conditions should be accommodated with due consideration of load transferral, stability, and practical, efficient framing configurations.

In this question type, there are numerous options available for structure types, such as (but not limited to):

- Renewable energy structures e.g. wind farms – (marine or land based – superstructure & substructure design)
- Offshore oil and gas recovery and processing structures
- Low carbon fuel refinery
- Decommissioning – (reverse installation and alternative removal methods with a focus on recycling of materials)
- Maritime structures
- Solar energy structures
- Subsea facilities [such as modular subsea structures, protection structures, templates etc.]
- Bridges

- Structures associated with nuclear power facilities

It is important to acknowledge, for each structure type and scheme presented, every critical loading scenario is considered. Listed below are some of the key considerations:

Functional framing

Illustrate geometry of structure and principal load bearing members.

- Type of connections
- Primary load paths
- Discussion on how structure behaves
- Stiffness of members / elements
- Support conditions – fixed or pinned

Load transferral

- Truss action / triangulation of forces
- Joint stiffness / portalisation
- Complexity of routes
- Number of load paths
- Longitudinal / lateral / vertical / plan bracing
- More members – less loads – smaller joints - (i.e. Discussions on the relationship between the number of members, magnitude of loads / size & complexity of joints are just some of the key points)
- Illustrate the load distribution throughout the structure

Stability

- Note direct load paths, both local and global
- Identify stability requirements for construction / load-out / installation / in place / accidental conditions

Lifting

- Single hook lift vs multi-hook
- Use of spreader bars and frames
- Consideration of skew loads for different lift configurations
- Accommodation of weight and centre of gravity uncertainties and potential shifts during lifting operations
- Consequence factors and redundancy in the vicinity of lift points

Efficiency / simplicity

- Efficient load paths
- Consideration of construction sequence
- Joint complexity – fixed versus pinned?
- Short columns versus long columns
- Fabricated or closed members versus rolled section
- Joint welding complexity – butts versus fillets (i.e. - construction access, extent of non-destructive testing etc)
- Constructability benefits

Stiffness

- Fewer members more complex joint detailing
- Greater number of members – stiffer more rigid structure
- Consideration of structural response to dynamic load scenarios – natural period
- Account for stress concentration factors

Tubular versus open sections

- Resistance to joint fatigue
- Structural response (wind/wave induced vibration)
- Susceptibility to corrosion
- Susceptibility to ice or marine growth build-up
- Ease of inspection and repair

Analysis

- Pinned trusses – straight forward to design with simple load paths
- Moment connection design and analysis is more complex

Construction

- Consideration should be given for both ease of fabrication and constructability (i.e. how easily major components can be integrated on site or in the field).
- Maximise pre-fabrication and minimise on-site hook-up and commissioning.

Layouts

- Structural framing configurations should consider the functionality of the facility in terms of plant layout, accessibility, escape and evacuation, open ventilation etc.

Weight

- Highlight any weight risks
- Highlight the importance of weight management and control and how it relates to structural design, analysis and construction risks.

How to appraise/differentiate between schemes

Further acknowledgement in this section *(pages 8-9)* should be given to the consequences of large structures being built off-site, resulting in a need to lift, transport and place at the final location. To achieve this consideration should also be given to:

- Load Out / Load In – method for transportation of structures and the key aspects to achieve safe manoeuvring
- Transportation – dependant on the type and form of structure, transportation must acknowledge the external forces and accelerations as a result of road or sea transportation and the challenges experienced to minimise the complexity and loading experienced by the structure. For example, additional support grillage / temporary steelwork / vessel sea fastening and equipment support during transportation.
- Lifting – in the event of structural lifting taking place, it is important to recognise the potential need for additional load transferral steelwork placed at strategic locations. These will generally, be at positions of high load concentration such as lift points and primary bracing. Similarly, there may be a need to further enhance the structure for possible racking effects due to lift rigging configurations and centre of gravity uncertainties.
- Accidental – the nature of hydrocarbon and other energy developments requires dealing with the effects of unplanned release or ignition of potentially volatile components and impacts from dropped objects or attendant/passing sea traffic. Consideration should be given to the potential release of significant energy, resulting in higher-than-expected loading, such as blast overpressures and collisions.

Calculations

For the energy question it is likely the structures will be large and substantial and will require demonstration that they are suitable for all temporary, permanent and accidental conditions. The principal structural elements will be different for each scheme proposed, but the following gives an indication of some of the elements likely to be addressed:

Topside / Land Based / Decommissioned Structures:

- Main Columns / Perimeter Beams / Face Bracing / Plan Deck Members / Top and Bottom Chords / Critical Joints / Weight Estimate / Simplified Foundation Assessment

Maritime / Subsea Structures:

- Substructure / Face Bracing / Plan Chords / Critical Joints / Weight Estimate / Simplified Foundation assessment / Environmental Loading from Wind, Wave and Current / Ship Impact / Installation Points / Acknowledgement of Launch, Lift and placement methods and procedures
- *(Although no formal assessment of fatigue and appurtenances is required, some acknowledgement of the associated design, construction and operational issues should be included.)*

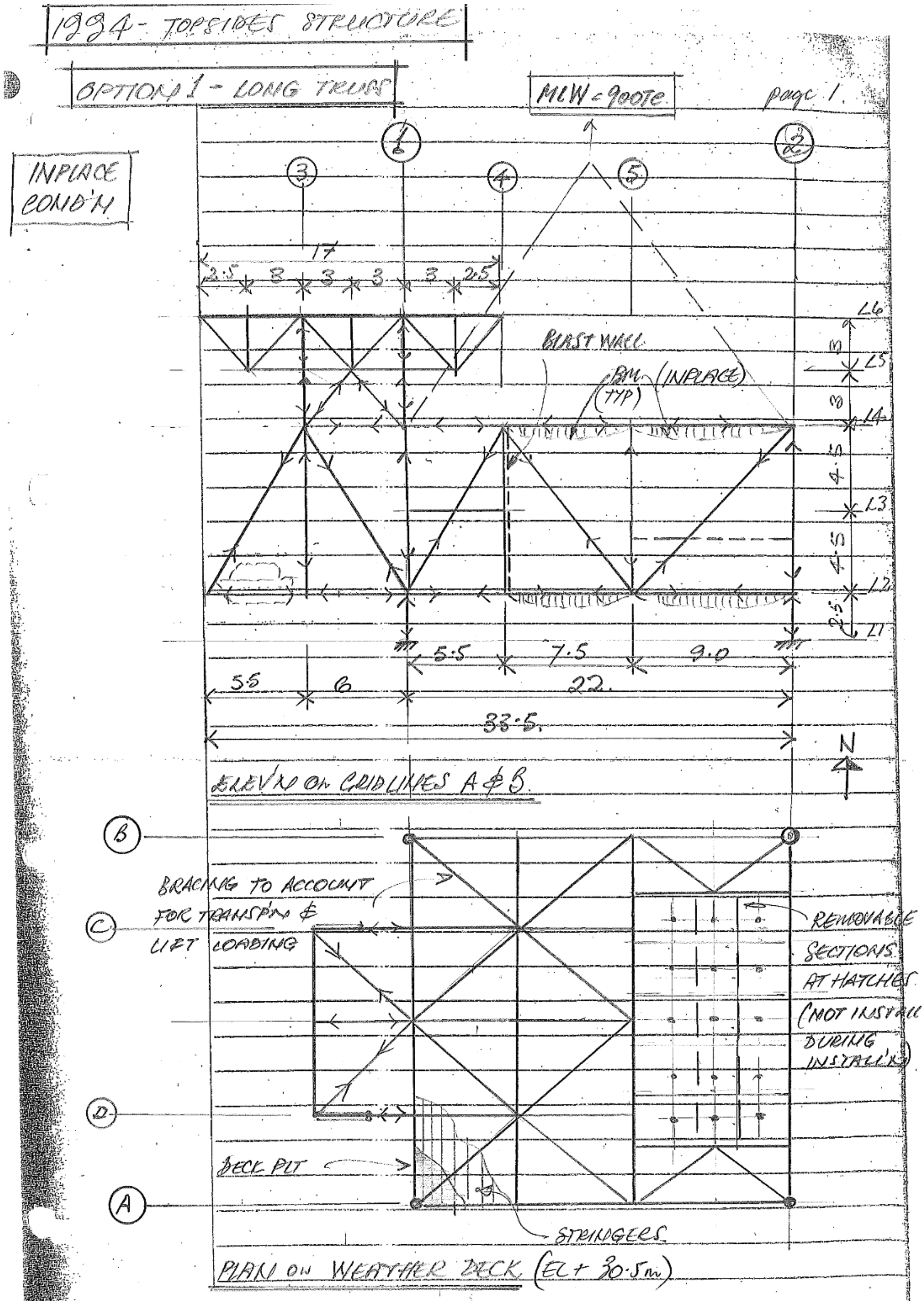
Wind Power Related Structures:

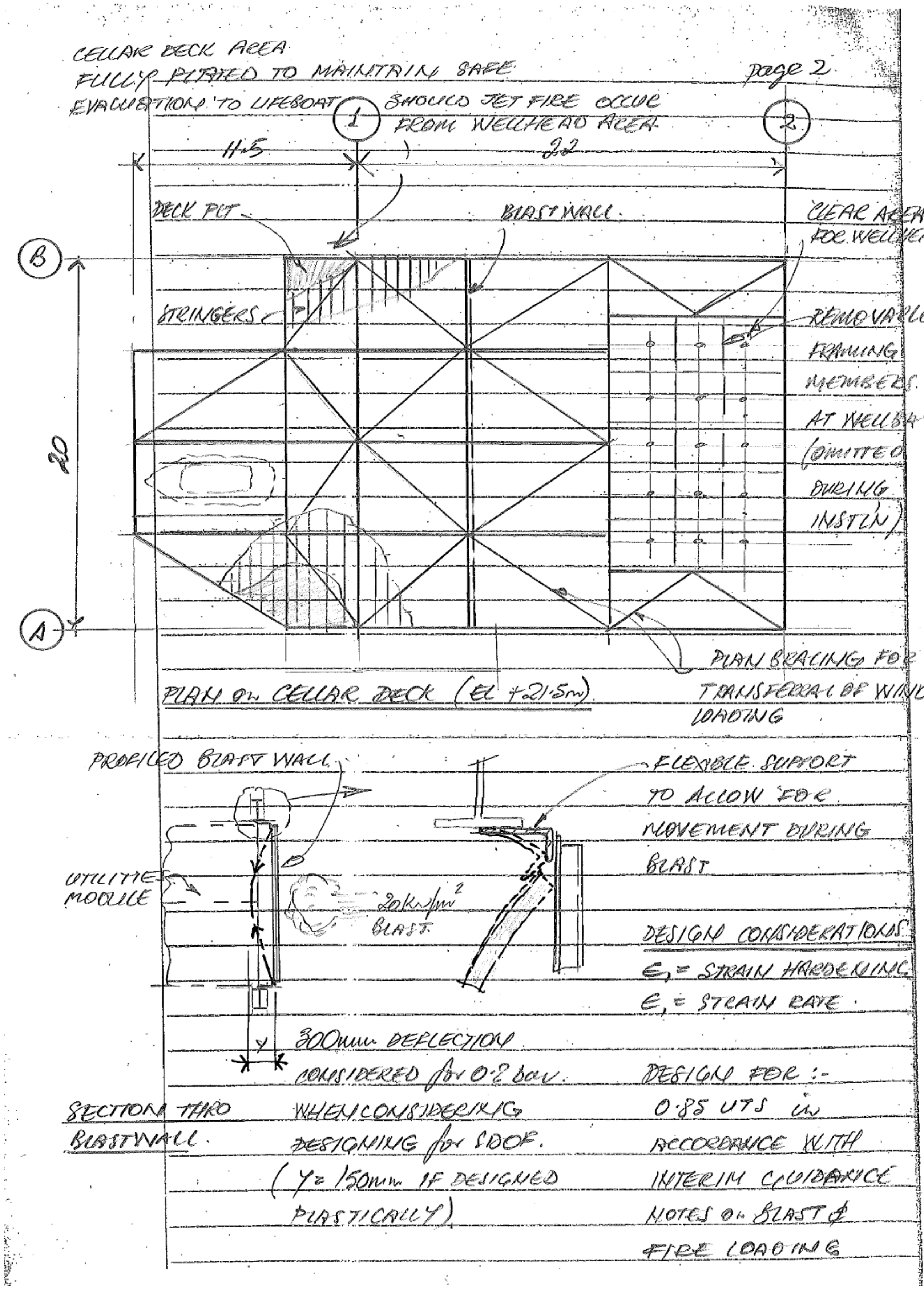
- Key components noted above relating to maritime structures, no requirement for the design of the blades and rotating mechanisms

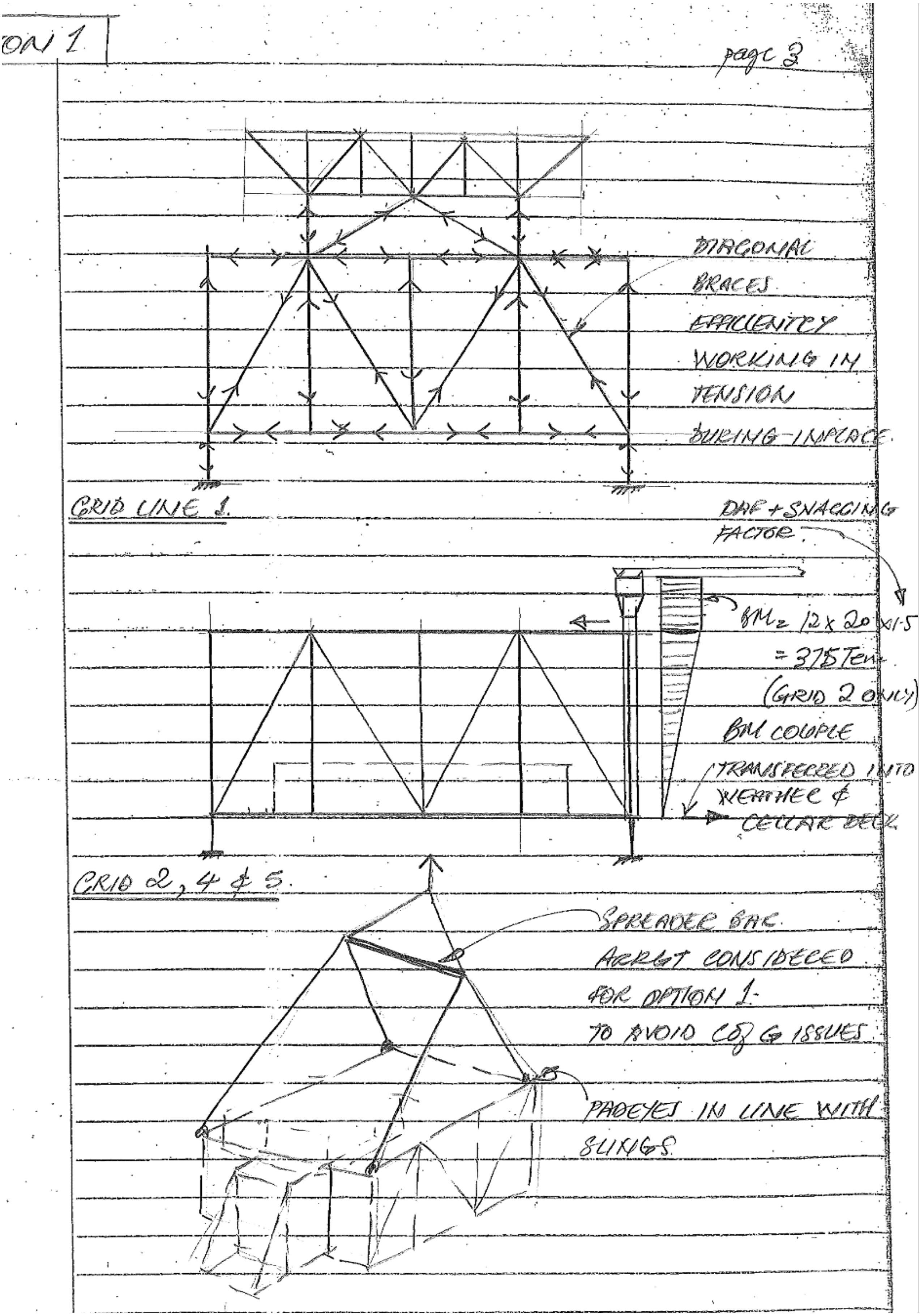
Preparation of proposed scheme General Arrangement drawings

Example – Minimum facility offshore platform – taken from 1994 exam

The 1994 question related to a minimum facility offshore platform, which is not normally manned. These structures were associated with providing additional cost-effective drilling facilities. Similar concepts are currently being developed as extensions to existing offshore production platforms to house equipment associated with the provision of imported electrical power to replace existing gas turbine generators and equipment drivers thereby reducing greenhouse gas emissions.

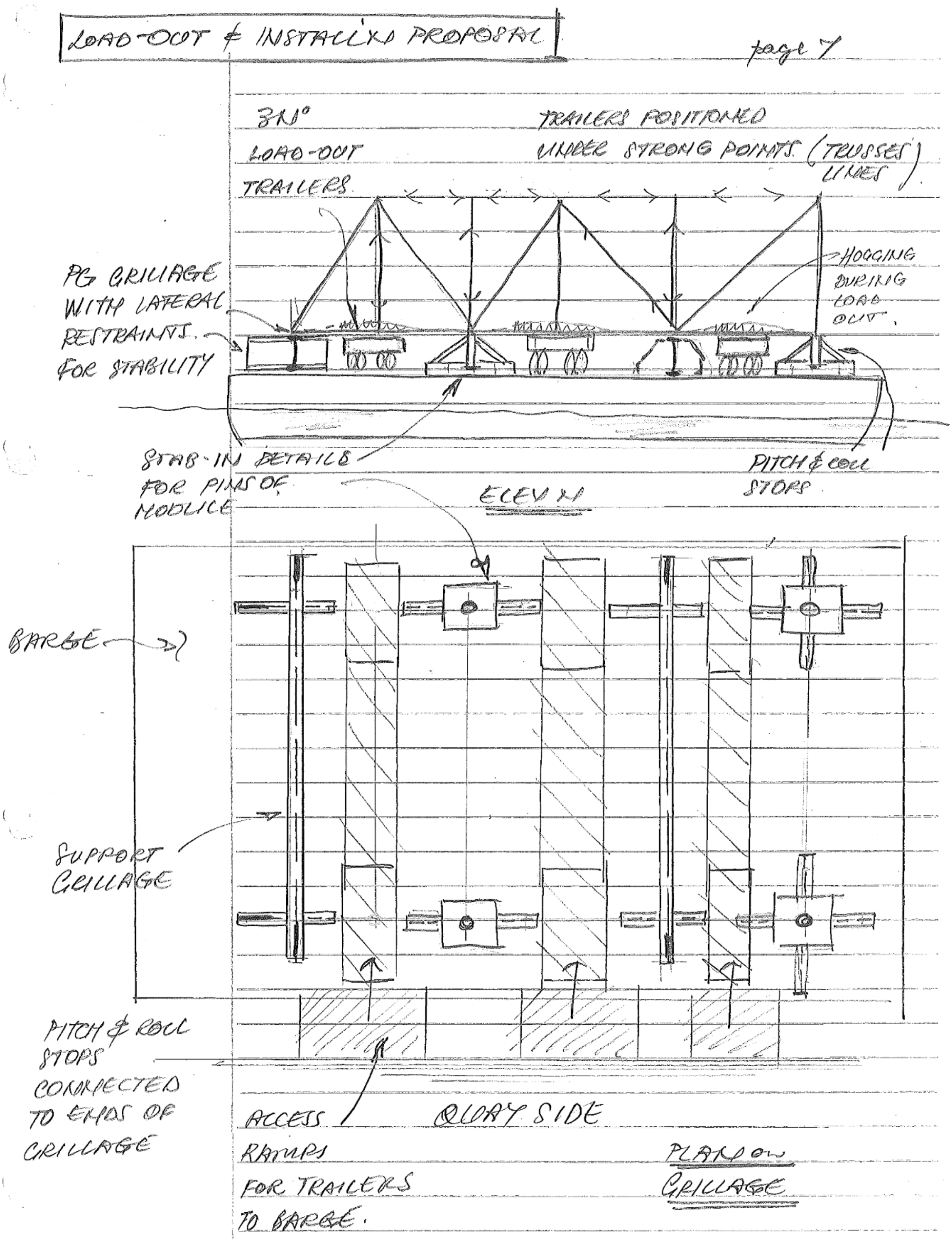

1994 - TOPSIDES STRUCTURE
OPTION 1 - LONG TRUSS
MLW = 900TE
page 1.
INPLACE COND'N
BLAST WALL
BM (TYP)
(INPLACE)
ELEV'N ON GRIDLINES A & B
BRACING TO ACCOUNT FOR TRANSP'N & LIFT LOADING
REMOVABLE SECTIONS AT HATCHES (NOT INSTALL DURING INSTALL'N)
DECK PIT
STRINGERS
PLAN ON WEATHER DECK (EL+ 30.5m)
N

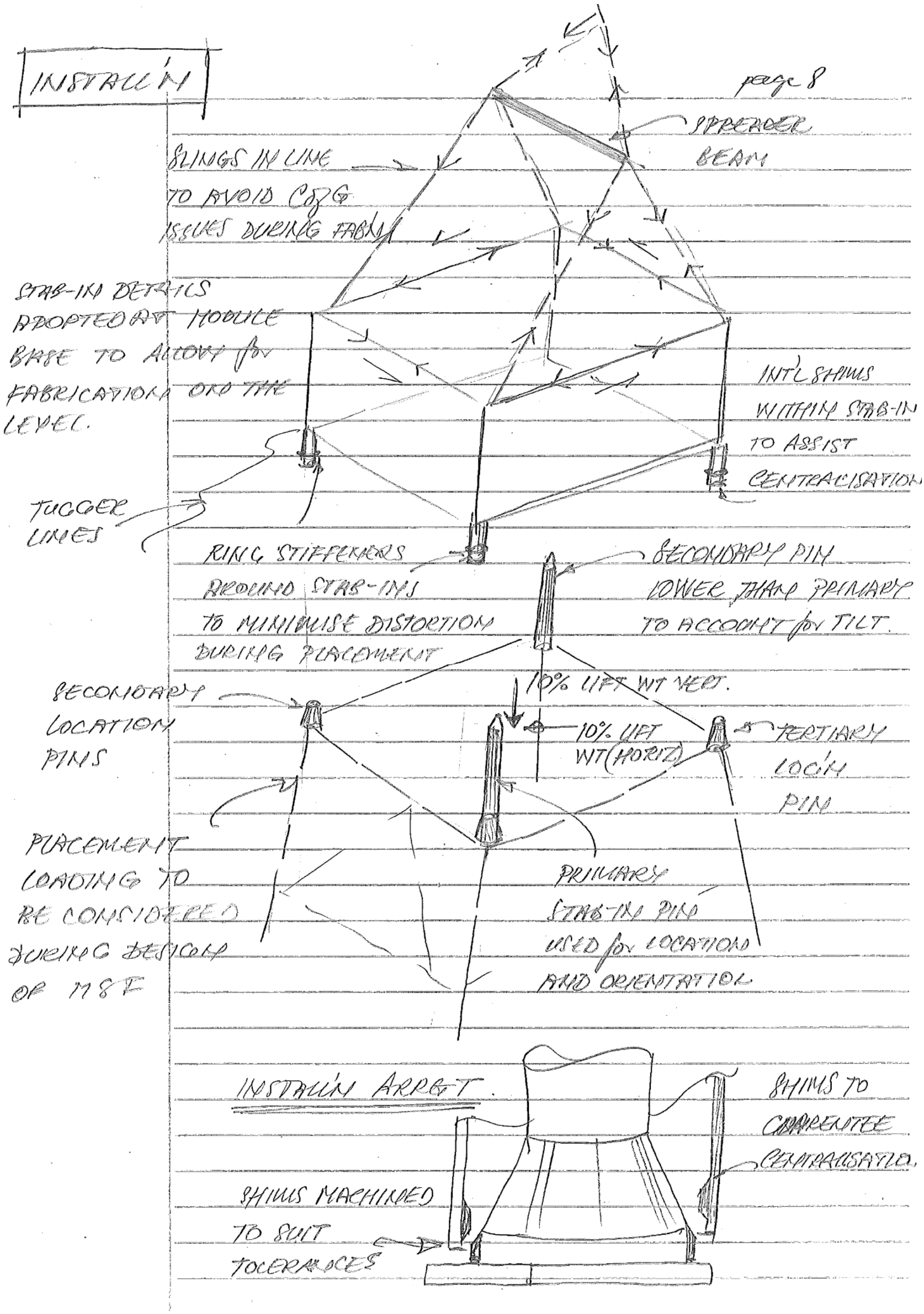

CELLAR DECK AREA
FULLY PLATED TO MAINTAIN SAFE
EVACUATION TO LIFEBOAT
Page 2
SHOULD JET FIRE OCCUR
FROM WELLHEAD AREA
11.5
22
DECK PIT
BLAST WALL
CLEAR AREA
FOR WELLHEAD
STRINGERS
REMOVABLE
FRAMING
MEMBERS
AT WELLBAY
(OMITTED
DURING
INSTLN)
20
PLAN BRACING FOR
TRANSFERRAL OF WIND
LOADING
PLAN ON CELLAR DECK (EL +21.5m)
PROFILED BLAST WALL
FLEXIBLE SUPPORT
TO ALLOW FOR
MOVEMENT DURING
BLAST
UTILITIES
MODULE
20kN/m2
BLAST
DESIGN CONSIDERATIONS
E1 = STRAIN HARDENING
E2 = STRAIN RATE
Y
300mm DEFLECTION
CONSIDERED for 0.2 bar
WHEN CONSIDERING
DESIGNING for SDOF.
(Y = 150mm IF DESIGNED
PLASTICALLY)
DESIGN FOR :-
0.85 UTS in
ACCORDANCE WITH
INTERIM GUIDANCE
NOTES ON BLAST &
FIRE LOADING
SECTION THRO
BLASTWALL


ON 1
page 3
DIAGONAL
BRACES
EFFICIENTLY
WORKING IN
TENSION
DURING-INPLACE
GRID LINE 1.
DAF + SNAGGING
FACTOR
BM = 12 x 20 x1·5
= 375 Tem
(GRID 2 ONLY)
BM COUPLE
TRANSFERRED INTO
WEATHER &
CELLAR DECK
GRID 2, 4 & 5.
SPREADER BAR
ARRGT CONSIDERED
FOR OPTION 1.
TO AVOID CoG ISSUES.
PADEYES IN LINE WITH
SLINGS.

Structural Components for Arrangement and Details Consideration:

1) Deck levels showing functional framing – suitable for in place and lift conditions
2) Face bracing – demonstrating load transferral and resistance to transportation / lateral forces
3) Indication of secondary & tertiary steelwork
4) Support and fixity considerations
5) Identification of key points affecting the structures behaviour during critical load cases




INSTALL'N
page 8
SPREADER BEAM
SLINGS IN LINE TO AVOID COG ISSUES DURING FABN
STAB-IN DETAILS ADOPTED AT MODULE BASE TO ALLOW for FABRICATION OUT THE LEVEL.
INT'L SHIMS WITHIN STAB-IN TO ASSIST CENTRALISATION
TUGGER LINES
RING STIFFENERS AROUND STAB-INS TO MINIMISE DISTORTION DURING PLACEMENT
SECONDARY PIN LOWER THAN PRIMARY TO ACCOUNT for TILT.
10% LIFT WT VERT.
SECONDARY LOCATION PINS
10% LIFT WT (HORIZ)
TERTIARY LOC'N PIN
PLACEMENT LOADING TO BE CONSIDERED DURING DESIGN OF MSF
PRIMARY STAB-IN PIN USED for LOCATION AND ORIENTATION
INSTALL'N ARRGT.
SHIMS TO GUARANTEE CENTRALISATION.
SHIMS MACHINED TO SUIT TOLERANCES

Load-in/out and installation methodology

The above sketches demonstrate the chosen method for load-out after fabrication. Within the sketch it shows an understanding for the need to manoeuvre the structure and the various construction methods to allow this to happen. Key points such as highlighting the appropriate position of bearing points and the consequences to the structure should be demonstrated and discussed.

Demonstration of an understanding of installation methodology must also be given to illustrate the proposed scheme which highlights the critical members and key points needed to allow a safe and controlled installation. This can be conveyed more easily with the use of annotated sketches as opposed to text.

Structural Behaviour & Observations

Candidates should demonstrate an understanding of the design brief and give a clear indication of the structure's behaviour under the differing load cases.

Volumetrically, a weight can be easily established to confirm the appropriate method for handling the structure. This will enable an appropriate scheme to be developed for the placement of the structure as well as establishment of the key areas of concentrated loading needed to establish the form and function of the primary and secondary steelwork.

In the event of a clear instruction being given in the question, it is essential that this be adhered to and accommodated within the scheme.

Local to areas of high load concentrations, such as lifting points and footings, consideration should be given to the placement of elements suitable to address load transferral and additional redundancy.

Whilst multiple alternatives exist for the member selection, due consideration should be given to the type of section presented ("open or closed sections"). This gives a clear understanding of conventional or established construction practices and considers ease of material availability and inspection requirements. In addition, standard (noncomplex) joint detailing could be discussed to convey an understanding of construction constraints, efficient design, inspection & maintenance needs.

Calculations

When developing the calculations, as noted previously, it is important to be clear and concise associated with the derivation of loading and any assumptions being considered.

The expectation is that calculations will be produced which demonstrate an understanding of the structural behaviour for during each load case. For example, the critical members to be considered for design should acknowledge (but not limited to):

- Load-In/Out
- Transportation
- Lift
- Inplace
- Accidental

Typical Example of calculations noted below:

1994 - CALCULATIONS.

DESIGN CONSIDERATIONS: (PART 2C) → page 1.

The following design considerations have been used :-

DESIGN CODE :- AISC 9th Edn
: CP3 Cpt V Pt 2 - Wind Code

MATERIAL USED :- GRD 355EM - PRIMARY (UNO)
:- GRD 355E - SECONDARY (UNO)

The Topsides structure shall be designed based on the following loading criteria :-

INPLACE - SELF WT + EQUIPT + LIVE + ENVIRON [Wind + Snow Ice]

TRANSPORTN - load induced during pitch Roll + Heave

Based on the following assumptions :-

ROLL = 20° AMPLITUDE 10s PERIOD.
PITCH = 12.5° —"— —"—
HEAVE = 5m —"—
ROLL - (Assumed governing criteria)
TYPICAL FORCE (HORIZ) = 0.7g
FORCE (VERT) = 1.2g.

LOAD-OUT = TRAILER MOVEMENT.

LIFTING = 60/40 sling distribution (Spreader Beam).

PERMISSIBLE STRESSES

SHEAR = 0.4Fy (Ref : AISC Section F4)
BENDING = 0.6Fy (Lateral Torsional will not be considered but will be noted when compression flange unrestrained).

page 2.

TENSION : 0.6 Fy but limit to 0.45 Fy to allow for secondary bending at joints.

COMPRESSION = As above = 0.45 Fy with $Kl/r_y > 75$ to avoid slender members

LIMITING VORTEX VIBRATIONS.

$L/D < 40$ and $D/T < 33$.

DECK PLATE — Reference SDM page 882

Maximum span of stringers = 5m (Stringers at 1000 c/cs)

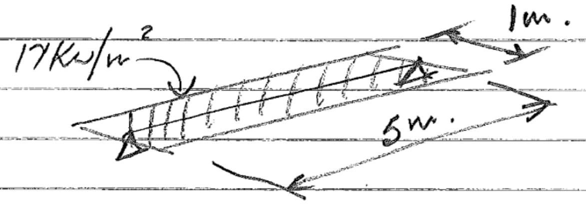
∴ Max. local load = 250Te (Cellar Deck).

∴ 7.5m × 20m = 150m² ∴ UDL = 250/150 = 1.67Te/m² = 17Kn/m²

∴ **Use 8mm GRD Z750 plt with UDL = 21.99Kn/m²**

Considering centres at 1000 & max. length = 2000mm.

STRINGER



Max. Span = 5m.

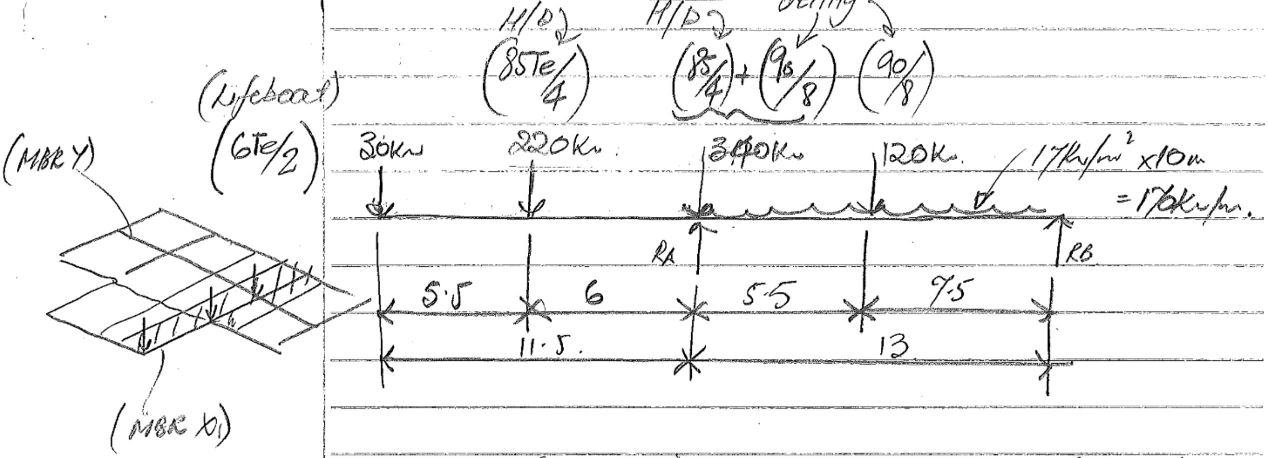
∴ BM = $wl^2/8$ = $17 \times 5^2/8$ = 53 Knm

∴ Z reqd = $53 \times 10^6 / 0.6 \times 345$ = 257cm³

ADOPT 305 × 102 × 33 UB Z = 415cm³.

(LONGITUDINAL) page 3

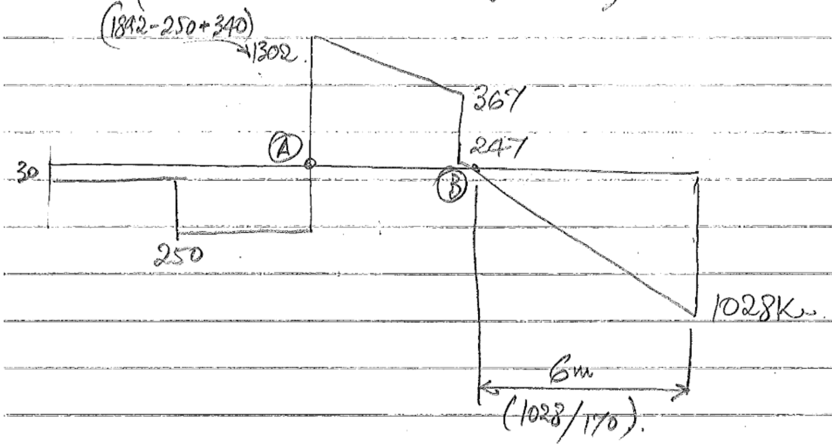
BOTTOM TRUSS MEMBER -(Local to Lifeboat Area)



$\therefore RA \times 13 = (30 \times 24.5) + (220 \times 19) + (340 \times 13) + (120 \times 7.5) + (17 \times 13 \times (13/2))$

$\therefore RA = \underline{1892\ kN}$

$\therefore RB = (30 + 220 + 340 + 120 + (170 \times 13)) - RA = \underline{1028\ kN}$



$\therefore BM_A = (30 \times 11.5) + (220 \times 6) = 1665\ kNm$

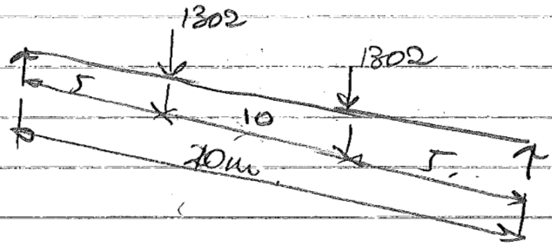
$\therefore BM_B = (1028 \times 6) - (170 \times 6 \times 3) = \boxed{3108\ kNm}$

$\therefore Z_{reqd} = 3108 \times 10^6 / (0.6 \times 345) = \boxed{15014\ cm^3}$

∴ ADOPT 1500 x 400 x 50 x 20 PG

$Z_{prov} = 34142\ cm^3$

BOTTOM TRANSVERSE (MBR Y) page 4.



∴ Ref SOM page 34.

∴ BM max = Pa.

∴ BM max = 1302 x 5

∴ BM = 6510kNm

∴ Zreqd = 6510 x 10^6 / 207 = 31450 cm³.

∴ ADOPT 1500 x 400 x 50 x 20 PG Z = 34142cm³

MAIN COLUMN.

TOTAL LOAD APPLIED TO STRUCTURE

= HD = 85 + 5 =	= 90Te.
EQUIPT = 300Te	= 300Te.
UTILITY MODULE = 90Te	= 90Te.
CRANE = 35Te	= 35Te.
VENT = 5Te.	= 5Te
LAYDN = 25 x 6 x 4	= 60Te
	580Te.

CONSIDER LIVE LOADING

∴ WEATHER DK = 2.5Te/m² x 20 x 22m	= 1100Te.
∴ CELLAR DK = 1.5Te/m² x 20 x 22	= 660Te.
	1760Te.

∴ (580 + 1760) / 4 columns = 585Te/column

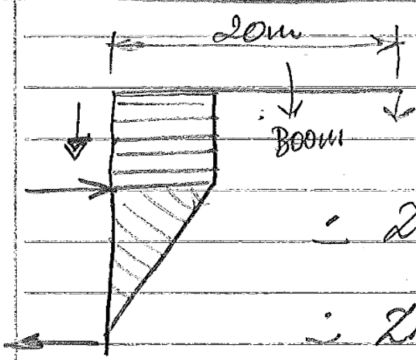
page 5.

∴ Area reqd = $585 \times 10 \times 10^3 / 0.45 \times 345$ = 37681 mm^2
= 377 cm^2

∴ ADOPT 800 × 20 WT TUBE A = 490 cm^2

∴ D/T = 800/20 = 40 < 60 ∴ local buckling prevented.

CRANE PEDESTAL



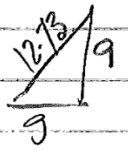
DAF (Snagging)
12.5Te × 20 × 2 = 500 Tem

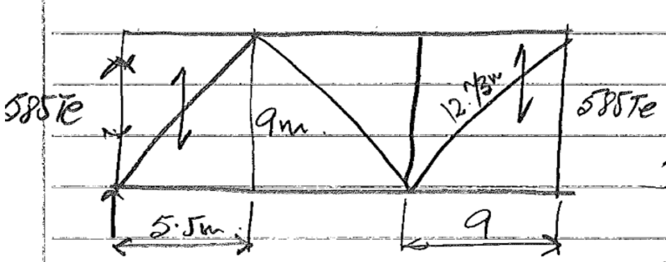
∴ Z reqd = $500 \times 10^6 \times 10 / 0.6 \times 345$.

∴ Z reqd = 24155 cm^3

∴ ADOPT. 1000mm × 40 TUBE Z = 27843 cm^3

LONGITUDINAL BRACES & TRANVERSE BRACES.





∴ Load / brace = 585 × 12.73 / 9

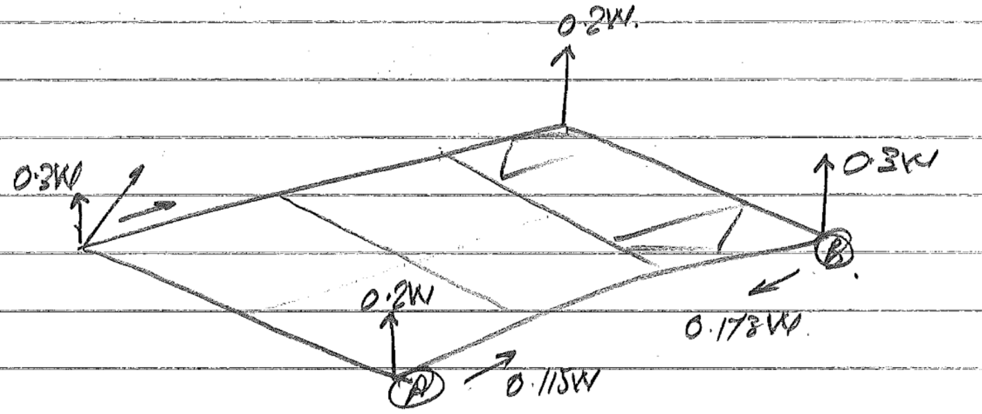
∴ load = 827 Te

∴ Area Reqd = $827 \times 10 \times 10^3 / 0.45 \times 345$ = 53230 mm^2
= 532 cm^2

∴ ADOPT 600 × 30 WT = Area = 537 cm^2

LIFT BRACING — Assume 60/40 Sling distribution — page 6.

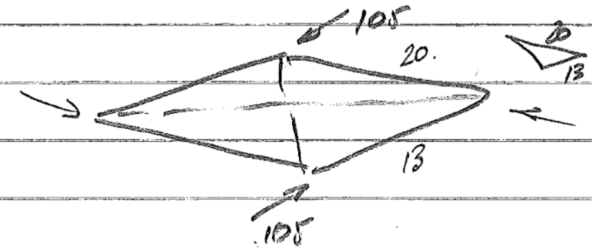
TOTAL LIFT WT = 900 Te × 2 (DAF) = **1800Te**



Racking load results in out of Balance Thrust $= 0.1W/\tan 30$

Thrust A-B = 0.058W. = 0.058 × 1800 = 105Te.

∴



∴ Torsion = 105 x 20m = 2100 Tem

∴ Resisted by couple = 2100/13 = 162Te.

∴ Tension Diagonals $= \sqrt{105^2 + 162^2}$ = **193Te.**

∴ Area reqd $= 193 \times 10 \times 10^3 / 0.45 \times 345$ = 12400mm²

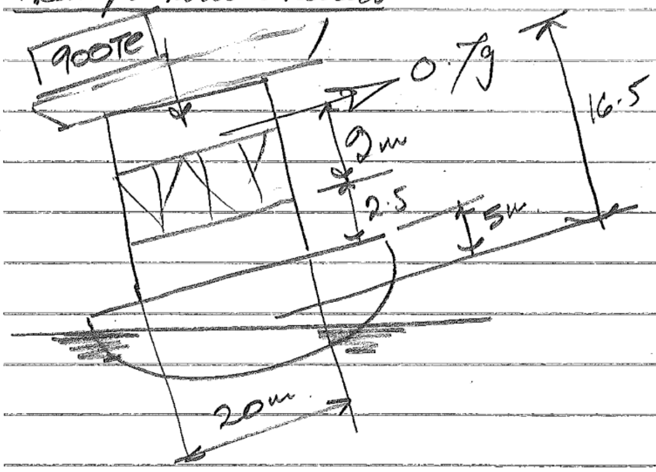
= **124cm²**

∴ **Use 305 UC 158 Area = 193cm²**

TRANSPORTATION

page. 7

Transportation Loads.



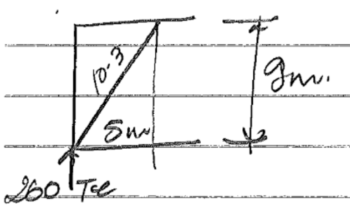
∴ Max accel. force due to Roll = 900Te × 0.7 = 630Te

∴ OTM = 630 × 16.5 = 10395Tem.

∴ Resisting Couple = 10395/20m = 520Te.

∴ Load/Leg = 520/2 = 260Te.

∴ Transverse Bracing resisting Roll =



∴ Load in Brace = 260 × 10.3/9 = 297Te.

∴ Area Reqd = 297 × 10 × 10^3/0.45 × 345 = 192cm^2

∴ ADOPT 457Ø × 25 WT Area = 290cm^2

70 → (Kl/r)/Cc = 0.70 & IR = 0.75 to allow for sec. bending.

page 8.

BLAST WALL DESIGN.

Given more time BIGG's SDOF method would have be considered, taken into account pressure, area and duration, however for the purpose of the exam it proposed to use a LINEAR ELASTIC DESIGN with ENHANCEMENTS in accordance with SCI - INTERIM GUIDANCE NOTES for DESIGN against EXPLOSION & FIRE - DOC. N° 150 -SCI-P-112.

The following enhancements have been considered:-

1.1 - Increase in Yield for add'l mat'l strength.
1.2 - " " " " Strain Hardening effects
1.3 - " " " " High strain rate.

It should be noted that in accordance with clause 3.5.4 - (The STRAIN HARDENING effects should not exceed 80% of UTS.

∴ 0.8 × 490 N/mm² (min UTS for Gr 355 material)
= 392 N/mm²

In general a proprietory profiled panel would be used to provide maximum utilisation whilst minimising depth, however for the purpose of design a fabricated panel wall shall be considered.

PLATED DESIGN - Use SDM page 880.

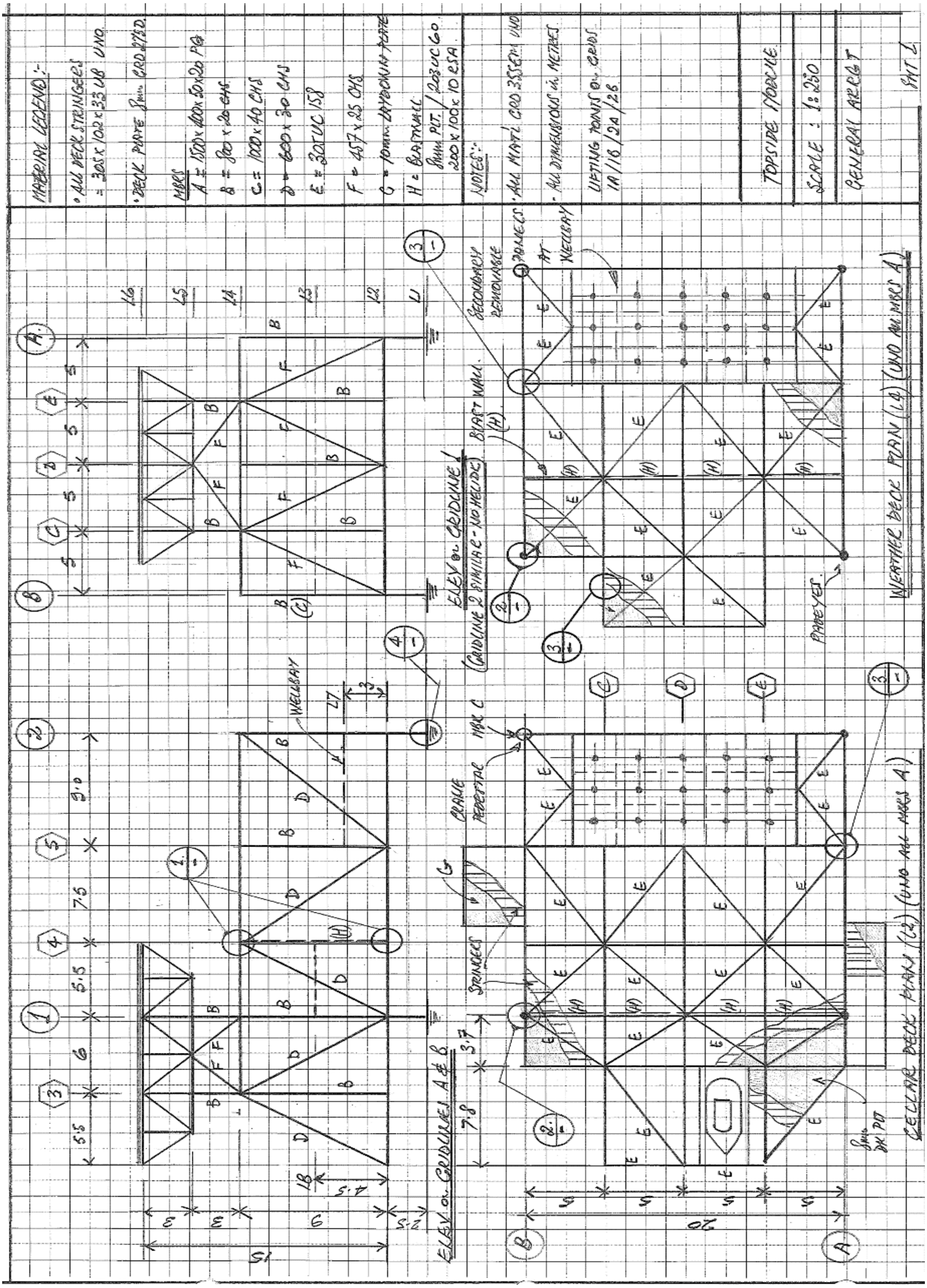
In accordance with POUNDERS FORMULA stiffeners will be place at an Aspect Ratio of 2.

∴ TABLE 3 page 881 use:-

8mm thk PLATE (Breadth 1m × 2m LENGTH) = 21.99 kN/m²

Drawings & critical details

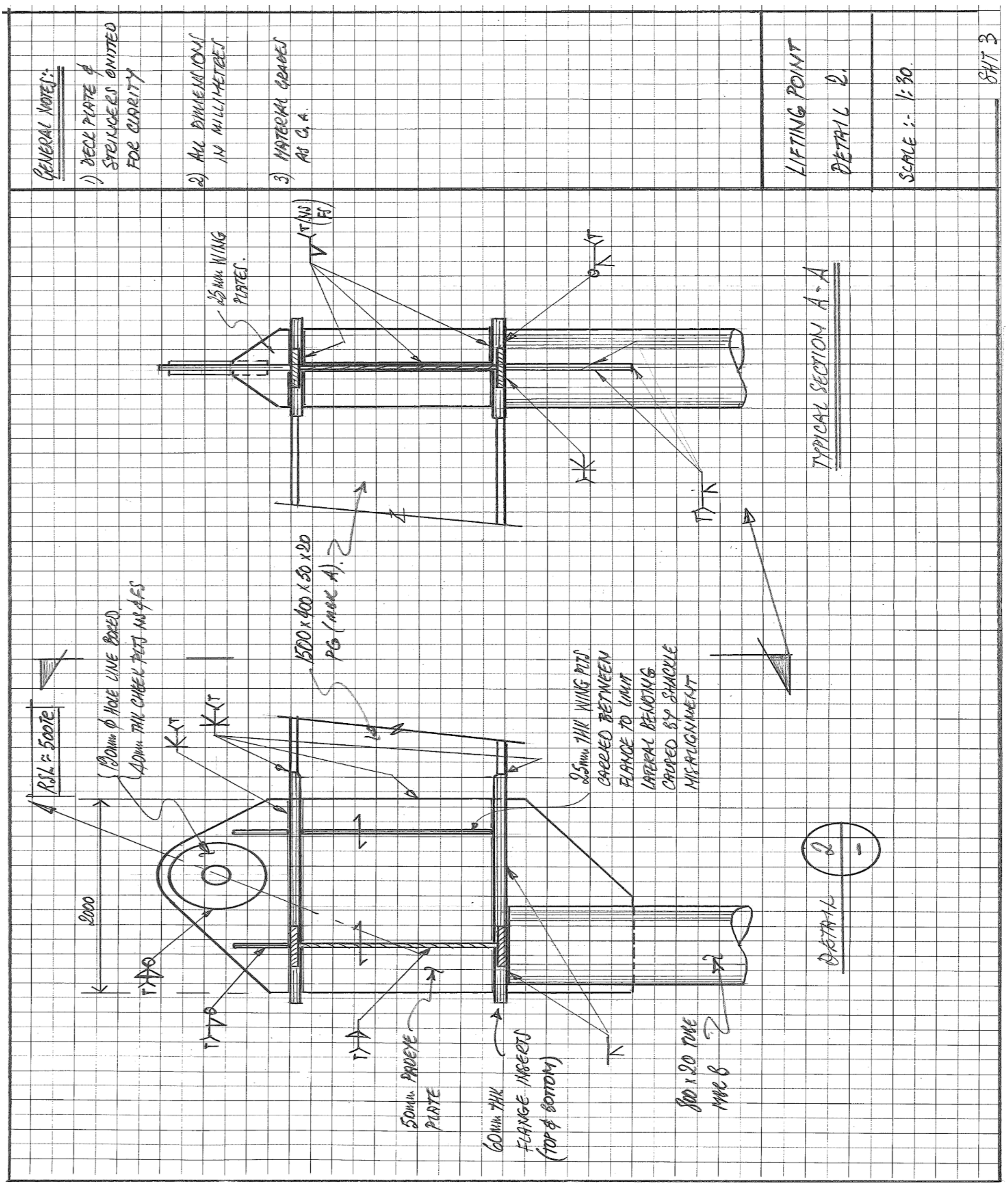
The critical details are subjective and unique to each individual scheme, and it is up to the candidate to identify such details appropriate to their scheme. Demonstrated below is the type of drawing and details expected which clearly shows the overall size and key dimensions and annotates the member selection to potentially allow a weight and estimate to be produced. The drawing also shows the secondary and tertiary steelwork along with material grade to be used. For additional clarity, the location of critical details can also be clearly highlighted. They can be sketched and do not have to be to scale but should be in proportion and should indicate sizes and thicknesses with notes for clarification.

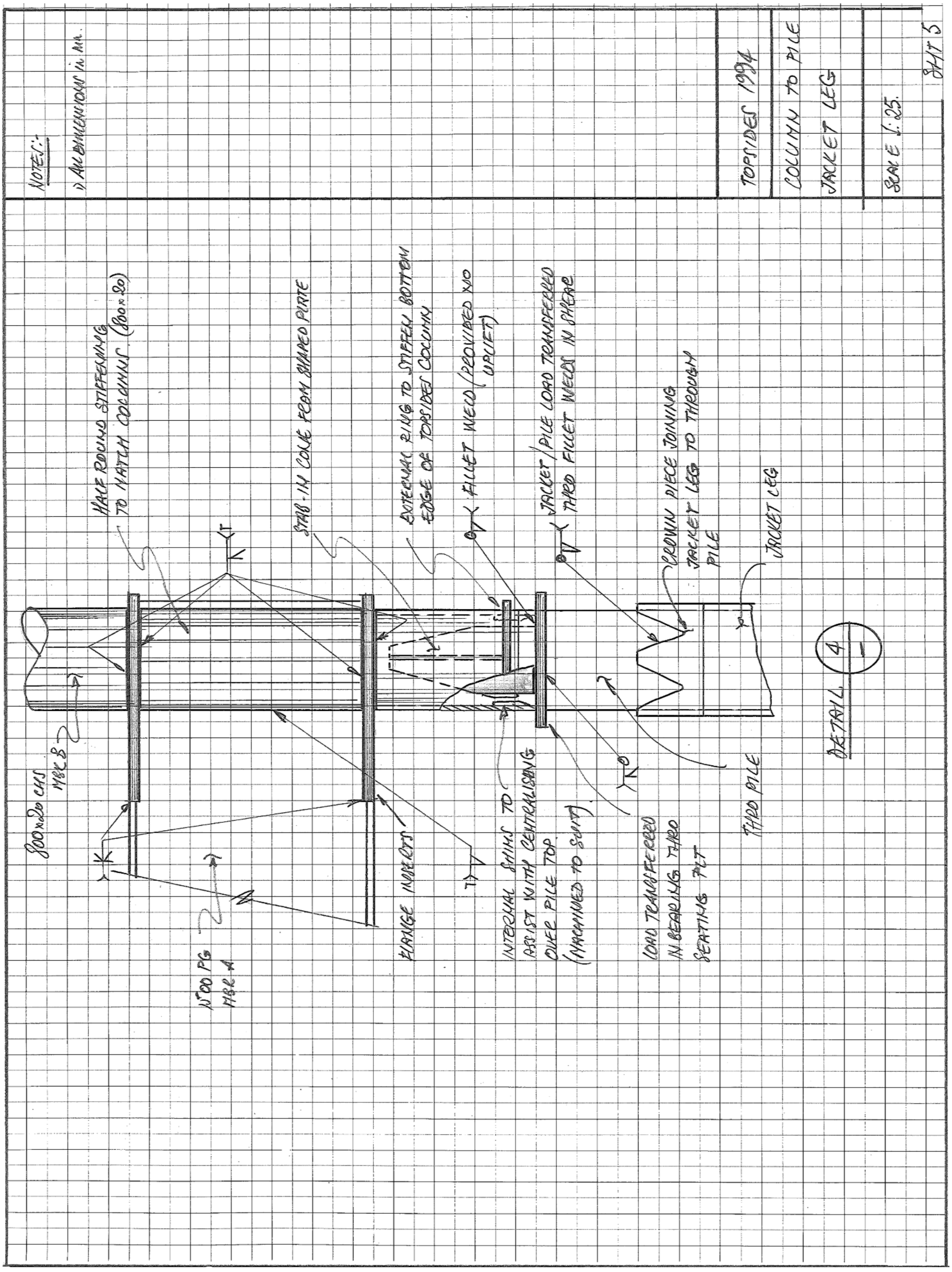

MATERIAL LEGEND:-
• ALL DECK STRINGERS = 305x102x33 UB UNO
MBRS
B = 800x20 CHS
C = 1000x40 CHS
D = 600x30 CHS
F = 457x25 CHS
G = 10mm LAYDOWN PLATE
H = BLASTWALL
NOTES:-
• ALL DIMENSIONS IN METRES
TOPSIDE MODULE
SCALE : 1:250
GENERAL ARRGT
SHT 1
WEATHER DECK PLAN (L4) (UNO ALL MBRS A)
CELLAR DECK PLAN (L2) (UNO ALL MBRS A)
ELEV ON GRIDLINE 1
ELEV ON GRIDLINES A & B
WELLBAY
CRANE PEDESTAL
STRINGERS
BLAST WALL
SECONDARY REMOVABLE

Critical details

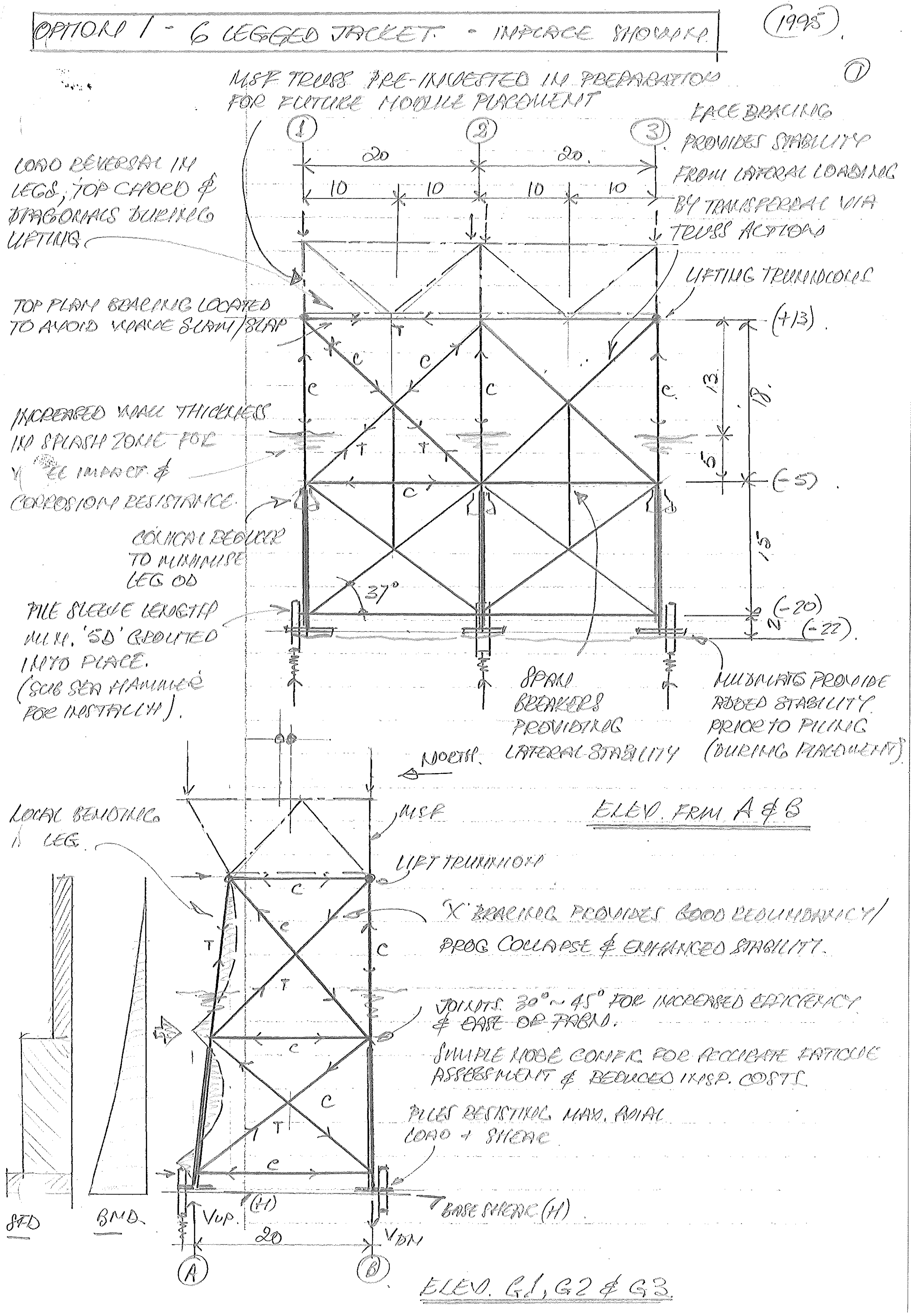
Inevitably there will be a requirement to demonstrate key critical details for development and discussion. These will generally be items that are fundamental to the function of the structure and should therefore be annotated appropriately to display an understanding of concentrated loading and distribution into the primary members effectively and efficiently.

A typical example of the lifting points and foundation is shown below:

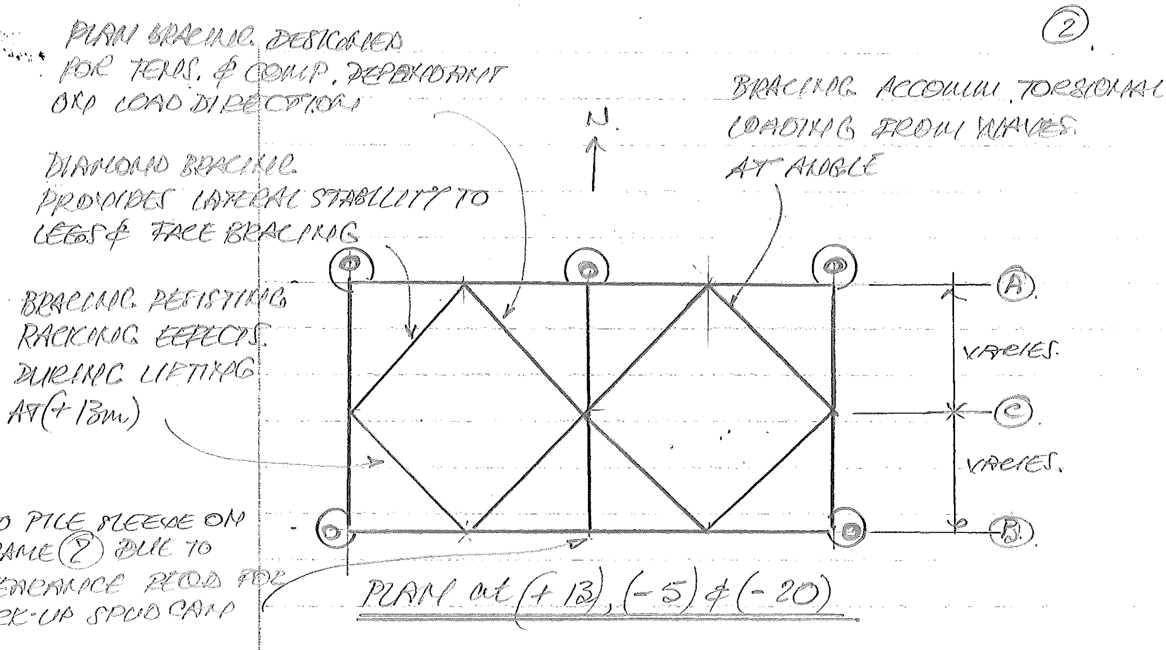



NOTES:-
1) ALL DIMENSIONS IN MM.
TOPSIDES 1994
COLUMN TO PILE
JACKET LEG
SCALE 1:25.
SHT 5
HALF ROUND STIFFENING TO MATCH COLUMNS (800×80)
STAB-IN CONE FROM SHAPED PLATE
EXTERNAL RING TO STIFFEN BOTTOM EDGE OF TOPSIDES COLUMN
FILLET WELD (PROVIDED NO UPLIFT)
JACKET/PILE LOAD TRANSFERRED THRO FILLET WELDS IN SHEAR
CROWN PIECE JOINING JACKET LEG TO THROUGH PILE
JACKET LEG
THRO PILE
DETAIL 4 1
800×20 CHS MBR B
1500 PG MBR A
FLANGE INSERTS
INTERNAL SHIMS TO ASSIST WITH CENTRALISING OVER PILE TOP (MACHINED TO SUIT)
LOAD TRANSFERRED IN BEARING THRO SEATING PLT

Example Script – 6-Legged Offshore Jacket



(2)



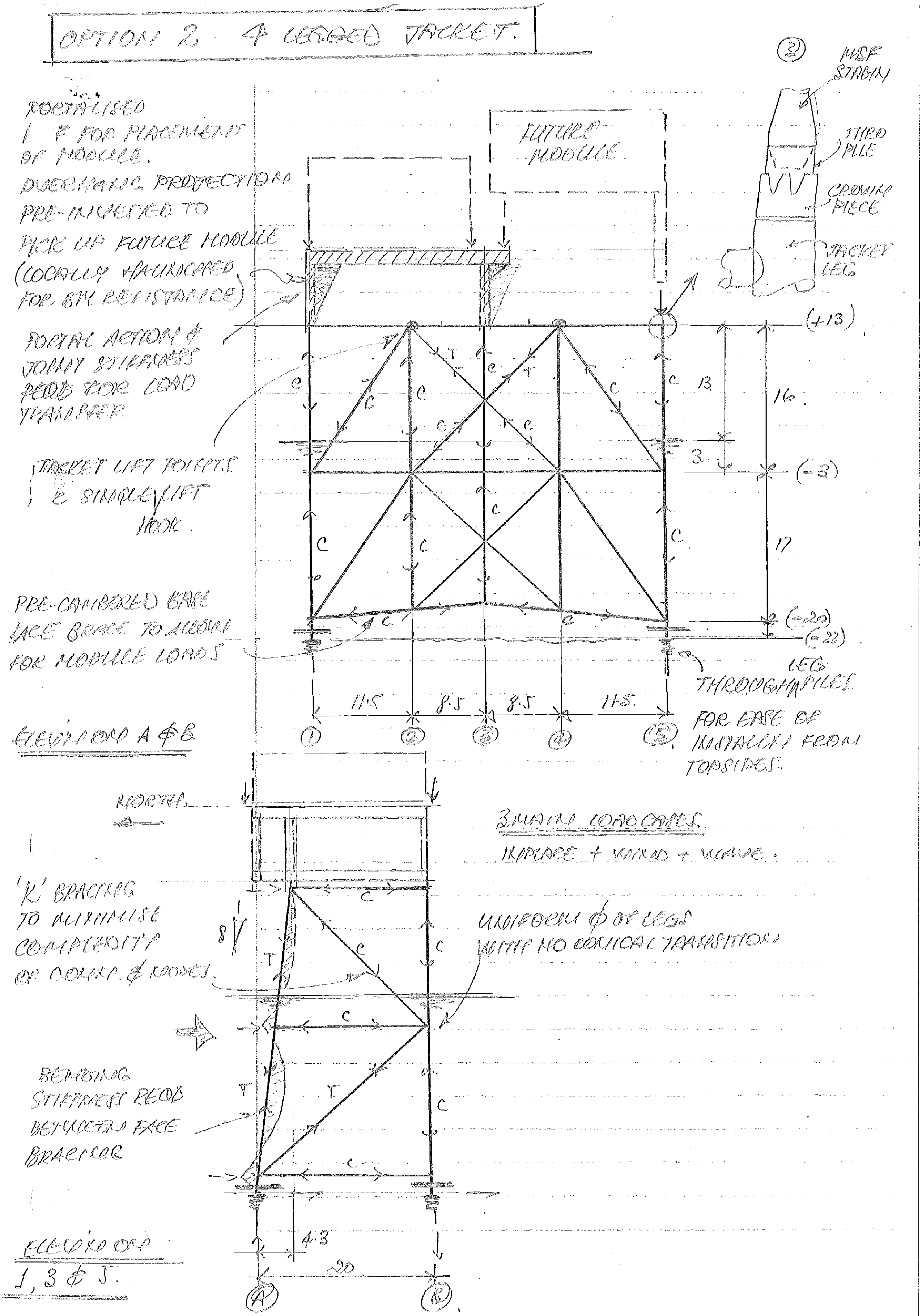
PLAN at (+13), (-5) & (-20)

FUNCTIONAL FRAMING / STABILITY / LOAD TRANSFER

- Inplace. vertical loads are transferred from the MSF into the leg tops at the point of STAB-IN via bearing.
- Once loads are within the jacket structure they are transferred to the pile foundations by truss action and triangulation. From the jacket base the load is usally transferred into the pile cluster by shear via diaphragm plts linking the jacket and piles together.

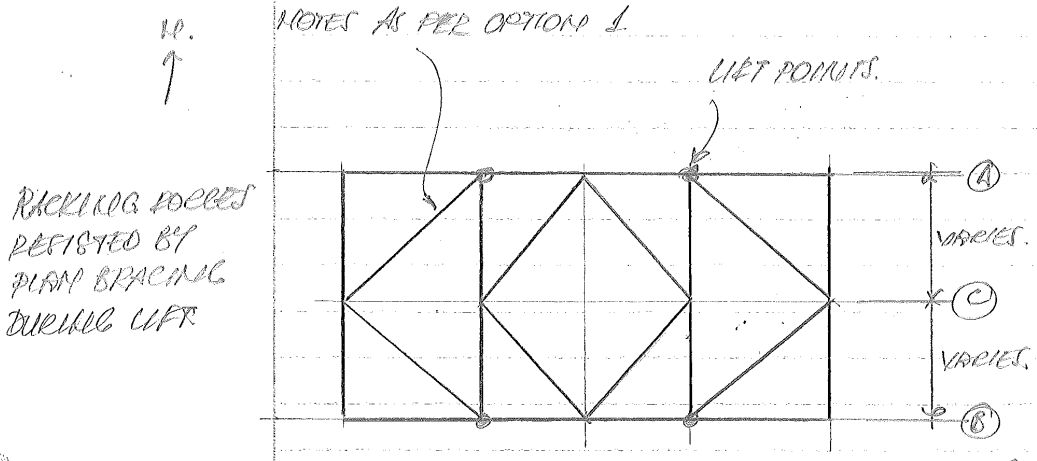
STABILITY from

- Lateral loads from offsets in CoG, wind and wave loading is provided by truss action and triangulation of forces between the face bracing.
- Plan bracing ensures lateral stability to the jacket legs by reducing spans.
- Between braces stiffness is defined by Kl/r. Sections chosen shall be based on preventing buckling, vibration & vortex shedding as well as localised limiting bending effects between spans.


OPTION 2 4 LEGGED JACKET.
FUTURE MODULE
PRE-INVESTED TO PICK UP FUTURE MODULE
PORTAL ACTION & JOINT STIFFNESS REQD FOR LOAD TRANSFER
JACKET LIFT POINTS.
SINGLE LIFT HOOK.
PRE-CAMBERED BRACE
MSF STAB-IN
THIRD PILE
CROWN PIECE
JACKET LEG
(+13)
13
16
3
(-3)
17
(-20)
(-22)
LEG THROUGH PILES
FOR EASE OF INSTALLN FROM TOPSIDES.
11.5
8.5
8.5
11.5
ELEVATION A & B.
NORTH
3 MAIN LOAD CASES
INPLACE + WIND + WAVE.
'K' BRACING TO MINIMISE COMPLEXITY OF CONN. & NODES.
UNIFORM ϕ OF LEGS WITH NO CONICAL TRANSITION
BENDING STIFFNESS REQD BETWEEN FACE BRACING
4.3
20
ELEVATION ON 1, 3 & 5.

④

PLAN BRACING
NOTES AS PER OPTION 1.



PLAN AT (+13) (-3) & (-20)

FUNCTIONAL FRAMING / STABILITY LOAD TRANSFER.

With the placement of only one module there is the possibility that uplift could occur during combined wind wave & inplace conditions. For this reason the centre of the pile group on frames 1 & 5 have been spaced such that the CofG will be well within the envelop of the jacket and the overturning couple is maximised.

- Stability is provided by the face and plan bracing with lateral loads transferred via truss action
- 'K' Bracing on frames 1, 3 & 5 has been selected with minimised complexity and ease of fab's in mind.
- Through piling has been considered on the basis that loads from the MSF are transferred into the pile connection between MSF. These are in turn transferred into the crown piece and into the jacket leg. Loads are then dispersed via triangulation of forces or pure compression in the legs.

CALCULATIONS

(10)

DESIGN

AISC 9th Edn.
API RP2A - Pile design.
BS6399 - Weld Code.

MATERIAL

Geo 855EM UNO. } EQUIV TO EN10225 IS8
GRO 855EM2 - lifting points }

DESIGN CONDITION.

INPLACE - Operational + Severe Storm wind + wave.
TRANSPORTN - 0.7g HORZ + 1.2g HEAVE.
LIFT. - 60/40 DIST.
LOAD-OUT.

PERMISSIBLES.

- SHEAR = 0.4Fy. (AISC Sect F4) = 0.4x345 = 138N/mm²

- BENDING = 0.6Fy. To account for double curvature due to global loading.
= 207N/mm²

- AXIAL TENSION/COMP = 0.5Fy = 172N/mm²
↑ limited for punching shear at joints.
LIMITED to account for secondary bending at joints.

GEOMETRIC SIZING

1) Slenderness Kl/r defines stiffness and should be limited to prevent BUCKLING/VIBRATION & WIND WAVE INDUCED VORTEX SHEDDING.

2). D/t ≯ 20 to limit unacceptable strain during rolling.

$$r = \frac{l \times k \times 100}{(Kl/r)}$$

(11)

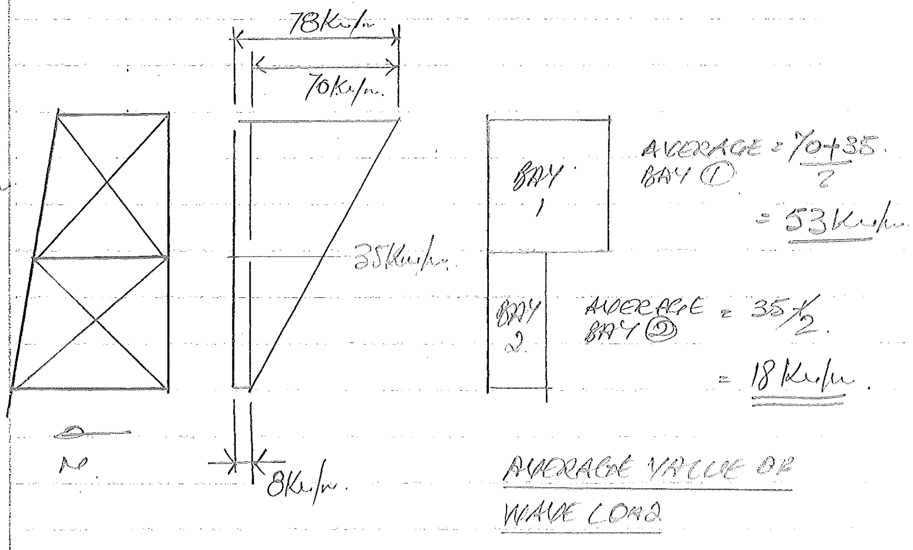
MBR SELECTION						
DESCRIPTION	LENGTH (m)	Kl/r	K	D/t	r (cm)	MBR SELECTED
LEG SPLASH ZONE	18	40	1	30	45	1500φ x 50WT
LEG	17	40	1	50	42.5	1600φ x 30WT
FACE BRACE (SPLASH)	27	50	0.5	30	27	800φ x 25WT
FACE BRACE	27	50	0.5	50	27	800φ x 15WT
PLAN BRACE (LAT)	20	50	0.8	50	32	1000φ x 20WT
PLAN BRACE	20	60	0.8	50	27	1000φ x 20WT

LOAD DERIVATION.

Normal design would consider wave loads in 8 directions, however for exam consider load in North Direction.

AVERAGE LOADS.

$(78-8)/2 = 35 kN/m$



Consider average values to all mbrs between levels.

(15)

PILE DESIGN

TRY 1600 ϕ PILE at CLUSTER

AXIAL (MAX) = (FA) ≈ 21750 kN × 1.5 (FOS) = 32625 kN = (3262 Te)

SHEAR (MAX) = (FS) 35500 kN (3550 Te)

DESIGN COND'N

95.7 kN/m² 1) • SKIN FRICTION – (inside/outside surfaces) – f = 9570 kg/m²

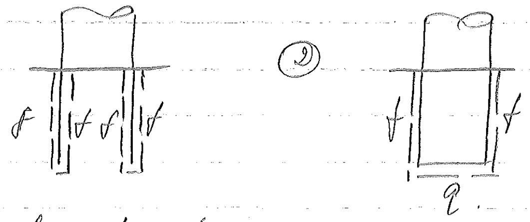
9600 kN/m² → 2) • " – (Outside + End bearing) – q = 960×10³ kg/m²

3) • TENSION – (Outside only)

4) • BENDING – (Due to Base shear)

Calculate the lesser capacity of (1) & (2).

∴ (1) (2)



(1) ∴ Surface Area/m = 2πr × 2 (surfaces) = 2 × π × 0.8 × 2 = 10 m.

∴ Req'd pile depth = 3262 ×10³ / 9570 × 10 = 34 m.

(2) Surface area/m = 2πr = 2 × π × 0.8 = 5 m.

End Bearing area = πr² = π × 0.8² = 2 m².

∴ Req'd depth of pile = (3262 × 10³) − (2 × 960 000) / 5 × 9570

= 28 m.

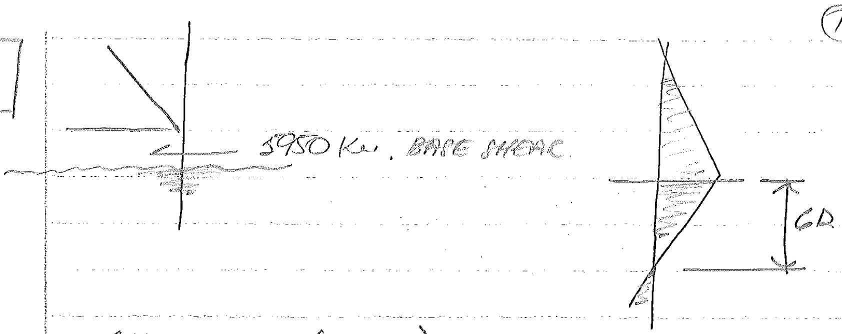
(3) Check Tension Only

∴ (−13250 kN) + (3500 kN) (Selfwt) − (5000 kN) (Future mod) = 4750 kN Tensile.

∴ 4750 / 5m (one surf.) × 95.7 = 10 m. ∴ option (2) OK.

(16)

CHECK PILE BENDING



∴ $BM = 5950 \times (6 \times 1.6) = 57120\ kNm$

∴ $Z\ reqd = 57120 \times 10^6 / 0.6 \times 345 = 276 \times 10^6\ mm^3$

$= 275942\ cm^3$

∴ Excessive wall thkness reqd ∴ Consider using 2 No piles at each leg.

∴ $Z\ reqd = 137971\ cm^3$

∴ ADOPT 1600 ϕ × 80 WT PILES at a PENETRATION DEPTH of 28m.