HM Government

T-LEVELS

T Level Technical Qualification in Design and Development for Engineering and Manufacturing (8714-34)

Structural Engineering (324)

Guide standard exemplification material
Threshold competence – Sample

City & Guilds

First teaching from September 2022
Version 1.1

Version and date	Change detail	Section
1.1 January 2023	Formatting of Task 1 evidence requirements	Task 1
1.2 February 2023	Evidence requirements updated	Task 1(h)

Contents

Introduction

The sample assessment materials within this document refer to the T Level Technical Qualification in Design and Development for Engineering and Manufacturing - Structural engineering occupational specialism sample assignment. The aim of these materials is to provide centres with examples of knowledge, skills and understanding that attest to minimal threshold competence. The examples provided do not reflect all evidence from the sample assignment as the focus of this material is the quality and standards that need to be achieved rather than the volume of exemplar evidence provided. However, the examples provided are representative of all tasks in the sample assignment. The evidence presented here has been developed to reflect minimal threshold competence within each task but is not necessarily intended to reflect the work of a single candidate. It is important to note that in live assessments a candidate's performance is very likely to exhibit a spikey profile and the standard of performance will vary across tasks. Minimal threshold competence will be based on a synoptic mark across all tasks.

The materials in this Guide Standard Exemplification Material (GSEM) are separated into three sections as described below. Materials are presented against a number of tasks from the assignment.

Task

This section details the tasks that the candidate has been asked to carry out, what needs to be submitted for marking and any additional evidence required including any photographic evidence. Also referenced in this section are the assessment themes the candidates will be marked against when completing the tasks within it. In addition, candidate evidence that has been included or not been included in this GSEM has been identified within this section.

In this GSEM there is candidate evidence from:

Task 1

Task 2

Task 3

Task 4

Candidate evidence

This section includes exemplars of candidate work, photographs of the work in production (or completed) and practical observation records of the assessment completed by centre assessors. This will be exemplar evidence that was captured as part of the assessment and then internally marked by the centre assessor.

Commentary

This section includes detailed comments to demonstrate how the candidate evidence attests to the standard of minimal threshold competence by directly correlating to the grade descriptors for this occupational area. Centres can compare the evidence against the performance indicators in the marking grid descriptors within the assessor packs, to provide guidance on the standard of knowledge, skills and understanding that need to be met for minimal threshold competence.

It is important to note that the commentary section is not part of the evidence or assessment but are evaluative statements on how and why that piece of evidence meets a particular standard.

Grade descriptors

To achieve a pass (threshold competence), a candidate will typically be able to:

Demonstrate a basic use of software/ technologies to model, evaluate and produce structural engineering diagrams and simulations that meets the requirements of the brief.

Demonstrate basic technical skills when developing models and prototypes, resulting in a model that may require some modifications.

Apply basic knowledge and understanding of testing processes, resulting in a model that has been tested against most of the design criteria.

Interpret information, plan, assess risk and follow safe working methods appropriately when applying practical skills to an acceptable standard in response to the requirements of the brief.

Apply basic knowledge and understanding of the design principles required for structural engineering resulting in proposals and solutions that meet the minimum requirements of the brief.

Work safely showing an understanding and suitable level of awareness in the preparation and application of processes, selection and use of tools and manufacturing materials and components, resulting in tasks that are carried out with some minor errors.

Use industry and technical terminology accurately most of the time in both written and verbal contexts.

Task 1 – Design

(Assessment themes: Health and safety, Design and planning)

For task 1, candidates need to produce the following pieces of evidence:

a) design specification
b) up to three annotated sketches
c) justification of the choice of one design for further development
d) justification of the selection of the materials and components
e) calculations, including all workings
f) engineering drawings of the proposed design
g) outcomes of the virtual modelling of the proposed design, either as screen captures or printouts
h) bill of materials.

For Task 1, the following additional evidence may also be submitted:

- any notes produced of research undertaken including citation of sources and internet search history.

1a) Design specification

Candidate evidence

A new pylon design is required to be developed for an electrical company. The pylon is to be modern in style and is to make a limited aesthetic impact on both the urban and rural landscape. I need to consider the colour and shape of the pylon so that you can't see it on the skyline. A light colour that matches the sky is a good idea like light grey, light blue or white. It might be possible to clad the pylon in mirror-polished stainless steel, so that the structure reflects changing light of the surrounding area. The pylon should:

- be developed so that it has a minimal need for ongoing maintenance
- be safe if it is struck by lightning. Pylons are tall structures and stand outside. They can be protected using a copper rod which extends the full height of the pylon.
- be able to stand up to all weather conditions.

Traditional pylons are manufactured from steel and are usually made from lattice sections introduced in the 1930s and nothing much has changed until now. To look modern, my pylon design will avoid using lattice steel members and may use round steel sections which are more appealing and trendier. I need to think about the overall shape of my pylon. A 'T' shape would be simple to construct and would keep the loads applied from the overhead lines balanced. However, this is a very basic shape, and it might be more interesting to included curves in the shape of the pylon. It could perhaps be shaped like an ellipse or have a curved head.

The pylon needs to be sustainable, with components that can be recycled when the pylon is finally taken down. Steel is a good choice of material for the pylon because it can be melted down. As the pylon needs to withstand different weather conditions it would be a good idea to galvanise the steel which will prevent corrosion. Concrete is not suitable because it is very heavy and might be difficult to erect when the pylon is put in the countryside. It might be possible to use a new modern composite material, such as a glass reinforced plastic. A composite material benefits from the fact that it might not be conductive.

We might need a new road to get to the place where the pylon is to be installed if it is in the countryside and it is better to have a design where the different parts can be easily moved.

The pylon needs to be strong. The pylon is to support a weight of 600 kN for the electrical lines at the end of each arm. It will also need to support its own weight and stand up in the wind. The considerations for maintenance would be cable fixing points, welded joins and the fixtures for the base, as they will be prone to wear and tear, so they should be inspected regularly. A 'cherry picker' crane could be used to access these parts of the pylon.

Commentary

The candidate has demonstrated the application of basic knowledge and understanding of design principles to prepare a design specification that meets the basic requirements of the project brief e.g. consideration of size, shapes and materials.

The design specification follows a loose structure that outlines the different considerations for the design. The specification develops in limited detail the different aspects required from the brief (e.g. visual appearance, selection of materials, applied loading, construction method, method to protect from lightning strike). The candidate has provided some justifications for design options selected, with consideration of different options presented. For example, the benefits of different properties of different types of material that could be used for developing the pylon. However, the format could have benefitted from further consideration of the overall structure, clearly highlighting the different areas of consideration.

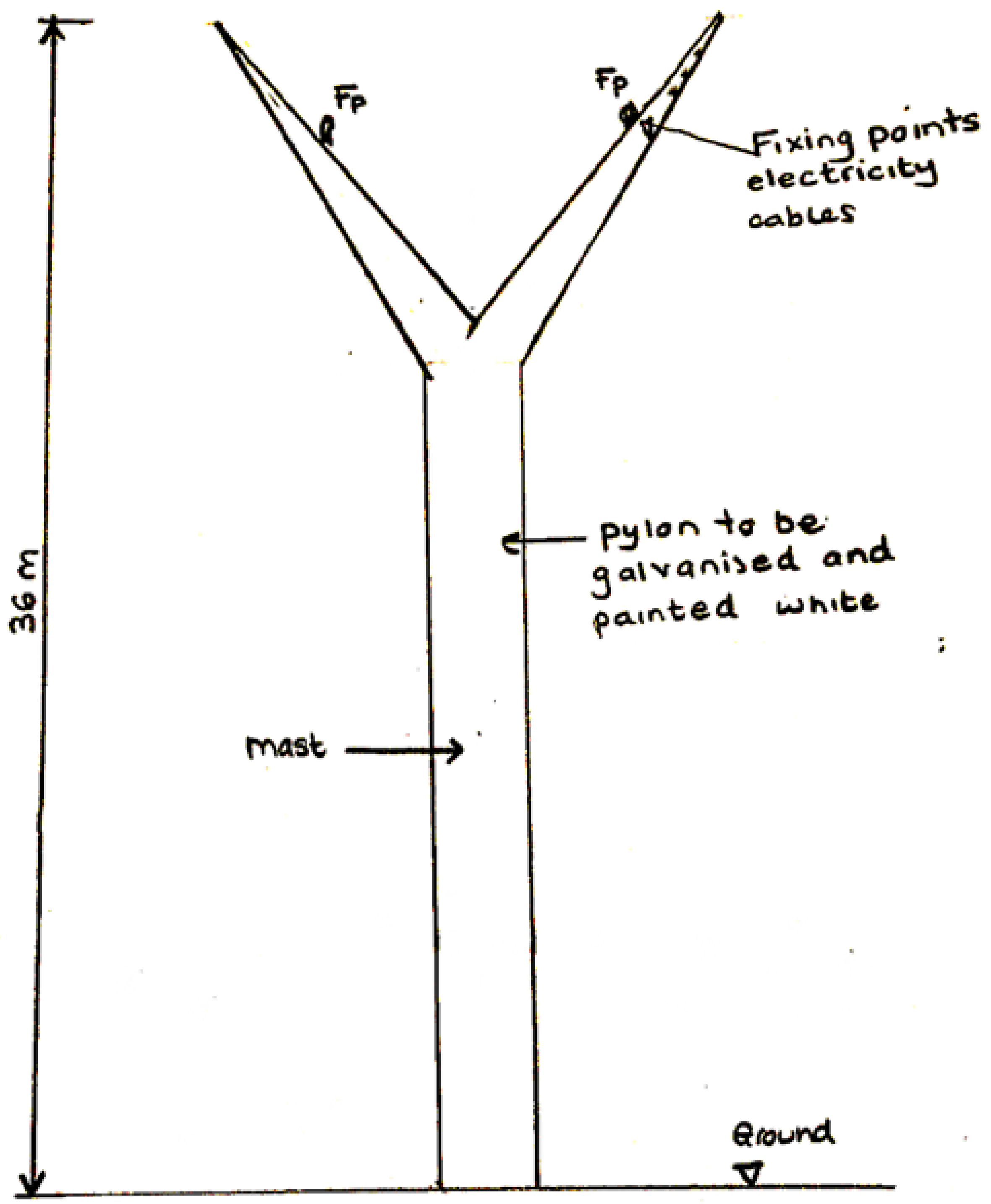
There is limited evidence of research, with intermittent evidence used or referenced. For example, the candidate mentions lattice pylons were first developed in the 1930s but provides no details of by whom, with no use of citations or references.

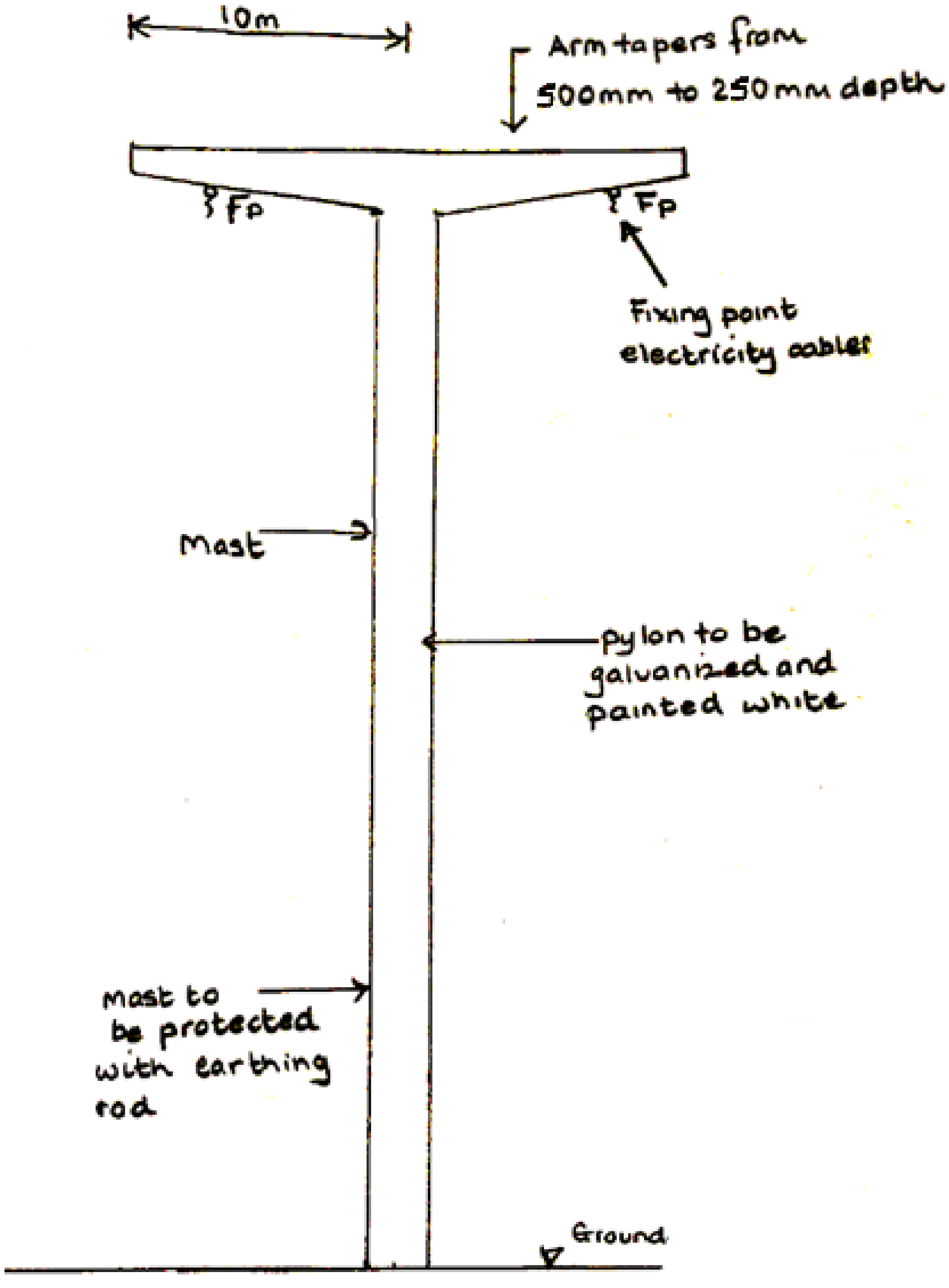
The specification generally has a weak structure between consecutive paragraphs and develops the aspects required by the brief in a limited way, including the visual appearance of the pylon, selection of materials, applied loading, construction sequence, and method to protect the pylon from lightning strike.

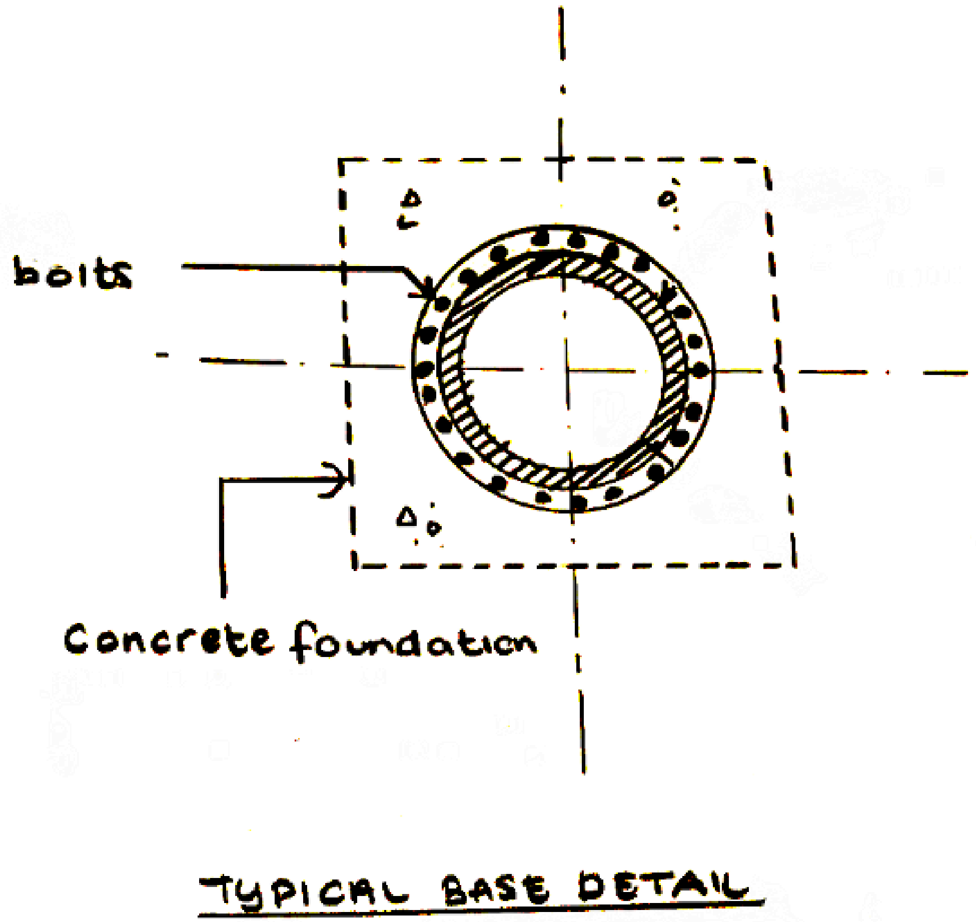
Whilst the candidate has provided some limited summary recommendations and has considered the design of the pylon, there are some solutions discussed that are not ideal based on the brief. For example, the maintenance considerations include wear and tear, but not tightness of the fixtures or environmental impact such as corrosion, which are likely to occur in exposed environments.

1b) Annotated sketches

Candidate evidence




10m
Arm tapers from
500mm to 250mm depth
Fp
Fp
Fixing point
electricity cables
Mast
pylon to be
galvanized and
painted white
mast to
be protected
with earthing
rod
Ground



Commentary

The candidate has prepared two annotated sketches. The sketches are drawn proportionally showing that the different structural elements' relative thicknesses/sizes are relational, although they are not drawn precisely to scale. The sketches include an elevation of the pylon for each design option and a base detail. There is basic evidence that the candidate has adopted the use of drawings conventions. For example, the use of different line types for the centre line of the pylon mast.

Whilst the sketches show that the candidate has a grasp of basic design and shows the ability to develop their design concepts visually, there are areas where the response could have been developed. The candidate could have given a compressive strength for the concrete of the foundation or provided detail on the number and sizes of the bolts used in the baseplate. The candidate could also have provided a steel section size for the pylon mast and arms.

The sketches have only one dimension and there are limited annotations that cover the details of the proposed materials, finishes and lightning protection system. The sketches also lack titling conventions which makes it difficult to understand what each sketch shows, and to differentiate between the different design concepts.

1c) Justification of the choice of one design for further development

Candidate evidence

The first design positions the pylon arms at an angle of 35.75 degrees. The arms have an overall length of 17.9m and come to a defined point. They are visually very slender and elegant, but the pointy end might represent a safety concern particularly if people are working from above, or if the arm falls during erection. In that case, there could be a possibility of impalement. The shape of the arm means that it does not have an inherently stable centre of gravity, and therefore it is likely to be tricky to balance and manoeuvre during erection. Additionally, the internal 'v' formed as the joint between the two arms will be hard to weld on site. As a consequence I have decided to progress with the second design.

My second design will consist of a mast made from a two-metre diameter circular steel section and tapered steel arms. The arms will need to carry a bending moment at the point where they connect to the pylon mast. To allow for this I am going to taper the arms of the pylon from a depth of 500 mm where they connect to the mast to 250 mm depth at the free end. The arms will be fabricated from plated steel, like a girder, and I will include fixing points for the insulators and overhead cables. Steel is a suitable material as it is good in bending, and if I pick a thick enough section for the mast it should also cope with the applied compressive force. This design will also fit in an urban or a rural landscape nicely.

The design is shaped like a 'T', so it is really easy to manufacture and install. The mast can be craned into position on the ground, and then the top 'T' section can be fixed into position and welded. This means that the pylon will just have one site weld. This will help with quality as site welds are undertaken in an 'uncontrolled' environment there is a chance for faults to occur in the weld. The 'T' shape of the top section uses symmetry which means moving the mast into position is easier, as the weight is distributed equally.

Commentary

The candidate has developed a written justification that presents the selection of their second design as the preferred choice for developing the pylon. The response provides only a brief rationale for discounting the first design option, although the argument presented in relation to the sloping arms in the first design is valid, there would have been a benefit from developing further rationale that supported the discounting of this option, in comparison to the favoured option.

For the option selected, the candidate has provided some relevant information for the selection of this as their chosen design. The rationale covers points in relation to a range of the key design criteria, for example the structural integrity of the selected design, as well as the materials from which it will be constructed. There is an attempt to provide justifications for the proposed solution, with some reference to specific aspects of the project brief and how the selected solution satisfies these aspects. However, the response is generally limited, and could have been developed further with more detailed rationale for each of the points identified.

The written responses make some limited summary recommendations, and uses industry and technical language, although this is generally limited.

1d) Justification of the selection of the materials and components

Candidate evidence

It is proposed to use concrete for the foundation of the pylon and steel for the mast and arms. Concrete is a suitable choice for the foundation, as aggregate, cement and water can be dry batched and mixed on site if necessary. This is useful as if the pylon is situated in a remote countryside location where it is not possible to get a delivery of ready-mix concrete.

Steel is light and also rigid, as well as resistant to stress, cracking and warping under pressure. It carries loads in bending and compression.

As the pylon is situated outside there is a potential it might rust and therefore it could be galvanised, and then painted white to merge into the skyline. Galvanising involves dipping cleaned steel into a vat of molten zinc, the zinc coats the steel and prevents rusting from occurring. To protect the pylon from a lightning strike a copper rod could be fixed to the pylon.

Commentary

The candidate has prepared a written response in a structure paragraph which presents a range of materials and components that will be required to support the development of all aspects of the pylon, including the base. The candidate has provided some brief justification for the selection of the specific materials and components for the pylon, explaining how these satisfy aspects of the project brief and would complement the design. For example, reflecting that the outside environment that the pylon is exposed to means that the steel is susceptible to rusting, so galvanising this would support the life of the pylon.

The candidate covers how the materials selected meet the requirements to minimise the visual impact of the pylon on the skyline.

The response is generally limited and would benefit from being developed in further detail with more explanation for the selection of different materials and components. For example, the candidate could have expanded more on the reasons why they discounted certain materials in favour for those selected.

1e) Calculations

Candidate evidence

Load applied to cross arm

Imposed point load = 60 kN

Dead load is the self-weight of arm (assumed) = 1.5 kN/m

Factored imposed loads = 60 × 1.5 = 90 kN

Factored dead load = 1.5 × 1.35 = 2.025 kN/m

Assume that the cross arm is cantilevering from the mast.

Span of the cantilever is 8m.

Biggest moment will occur at the point of connection.

B_{max} = (90 × 8) + (2.025 × 8 × 4) = 720 + 64.8 = 784.8 kNm

Height of mast = 36 m

Assumed self-weight of steel mast section = 2 kN/m

Axial imposed load applied to the mast from the cross arms = 2 × 60 = 120 kN

Axial dead load applied to the mast from the cross arms = 1.5 × 8 × 2 = 24 kN

Axial dead load self-weight of the mast = 2 × 36 = 72 kN

Total dead load = 24 + 72 kN = 96 kN

Total factored axial load = (120 × 1.5) + (96 × 1.35) = 180 + 129.6 = 309.6 kN say 310 kN

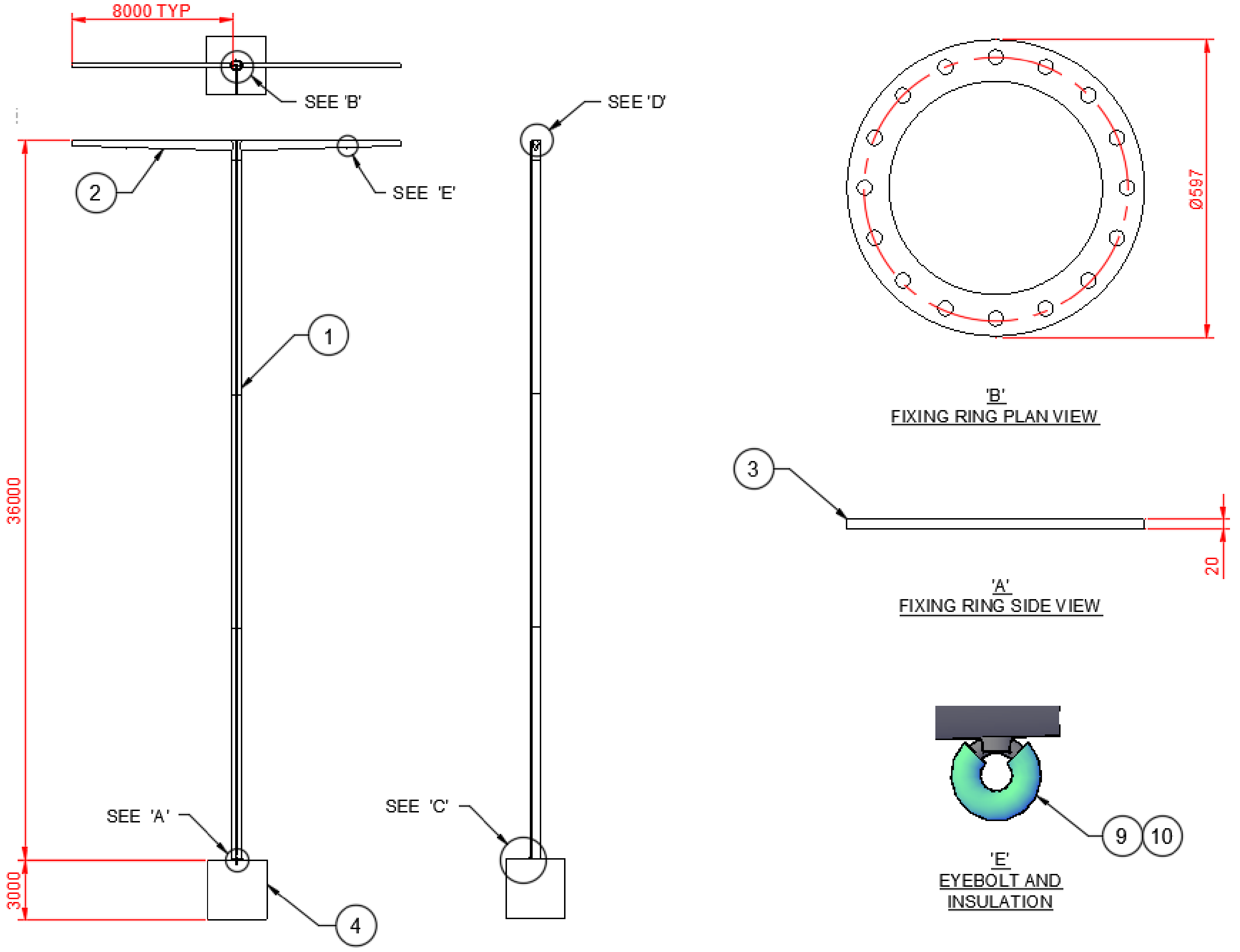
Commentary

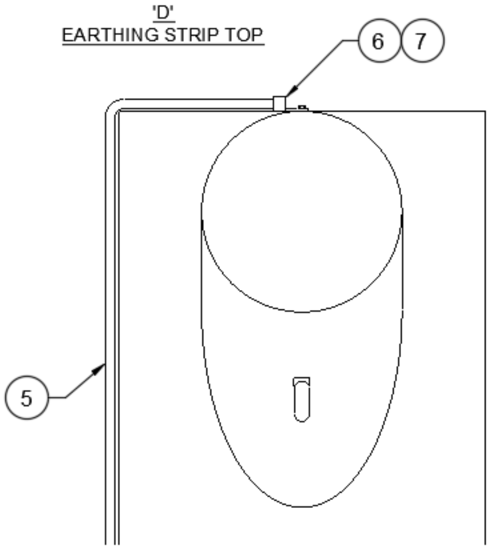
The candidate has presented calculations that show that they are just able to accurately calculate the applied bending moment at the fixed end of the cantilevering cross arm and the axial compressive load applied to the mast.

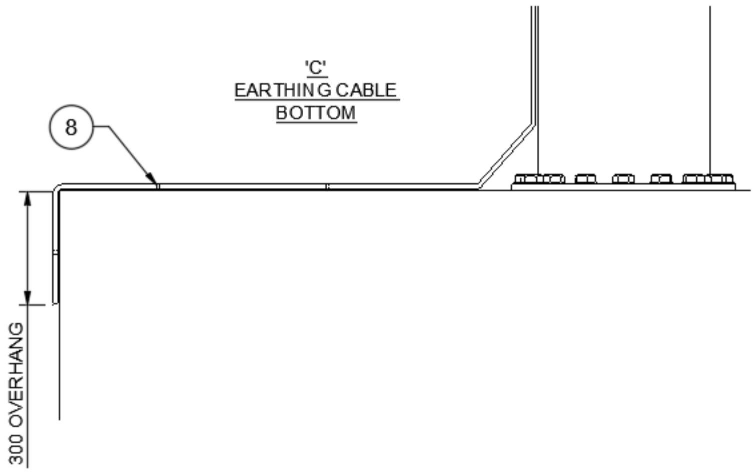
The candidate has followed calculation conventions by using partial factors of safety. The candidate was unable to provide an estimate of the initial concept sizes for the main mast and cross arms of the pylon, which would have developed their response further.

1f) Engineering drawings of the proposed design

Candidate evidence







PARTS LIST		
BALLOON No.	ITEM	QUANTITY
1	MAST	1
2	CROSS ARM	2
3	FIXING RING	1
4	FOUNDATION	1
5	EARTHING CABLE	40M
6	CRIMP WIRE CONNECTOR	1
7	BOLT x 10	1
8	NYLON ADJUSTMENT CLAMP	11
9	EYEBOLT	2
10	INSULATION	2

NOTES:

1. ITEM 1 - MAST: Ø457 x 14.2 CHS
2. ITEM 2 - CROSS ARM: (500 x 250 x 16) TO (Ø250 x 16) ELLIPTICAL TO CIRCULAR CROSS SECTION
3. ALL DIMENSIONS ARE IN MM

Commentary

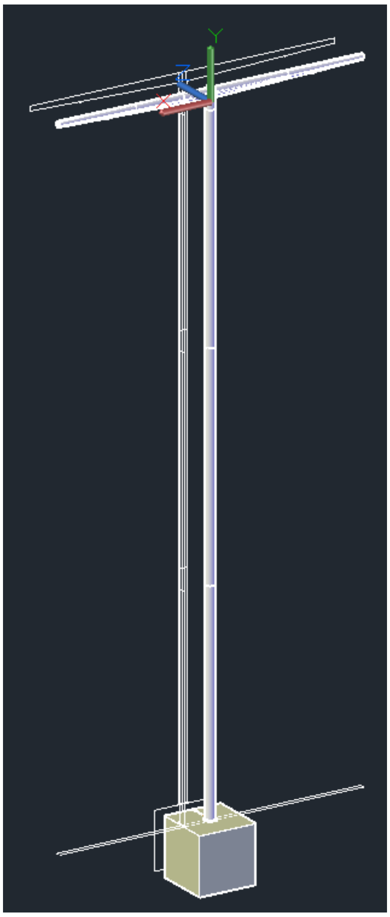
The candidate has demonstrated the ability to develop their design concept into a basic drawing using a CAD package. The drawing provides some detail of the concept, including an elevation and base plate detail showing a cross section through the mast, the edge of the plate and a number of bolts for the selected design solution.

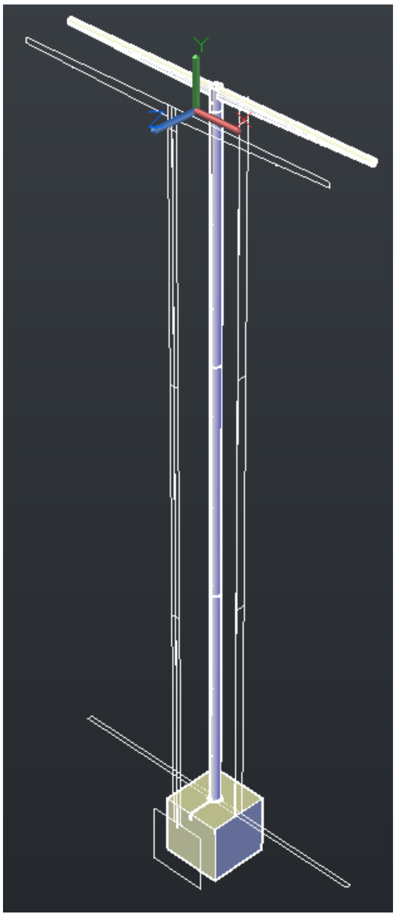
The candidate has provided a few accurate dimensions, and some labelling as part of the drawings. The response would have benefitted further if it included more annotations. For example, the drawings only identify the basic characteristics of the components of the pylon, with limited details of the proposed materials and finishes.

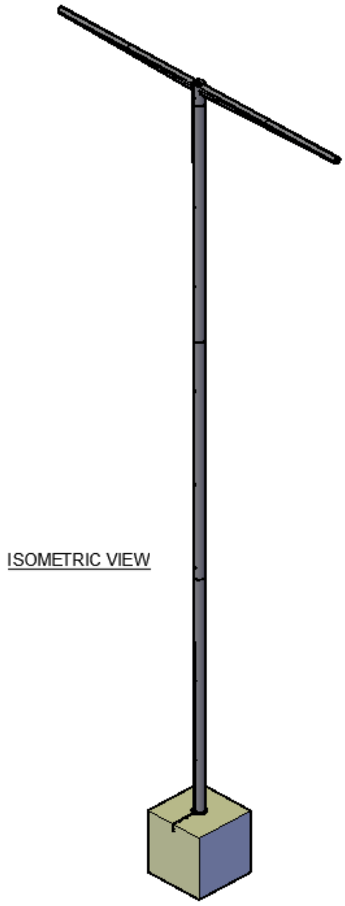
The candidate has demonstrated the use of basic CAD drawing conventions. The response would have benefitted from further development using industry drawing drafting standards. For example, the candidate would have benefitted from inserting an informative titling block on the drawing frame to support their evidence.

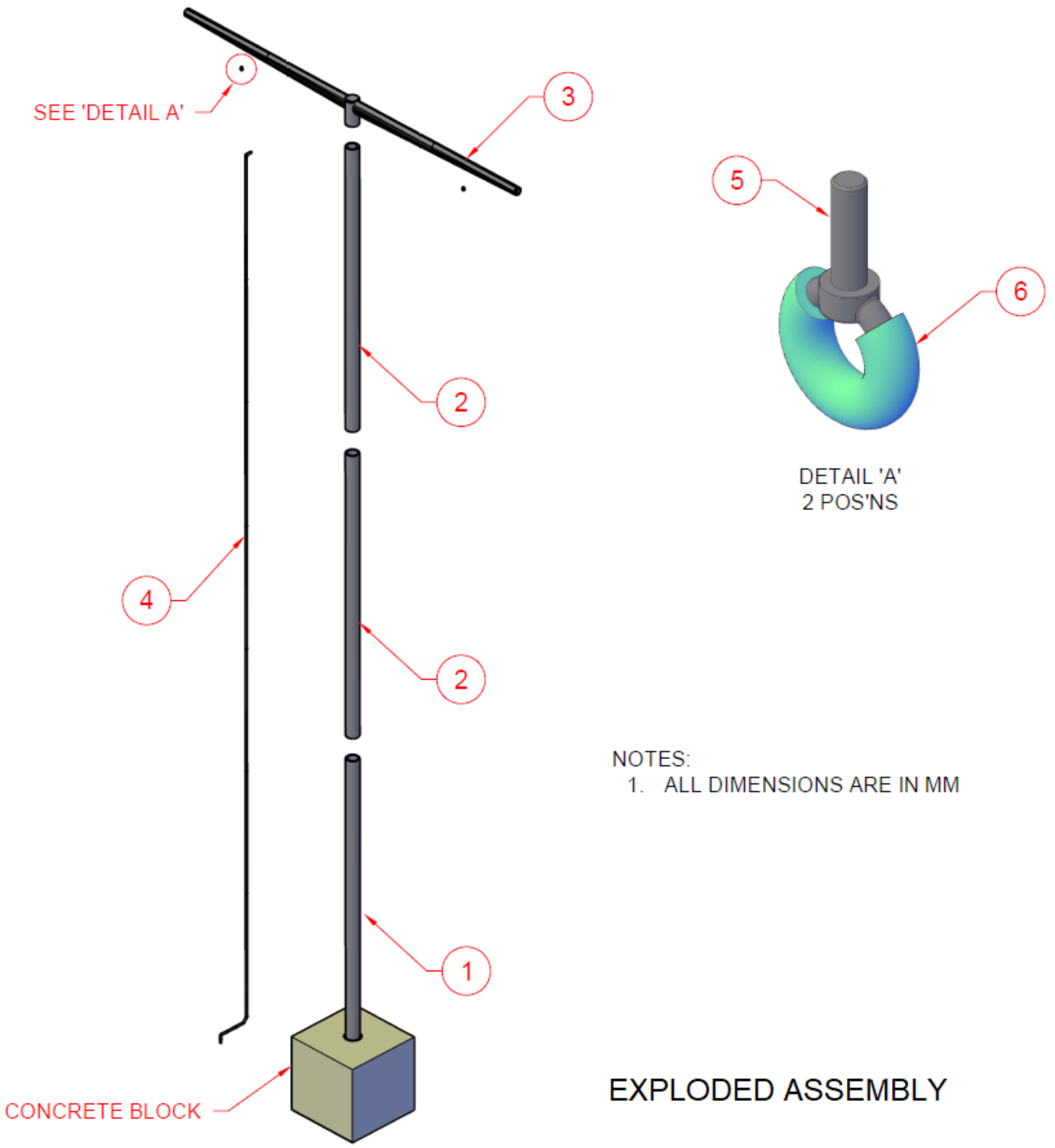
1g) Outcomes of the virtual modelling of the proposed design

Candidate evidence









Commentary

The candidate has used software to prepare a basic 3D model of their proposed pylon depicting the relationship of the principal components of the mast and arm. They have also produced an accurate isometric view of the pylon. The 3D images are proportionally correct, but they contain limited annotation.

An exploded view of the assembly is included, which provides insight around the steps of the construction of the model and how the different parts are assembled. This contains some numbered annotations and would have benefitted from further detail, such as an explanation of the different parts involved.

The candidate has not developed a 3D image that simulates the pylon positioned in a rural and urban landscape along with other isometric views.

To develop further, the candidate could have included more viewing angles of the model and more images in order to showcase the simulation of the function, such as the construction sequence. They could also have included more extensive annotations. The candidate had mentioned at an earlier stage that they were considering adding a lightning protection system, but this has not been carried through to the virtual images.

1h) Bill of materials

Candidate evidence

Item	Description	Unit	Quantity	Rate per Unit (£)
1	Provision and installation of 457 × 14.2 circular hollow mast section in grade S275 steel. Section to be galvanised and finished with a white polyester powder coating.	m	36	
2	Provision of M28 grade 8.8 holding down bolts to fit base plate of pylon.	items	16	
3	Provision and installation of elliptical steel cross arm in grade S275 steel. Section to be manufactured from 14.2 mm thick plate galvanised and finished with white polyester powder coating.	m	18	
4	Provision of 700 mm diameter circular flat base plate in 45 mm thick grade S275 galvanised steel.	item	1	
5	Excavation for concrete pad foundation maximum depth 3 m	m^3	To be confirmed on site	
6	Provision and compaction of grade RC32/40 concrete.	m^3	To be confirmed on site	
7	Copper earthing strip with fixings for lightning protection.	m	38	

Commentary

The candidate has prepared a basic bill of materials laid out in a manner reflecting industry standards including columns covering ‘item’, ‘description’, ‘unit’ and ‘quantity’. The candidate has also included a ‘rate’ column, but this has not been populated.

The candidate has itemised only a few of the principal pylon materials and associated activities that are to be undertaken for the construction and erection of the pylon, e.g. excavation of a foundation or provision of steelwork for the mast.

The response would have benefitted from further development, with greater consideration of the range of activities that would need to be considered as part of the erection of the pylon, for example, transport of materials to the proposed installation site.

Notes of research undertaken

Recently a new design of pylon has been developed by the National Grid referred to as the T-Pylon 186 (Hewitt, 2015).

The first pylon was developed in 1930s for the Central Electricity Board by American designers the Milliken Brothers (Glancey, 2011)

References

Glancey, J (2011) Loved and loathed – the armoured knights of the National Grid. Guardian [Online] Available at https://www.theguardian.com/artanddesign/2011/may/22/national-grid-pylons-design (Accessed 18th December 2021)

Hewitt, A (2015) Britain's first new electricity pylons in 100 years are unveiled – and they look very different. The Mirror. [Online] Available at: https://www.mirror.co.uk/news/uk-news/britains-first-new-electricity-pylons-5497708 (Accessed 18th December 2021)

National Grid (2021) Everything you ever wanted to know about electricity pylons. National Grid

Task 2 – Manufacture and test

(Assessment themes: Health and safety, Manufacturing, Reports)

For task 2, candidates need to produce the following pieces of evidence:

a) risk assessment
b) prototype
c) test records.

Additional evidence of candidate performance that must be captured for marking:

- assessor observations:
  - development of scaled prototype.
  - testing.

Photographic evidence which shows:

- results of tool selection and usage (photograph 1)
- cutting and preparation of model components (photographs 2-3)
- connecting of model components (photographs 4-7)
- arrangement of model components in plan, elevation and detail (photographs 8-13)
- 3D view of the final prototype (photographs 8-13).

2a) Risk assessment

Candidate evidence

Hazard	Control measures	Likelihood	Severity
Mechanical equipment	Restricted access to the workshops. Training. Complete specific risk assessments for each piece of mechanical equipment used to manufacture the pylon. Machine guards. Maintenance.	3	3
Electrical equipment	Regular test and calibrated electrical equipment used to manufacture the pylon. All electrical equipment should be PAT tested. Safe isolation. Follow manufacturers' instructions.	3	4
Manual handling of heavy / bulky objects	Risk assessment for lifting. Before undertaking any work manufacturing the pylon it is necessary to be trained in lifting techniques. PPE. Inspection of equipment.	4	1
Hazardous substances	COSHH risk assessment for pylon prototype painting materials are to be prepared. Material Safety Data Sheet (MSDS) to be kept together with a risk assessment for each type of paint. Containers used for storage must be labelled.	4	1
Slips and trips	Keep area clean, tidy and well lit. Report any hazards immediately.	1	1
Fire	Switch off equipment after use. Testing. Keep flammable substances away from flames. Keep area free of any waste materials Correct storage. Fire alarm. Fire procedure and fire stewards.	2	4
Welding equipment	Ensure welder is properly installed and grounded. Ventilation. Eye protection and fire retardant clothing.	3	2

Likelihood		Severity	
1	Very unlikely to happen	1	Minor injury
2	Unlikely to happen	2	Major injury
3	Possible to happen	3	Loss of limb
4	Likely to happen	4	Death of an individual
5	Very likely to happen	5	Multiple deaths

Commentary

The candidate has produced a clear but basic risk assessment for the construction of the pylon, that identifies the main hazards in broad categories, and suggests control measures for each category. The candidate has considered the likelihood and severity of injury caused by each hazard, and they have also provided a chart to explain the likelihood and severity scores.

The recommended control measures are correct but quite basic, without further explanation, and several more could have been identified.

To develop the response further, the candidate could have included specific risks that relate to each hazard, such as contact injuries, burns, abrasions, smoke inhalation or electric shocks. They could also have included more risk mitigation methods, for example indicating that long hair should be secured, and eye protection should be worn when working on mechanical equipment.

2b) Manufacture of the prototype

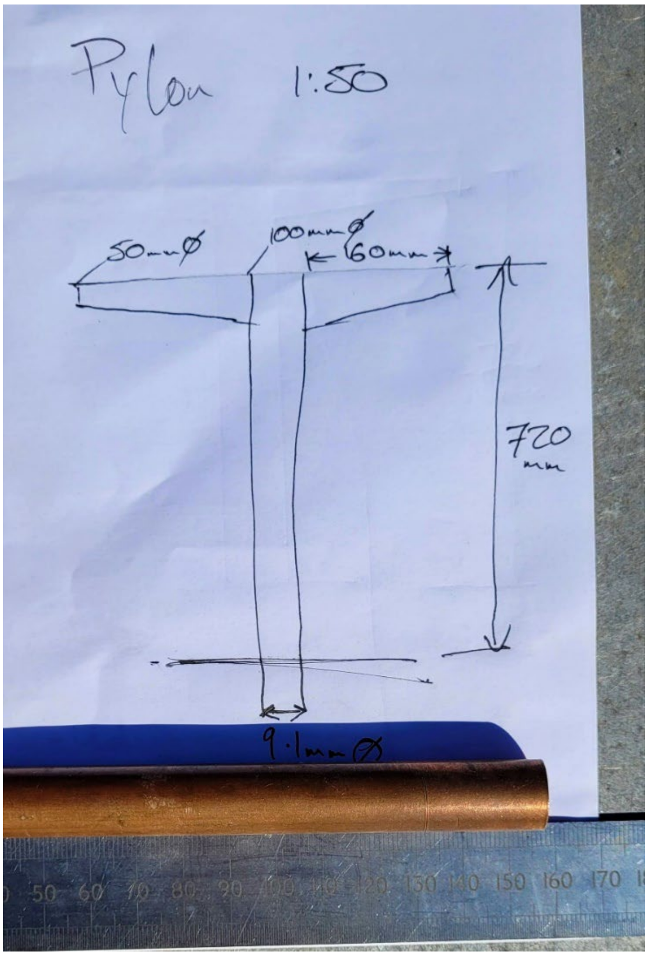
Candidate evidence

I am manufacturing a scaled prototype, at a scale 1:50.

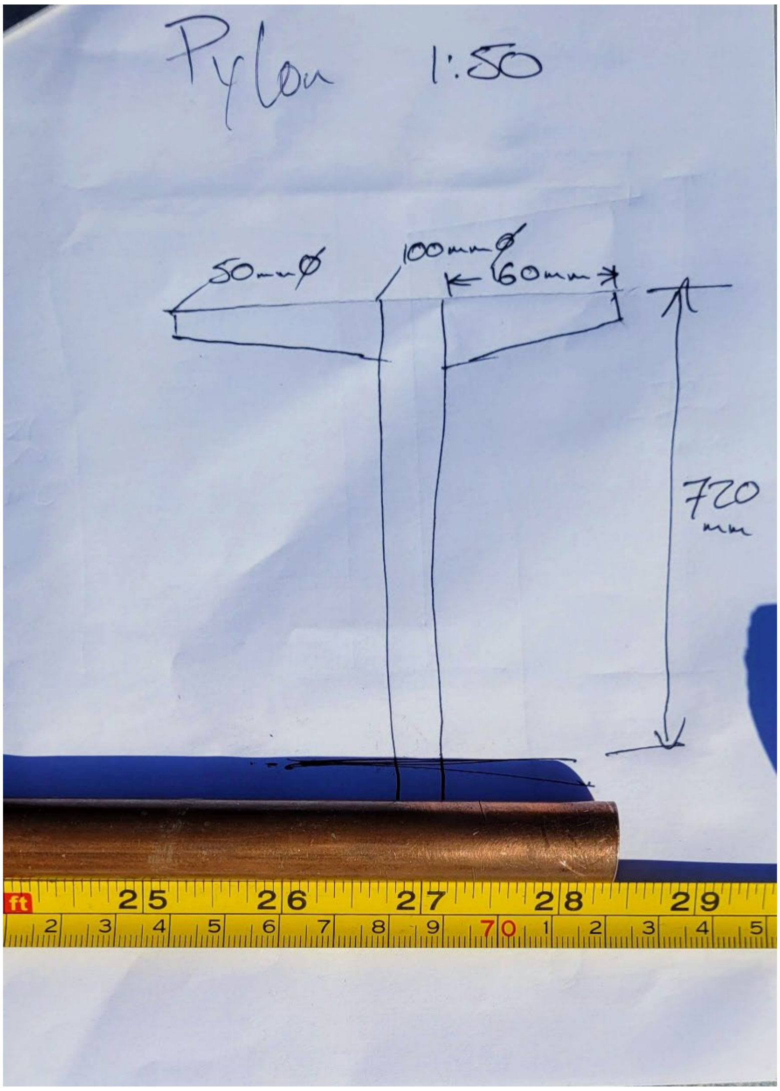
I used copper to manufacture the scaled prototype, because it is a resource readily available at the college and most cost effective.

However, I used steel for the testing, which is the actual material I recommended for the manufacture, because I needed the testing to be done to the same material to get realistic results.

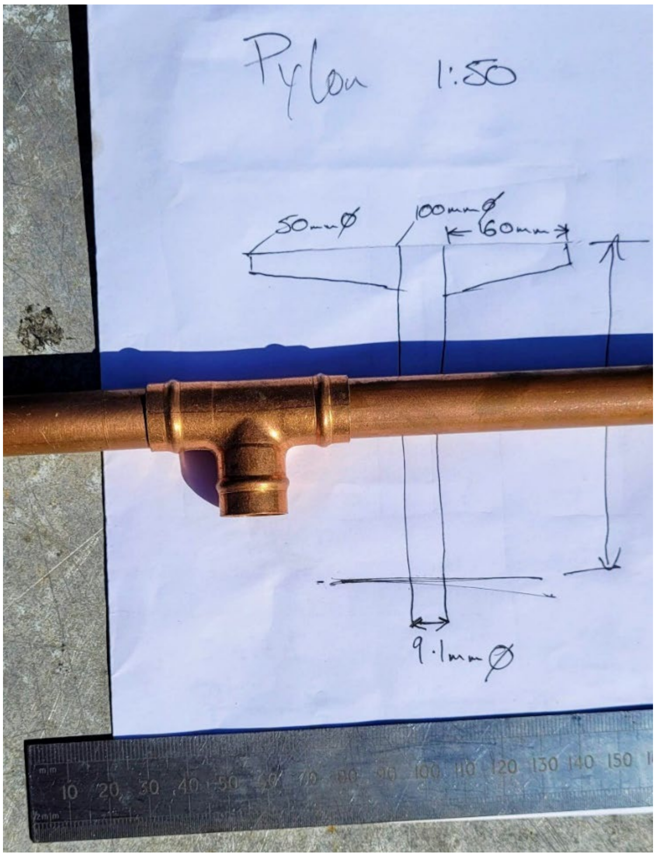
Photograph 1 shows that the candidate has selected the tools, equipment and PPE for the task and set these to the side of the work area. A copy of their design was also to hand. The blade of the hacksaw was observed to be blunt so not in optimal condition for the work needed to be undertaken.



Photograph 2 shows the arm cut to length against a steel rule. The length is very slightly inaccurate at 158 mm, when it should have been 160 mm as the sketch demonstrates, however this difference is absorbed later on in the process, with the use of a T-connector.



Photograph 3 shows the mast cut to length against a tape measure. The length is slightly inaccurate at 722 mm, when it should have been 720 mm as the sketch demonstrates.



Photographs 4 and 5 show the connected components. The joining of the arms to the mast does not exactly match the drawing plan, as the candidate has used a T-connector, which adds to the overall length.

Photographs 6 and 7 show the completed soldered joins, demonstrating the taper of the arms, the cable fixing points, with insulation and base.

Photograph 8 shows the pylon prototype in situ.

Photograph 9 shows a bird's eye view of the pylon. The join of the arms to the mast from the top is different to the CAD model, as it is soldered flush.

Photographs 10 and 11 show the fitted wire which acts as lightning protection. The pylon has been painted in a white finish with and fitted with sporadic cable ties. The cable fixings have also been fitted with insulation, visible in the left photograph.

Photograph 12 shows a bird's eye view of the base plate.

Photograph 13 shows a close-up view of the pylon. The quality of the finish is slightly patchy.

Practical observation form – Prototype

Assessment ID	Qualification number
8714-324	8714-34
Candidate name	**Candidate number**
Candidate A	CG12345
Centre name	**Assessment theme**
City & Guilds	Health and Safety Manufacturing

Complete the table below referring to the relevant marking grid, found in the assessment pack. **Do not** allocate marks at this stage.

Task	Notes – *detailed, accurate and differentiating notes which identify areas of strength and weakness are necessary to distinguish between different qualities of performance and to facilitate accurate allocation of marks once all evidence has been submitted.*
Prototype	The candidate set-up a space in the workshop and collected the tools, equipment and PPE needed for the task. The resources were placed together to one side of the workstation. The hacksaw that was selected had a blunt blade and was not in optimal condition. The candidate undertook some basic visual checks of the immediate working area. The candidate placed technical information, including their risk assessment, within reach of the working area and ensured that all basic controls were checked before starting work. The candidate undertook the manufacture of the prototype. The selection of equipment was appropriate for the task in hand. Each piece was used correctly for the different stages of the development of the prototype. The candidate undertook basic measurement of the different materials required, which were mostly accurate. On several occasions, measurements were not quite correct, and this required the candidate to re-measure and correct the mistake. This was done successfully. The candidate used safe cutting techniques at all times. The cutting of materials was generally accurate – but with some minor discrepancies in finish of final cut materials. Some waste cuttings were not immediately cleared away. Once the parts were soldered together, the arms were cut and rolled to create the taper. The candidate used the vice to manipulate the pipe, as per the requirements of the design. The candidate compiled the prototype, and the outcome mostly reflected the initial design specification and the design sketches developed. The candidate made an attempt to finish the product off, with some attention to the alignment of the parts and to the overall surface finish, which was sanded down. The quality of the final finish was acceptable but could have benefitted from further care and improvement. A T-connector was soldered to join the two arms, which added to the length and height of the prototype. The lightning protection

Task	Notes – ***detailed, accurate and differentiating notes which identify areas of strength and weakness are necessary to distinguish between different qualities of performance and to facilitate accurate allocation of marks once all evidence has been submitted.***
	system, which was included in the planning and design stages was not included in the prototype. The candidate measured the final prototype and, after realising that the height exceeded the measurements in the design, they cut the central mast to the correct height. There was 3mm added length on the arms of the mast, due to the use of the T-connector. This was just within the required tolerances for the prototype. Throughout the task, the candidate was noted observing health and safety practices. PPE was worn at all times. The candidate put all tools and equipment back where they were found at the end of the session and did a basic visual check of the work area. Waste was disposed of, but the area used was not cleaned thoroughly.

Assessor signature	Date
Assessor A	03/04/2022

Commentary

The candidate was observed undertaking the construction of the prototype. The overall production was adequate in developing a finished and scaled prototype that reflected the initial design specification. The work was undertaken safely, with some consideration given to pre-work checks of the work area and with safe working practices followed during the construction of the prototype.

The candidate was able to undertake all stages of the construction successfully. Tools and equipment were used correctly, and mostly used appropriately. The candidate would have benefitted from showing greater precision with their use of hand skills and in relation to measuring. This would have supported a more accurate final prototype. The candidate paid attention to detail, but with some notable omissions with the final finish of the prototype.

The prototype was developed within tolerances but was demonstrated to be at the upper limit of permitted tolerance. The developed prototype would have benefitted from greater precision to ensure it was closer to the original design parameters.

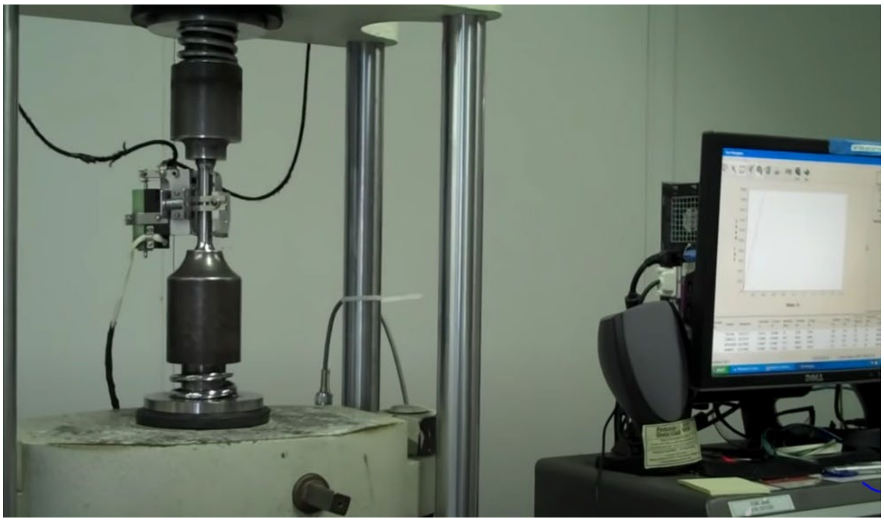
2c) Testing

Candidate evidence

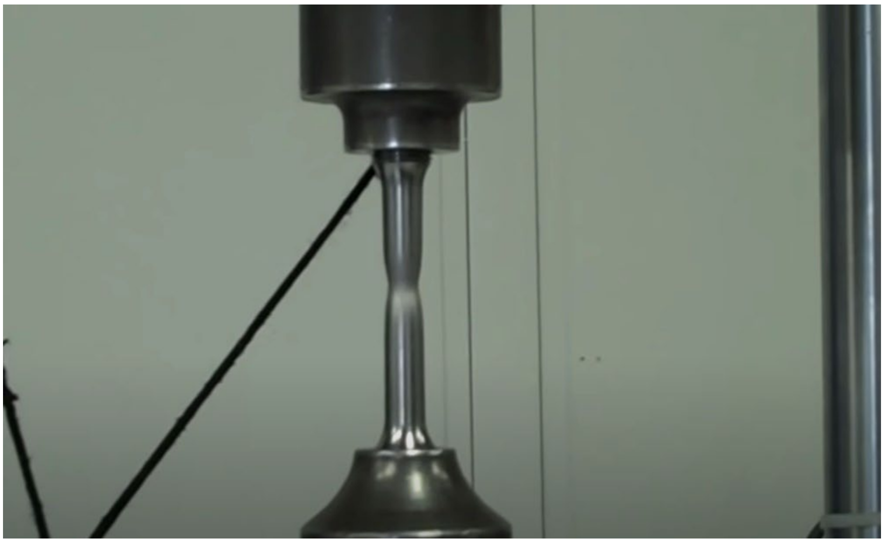
Tensile test results

Loads (KN)	Strain readings (mm)		Average strain reading	Average X 0.2%	Diameter (mm)	Stress (N/mm^2)
	LR	RR				
0	0	0	0		25.7	
60 100	0.6 0.8	0.5 0.7	0.55 0.75		25.7 25.7	
140 160	1.2 1.6	0.9 0.8	1.05 1.20		25.7 25.7	
180 200	2.0 2.4	2.1 2.2	2.05 2.30		25.7 25.7	
220	Young's Modulus exceeded				25.5	
240					24.8	
260					24.2	
280					23.4	

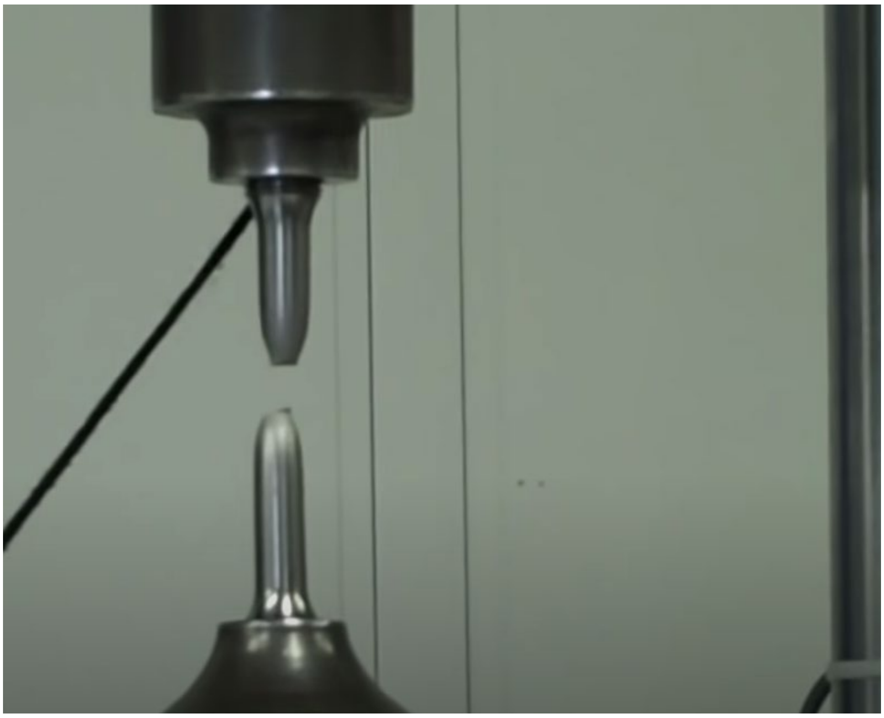
Candidate setting up the tensile testing machine with the appropriate PPE.



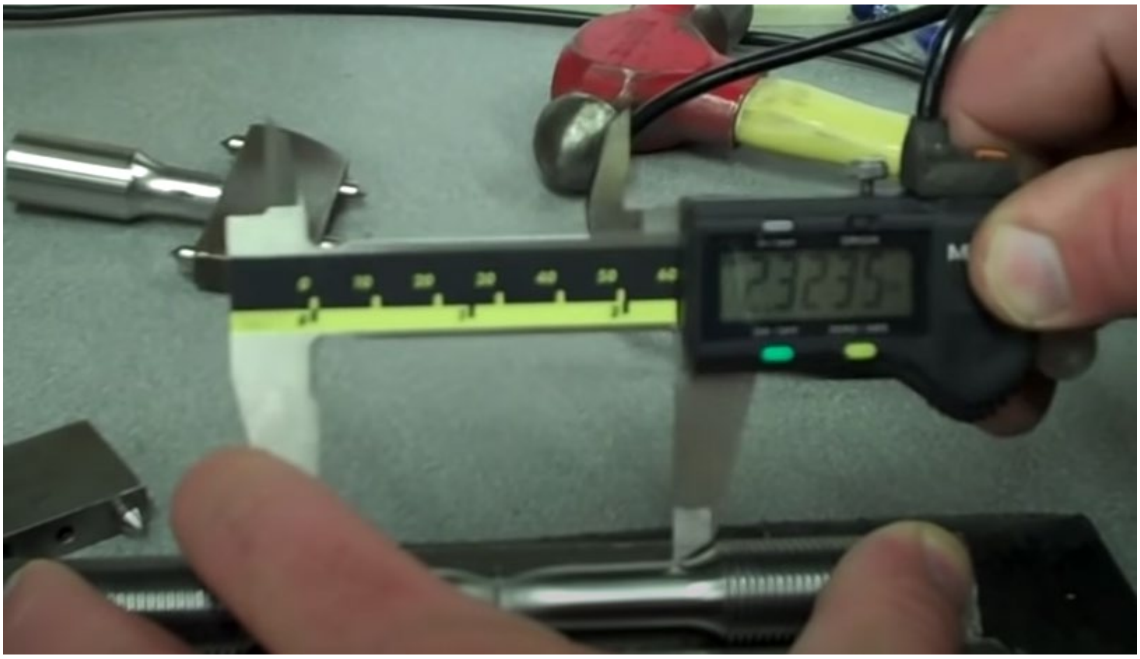
Threaded bar fitted to machine ready for test to commence.



Test piece ‘necking’ under load.



Test piece fractured after Young’s modulus has been met.

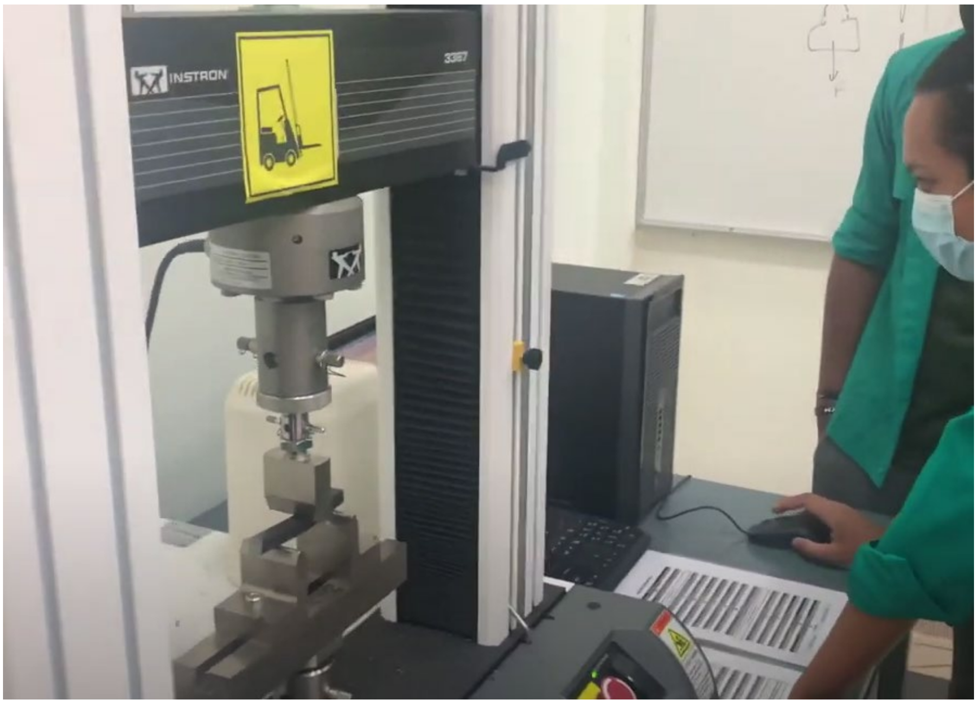


Measuring to determine and prove fracture location, this can then be scaled to an approximate location on the pylon.

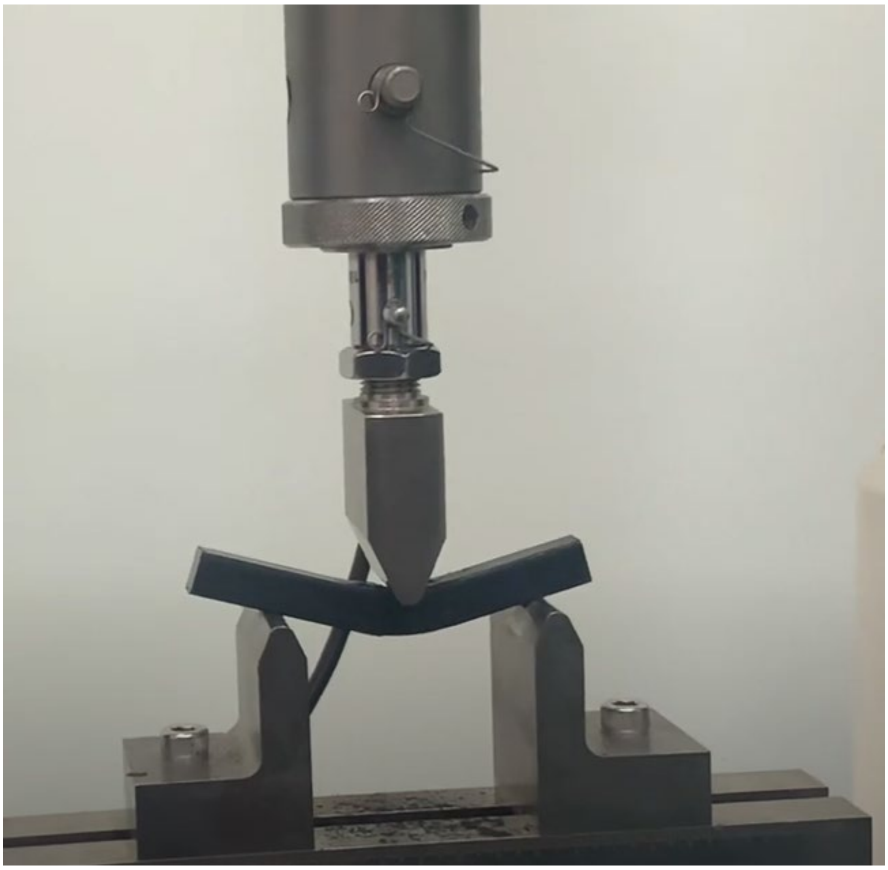
Three Point Bending Test

Specimen span: 100 mm
Specimen dimension: 8 × 8 mm
Modulus of elasticity of the material: 200 kN/mm^2
Position of neutral access: 50 × 4 × 4 mm

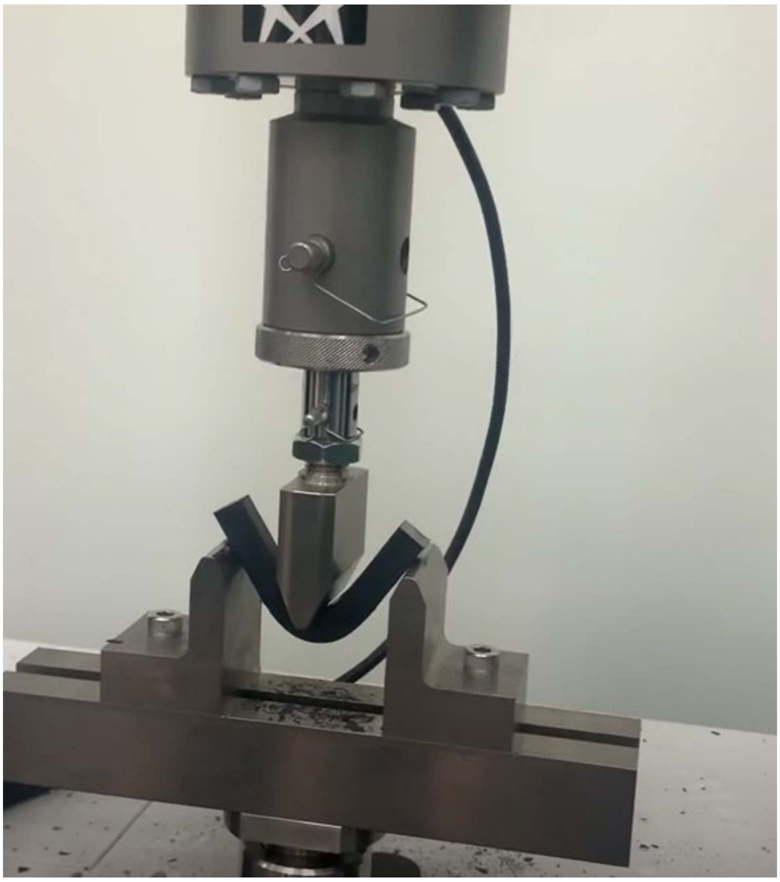
Applied force (N)	Vertical strain (mm)	Experimental bending stress E (N/mm^2)	Theoretical bending stress (N/mm^2)	Error
20	0.04	60	0.5	+/- 0.1
40	0.07	120	1.3	+/- 0.5
60	0.11	180	1.9	+/- 0.6
100	0.18	200	2.1	+/- 1
120	0.2	210	4	+/- 1.2
140	Young's Modulus exceeded			
160			4.3	+/- 1.5



Candidate setting up the three-point bending machine using a 'known' piece to check calibration.



Test piece beginning to show the bend from load applied.



Test piece has now bent beyond Young’s modulus point.

Practical observation form – Testing

Assessment ID	**Qualification number**
8714-324	8714-34
Candidate name	**Candidate number**
Candidate A	CG12345
Centre name	**Assessment theme**
City & Guilds	Manufacturing Reports

Complete the table below referring to the relevant marking grid, found in the assessment pack. **Do not** allocate marks at this stage.

Task	Notes – ***detailed, accurate and differentiating notes which identify areas of strength and weakness are necessary to distinguish between different qualities of performance and to facilitate accurate allocation of marks once all evidence has been submitted.***
Testing	Following the development of the prototype, the candidate set the work area up in order to carry out testing. The candidate undertook some basic pre-testing visual checks to confirm the continued integrity of the work area. Before starting, the candidate rechecked the design criteria briefly. The candidate undertook basic tensile testing to confirm the tensile strength and yield point at which the prototype necked and snapped under the exerted force. The candidate operated the testing equipment correctly but failed to check the calibration of the equipment before commencing the test. The candidate used a three-point flexural testing machine to undertake a bending test. The candidate operated the testing equipment correctly but failed to check the calibration of the equipment before commencing the test. The candidate tested against some but not all of the design criteria and as a result it was not determined whether the requirements of the brief are fully met. The tests were undertaken in accordance with the requirements of the standard testing methods, in a safe manner. The steps were largely followed, and the candidate recorded the results on a test sheet, with some errors in accuracy. When the testing had been completed, the candidate returned equipment correctly to its location in the workspace.

Assessor signature	**Date**
Assessor A	03/04/2022

Commentary

The candidate successfully demonstrated the ability to undertake basic testing by accurately using testing equipment to undertake basic tensile testing, and a three-point bending test. The testing was accurate and demonstrated the use of the correct methodology through using basic testing steps. The candidate adhered to basic safety conditions at all times and demonstrated that they could undertake testing appropriately through maintaining the testing environment.

The candidate could have demonstrated wider knowledge and understanding of the testing process if they had shown a more developed consideration of accuracy in the testing process. For example, the candidate could have ensured that the calibration of testing equipment was correct before use, rather than assuming this to be the case.

The candidate recorded their test results, but there was limited interpretation of the results and limited reference to the original design criteria. To further develop their response, the candidate could have ensured to test the pylon fully against all of the original design criteria.

Task 3 – Peer review

(Assessment themes: Reports)

For task 3, candidates must produce the following pieces of evidence:

- Candidate notes on the candidate feedback record form

  The candidate notes are not included in this document as the notes will vary from candidate to candidate and are not used to inform any other task.

- peer review feedback form.

  This is supporting evidence for assessors to see what feedback the candidate received and how they used it in their review for task 4, and will not be marked.

Peer review feedback form

Candidate name	Candidate number
Candidate B	CG01234
Centre name	**Centre number**
City & Guilds	12345

Question	Feedback
Explain how well the diagrams/drawings meet the design criteria.	*I have reviewed the presented design from the drawings provided against the original design criteria.* *The pylon has been developed correctly to the stated dimensions, for the 8 m cross arms to support the electric power lines. The height of the pylon is also correctly and clearly stated at 36 m.* *The concept sizes for the cross arm are not shown on the drawing so it is not possible to determine if the required imposed load can be accommodated by the design. The mast section is specified as a 457 × 14.2 mm circular hollow section, this seems under sized for the anticipated loading and height of the structure and is unlikely to be structurally adequate.* *The pylon has been designed to be galvanised and painted white.* *The candidate showed that consideration to lightning strike has been included by considering the addition of an earthing rod, but this was not implemented. This would be extra equipment on the pylon that will need to be maintained.*
Explain how well the diagrams/drawings meet the specification criteria.	*The drawings mostly show the design intended from the specification, but there are gaps – the full details of the materials used to develop the pylon have not been included in the drawings.*
What are the implications for the proposed maintenance of the pylon?	*Accessing the pylon will be challenging as some parts of it are very high. There is recommendation for use of a cherry picker, but access to each pylon's location will need to be considered, as it can be difficult for cherry pickers to access different terrains.*
Explain how the system could be optimised/improved.	*The pylon has been designed to be painted white, but other colours could have been considered – light grey may be a more aesthetically pleasing colour that is less intrusive in a range of environments.* *The pylon might be better protected from lightning strikes by using an air-terminating lighting protection system.*

Task 4 – Evaluation and implementation

(Assessment themes: Health and safety, Design and planning, Reports)

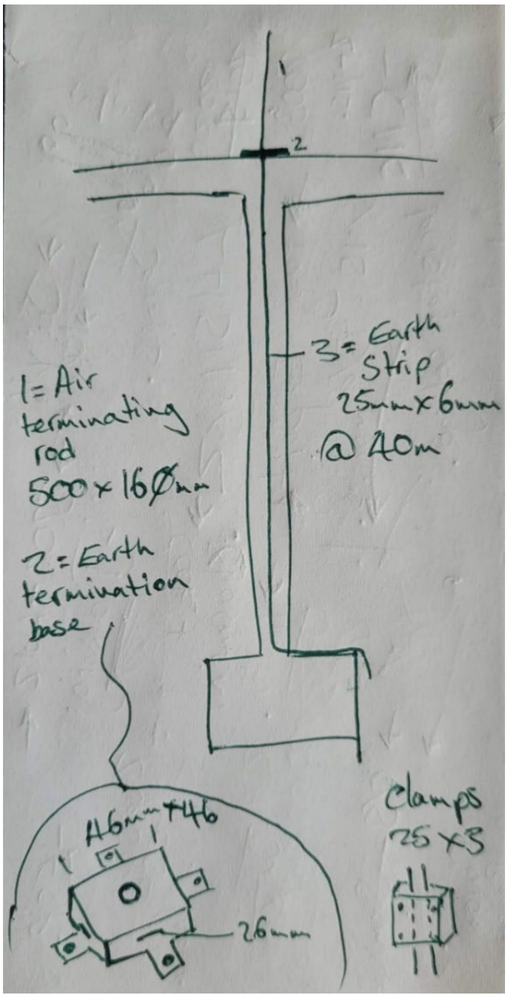
For task 4, candidates need to produce the following pieces of evidence:

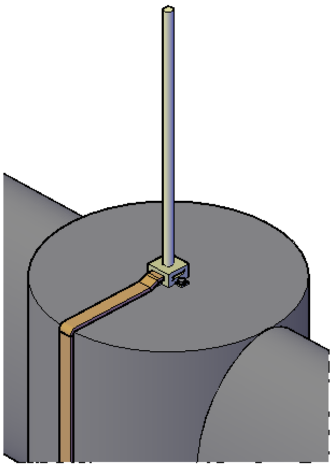
a) outcomes of virtual modelling
b) revision control document
c) evaluation and implementation report.

4a) Outcomes of virtual modelling

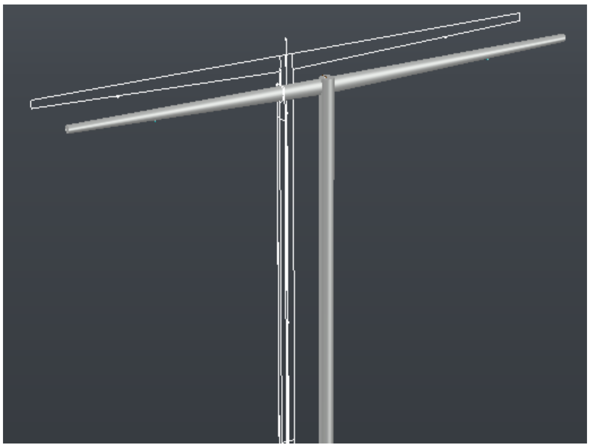
Candidate evidence

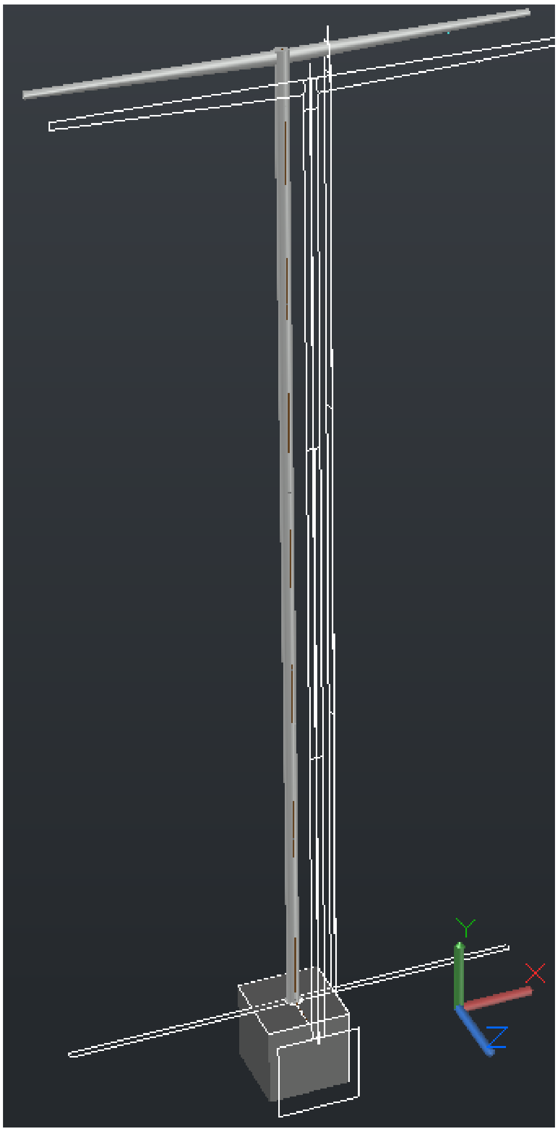
I have updated the pylon to include earthing from ground level to the top of the mast. I first sketched the pylon with the addition and then updated my 3D virtual model and the isometric views.





Isometric view of the top of the pylon





Commentary

The candidate demonstrated logical thinking by first planning the idea and doing correct and appropriate research for the scale and dimensions of existing components that can be added to further improve the pylon. The candidate gathered all this information and put it together in the CAD program to create the virtual model. The design demonstrates good skill of complex design skills and is of good quality. The candidate also used correct measurements to scale. The candidate has included an isometric view of the updated pylon which shows detail of the earthing strap on the top of the pylon.

The earthing strap runs the full length of the pylon and goes into the ground. In order to further improve, the fixings used to bolt this to the concrete base could have been specialised concrete fixings, instead of the standard fixings used. Technically an earth strip is surplus to requirements as the lightning air terminating rod is fixed to the pylon which is earthed via the concrete base. The candidate could have included more isometric views that include detail on the fixing of the earthing onto the pylon.

4b) Revision control document

Structural development	Development of a new pylon
Prototype number	PYLON0001
Department responsible for equipment	Design and Development department
System designed by:	Candidate A

Design description:
The design specification and drawings mainly reflect the development of a new pylon with some omissions which I have decided to incorporate as changes. A prototype for this has been developed based on original design criteria.
Changes to current design:
The peer review noted a number of suggestions for improvement of the design. There was a suggestion that the colour of the pylon could be changed to a light grey colour. This is an alternative to what I have proposed. However, it doesn't seem that light grey would be any less visually aesthetic than white. I think that white is the colour that most people expect a pylon to be, and I will stick with this for the design. Another solution would be to manufacture the pylon from mirrored stainless steel. The reflective surface of the stainless steel will ensure that the pylon disappears into the countryside but might also increase the overall cost. The feedback suggested that the location of each pylon will need to be considered because it can be difficult for cherry picker cranes to access some types of terrain. This is true and relevant, for example a pylon in the middle of a field has grassy and muddy terrain, so an all-terrain vehicle would need to drop off the cherry picker and a suitable temporary flooring would need to be laid out for the cherry picker to travel on. Changing the tyres of the cherry picker would not be feasible. This would also involve a cost impact on the maintenance. The suggestion for using an air-terminating lightning protection system is a sensible alternative to my proposal, and this shall be adopted into the design. This will consist of an appropriate-sized air terminating rod with fixtures and a length of copper to run the full length of the pylon and down into the surrounding ground, beyond the concrete base. There is a real risk of electrical strike to the pylon as it is exposed in an open place and will be expected to stay there for a significant period of time. The risk of damage if lightning did strike is also high, for example setting fire to any dry debris, or burning the pylon itself. Therefore, using the most optimal lightning protection system would be valid and a consideration of the impact of the welded joins due to excessive heat caused by a lightning strike.

Validation performed by:	Assessor 1

Prototype approved by:	Assessor 1

Date:	16/06/2022

Commentary

The candidate has demonstrated the ability to produce a basic revision report. The document produced is of a good standard that gives an overview of the main consideration of changes made to the pylon, including a cost implication. The candidate has structured their response to reflect that the changes made to the existing pylon and has shown what would need to be updated and reflected in the appropriate technical documentation. The document is generally limited in the level of detail it provides on the changes required.

The candidate has provided some justification for the changes that they have adopted, and for areas where no further change has been undertaken. For example, the candidate has identified that they don't believe changing the colour of the pylon to light grey would have any different impact to their current proposal of using white paint. Justifications provided are however limited, and the response could have been developed further through providing a more detailed rationale for their choices and reasoning.

The candidate could have developed their response by providing a greater depth of explanation of the changes identified. This could have been expanded through providing a greater insight into the technical detail of the changes. For example, the addition of a lightning protection system is selected over the use of a copper rod extending the height of the pylon, however there is little detail as to why this alternative technically would provide a better level of protection for the pylon.

4c) Evaluation and implementation report

Evaluation – The designs have been considered and discussed. Through peer review it is agreed that the proposed design meets the requirements of the brief and will allow for the development of a pylon that meets the design criteria.

The prototype was tested using techniques to confirm the tensile strength, and a bending test. The testing demonstrated the ability of the structure to operate when exerted to the expected forces. The bending test provided the most useful information as loading on the structure will induce bending. The tensile test is less helpful when considering the behaviour of the overall pylon but is useful to confirm the quality of the steel material from which the pylon is manufactured.

However, as the prototype is a much smaller replication of the design, it should be noted that full testing would be needed on the full structure. This is because a full structure pylon would be subject to much stronger forces, and therefore may not necessarily perform fully as the scaled prototype has demonstrated. It is important to recognise also that the testing regime might not be completely suitable for the anticipated loads that will be applied to the pylon. It would be sensible to also test the pylon under compressive loading. Arguably this is likely to be more critical as the pylon mast will fail initially, in buckling under compressive load.

Implementation – Upon approval of the prototype and proposed design, the sections of the pylon will be fabricated ready for delivery to each site. The erection sequence for the pylon will need to be communicated to the erection team. The team will need information on the weights for each part of the pylon and details of the safe working loads. On a site-by-site basis it will also be necessary to determine information relating to ground conditions and services, so that the final details of the foundations can be prepared. It may be necessary to adjust the compressive strength of the concrete to accommodate weaker ground conditions or make the foundation bigger. For remote locations, equipment may need to be delivered to site using helicopters, so individual sections will be fitted with lifting points.

The pylon will be erected in key stages. First a back acting excavator will be used to dig out a hole for the foundations. It will be necessary to check on site that there are no existing services within the vicinity of the excavation. This can be done using a cable locator to sweep the area. The locator will beep when a service has been encountered. Once the foundations have been excavated, the holding down bolt assemblies will be introduced to the concrete foundations and fixed in place along with any necessary reinforcement steel. The concrete can then be mixed on site or delivered ready mixed. The concrete will need to be placed into the excavation and compacted using a vibrating poker. The concrete will then cure, and gain strength over a period of days; as a minimum this might be 7 days. After the concrete has set, the bottom section of the pylon mast will be craned into position and fixed with bolts. The pylon arms will then be craned into position and the construction site weld made from a cherry picker. The mast and pylon arms will be craned making use of slings and the lifting points added to individual sections of the pylon.

Commentary

The candidate has demonstrated the ability to create a basic evaluation and implementation report. The evaluation report provided identifies relevant improvements that could be made to the design. However, the reasoning given is generally related to its general quality and does not focus on specific points within the design criteria. The candidate could have developed their response further by expanding on the amount of detail and referring each point back to the original design criteria. The report could also include further justification on the reasoning behind each of the proposed amends, as well as justification for the areas where no adaptations will be made.

The candidate has identified how improvements could be implemented in the implementation section of the report, but the level of detail provided is limited. The report provides an overview of implementing potential modifications, but these are not clearly defined. The candidate has gone into some detail relating to the specifics of how the changes will be implemented and they have expanded on the individual steps needed to implement potential modifications. To develop their response further, they could also have considered the requirements of long-term maintenance of the pylon, suggesting how the operational maintenance could be minimised, for example by selecting finishes that do not require routine painting.