

# IVQs in Construction (6165)

- Level 5 IVQ Advanced Technician Diploma in
- Construction (6165-30) (500/5785/6)
- Construction (Quantity Surveying) (6155-32) (500/5785/6)

Qualification handbook for centres



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## Important notice

Following the accreditation of the Technician IVQs in Construction (6165) on the National Qualifications Framework of England, Wales and Northern Ireland (NQF), some changes have been made to the qualification, at the request of the Office of the Qualifications and Examinations Regulator (Ofqual), the qualifications regulator in England.

These changes took effect on 1 June 2009 and are outlined on pages 05–06.

**Note:** the content of the qualifications has not changed following accreditation.

### Changes to the qualification titles

The qualification titles have changed as follows:

Advanced Technician Diploma in Construction – Applied (6165-30)  
*changed to*

**Level 5 IVQ Advanced Technician Diploma in Construction (6165-30)**

Accreditation number: 500/5785/6

International Advanced Technician Diploma in Quantity Surveying (Applied) (6165-32)  
*changed to*

**Level 5 IVQ Advanced Technician Diploma in Construction (Quantity Surveying) (6165-32)**

Accreditation number: 500/5785/6

### Changes to the unit titles

Following the accreditation of Technician IVQs in Construction, each unit has been given an accreditation reference number which will appear on the Certificate of Unit Credit.

The content of the units is unchanged.

### Level 5 IVQ Advanced Technician Diploma in Construction (6165-30)

Accreditation number: 500/5785/6

#### Mandatory units

M/502/2806 – Site Surveying 3 Principles

T/502/2807 – Site Surveying 3 Practice

A/502/2808 – Materials and Construction Technology 4 Principles

F/502/2809 – Materials and Construction Technology 4 Practice

T/502/2810 – Construction Management and Law 4 Principles

A/502/2811 – Construction Management and Law 4 Practice

#### Optional units (two pairs of the same subject required)

F/502/2812 – Tendering, Estimating and Quantity Surveying 4 Principles

J/502/2813 – Tendering, Estimating and Quantity Surveying 4 Practice

L/502/2814 – Building Services, Science and Technology 4 Principles

R/502/2815 – Building Services, Science and Technology 4 Practice

Y/502/2816 – Structural Elements, Geology, Soil Mechanics and Hydraulics 4 Principles

D/502/2817 – Structural Elements, Geology, Soil Mechanics and Hydraulics 4 Practice

H/502/2818 – Architectural Design 4 Principles

K/502/2819 – Architectural Design 4 Practice

D/502/2820 – Construction Mathematics 4 Principles

H/502/2821 – Construction Mathematics 4 Practice

### Level 5 IVQ Advanced Technician Diploma in Construction (Quantity Surveying) (6165-32)

Accreditation number: 500/5785/6

M/502/2806 – Site Surveying 3 Principles

T/502/2807 – Site Surveying 3 Practice

A/502/2808 – Materials and Construction Technology 4 Principles

F/502/2809 – Materials and Construction Technology 4 Practice

T/502/2810 – Construction Management and Law 4 Principles

A/502/2811 – Construction Management and Law 4 Practice

F/502/2812 – Tendering, Estimating and Quantity Surveying 4 Principles

J/502/2813 – Tendering, Estimating and Quantity Surveying 4 Practice

H/502/2818 – Architectural Design 4 Principles

K/502/2819 – Architectural Design 4 Practice

**Registration for theory examination**

Registration process for the theory examination has not changed.

**Result submission for practical assessment**

Result submission process for the practical assessments has not changed.

**Change to the grading**

The grade 'Credit' has been changed to 'Merit'. All other grades are unchanged. The content of the units concerned is also unchanged.

**Notification of Candidate Results (NCR) and Certificate of Unit Credit (CUC)**

Notification of Candidate Results (NCR) and Certificate of Unit Credit (CUCs) continue to be available on completion of each assessment (theory or practical).

Final certificate will be issued on successful completion of all the required assessments.

**'Theory only' route**

The 'Theory only' route continues to be available as an unaccredited qualification.

**Changes to the certificate layout**

Certificates issued on completion of an accredited IVQ show the accredited title and the accreditation number for the qualification. The level in the accredited title refers to the NQF level the qualification is accredited at.

The certificate also lists all the units achieved, including the grade and the unit accreditation number.

The certificate carries the logos of the regulatory authorities in England, Wales and Northern Ireland indicating that the NQF accreditation only applies to these countries.

## Levels of City & Guilds qualifications

All City & Guilds qualifications are part of an integrated progressive structure of awards arranged over eight levels, allowing people to progress from foundation to the highest level of professional competence. Senior awards, at levels 4 to 7, recognise outstanding achievement in industry, commerce and the public services. They offer a progressive vocational, rather than academic, route to professional qualifications. An indication of the different levels and their significance is given below.

NQF level#	City & Guilds qualifications/programmes	Other qualifications*
8	Fellowship (FCGI)	Doctorate
7	Membership (MCGI) Master Professional Diploma Level 5 vocational awards NVQ/SVQ Level 5	Master's Degree Postgraduate Diploma Postgraduate Certificate
6	Graduateship (GCGI) Associateship (ACGI)**	Bachelor's Degree Graduate Certificate and Diploma
5	Level 5 IVQ Advanced Technician Diploma Full Technological Diploma	Higher National Diplomas Foundation Degree Diplomas of Higher and Further Education
4	Licentiate (LCGI) Higher Professional Diploma Level 4 vocational awards NVQ/SVQ Level 4	Certificate of Higher Education
3	Level 3 IVQ Advanced Diploma Level 3 IVQ Specialist Advanced Diploma*** Level 3 IVQ Technician Diploma Level 3 vocational awards NVQ/SVQ Level 3	A Level Scottish Higher Advanced National Certificate in Education BTEC National Certificate/Diploma
2	Level 2 IVQ Diploma Level 2 IVQ Specialist Diploma*** Level 2 IVQ Technician Certificate Level 2 vocational awards NVQ/SVQ Level 2	GCSE grades A*-C Scottish Intermediate 2/Credit 5 Grade BTEC First Certificate
1	Level 1 IVQ Certificate Level 1 vocational awards NVQ/SVQ Level 1	GCSE grades D-G Scottish Intermediate 1/General 5 Grade Scottish Access 1 and 2

# National Qualifications Framework of England, Wales and Northern Ireland (NQF)

\* Broad comparability in level

\*\* Only graduates of the City & Guilds College, Imperial College of Science, Technology and Medicine, are awarded the Associateship (ACGI)

\*\*\* Part of a new qualification structure which is being introduced across the IVQ provision

IVQ International Vocational Qualifications

NVQ National Vocational Qualifications

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# IVQ in Construction Industry 6165

## About City & Guilds

We provide assessment and certification services for schools and colleges, business and industry, trade associations and government agencies in more than 100 countries. We have over 120 years of experience in identifying training needs, developing assessment materials, carrying out assessments and training assessment staff. We award certificates to people who have shown they have mastered skills that are based on world-class standards set by industry. City & Guilds International provides a particular service to customers around the world who need high quality assessments and certification.

## Introduction to this programme

We have designed the Advanced Technician Diploma in Construction programme for those undergoing training or employed in this area of work. The programme aims to reflect the international nature of the knowledge and skills and activities needed for different countries or cultures.

We do not say the amount of time a candidate would need to carry out the programme, but we do provide advice on guided learning hours for each level (see below). The programme has three levels.

### Certificate

The certificate (about 375 guided learning hours) provides a broad introduction to the theory and practical side of construction for a front-line worker or a person beginning an academic training programme.

### Diploma

The diploma (about 720 guided learning hours) provides more specific theory and practice suitable for a person starting to specialise in their occupational area, who will be working independently and who may supervise others.

### Advanced Diploma

The advanced diploma (about 660 guided learning hours) takes these skills to the level appropriate for a person preparing for or working in a supervisory or management role within their chosen occupation, or who intends to continue their academic training through degree/professional level.

We stress that these figures are only a guideline and that we award certificates and diplomas for gaining and showing skills by whatever mode of study, and not for periods of time spent in study.

We provide certificates for all work-related areas at seven levels within our structure of awards shown in appendix B. This programme covers level 4. The standards and assessments for the certificate (level 2) and the diploma (level 3) are published separately.

## Full Technological Diploma

We will award the Full Technological Diploma (FTD) in Construction to someone who is at least 21, who has had at least two years relevant industrial experience, and who has successfully finished the assessments for the diploma and advanced diploma levels of this award. If candidates enter for this diploma, they must also send us a portfolio of evidence to support their application.

## Making entries for assessments

Candidates can only be entered for the assessments in this subject if the approved examination centres agree. Candidates must enter through an examination centre we have approved to carry out the assessments for 6165 Advanced Technician Diploma in Construction.

There are two ways of entering candidates for assessments.

### Internal candidates

Candidates can enter for examinations if they are taking or have already finished a course at a school, college or similar training institution that has directed their preparation whether by going to a training centre, working with another institution, or by open-learning methods.

### External candidates

These are candidates who have not finished a programme as described above. The examination centres must receive their application for entry well before the date of the examination concerned. This allows them to act on any advice you give about assessment arrangements or any further preparation needed. External candidates must carry out practical assessments and projects if necessary, and they will need extra time and guidance to make sure that they meet all the requirements for this part of the assessment.

In this publication we use the term 'centre' to mean a school, college, place of work or other institution.

## Resources

If you want to use this programme as the basis for a course, you must read this booklet and make sure that you have the staff and equipment to carry out all parts of the programme. If there are no facilities for realistic practical work, we strongly recommend that you develop links with local industry to provide opportunities for hands-on experience.

## Assessments

There is one level of this award.

### Advanced Diploma

We use a numbering system to allow entries to be made for our awards. The numbers used for this programme are as follows.

#### Award number

6165-30 Advanced Technician Diploma in Construction (Applied)

Advanced Technician Diploma in Construction (Theory)

We use award numbers to describe the subject and level of the award.

#### Component numbers

061 Site Surveying 3 Principles  
161 Site Surveying 3 Practice  
062 Materials and Construction Technology 4 Principles  
162 Materials and Construction Technology 4 Practice  
063 Construction Management 4 Principles  
163 Construction Management 4 and Law Practice  
071 Tendering, Estimating and Quantity Surveying 4 Principles  
171 Tendering, Estimating and Quantity Surveying 4 Practice  
072 Building Services, Science and Technology 4 Principles  
172 Building Services, Science and Technology 4 Practice  
073 Structural Elements, Geology, Soil Mechanics and Hydraulics 4 Principles  
173 Structural Elements, Geology, Soil Mechanics and Hydraulics 4 Practice  
074 Architectural Design 4 Principles  
174 Architectural Design 4 Practice  
075 Construction Mathematics 4 Principles  
175 Construction Mathematics 4 Practice

We use component numbers to show units for which we may award a certificate of unit credit.

We use these numbers throughout this booklet. You must use these numbers correctly if you send forms to us.

### Advanced Technician Diploma in Construction (Applied)

To carry out what is needed for the Advanced Technician Diploma in Construction (Applied), candidates must be successful in all of the following assessments.

6165-30-061	Site surveying 3 principles (written paper which lasts 3 hours)
[6165-30-161]	Site Surveying 3 – practice
6165-30-062	Materials and construction technology 4 – principles (written paper which lasts 3 hours)
[6165-30-162]	Materials and construction technology 4 – practice
6165-30-063	Construction management 4 – principles (written paper which lasts 1 1/2 hours)
[6165-30-163]	Construction management 4 and law – practice (Total three written papers)

And any two of the following pairs of assessments.

6165-30-071	Tendering, estimating and quantity surveying 4 – principles (written paper which lasts 3 hours)
[6165-30-171]	Tendering, estimating and quantity surveying 4 – practice
6165-30-072	Building services, science and technology 4 – principles (written paper which lasts 3 hours)
6165-30-172]	Building services, science and technology 4 practice
6165-30-73	Structural elements, geology, soil mechanics and hydraulics 4 (written paper which lasts 3 hours)
[6165-30-173]	Structural geology, soil mechanics and hydraulics 4 – practice
6165-30-074	Architectural design 4 – principles (written paper which lasts 3 hours)
[6165-30-174]	Architectural design 4 – practice
6165-30-075	Construction mathematics 4 – principles (written paper which lasts 3 hours)
[6165-30-175]	Construction mathematics 4 – practice (Total two written papers)

The practical assessments are carried out during the learning programme and should be finished by the date of the written examination so that you can send all the results to us. (See appendix A.)

### Advanced Technician Diploma in Construction (Theory)

To carry out what is needed for the Advanced Technician Diploma in Construction (Theory), candidates must be successful in all of the following assessments.

- 6165-30-061 Site surveying 3 – principles (written paper which lasts 3 hours)
- 6165-30-062 Materials and construction technology 4 – principles (written paper which lasts 3 hours)
- 6165-30-063 Construction management 4 – principles (written paper which lasts 1 1/2 hours)  
(Total three written papers)

And any two of the following assessments.

- 6165-30-071 Tendering, estimating and quantity surveying 4 – principles – (written paper which lasts 3 hours)
- 6165-30-072 Building services, science and technology 4 – principles (written paper which lasts 3 hours)
- 6165-30-073 Structural elements, geology, soil mechanics and hydraulics 4 – principles (written paper which lasts 3 hours)
- 6165-30-074 Architectural design 4 – principles (written paper which lasts 3 hours)
- 6165-30-075 Construction mathematics 4 – principles (written paper which lasts 3 hours)  
(Total two written papers)

We provide assessments in two ways.

#### a Fixed date

These are assessments which are carried out on dates and times we set. These assessments have no brackets around their numbers.

#### b Free date

These are assessments which are carried out at a college or other training establishment on a date or over a period which the college chooses. These assessments have brackets around their numbers.

In this programme the written assessments are fixed date. The practical assessments are free date.

You must carry out assessments according to our International Directory of Examinations and Assessments. If there are any differences between information in this publication and the current directory, the Directory has the most up-to-date information.

## Results and certification

Everyone who enters for our certificates, diplomas and advanced diplomas receives a 'Notification of Candidate Results' giving details of how they performed.

If candidates successfully finish any assessment within this programme (for example, any one of the examination papers) they will receive a certificate of unit credit towards the certificate for which they are aiming. We grade course work assessments as pass or fail. We grade written assessments on the basis of fail, pass, credit or distinction. The certificate of unit credit will not mention assessments which they do not enter, which they failed or from which they were absent.

Each certificate clearly states what candidates need for full certification at the relevant level, allowing schools, colleges and employers to see whether they have met the full requirements.

If candidates successfully finish all the requirements for a full certificate, they will automatically receive the appropriate certificate.

We will send the 'Notification of Candidate Results', certificates of unit credit, certificates, diplomas and advanced diplomas to the examination centre to be awarded to successful candidates. It is your responsibility to give the candidates the certificates. If candidates have a question about the results and certificates, they must contact you. You may then contact us if necessary.

We will also send you a results list showing how all candidates performed.

## How to offer this programme

To offer this programme you must get approval from us. There are two categories of approval.

### Subject approval

We give approval to offer a teaching course based on this syllabus.

### Examination centre approval

We give approval to enter candidates for examinations.

To be approved by us to offer a teaching course you must send us the application form.

To enter candidates for examinations you must be approved by us as an examination centre. For this programme it is possible to act as a registered examination centre only, and accept external candidates. Approved examination centres must provide suitable facilities for taking examinations, secure places to keep the examination papers and materials, and may have an appointed visiting verifier to review practical work.

After we have received and accepted an application, we will send an approval letter confirming this. You can then send entries in at any time using the International Directory of Examinations and Assessments for guidance.

**Please note that in this section we have provided an overview of centre approval procedures. Please refer to the current issue of 'Delivering International Qualifications – Centre Guide' for full details of each aspect of these procedures.**

## Additional information

### Designing courses of study

Candidates for the Advanced Technician Diploma in Construction will have come from different backgrounds and will have different employment and training experiences. We recommend the following:

- carry out an assessment of the candidates' achievements so you can see what learning they already have and decide the level of entry they will need; and
- consider what learning methods and places will best suit them.

When you assess a candidate's needs, you should design teaching programmes that consider:

- what, if any, previous education qualifications or training the candidate has, especially in the various general vocational education certificates we provide; and
- what, if any, previous practical experience the candidate has which is relevant to the aims of the programme and from which they may have learned the relevant skills and knowledge.

When you choose learning methods and places, you should consider the results of your assessments and whether the following are available.

- Open or distance learning material.
- Workplace learning that can be carried out on site or between you and a local workplace. This will allow the candidates access to specialised equipment and work experience.
- Working with other registered centres to share facilities.
- Opportunities for co-operative learning between candidates who need to gain similar skills.

As long as the candidates meet the aims of this learning programme the structures of courses of study are up to you. So, it is possible to include extra topics that meet local needs.

You should avoid teaching theory alone. As far as possible the practical work should be closely related to work in the classroom so that candidates use their theory in a realistic work environment. You can use formal lectures in the classroom with appropriate exercises and demonstrations. Candidates should keep records of the practical work they do so they can refer to it at a later date.

We assume that you will include core skills, such as numeracy, communication, working with people and organisation and planning throughout a teaching programme.

## Presentation format of units

### Practical competences

Each module starts with a section on practical competences which shows the practical skills candidates must have.

At times we give more detail about important words in each 'competence statement'.

For example:

'1.10a Identify the various types of protective clothing/equipment and their uses.

**Protective clothing:** overalls, ear defenders/plugs, safety boots, knee pads, gloves/gauntlets, hard hats, particle masks, glasses/goggles/visors'

In the above statement the words 'protective clothing' are given as a range which the candidate should be familiar with. If a range starts with the abbreviation 'eg' the candidates only need to cover some of the ranged areas or you can use suitable alternatives.

### Knowledge requirements

Immediately after the section on practical competences the module tells you what knowledge is needed for that area. The knowledge needed is closely linked to the practical competences, so it is best to teach the two together so that the candidate appreciates the topic more.

### Practical assessments

The end of each unit contains practical assessments which deal with the practical competences we mentioned earlier. Candidates must carry out the practical assessments. You should make sure all practical assessments are supervised and instructors should make sure that the results reflect the candidate's own performance. You must hold all the evidence in a file (portfolio) for each candidate for eight weeks after the application for a certificate. You must also keep separate records of the dates of all attempts by each candidate.

## Entry levels

We consider the following programmes to be relevant preparation for this programme.

Technician Diploma in Construction (6165)  
Ordinary Technician Diploma in Building and Civil Engineering (8010)  
Construction Technicians Part 2 (6260)  
Quantity Surveying Part 2 (6270)  
Construction Crafts Supplementary Studies (6000)

We also consider the following Pitman Qualifications award as relevant alongside this programme.

English for Speakers of Other Languages – higher intermediate level

## Progression routes and recognition

A number of UK universities and other higher-education institutions may accept success in this programme towards evidence for direct entry onto higher-level programmes. The decision to accept a candidate on to a degree programme, and the level of entry, is up to the institution. We provide details of organisations recognising achievement in this programme.

## Useful publications

We can provide a list of suggested text books covering specific areas of this programme. We may also have knowledge about other support materials. You should make sure that you have the latest information. We will automatically send updated lists to centres we have approved to offer this programme.

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# Syllabus

## IVQ in Construction Industry 6165

### Section numbers and titles

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**16 61 Site Surveying 3**

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17 Site Surveying

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**21 62 Materials and Construction Technology 4**

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22 Materials Technology

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23 Construction Technology

---

**29 63 Construction Management 4 and Law**

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30 Construction Law

---

31 Construction Management and procedures

---

**35 71 Tendering, Estimating and Quantity Surveying 4**

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36 Tendering and Estimating

---

37 Quantity Surveying

---

**42 72 Building Services' Science and Technology 4**

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43 Building Services

---

49 Science and Technology

---

**55 73 Structural Elements, Geology, Soil Mechanics, and Hydraulics 4**

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56 Designing of structural elements

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58 Geology, soil mechanics and hydraulics

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**64 74 Architectural Design 4**

---

65 Architectural Detailing

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66 Computer Aided Design (CAD)

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**71 75 Construction Mathematics 4**

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72 Construction Mathematics

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# 61 Site Surveying 3 – Summary of syllabus sections

Page 17 **Site Surveying 3**  
(Objectives 61.1 to 61.41)

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The aim of this unit is to develop the surveying principles covered at Diploma Level (Site Surveying 2) with particular emphasis on current setting out practice in the construction industry.

**Note: The unit requires that there is access to electronic distance instruments and laser alignment equipment.**

# Site Surveying 3

## Practical competences

The candidate must be able to do the following:

- 61.1 Establish co-ordinates for use in setting out and carry out independent checks.  
**Checks:** measurements between co-ordinated points
- 61.2 Calculate the bearing and distance between co-ordinated points.
- 61.3 Set out buildings, foundations, drainage runs.  
**Buildings:** eg light industrial
- 61.4 Carry out independent checks to ensure accuracy of dimensional control.  
**Checks:** eg additional measurements, tie measurements
- 61.5 Establish the site datum and maintain reference surface on site.  
**Site datum:** eg floor level, temporary bench mark
- 61.6 Establish verticality of structure using an optical plumb, a theodolite and an alignment laser.  
**Verticality of structure:** position of columns floor by floor
- 61.7 Set out a grid of levels over a site to ensure its relationship to the survey control.
- 61.8 Establish contours by interpolation.  
**Interpolation:** proportion between levels
- 61.9 Plot ground sections from contours.  
**Ground sections:** longitudinal, cross
- 61.10 Compute earthwork volumes from contours, spot heights and ground sections.  
**Earthworks:** embankments, cuttings
- 61.11 Prepare setting out data for setting out a circular curve by deflection angle.  
**Setting out data:** tabulation for use on site
- 61.12 Set out a horizontal circular curve for road centre line.

## Knowledge requirements

The instructor must ensure the candidate is able to:

### Contouring

- 61.13 Describe the levelling grid method associated with representative spot heights.  
**Representative spot heights:** high/low points, change of slope, detail features
- 61.14 Describe the terms contour line, vertical interval and horizontal equivalent.

- 61.15 Explain the method of contour interpolation from grid and spot heights.  
**Contour interpolation:** tracing paper overlay, scaling, random line, calculation method
  - 61.16 Describe the method of positioning contours directly related to the site datum.
  - 61.17 Explain the use of contours for plotting sections or for the design of earthworks.  
**Design of earthworks:** plan view (embankments, cuttings)
  - 61.18 Describe the hardware and software required for computerised digital modelling used in the design of earthworks.
- ### Earthwork volumes
- 61.19 Describe the method of calculating the volume of earthworks by spot heights, contours and cross sections.  
**Calculations:** Simpson's Rule for volumes, End Areas Rule, Prismoidal correction
  - 61.20 Explain the terms borrow pit, bulking, shrinkage, free haul, overhaul and balancing procedures.
  - 61.21 Explain the purpose of mass haul curves.  
**Mass haul curves:** for balancing cut/fill, moving quantities of materials

### Setting out

- 61.22 Define the term 'setting out'.
- 61.23 Explain the method of setting out and the relationship between the survey plan and the site developments.  
**Methods:** baseline, reference line, bearing/distance
- 61.24 Describe various instruments used for setting out.  
**Instruments:** optical reading theodolite, total station
- 61.25 Describe the method of calculation using co-ordinates for setting out.
- 61.26 Describe the checks applicable to setting out.  
**Checks:** observing on both faces, measuring between points, independent measurements
- 61.27 Describe the use of loggers as a check for setting out data.  
**Loggers:** data for tracking function
- 61.28 Describe the use of a rotating laser for maintaining the site datum.
- 61.29 Describe the use of a pipe laying laser for drainage runs, supplementary to the use of sight rails and travellers.

- 61.30 Explain the use of various equipment for ensuring the verticality of structure.  
**Equipment:** autoplumb, theodolite with diagonal eyepiece, laser alignment  
**Verticality of structure:** use of reference frame, plumbing by inclined sights, optical plumbing
- 61.31 Define the elements of the horizontal circular curve.  
**Curve elements:** angle of deflection, intersection point (IP), angle of deviation, tangent distance, tangent point (TP), long chord, running chainage, standard chord, sub chords
- 61.32 Describe the method of setting out circular curves by tape only.  
**Method:** tangent/offset, deflection distance, chord bisection
- 61.33 Describe the method of calculating data for setting out a circular curve by deflection angle.  
**Setting out data:** tabulation for use on site
- 61.34 Describe how to set out a circular curve with appropriate field checks.
- 61.35 Describe the use of electronic instruments with a tracking function to set out a circular curve.
- 61.36 Explain various methods of overcoming obstacles when setting out a curve, including the use of co-ordinates.  
**Methods:** obstacles where IP/ TP are inaccessible, where features prevent direct measurement of points on the curve itself
- 61.37 Identify the various elements and purpose of the vertical curve.  
**Elements:** geometry (parabolic), summit/valley curves, design length, gradients, high/low points
- 61.38 Identify the various elements and purpose of a transition curve.  
**Elements:** super elevation, length of curve, spirals, deflection angles, shift, tangent length, offsets

#### **Application of current technology**

- 61.39 Explain the use of Global Positioning Systems (GPS) for surveying and setting out.  
**Use:** concept of satellite links, GPS receivers, control/detail surveys on the country of studies National Grid system, use of Differential GPS for setting out
- 61.40 Explain the use of Geographical Information Systems (GIS) for updating plans and identifying developments in relation to existing features.  
**Use:** concept of databases, background maps, positioning of services, appropriate computer software
- 61.41 Explain the use of AutoCAD for processing field data and plotting site information.

# Assessment

## Test specification for written paper Site Surveying 3 (6165-30-061)

This is a written paper lasting three hours with 5 questions.  
Candidates must answer **all** questions.

<b>Topic</b>	<b>Approximate % examination weighting</b>
Contouring	20
Earthwork volume	20
Setting out	50
Application of current technology	10

# 61 Site Surveying 3

## Practical competences

The candidate must be able to do the following:

- |       |   |                          |
|-------|---|--------------------------|
| 61.1  | Establish co-ordinates for use in setting out and carry out independent checks.                 | <input type="checkbox"/> |
| 61.2  | Calculate the bearing and distance between co-ordinated points.                                 | <input type="checkbox"/> |
| 61.3  | Set out buildings, foundations, drainage runs.  | <input type="checkbox"/> |
| 61.4  | Carry out independent checks to ensure accuracy of dimensional control.                         | <input type="checkbox"/> |
| 61.5  | Establish the site datum and maintain reference surface on site.                                | <input type="checkbox"/> |
| 61.6  | Establish verticality of structure using an optical plumb, a theodolite and an alignment laser. | <input type="checkbox"/> |
| 61.7  | Set out a grid of levels over a site to ensure its relationship to the survey control.          | <input type="checkbox"/> |
| 61.8  | Establish contours by interpolation.  | <input type="checkbox"/> |
| 61.9  | Plot ground sections from contours.   | <input type="checkbox"/> |
| 61.10 | Compute earthwork volumes from contours, spot heights and ground sections.                      | <input type="checkbox"/> |
| 61.11 | Prepare setting out data for setting out a circular curve by deflection angle.                  | <input type="checkbox"/> |
| 61.12 | Set out a horizontal circular curve for road centre line.                                       | <input type="checkbox"/> |

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature

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Candidate name (please print)

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Instructor signature

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Instructor name (please print)

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Completion date

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# 62 Materials and Construction Technology 4 – Summary of syllabus sections

Page 22 **Materials Technology 4**  
(Objectives 62.1 to 62.13)

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The aim of this unit is to develop an understanding of the scientific principles which determine the behaviour of materials and the relevant technological processes involved in the construction project.

Page 23 **Construction Technology 4**  
(Objectives 62.14 to 62.58)

---

The aim of this unit is to further develop the knowledge requirements of Diploma Level (Construction Technology 2 and 3) to enable the

- a relate the principles gained to long span, low rise and multi-storey buildings and
- b consider the implications for alterations, modification and demolition of existing buildings.

## Practical competences

The candidate must be able to do the following:

- 62.1 Predict the likely behaviour of materials in a given situation, based on chemical/biological and physical nature.  
**Materials:** cement products (mortar, dense concrete), metals (ferrous, non ferrous), plastics (thermo setting, thermo plastics), timber (soft woods, hard woods)
- 62.2 Identify the role of water in the degradation of building materials.  
**Water:** sources (rain water, ground water, condensation, humidity, drying out process), effects (chemical reactions, corrosion, erosion, expansion/contraction, decay)
- 62.3 Identify the role of the sun in the degradation of building materials.  
**Degradation:** effect (ultraviolet, infra-red)
- 62.4 Select appropriate materials for a specific end use and environment and justify the choice.  
**End use/environment:** performance requirements, properties of materials, cost, availability, health/safety, environmental issues
- 62.5 Devise strategies for limiting performance failures due to the degradation of materials.  
**Strategies:** selection of inherently durable materials, protection by design, treatments, maintenance, replacement
- 62.10 Identify the role of water in the degradation of construction materials and propose strategies for limitation.  
**Water:** supplies, water cycle  
**Degradation:** water (entry, exclusion, effects), moisture content of materials (cement products, metals, plastics, timber)
- 62.11 Describe the factors relevant to the strength of materials.  
**Factors:** compression, tension, elasticity, plasticity, Young's modulus, factor of safety  
**Materials:** cement products, metals, timber
- 62.12 Describe strategies for limiting the degradation of construction materials.  
**Strategies:** selection of inherently durable materials, protection by design, treatments, maintenance, replacement
- 62.13 Identify materials suitable for a specific end use and location, taking into account various factors.  
**Factors:** performance requirements, properties of materials, cost, availability, health/safety, environmental issues

## Knowledge requirements

The instructor must ensure the candidate is able to:

- 62.6 Indicate how the properties of materials are determined by the physical and chemical nature of their constituents.  
**Physical/chemical nature:** atoms, molecules, elements, compounds, solutions, mixtures, bonding, crystals, grains (metals), physical state (solid, liquid, gas)
- 62.7 Distinguish between chemical and physical change.  
**Chemical/physical change:** change of state, chemical reaction (energy, stability, reversion)
- 62.8 Indicate how the properties of timbers are determined by their cell structure.  
**Properties:** hardness, resistance to fungal/insect attack, grain structure
- 62.9 Relate the chemical principles in 62.6 and 62.7 above to a range of materials used in construction.  
**Materials:** cement products, metals, plastics

## Practical competences

The candidate must be able to do the following:

- 62.14 Compare and recommend various types of construction for long span, low rise and multi-storey buildings.
- 62.15 Investigate and prepare a report on the considerations to be made during the design and construction of the various types of building specified in 62.14 above as a result of established legislation.
- 62.16 Produce sketches, including details of any reinforcement required, of the various foundations available for the types of buildings specified in 62.14 above giving consideration to the building load, building layout and the type/bearing capacity of the ground.
- 62.17 Investigate and prepare a report on the suitability and lifespan of a range of building materials for the various types of buildings specified in 62.14 above.
- 62.18 Develop a safety, health and welfare policy for a specific site based on existing legislation to give consideration to site personnel, building user, general public and adjacent property during the construction of the building, to include the alteration, modification and demolition of adjacent buildings.
- 62.19 Develop economic design solutions for the various types of building specified in 62.14 above.
- 62.20 Develop a logical approach to the sequence of operations for the various types of building specified in 62.14 above.
- 62.21 Illustrate, by means of annotated and dimensioned drawings/sketches, an understanding of the knowledge requirements of this unit.
- 62.22 Prepare lists of materials, components and sequences of operations to illustrate an understanding of the knowledge requirements of this unit.
- 62.23 Carry out a realistic site investigation of a specific site.  
**Site investigation:** establish soil condition from established data, observe contours, record topography/existing structures, obtain details of existing services or the proximity of existing services, obtain details of facilities in the area (labour force, material suppliers, plant hire), possible need for importing facilities

## Knowledge requirements

The instructor must ensure the candidate is able to:

### Site evaluation

- 62.24 Explain and illustrate the need for adequate site and soil investigation prior to the start of construction work on site.  
**Adequate investigation:** methodical approach using standard forms, site visit, archive research, standard soil test procedures, investigation for filled/contaminated sites, problems relating to particular areas (eg mining, subsidence)

### Substructure

- 62.25 Compare and describe, with the aid of sketches, the typical methods available for excavating to depths of up to 10m for foundation trenches and basements for high rise buildings.  
**Methods:** trenches (timbering as work proceeds, between sheet steel piling, bentonite slurry), basements (between sheet piles/supporting as work proceeds, dumping method, cast in-situ piles, precast concrete piles, diaphragm walls)
- 62.26 Describe temporary and permanent methods of controlling ground water in deep excavations.  
**Methods:** sumps/pumps, interlocking sheet steel piles, diaphragm walls, freezing, grout injection, well points, cut off walls
- 62.27 Describe and detail the common methods of constructing basements.  
**Methods:** brick with integrated tanking, cast in-situ concrete with integrated tanking, waterproofed concrete/water bars, diaphragm walls, ground anchors
- 62.28 List and describe the procedures for forming the types of basement specified in 62.27 above.
- 62.29 List and describe the procedures for effectively waterproofing an existing basement from the inside.  
**Waterproofing:** floor/wall tanking linked, loading coat to floor/walls to prevent water pressure movement, grouting between wall loading/coat tanking, drained cavity/sump alternative

### Foundations

- 62.30 Identify and describe the common forms of foundation used for various types of building.  
**Types of building:** long span, low rise, multi-store  
**Forms of foundations:** reinforced concrete rafts including edge beams, cellular rafts, reinforced concrete strips/ pads, piles/pile caps, piles/ground beams, pads/ground beams
- 62.31 Identify and describe the common types of piling systems.  
**Types:** displacement, replacement, combination, friction, end bearing, precast concrete, cast in-situ concrete, concrete shell, steel shell

62.32 Sketch details of the linkage between a pile and pile cap including the location of reinforcing in the ground beam.

62.33 Sketch details of the linkage between piles and a ground beam including location of the reinforcing in the ground beam.

62.34 Describe common methods used to improve the effectiveness of foundations in low bearing capacity ground.  
**Methods:** rolling, injection grouting, vibro flotation, permanent reduction of ground water

62.35 Describe the various types of foundation available given situations.  
**Situations:** sand, gravel, made up ground, deep clay, uncontrolled fill

### Superstructure

62.36 Describe, with the aid of sketches, the common forms of construction used for low rise, medium and long span buildings.

**Forms of construction:** rigid and pin jointed portal frames, columns and lattice trusses, space decks, space frames, shell roofs in timber/concrete (single curvature, double curvature)

62.37 Describe, with the aid of sketches, the common forms of construction used for high rise buildings.  
**Forms of construction:** cast in-situ concrete frame, precast concrete frame, steel frame with precast concrete floors, prestressed concrete frames, braced frames, shear wall structures, core structure, hull core structure, box frame structure

62.38 Describe, with the aid of sketches, the range of claddings, infilling and roof coverings commonly used for the types of building in 62.36 and 62.37 above.  
**Range:** coated sheet metals, cementitious, sheet materials, brickwork, blockwork, precast concrete, GRC, GRP

62.39 Describe and detail how heat insulation, fire protection, corrosion resistance and aesthetic requirements can be satisfied in the range of materials in 62.38 above including painting and spraying treatments.

62.40 Describe, with the aid of sketches, curtain walling as a cladding to high rise buildings and list the desirable performance requirements.  
**Performance requirements:** fixing tolerances, differential expansion/contraction, fixing/jointing arrangements, insulation for heat loss/noise, resistance to weather/fire

62.41 Illustrate typical methods of concealing services in high rise buildings.  
**Methods:** floor ducts, above suspended ceilings, wall casings/ducts, skirting ducts

62.42 Explain the basic principles of prestressed concrete.

**Basic principles:** high quality concrete, high tensile steel tendons, inducing force before load is applied, tendency of high tensile steel to return to its original length

62.43 Differentiate between prestressed pre-tensioned concrete units and prestressed post-tensioned concrete units.

62.44 Illustrate the different means of anchorage used for pre-tensioned and post-tensioned tendons to concrete in prestressed concrete.

62.45 Describe and illustrate typical methods of providing natural lighting and ventilation in medium to long span roofs.  
**Methods:** translucent sheets in pitched roofs, north light, monitor light, lantern light

62.46 Sketch typical details of the types of roof light in 62.45 above to indicate waterproofing and ventilation adjustment provision.

62.47 Sketch typical details of providing egress for moisture from large area cast in-situ flat concrete roofs when covered in bituminous and asphalt finishes.  
**Details:** spot bonded granular felt first layer/paravents

62.48 Describe how the roof of a high rise building may be used to incorporate typical equipment and services of a permanent and temporary nature to allow cleaning and maintenance of the external finishes.  
**Equipment/services:** suspended scaffolds, suspended work platforms, suspended cradles, bosun chairs

### Internal works

62.49 Describe, with the aid of sketches, the range of suspended ceilings available for medium span and high rise buildings including their ability to conceal services.

62.50 Describe, with the aid of sketches, the range of partition systems available for medium span and high rise buildings including their ability to conceal services.

62.51 List the factors which allow flexibility of layout for medium to large span floor areas.  
**Factors:** demountability of internal partitions, provision of floor/ceiling/wall ducting for services, adaptability of services equipment, provision of equipment (light, ventilation)

### Alteration, modification and remedial work

62.52 Describe, illustrate and list the sequence of operations for the various methods of providing support to existing buildings of brick or stone to ensure that structural stability is maintained while remedial or alteration work is carried out.  
**Methods:** dead shores, raking shores, flying shores  
**Sequence:** strut existing windows, prop floors, locate/cut holes for needles, construct shoring/ensure tightening to support building, carry out alterations, bond to/securely support existing building, remove shoring

- 62.53 Describe the precautions to be taken when using timber and steel as shoring members.  
**Precautions:** problems of steel to steel, flexibility of materials, expansion/contraction during loading
- 62.54 Identify the circumstances which may require buildings or parts of buildings to be underpinned.  
**Circumstances:** differential settlement, work on new adjacent buildings, provision of basements, settlement due to loading not considered when existing building was designed (eg traffic, vibration)
- 62.55 Describe common methods of providing underpinning to existing buildings.  
**Methods:** traditional brick/stone sequenced steps, precast concrete stools, jacked piles from existing structure, diaphragm walls, pressure grouting
- 62.56 Explain why that in many circumstances where underpinning is required some means of shoring will also be required.
- 62.57 Describe the effects of alterations and modifications to the design of new buildings after construction work has begun.
- 62.58 Explain the terms 'useful life' of a building and 'change of use' of a building and describe the effect they may have on the building's value.

# Assessment

## Test specification for written paper Materials and Construction Technology 4 (6165-30-062)

This is a written paper lasting three hours with 10 questions.  
Candidates must answer **all** questions.

<b>Topic</b>	<b>Approximate % examination weighting</b>
Materials technology	50
Construction technology	50

# 62 Materials Technology 3

## Practical competences

The candidate must be able to do the following:

- 62.1 Predict the likely behaviour of materials in a given situation, based on chemical/biological and physical nature.
- 62.2 Identify the role of water in the degradation of building materials.
- 62.3 Identify the role of the sun in the degradation of building materials.
- 62.6 Select appropriate materials for a specific end use and environment and justify the choice.
- 62.5 Devise strategies for limiting performance failures due to the degradation of materials.

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature \_\_\_\_\_

Candidate name (please print) \_\_\_\_\_

Instructor signature \_\_\_\_\_

Instructor name (please print) \_\_\_\_\_

Completion date \_\_\_\_\_

# 62 Construction Technology 4

## Practical competences

The candidate must be able to do the following:

- |   |                          |   |                          |
|---|--------------------------|---|--------------------------|
| 62.14 Compare and recommend various types of construction for long span, low rise and multi-storey buildings.   | <input type="checkbox"/> | 62.18 Develop a safety, health and welfare policy for a specific site based on existing legislation to give consideration to site personnel, building user, general public and adjacent property during the construction of the building, to include the alteration, modification and demolition of adjacent buildings. | <input type="checkbox"/> |
| 62.15 Investigate and prepare a report on the considerations to be made during the design and construction of the various types of building specified in 62.14 above as a result of established legislation.  | <input type="checkbox"/> | 62.19 Develop economic design solutions for the various types of building specified in 62.14 above.   | <input type="checkbox"/> |
| 62.16 Produce sketches, including details of any reinforcement required, of the various foundations available for the types of buildings specified in 62.14 above giving consideration to the building load, building layout and the type/bearing capacity of the ground. | <input type="checkbox"/> | 62.20 Develop a logical approach to the sequence of operations for the various types of building specified in 62.14 above.  | <input type="checkbox"/> |
| 62.17 Investigate and prepare a report on the suitability and lifespan of a range of building materials for the various types of buildings specified in 62.14 above.  | <input type="checkbox"/> | 62.21 Illustrate, by means of annotated and dimensioned drawings/sketches, an understanding of the knowledge requirements of this unit.   | <input type="checkbox"/> |
|   |                          | 62.22 Prepare lists of materials, components and sequences of operations to illustrate an understanding of the knowledge requirements of this unit.   | <input type="checkbox"/> |
|   |                          | 62.23 Carry out a realistic site investigation of a specific site.  | <input type="checkbox"/> |

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature

Candidate name (please print)

Instructor signature

Instructor name (please print)

Completion date

# 63 Construction Management 4 and Law – Summary of syllabus sections

Page 30 **Construction Law**  
(Objectives 63.1 to 63.10)

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The aim of this unit is to

- a identify the legal system and framework within the country of study
- b introduce the concepts of civil and criminal law
- c outline the legal principles.

Notes:

- 1 This unit comprises only practical competences and is based on the legal system and framework within the country of study
- 2 This unit requires the candidate to have sufficient familiarity with the legislation applicable to the construction industry within the country of study in order to be able to comply with the requirements and minimise breaches of duty under common law.
- 3 A good standard of communication skills is required along with interpretation of events and their legal implications.

Page 31 **Construction Management 4**  
(Objectives 63.11 to 63.20)

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The aim of this unit is to

- a develop an awareness of management theory, including the roles and competences of management
- b consider the principles of personnel management and industrial relations applicable to the construction industry
- c identify all aspects of pre-construction procedures including the tender, pre-construction/construction planning, method study; method statements and programming taking into account safe practices, welfare and efficiency.

## Practical competences

The candidate must be able to do the following:

- 63.1 Comply with relevant legislation and common law philosophies within the construction industry role.  
**Role:** contract, employment, tort, purchase, supply
- 63.2 Ensure that subordinates are aware of their legal duties and responsibilities in 63.1 above.
- 63.3 Communicate effectively in order to avoid a breach of legal duties and responsibilities.  
**Communication:** verbal, written instructions, orders, contracts
- 63.4 Refer to relevant sources for information and advice on legal issues.  
**Sources:** regulations, codes of practice, professionals (legal, guidance)
- 63.5 Extract the legal principles which apply to a given scenario/case study and explain the legal implications of the sequence of events.
- 63.6 Carry out research and prepare a report on the legal system within the country of study.  
**Report:** description of legal system, differences between civil law/criminal law, examples of differences relevant to the construction industry, sources of law (case law, statute law)
- 63.7 Describe to a manager or lecturer the law of tort, and in particular negligence, and explain the relevance to the work of the construction industry within the country of study.
- 63.8 Prepare a list of the major statutes currently in force within the country of study and indicate their intentions and scope with regard to the construction industry.
- 63.9 Define what is meant by a legal contract and what are the rights and obligations of the various parties to a contract within the country of study.
- 63.10 Prepare a list of sources of information and advice on legal issues within the country of study.

# Construction Management 4

## Practical competences

The candidate must be able to do the following:

- 63.11 Recognise the structure and culture of a given organisation and how this influences the way in which the organisation performs in the market place.  
**Structure/culture:** role, task, matrix/power, organic/person, line responsibilities of the respective supporting structure  
**Performance:** market trends, company responses, product categories, performance analysis/ indicators, interface with the structure of the organisation
- 63.12 Identify a strategy to ensure the appropriate selection and deployment of personnel, taking into account performance requirements and including incentives for productivity.  
**Strategy:** recruitment/selection, manpower planning, staff turnover, general people policies  
**Performance requirements:** job descriptions, job specifications, job analysis, leadership  
**Incentives:** work measurement, bench marking, bonus schemes, promotion opportunities, worker involvement
- 63.13 Prepare simple method statements including temporary works, the choice of plant and site layout planning.  
**Method statement:** work measurement, work study, site organisation, presentation/recording systems, health, safety
- 63.14 Develop a programme of work for a small construction project.  
**Programme:** techniques (critical path analysis, precedence diagrams, line of balance, bar charts, resource levelling ), incorporate standard performance output data
- 63.17 Identify the role of personnel management/organisation including reference to workforce relations and productivity incentives.  
**Role:** recruitment, selection, training, staff development, industrial relations
- 63.18 Describe concepts of training and staff development within the construction industry and identify potential providers.  
**Training/staff development:** essential training (eg health, safety), career development training, role change training, re-location training, exit training  
**Training providers:** formal institutions, in-company training, professional bodies, private training organisations
- 63.19 Explain the principles of method statements, both descriptive and quantitative, applicable to specific tasks and projects.  
**Principles:** labour, plant/materials organisation, activity durations, bulk quantities, safety aspects, productivity issues, technology evaluation
- 63.20 Describe the various methods and applications of programming site activities taking into account the concept of logic, resource and real time.  
**Methods:** critical path analysis, precedence diagrams, line of balance, bar charts, resource levelling

## Knowledge requirements

The instructor must ensure the candidate is able to:

- 63.15 Describe various structures and cultures of organisations and explain how this influences the way in which the organisation performs in the market place.  
**Structure/culture:** role, task, matrix/power, organic/person, line responsibilities of the respective supporting structure  
**Performance:** market trends, company responses, product categories, performance analysis/ indicators, interface with the structure of the organisation
- 63.16 Describe management theories applicable to construction organisations and their operations on site.  
**Management theories:** behaviourist, scientific, motivation, leadership, satisfiers/dissatisfiers

# Assessment

## Test specification for written paper Construction Management 4 (6165-30-063)

This is a written paper lasting one and a half hours with 5 questions. Candidates must answer **all** questions.

<b>Topic</b>	<b>Approximate % examination weighting</b>
Construction Management	100

Note: There is no written paper for Construction Law 3  
(see notes on page 26 of this unit)

# 63 Construction Law

## Practical competences

The candidate must be able to do the following:

- 63.1 Comply with relevant legislation and common law philosophies within the construction industry role.
- 63.2 Ensure that subordinates are aware of legal duties and responsibilities in 63.1 above.
- 63.3 Communicate effectively in order to avoid a breach of legal duties and responsibilities.
- 63.4 Refer to relevant sources for information and advice on legal issues.
- 63.5 Extract the legal principles which apply to a given scenario/case study and explain the legal implications of the sequence of events.
- 63.6 Carry out research and prepare a report on the legal system within the country of study.
- 63.7 Describe to a manager or lecturer the law of tort, and in particular negligence, and explain the relevance to the work of the construction industry within the country of study.
- 63.8 Prepare a list of the major statutes currently in force within the country of study and indicate their intentions and scope with regard to the construction industry.
- 63.9 Define what is meant by a legal contract and what are the rights and obligations of the various parties to a contract within the country of study.
- 63.10 Prepare a list of sources of information and advice on legal issues within the country of study.

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature

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Candidate name (please print)

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Instructor signature

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Instructor name (please print)

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Completion date

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# 63 Construction Management 4

## Practical competences

The candidate must be able to do the following:

- 63.11 Recognise the structure and culture of a given organisation and how this influences the way in which the organisation performs in the market place.
- 63.12 Identify a strategy to ensure the appropriate selection and deployment of personnel, taking into account performance requirements and including incentives for productivity.
- 63.13 Prepare simple method statements including temporary works, the choice of plant and site layout planning.
- 63.14 Develop a programme of work for a small construction project.

This is to confirm that the candidate has successfully completed the above tasks:

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Candidate name (please print) \_\_\_\_\_

Instructor signature \_\_\_\_\_

Instructor name (please print) \_\_\_\_\_

Completion date \_\_\_\_\_

# Tendering, Estimating and Quantity Surveying 4 – Summary of syllabus sections

Page 36 **Tendering and Estimating 4**  
(Objectives 71.1 to 71.21)

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The aim of this unit is to develop the principles covered in Resources Management Level 2 (Unit 23), extending the knowledge to cover the functions of the estimator, buyer and senior management to submit a formal tender for small residential works.

Page 37 **Quantity Surveying 4**  
(Objectives 71.22 to 71.48)

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The aim of this unit is to enable the candidate to:

- a develop their skills in the preparation of Bills of Quantities for domestic, commercial and industrial buildings using traditional, non-traditional and computer aided techniques
- b establish, organise and manage a quantity surveying office.

# Tendering and Estimating 4

## Practical competences

The candidate must be able to do the following:

- 71.1 Prepare different methods of approximate costing of construction for use at the budget evaluation stage.
- 71.2 Undertake the measurement of a low rise building in accordance with local/national practices.  
**Local/national practices:** eg Standard Method of Measurement of Building Works, Civil Engineering Standard Method of Measurement
- 71.3 Prepare a sample overhead budget for a typical medium sized contractor.
- 71.4 Prepare an 'All-in' hourly rate for labour (craftsman, general building operative) based on locally agreed rates, to include all associated incidental costs.
- 71.5 Prepare an 'All-in' rate for materials for a variety of applications, including appropriate allowances for cutting waste, direct waste and indirect waste.
- 71.6 Prepare an 'All in' hourly rate for a typical item of plant for a builder or civil engineer.
- 71.7 Compile unit rates using first principles for a variety of building/civil engineering trade items, excluding overhead costs and profit.
- 71.8 Identify the various forms of contractual arrangements for tendering available within the country of study.  
**Contractual arrangements:** eg JCT80 and its variants (eg Local Authorities, Private Edition, With Quantities, Without Quantities, Small Works, New Engineering and Construction Contract, British Property Federation Contract, Management Contracting, Package Deal/Turnkey)

## Knowledge requirements

The instructor must ensure the candidate is able to:

- 71.9 Explain the difference between an estimate and a tender.
- 71.10 Detail the difference between open, selective and negotiated methods of tendering.
- 71.11 Describe the different contractual arrangements for letting contracts.  
**Arrangements:** lump sum, cost reimbursement, serial, term, design and build
- 71.12 Describe the procedure involved in the preparation of a tender by a contractor from the initial enquiry by the client to the formal submission of the tender bid.

- 71.13 Describe, with the aid of flow charts, the methodology of the tender process.  
**Flow charts:** bar charts, simple network  
**Process:** pre tender meeting, invitation to tender, estimating timetable, tender programme, site visit, abstracting of information, supplier/sub contract enquiries, analysis of quotations, tender summary, late amendments, adjudication meeting, tender submission, review of competitiveness relative to other bids
- 71.14 Describe the various sections of a typical Bill of Quantities.  
**Sections:** preliminaries, PC/provisional sums, preambles, trade sections, summary
- 71.15 Distinguish between a general overhead cost and a project overhead cost.
- 71.16 Describe the means and considerations involved when allocating overhead costs and profit to an estimate.
- 71.17 Describe the difference between general overhead and project overhead.  
**General overhead:** indirect cost involved with running the business  
**Site/Project overhead:** direct costs (setting up the site, administering the particular site requirements, preliminaries section of the Bill of Quantities)
- 71.18 Describe how the general overhead costs are determined.  
**Costs:** head office staff, cost of owning/renting the buildings, accountancy, legal, computer (hardware, software, maintenance), leasing/purchase costs of equipment, stationery, vehicle costs
- 71.19 Explain the different methods of calculating the approximate cost of a proposed new building.  
**Methods:** cost per functional unit, cost per floor area, elemental cost plan, approximate measure
- 71.20 Describe the items to be included within a net unit rate and a gross unit rate.
- 71.21 Explain the use of unit rates within the construction and civil engineering industry as a means of cost control.  
**Use:** re-measurement, valuations, variations, historical unit costing comparisons, approximate costing

# Quantity Surveying 4

## Practical competences

The candidate must be able to do the following:

- 71.22 Prepare and apply schedules.  
**Schedules:** eg reinforcement, services  
**Application:** assemble the appropriate data, complex schedules (design, prepare), use schedules as an aid to measurement
- 71.23 Using the appropriate Code of Measurement, measure excavations and fillings, from issued drawings and specifications.  
**Excavation and fillings:** undulating sites (contoured, gridded), cuttings/embankments (roads, railways)
- 71.24 Using the appropriate Code of Measurement, measure substructures, including Prime Cost items, from issued drawings and specifications.  
**Substructure:** basements, column/stanchion bases, retaining walls, underpinning
- 71.25 Using the appropriate Code of Measurement, measure superstructures, including Prime Cost items, from issued drawings and specifications.  
**Superstructure:** reinforced in-situ concrete (frames, floors), floors (precast concrete, timber), walls (precast concrete, brick, masonry), sheet cladding, concrete staircases (precast, in-situ), balustrading
- 71.26 Using the appropriate Code of Measurement, measure roofs, including Prime Cost items, from issued drawings and specifications.  
**Roofs:** timber construction with slate/tile (pitched, flat), sheeting (built-up felt), reinforced in-situ concrete flat roofs, above ground drainage
- 71.27 Using the appropriate Code of Measurement, measure windows and doors, including Prime Cost items, from issued drawings and specifications.  
**Windows/doors:** windows, external doors including semi-circular fanlights, internal doors, adjustments for openings
- 71.28 Using the appropriate Code of Measurement, measure joinery fittings, including Prime Cost items, from issued drawings and specifications.  
**Joinery fittings:** screens, kitchen fitments
- 71.29 Using the appropriate Code of Measurement, measure finishings, including Prime Cost items, from issued drawings and specifications.  
**Finishings:** internal/external walls (rendered, plastered, glazed tile), floors (timber, wood block, cork, PVC/ceramic tile), ceilings (rendered/plasterboard/plaster)
- 71.30 Using the appropriate Code of Measurement, measure decorations, including Prime Cost items, from issued drawings and specifications.  
**Decorations:** internal walls/ceilings (emulsion paint, paper), external walls (eg tyrolean, pebbledash)
- 71.31 Using the appropriate Code of Measurement, measure plumbing installations, including Prime Cost items, from issued drawings and specifications.  
**Plumbing installations:** sanitary appliances, hot/cold water installations, above ground drainage, connections, builders work (services, testing, commissioning)
- 71.32 Using the appropriate Code of Measurement, measure below ground drainage, including Prime Cost items, from issued drawings and specifications.  
**Below ground drainage:** inspection chambers, drain runs (main, branch, fittings), accessories, connection to sewers, testing, commissioning
- 71.33 Using the appropriate Code of Measurement, measure provisional quantities, including Prime Cost items, from issued drawings and specifications.  
**Provisional quantities:** foundations, below ground drainage
- 71.34 Prepare Bills of Quantities from data obtained from 71.23 – 71.33 above or from simulated measurements.  
**Preparation:** process measurements, prepare abstracts, write draft Bills of Quantities in the 'trade' format using traditional/non-traditional techniques, bill direct, write clauses (preliminary items, preamble), prepare general summary
- 71.35 Apply computer technology to the production of Bills of Quantities.
- 71.36 Use computer libraries to obtain standard descriptions for use in Bills of Quantities.
- 71.37 Use electronic measurement and AutoCAD techniques in the measurement process.
- 71.38 Produce a method statement to establish, organise and supervise an office for a medium-sized quantity surveying practice or contractor's quantity surveying department.  
**Establish:** select (accommodation, staff, furnishings, equipment)  
**Organise/supervise:** production of documents, ordering/management (consumable stock, computer software), letter writing, correspondence (dispatch, filing), preservation of documents, library (reference books, trade literature, professional journals), reproduction of documents, staff (time records, salaries), application (statutory acts, insurance requirements)

## Knowledge requirements

The instructor must ensure the candidate is able to:

- 71.39 Interpret drawings for complex structures, including industrial and commercial buildings, services and access roads.
- 71.40 Identify components of a building from drawings and specifications for the purpose of their measurement.
- 71.41 Describe alternative formats for Bills of Quantities and their uses.  
**Formats:** elemental, operational, annotated
- 71.42 Describe the use of standard terminology in the measurement process.
- 71.43 Describe the method for extracting and recording dimensions from scale drawings on to dimension paper and writing appropriate dimensions in abbreviated form.
- 71.44 Describe the function of the Code of Measurement.  
**Code of Measurement:** appropriate to the country of study
- 71.45 Interpret specifications, preamble and preliminary clauses.
- 71.46 Describe the use of schedules as an aid to measurement.
- 71.47 Describe the role of an independent and a contractor's quantity surveyor.
- 71.48 Describe office procedures.  
**Procedures:** production of documents, ordering/management (consumable stock, computer software), letter writing, correspondence (despatch, filing), preservation of documents, library (reference books, trade literature, professional journals), reproduction of documents, staff (time records, salaries), apply (statutory acts, insurance requirements)

# Assessment

## **Test specification for written paper Tendering, Estimating and Quantity Surveying 4 (6165-30-071)**

This is a written paper lasting three hours with 10 questions.  
Candidates must answer **all** questions.

<b>Topic</b>	<b>Approximate % examination weighting</b>
Tendering and estimating 4	50
Quantity surveying practice 4	50

# 71 Tendering and Estimating 4

## Practical competences

The candidate must be able to do the following:

- 71.1 Prepare different methods of approximate costing of construction for use at the budget evaluation stage.
- 71.2 Undertake the measurement of a low rise building in accordance with local/national practices.
- 71.3 Prepare a sample overhead budget for a typical medium sized contractor.
- 71.4 Prepare an 'All-in' hourly rate for labour (craftsman, general building operative) based on locally agreed rates, to include all incidental costs.
- 71.5 Prepare an 'All-in' rate for materials for a variety of applications, including appropriate allowances for cutting waste, direct waste and indirect waste.
- 71.6 Prepare an 'All in' hourly rate for a typical item of plant for a builder or civil engineer.
- 71.7 Compile unit rates using first principles for a variety of building/civil engineering trade items, excluding overhead costs and profit.
- 71.8 Identify the various forms of contractual arrangements for tendering available within the country of study.

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature \_\_\_\_\_

Candidate name (please print) \_\_\_\_\_

Instructor signature \_\_\_\_\_

Instructor name (please print) \_\_\_\_\_

Completion date \_\_\_\_\_

# 71 Quantity Surveying 4

## Practical competences

The candidate must be able to do the following:

- |       |   |                          |       |   |                          |
|-------|---|--------------------------|-------|---|--------------------------|
| 71.22 | Prepare and apply schedules.  | <input type="checkbox"/> | 71.32 | Using the appropriate Code of Measurement, measure below ground drainage, including Prime Cost items, from issued drawings and specifications.                          | <input type="checkbox"/> |
| 71.23 | Using the appropriate Code of Measurement, measure excavations and fillings, including Prime Cost items, from issued drawings and specifications. | <input type="checkbox"/> | 71.33 | Using the appropriate Code of Measurement, measure provisional quantities, including Prime Cost items, from issued drawings and specifications.                         | <input type="checkbox"/> |
| 71.24 | Using the appropriate Code of Measurement, measure substructures, including Prime Cost items, from issued drawings and specifications.            | <input type="checkbox"/> | 71.34 | Prepare Bills of Quantities from data obtained from 71.23 –71.33 above or from simulated measurements.  | <input type="checkbox"/> |
| 71.25 | Using the appropriate Code of Measurement, measure superstructures, including Prime Cost items, from issued drawings and specifications.          | <input type="checkbox"/> | 71.35 | Apply computer technology to the production of Bills of Quantities.   | <input type="checkbox"/> |
| 71.26 | Using the appropriate Code of Measurement, measure roofs, including Prime Cost items, from issued drawings and specifications.                    | <input type="checkbox"/> | 71.36 | Use computer libraries to obtain standard descriptions for use in Bills of Quantities.  | <input type="checkbox"/> |
| 71.27 | Using the appropriate Code of Measurement, measure windows and doors, including Prime Cost items, from issued drawings and specifications.        | <input type="checkbox"/> | 71.37 | Use electronic measurement and AutoCAD techniques in the measurement process.   | <input type="checkbox"/> |
| 71.28 | Using the appropriate Code of Measurement, measure joinery fittings, including Prime Cost items, from issued drawings and specifications.         | <input type="checkbox"/> | 71.38 | Produce a method statement to establish, organise and supervise an office for a medium-sized quantity surveying practice or contractor's quantity surveying department. | <input type="checkbox"/> |
| 71.29 | Using the appropriate Code of Measurement, measure finishings, including Prime Cost items, from issued drawings and specifications.               | <input type="checkbox"/> |       |   |                          |
| 71.30 | Using the appropriate Code of Measurement, measure decorations, including Prime Cost items, from issued drawings and specifications.              | <input type="checkbox"/> |       |   |                          |
| 71.31 | Using the appropriate Code of Measurement, measure plumbing installations, including Prime Cost items, from issued drawings and specifications.   | <input type="checkbox"/> |       |   |                          |

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature

Candidate name (please print)

Instructor signature

Instructor name (please print)

Completion date

# 72 Building Services, Science and Technology 4 – Summary of syllabus sections

Page 43 **Building Services Science 4**  
(Objectives 72.1 to 72.97)

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The aim of this unit is to enable the candidate to understand and apply the theories and principles of various systems into the framework of building design, construction and services across domestic, industrial and commercial projects.

Systems

- a water sources, storage, treatment and distribution (to, within and external to the building)
- b sound generation and acoustic performance within a building
- c levels of artificial lighting to match usage and/or occupancy of a building, relevant to geographical location
- d heating and air conditioning requirements and design.

Page 49 **Building Services Technology 4**  
(Objectives 72.97 to 72.126)

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The aim of this unit is to:

- a further develop the knowledge requirements of diploma level (Building Services 3) particularly in the areas of heating, air conditioning and electrical/electronic services and
- b allow development of the co-ordination requirements at design project planning, installation and commissioning of services installations.

## Practical competences

The candidate must be able to do the following:

### Water systems

- 72.1 Carry out a field survey to identify sources of water supply.  
**Sources:** hydrologic (ground water, streams, atmospheric moisture, transpiration from plants) artificial (waste water, processing, reservoirs, desalination)
- 72.2 Carry out tests on water samples.  
**Tests:** taste, odour, colour, turbidity, pH, hardness, total coliform count, conductivity, corrosion, gas solubility
- 72.3 Research and prepare a report on the factors that influence the quality of untreated water supplies within the local or national region.  
**Factors:** eg wastes (industrial, agricultural, domestic), atmospheric pollution, inorganic solids, organic matter (natural, waste), dissolved minerals, eutrophication
- 72.4 Research and prepare a report on water treatment methods and waste collection systems in the country of study.  
**Treatment methods:** eg flocculation, sedimentation, filtration, chlorination, turbidity, bactericides  
**Collection systems:** eg sewers (storm, sanitary), septic tanks, motorised biological treatment
- 72.5 Draw a driven rain index map for the region/country of study, showing exposure gradings.  
**Exposure gradings:** severe, moderate, sheltered
- 72.6 Research those aspects of building design that are influenced by precipitation or a high humidity environment.  
**Aspects:** eg rainwater run off, absorption of moisture, capillary forces, moisture migration, dimensional change in absorbent components, condensation, exposure grading
- 72.7 Draw a diagram to show how a mains water distribution system is piped to users from a service reservoir.  
**Distribution system:** eg trunk mains (two to serve a given region or area), secondary/ring mains, branch/building service mains, arrangement of service pipes (termination, accessories, associated control equipment)
- 72.8 Carry out calculations related to stored water systems for a range of buildings.  
**Systems:** domestic dwellings to three storeys, buildings up to 10 storeys (pumped with low level break tank /high level header, pneumatic), buildings of 15 storeys or more (separate drinking/general water systems with intermediate break tank)
- 72.9 Calculate flow rates at sanitary fittings for given applications.  
**Applications:** eg individual dwellings (no diversity), all fittings of the same type in large buildings, distribution method (binomial, Poisson)
- 72.10 Calculate pipe sizes for different systems.  
**Systems:** cold water, hot water heating, fire fighting (hose reel, dry risers, wet risers, foam installations, automatic sprinklers, deluge/drencher systems)
- 72.11 Carry out calculations related to pressurised supply systems, open channels and ground water drainage.  
**Calculations:** head loss/flow rate (Hazen Williams, Manning formula, equation for venturi meter, formula for Parshall flume, formula for 90° V notch weir)
- 72.12 Measure the pressure of water in a pressurised system.  
**Measurement:** eg piezometer, manometer pressure gauge
- 72.13 Carry out calculations related to open and closed sewer pipe systems.  
**Calculations:** sizing of storm sewers relative to sanitary sewage piped systems for a given population, imposed loads on buried pipes, gradients to maintain self cleaning velocities.
- 72.14 Measure the flow rate of waste water in an open channel using a Parshall flume.

### Sound

- 72.15 Draw waveforms to illustrate the nature and propagation of sound waves through various mediums.  
**Mediums:** liquids, gases, solids
- 72.16 Use sound wave diagrams to indicate the properties of sound.  
**Properties:** frequency, wavelength, amplitude, velocity
- 72.17 Use a sound meter to measure the levels and intensity of sound.  
**Measurement:** intensity, loudness, threshold levels, pressure level, power level
- 72.18 Conduct an experiment to determine the velocity of sound using a resonance tube.
- 72.19 Conduct an experiment to determine the velocity of sound in and the modulus of brass using Kundt's tube.
- 72.20 Conduct experiments to determine Young's modulus of elasticity for concrete.  
**Experiments:** electro-dynamics method, ultrasonic pulse velocity apparatus

72.21 Use a sound level meter to measure sound pressure levels and sound levels.

72.22 Measure L10 levels of traffic noise using a sound level meter.

72.23 Conduct an experiment to determine the way in which loudness varies with frequency.

72.24 Conduct an experiment to measure the airborne sound insulation of a partition.

72.25 Conduct an experiment to measure the impact sound insulation of a floor.

### Artificial lighting

72.26 Produce diagrams to show the relationship between the units of illumination.

**Units:** steradian, lux, candela, illuminance, luminance

72.27 Carry out calculations involving different lighting laws and methods.

**Laws:** inverse square, cosine

**Methods:** use of indirect component of illuminance, lumen design, space/height ratio, published data (limiting glare index, efficacies of lamps, luminance classification), polar curves, room index

72.28 Produce diagrams to show the relationship between various illuminance factors due to daylight and permanent supplementary artificial lighting in a room or office.

**Factors:** supplementary light fitting (luminaire), total horizontal illuminance, illuminance due to light fitting, illuminance due to daylight

72.29 Conduct a survey to establish the luminous values of surfaces within a room.

**Survey:** using a Hag meter or similar

72.30 Conduct an experiment to plot a polar curve using a model lamp fitting.

72.31 Produce diagrams to show the relationship between wavelength, colour and the human eye.

**Diagrams:** electromagnetic spectrum, visible wavelength, colour bands, eye sensitivity

72.32 Carry out calculations to establish the glare index for a lighting scheme.

**Calculations:** use of discomfort glare, disability glare, glare index (published data)

### Heating and air conditioning requirements and design

72.33 Calculate 'whole body' comfort checks as a design requirement using the 'Resultant temperature' method.

**Method:** check comfort at centre of room, check comfort at other room locations

72.34 Calculate 'whole body' comfort checks as a design requirement using the 'Fanger's Criteria' method.

**Method:** check comfort at centre of room, check comfort at other room locations

72.35 Calculate heat losses through different building components.

**Components:** roof (flat, pitched with ceiling void), solid ground floor, walls, windows, doors, ventilators

72.36 Calculate heat emission from installed systems and building components.

**Systems:** bare pipes, insulated pipes, radiators, convectors, radiant strip heaters, high temperature radiant panels, forced convectors (fan assisted)

**Components:** ceilings (embedded, suspended ceiling void), embedded in floors/walls

72.37 Draw heating circuit diagrams for different systems.

**Systems:** natural convection, natural circulation, domestic systems (one pipe, two pipe, small bore, microbore), large buildings (pumped, mixer valves, reversed return, pressurised), group/district distribution systems (central boiler), ducted air, recirculation of heated air from installed luminaries

72.38 Use manufacturers' published data to quantify and cost materials and equipment for a proposed heating scheme within a chosen building.

**Published data:** manufacturers' catalogues, scale drawings, specification, bill of quantities

### Air Conditioning

72.39 Calculate, using published data, the cooling load for a single zone system in an area of less than 300m<sup>2</sup>, in order to provide 'comfort conditioning' within a building located in the region/area of study.

**Cooling load:** factors (size, location, occupancy, usage, ventilation of building, formula for sensible heat ratio)

72.40 Carry out calculations in designing an air conditioning system for a given application.

**Application:** eg private office, small shop sited at the corner of a building, small restaurant

## Knowledge requirements

The instructor must ensure that the candidate is able to:

### Water systems

72.41 Explain how a water source is part of either the hydrologic or artificial water cycle.

**Water source:** hydrologic (precipitation, ground water, streams, transpiration from plants), artificial (waste water, processing, reservoirs, desalination)

- 72.42 Identify the source of water for the country, region or area of study.  
**Source:** hydrologic, artificial
- 72.43 Describe, with the aid of schematic diagrams, various methods of conducting the bacteriological test of potable water.  
**Schematic diagrams:** complete test for coliform group  
**Tests:** dechlorination, fermentation, gas detector, bacterial growth, Gram-stains precautions (avoid contamination when collecting samples, protective clothing)
- 72.44 Describe the factors that can influence the quality of untreated water supplies.  
**Factors:** wastes (industrial, agricultural, domestic), atmospheric pollution, inorganic solids, organic matter (natural, waste), dissolved minerals, eutrophication
- 72.45 Identify water borne diseases that affect humans.  
**Diseases:** typhoid, cholera, salmonella, legionella, dysentery
- 72.46 Explain, by means of a case study from the country, region or area of study, how disease may be passed to humans through contact with, or consumption of, contaminated water.  
**Contamination:** bacteria, viruses, protozoa, parasitic worms
- 72.47 Describe, with the aid of diagrams, the stages of treatment within a waste water processing plant.  
**Stages:** screening, pumping, flow measurement, grit removal, chemical coagulation, chlorination, sedimentation, clarifiers, biological filtration
- 72.48 Identify the characteristics of flow analysis and apply related theorems.  
**Characteristics:** compressibility, viscosity, vapourisation  
**Theorems:** bulk modulus, coefficient of viscosity, kinematic viscosity, Reynold's number, laminar flow, turbulent flow, Euler equations, Bernoulli equations, Darcy equations
- 72.49 Identify the factors that contribute to losses in a plant pipework system.  
**Factors:** head loss, slope of hydraulic gradient, coefficient of pipe friction, lengths of pipework, valves, fittings
- 72.50 Explain, by means of a case study for a building in the country, region or area of study, the environmental factors that influence the location and structural design of a building.  
**Factors:** rainfall, wind pressure, humidity, solar radiation, thunderstorms
- 72.51 Describe the factors that influence the location and design of a mains water distribution system.  
**Factors:** water source, topography, consumers (industrial, agricultural, domestic), aesthetics
- 72.52 Describe, with the aid of diagrams, the methods of measuring water pressure.  
**Methods:** piezometer, manometer, pressure gauge
- 72.53 Describe, with the aid of a diagram, how the flow of water in an open channel may be measured.  
**Diagram:** Parshall flume
- 72.54 Describe, with the aid of a diagram, how a venturi type meter in conjunction with a sensor, transmitter and flow recorder, would be connected into a water pipeline.  
**Diagram:** meter, sensor, recorder connections, pipeline
- 72.55 Describe, with the aid of sketches, the different designs of stored water systems for given buildings.  
**Systems:** domestic dwelling (3 storey maximum), building up to 10 storey (pumped, break tank, header tank, pneumatic), buildings above 15 storeys (separate drinking water/general water systems, intermediate break tanks)
- 72.56 Describe methods of calculating flow rates at sanitary fittings for given applications.  
**Applications:** individual dwellings (no diversity), large buildings (all fittings of same type)
- 72.57 Describe the methods of calculating pipe sizes for different systems.  
**Piped systems:** cold water, hot water, heating, fire fighting (hose reel, dry risers, wet risers, foam installations, automatic sprinklers, deluge/drencher), open channels, ground water drainage
- 72.58 Describe the method of carrying out calculations relating to open and closed sewer pipe systems.  
**Calculations:** sizing of storm sewers relative to sanitary sewage pipe systems for a given population, imposed loads on buried pipes, gradients to maintain self cleaning velocities
- Sound**
- 72.59 Explain the characteristics of sound waves.  
**Characteristics:** velocity, pitch, frequency, wave length, intensity, pressure, loudness, temperature, medium, reflection, refraction, diffraction, interference
- 72.60 List the requirements for good room acoustics.  
**Requirements:** adequate amount of sound to all parts/areas, even distribution of the sound, adequate insulation against outside noise, rate of decay of sound (reverberation time), should be the optimum for the required use of the room, avoidance of long delay echo

- 72.61 Describe, with the aid of sketches, various methods of absorbing sound.  
**Method:** materials (fibrous, membrane), construction (cavity resonators)
- 72.62 Compare the absorption coefficients of different building materials.  
**Materials:** plaster board on joists or studding, suspended ceiling (gypsum or fibrous) with large air space above, wood boards on joists or battens, wood-wool slabs solidly mounted
- 72.63 State the factors, which influence noise measurements.  
**Factors:** background noise, wind created velocity gradients, temperature created velocity gradients
- 72.64 Explain how sound may be transmitted in a building by different methods.  
**Methods:** airborne, impact
- 72.65 Explain the various methods for achieving sound insulation in a building.  
**Methods:** airborne (mass of structure, completeness, multiple/discontinuous construction, double/triple glazing), impact (floating floors, suspended ceilings, resilient mountings, insulation in floors, partitions)
- 72.66 Describe the method of calculating sound levels.  
**Calculations:** using (sound power level, sound pressure level), addition of sound levels, sound level for sources having different sound power levels, weighting scales
- 72.67 Describe the method of calculating the level of absorption within a given room/hall.  
**Calculations:** use of absorption characteristics for different materials, use of manufacturers'/published absorption coefficients
- 72.68 Describe the method of calculating reverberation time within a given room/hall.  
**Calculations:** Sabine's formula, Stevens and Bates formula, room/hall (volume, shape, use), published acoustical data for known types of room/hall
- 72.69 Describe the method of calculating the sound reduction for a given building component.  
**Calculations:** use of sound transmission index, published sound reduction indices for different structural components, 3rd octave band centre frequency
- Artificial lighting**
- 72.70 Describe, with the aid of diagrams, the relationship between the units of illumination.  
**Units:** steradian, lux, candela, illuminance, luminance
- 72.71 Describe the method of calculating the required number and arrangement of various luminaries to provide a level of illumination that meets national or regional standards for a given room or external area.  
**Calculation:** lumen design method, space-height ratio, published data/glare index, room index, luminaire classification, efficiency of lamps chosen.
- 72.72 Explain, with the aid of a diagram, how the design of an internal lighting scheme is affected by the geographical location and climatic conditions relative to the building concerned.  
**Design criteria:** daylight, solar radiation, sky (clear, overcast), internal/external reflected components, influence of windows (size, shape, position, quantity)
- 72.73 List the factors involved in determining the 'daylight factor'.  
**Factors:** geographical location of building, data (uniform overcast sky, standard overcast sky), internal illuminance, external illuminance, sky component, externally reflected component, internally reflected component
- 72.74 Explain the use of daylight protractors as a design tool.  
**Use:** establish sky component in relation to (angular size of windows, angle of incident light to the working plane, angle of elevation of the patch of sky visible from a point on the working plane)
- 72.75 Explain how the action of the human eye discerns light and colour.  
**Action of the eye:** light/image focussed through lens to retina, cones/rod sensors send signal to brain  
**Light:** Definition (that part of the electromagnetic spectrum between ultra-violet and infra red radiation)  
**Colour:** visible light as a mix of wavelengths between 370nm (violet) to 700nm (red)
- 72.76 Describe the causes of visual fatigue within the working environment.  
**Causes:** visual activity, workpiece/task too small, contrast of workpiece/task too low, visual task moves, surface texture, pattern of task, level of illuminance, glare, reflection, colour rendering of light sources
- 72.77 List the factors within a working environment that may contribute visual fatigue.  
**Factors:** inadequate illuminance, too great a contrast between task/background, discomfort/disability glare, flicker from fluorescent lamps, psychological satisfaction of an individual within the working environment
- 72.78 Describe the need to control glare when designing a lighting scheme.  
**Glare:** components (discomfort, disability, sky glare, indirect/reflected glare), use of published data (glare index values)

## Heating and air conditioning requirements and design

- 72.79 Compare human body physiology with those environmental variables, which influence body heat balance.  
**Physiology:** levels of activity (sleep, rest, work, recreation), energy transfer (convection, radiation, evaporation)  
**Environmental variables:** air (temperature, velocity, humidity), mean radiant temperature
- 72.80 Explain the need to relate workplace activity to the workplace environment.  
**Activity:** internal heat production (sleeping, seated at rest, light bench work, moderate work, heavy work, intermittent/sustained)  
**Environment:** variables (air temperature, velocity, mean radiant temperature)
- 72.81 Describe the methods of carrying out calculations for 'whole body comfort checks'.  
**Methods:** use of published data, Fanger's comfort criteria, personal variables, environmental variables
- 72.82 List the parameters for 'Fanger's Comfort Criteria'.  
**Parameters:** personal variables (metabolic rate at activity level, thermal resistance of clothing), environmental variables (air dry bulb temperature, mean radiant temperature, air velocity, humidity)
- 72.83 Explain how published data are used when calculating thermal transmission losses for a building (whole or part).  
**Thermal losses:** published data (roofs, floors, walls, doors, windows, ventilation, types of structure, location, climate)
- 72.84 Explain the methods of calculating heat emission from installed systems and building components.  
**Installed systems:** pipework, radiators, convectors, radiant strip heaters, high temperature radiant panels, forced convectors, ducted air  
**Building components:** installed in ceilings (embedded, in suspended ceiling voids), embedded in floors/walls
- 72.85 Describe, with the aid of diagrams, methods of reducing thermal transmission losses through a building's structural components.  
**Methods:** foil backed (boards, felt), composite board, cavity structure/infill (air, foam, mineral fibre, vermiculite, glass wool/fibre), double/triple glazing, suspended ceilings
- 72.86 List methods of reducing thermal transmission through internal walls.  
**Methods:** aluminium backed plasterboard fixed to treated timber battens, plasterboard fixed to treated timber battens with insulation filling the cavity, composite board of plasterboard laminated to an insulant fixed to the wall with an adhesive
- 72.87 List methods of reducing thermal transmission through external walls.  
**Methods:** cavity (air, foam, blown mineral fibre, expanded polystyrene bead, sheet of water-repellant insulant laminated to fixing with a waterproof render)
- 72.88 List methods of reducing thermal transmission through roof voids.  
**Methods:** bitumastic felt with aluminium foil, loose fill insulation, glass fibre blanket
- 72.89 List methods of reducing thermal transmission through windows.  
**Methods:** double glazing, triple glazing, special glass
- 72.90 List methods of reducing thermal transmission through floors.  
**Methods:** concrete floors (thermal insulation boards between waterproof membrane/floor screed), perimeter insulation, timber floors (glass wool infill/plugging, fibre glass quilting to form further void)
- 72.91 Describe different heating systems for domestic premises and large buildings.  
**Domestic:** one pipe, two pipe, small bore, microbore, ducted air  
**Large buildings:** pumped, mixer valves, reversed return, pressurised, recirculation of air heated by installed equipment (eg luminaires), group/district distribution from central boiler house
- 72.92 Describe in detail the parameters for costing a heating project.  
**Parameters:** quantity preferential discounts (equipment, materials), delivery charges (air, sea, road), labour rates for different grades of staff, transport, plant, subsistence, accommodation, overheads, insurance, profit

## Air conditioning

- 72.93 List the information required prior to selecting a single zone packaged air conditioning unit for installation.  
**Information:** design loads (heating, cooling) with cooling loads (sensible heat, latent heat), design temperature conditions (external, internal), condition of air entering the unit (where outside air is mixed with room air), projected extreme operating conditions, location of plant, any special considerations (filtration, corrosive atmosphere, flammable atmosphere), acceptable noise levels (external, internal)
- 72.94 List the various types of single zone packaged air conditioning systems.  
**Types:** window, console, roof, ceiling void, high side wall mounted, wall mounted condensing unit, cassette unit
- 72.95 Describe, with the aid of a diagram, one type of single zone packaged air conditioning unit.  
**Types:** window, console, roof, ceiling void, high side wall mounted, wall mounted condensing unit, cassette unit

72.96 Describe the method of calculating the size of ducts for a given air conditioning system.

**Requirements:** published data (duct sizing charts), application (residential, commercial, industrial), layout, diffusers (number, type, size, air volume), index circuit of system, lengths of ducts, bends, intersections

72.97 Describe the method for designing an air conditioning system for a given application.

**Application:** domestic premises, private office, small shop sited at the corner of a building, small restaurant, commercial garage, engineering workshop

# Building Services Technology 4

## Practical competences

The candidate must be able to do the following:

- 72.98 Investigate the relationship between the design and function of building services installations.
- 72.99 Investigate and prepare a report on the main design considerations for building services installations to meet the needs of established laws, regulations and standards in the country of study.
- 72.100 Prepare a report on the uses and limitations of a range of building services installations giving consideration to maintenance costs and cost-in-use.
- 72.101 Produce an overall programme to show the stages at which consideration must be given to the influence of building services on other building components and finishes.
- 72.102 Produce a flow chart with a systematic and logical approach to the sequence of operations of installations throughout the construction of a building.
- 72.103 Illustrate, by means of annotated and dimensioned drawings and sketches, an understanding of the knowledge requirements of the unit.
- 72.104 Prepare lists of materials, components and sequences of operations illustrating an understanding of the unit.
- 72.105 Develop a safety, health and welfare policy for a specific site based on existing legislation to give consideration to installation and other site personnel, building user, general public and adjacent property for building services installations during construction and after commissioning of the building.

## Knowledge requirements

The instructor must ensure the candidate is able to:

### Ventilating and air conditioning

- 72.106 Describe the factors to be considered when designing ventilating and air conditioning systems.  
**Factors:** size of building, internal requirements (temperature, humidity), external range (temperature, humidity), control requirements (overall, localised), thermal insulation of building structure, air cleanliness (input points, extract points), number of occupants

- 72.107 Examine the types of systems generally available for ventilating and air conditioning.  
**Types:** single zone systems with 100% fresh air, single zone systems with recirculation, multiple zone systems, terminal re-heat systems, dual duct and hot deck/cold deck systems, induction/fan coil systems, variable air volume systems
- 72.108 List the problems likely to be encountered with ductwork in ventilating and air conditioning installations.  
**Problems:** insulation, leakage, noise, vibration, sound attenuation
- 72.109 Describe the considerations for the zoning of buildings to meet functional requirements.  
**Considerations:** size of zone, maintenance of zones, location (grills, diffusers, sensors, controls), thermal response of types of structure, energy management
- 72.110 Explain the need for effective maintenance and access to plant equipment.  
**Maintenance:** repair (electrical, mechanical), changing air filters, air cleaning pads, planned maintenance, preventative maintenance

### Space heating

- 72.111 Compare heating systems for more complex and multi storey buildings.  
**Compare:** range of energy sources, distribution systems, flexibility in use, costs, requirements (location, space), fuel (storage, handling)
- 72.112 Describe the feasibility and cost implications of heating systems for various types of site.  
**Sites:** total, group, district
- 72.113 Describe alternative energy sources which are currently being explored and adopted.  
**Sources:** generators (heat, power), heat recovery systems, solar power, geothermal energy, wind generators
- 72.114 Describe the economic relationship between improved thermal insulation and building performance in terms of heating installations.  
**Economic relationship:** energy (cost, quantity), source required, reduced size (plant, ducting, pipe size), less emission to atmosphere, less environmental pollution

### Electrical/electronics

- 72.115 Describe the likely requirements for the provision of electrical supplies to more complex buildings in relation to existing regulations.  
**Requirements:** on site substations, tapped systems (cable, busbar), rising main systems, conduit, tray, trunking, distribution boards, switchgear, protective enclosures

- 72.116 List and describe locations where extra low voltage and/or special provision may be needed.  
**Locations:** car parks, plant rooms, fuel stores, hospital operating theatres, pathology laboratories, experimental laboratories
- 72.117 Describe the likely requirements for various systems.  
**Systems:** fire (detection, alarm), emergency lighting, security  
**Requirements:** fire resistant, independent of main installation, vandal proof, tamper proof, location, accessibility, audibility of alarms, location of emergency lighting
- 72.118 Describe the considerations when designing electronic control and energy management systems in relationship to the basic electrical/electronic installations in a building.  
**Considerations:** compatibility with basic supply, independence from basic supply, other electrical services, cable systems, outlet provision, floor systems (modular, integrated)
- 72.119 Explain the requirements for protecting electrical and electronic supplies from lightning.  
**Requirements:** lightning risk index, terminal devices, zones of protection, down conductors, earth terminators
- 72.120 Describe the likely requirements and functions of mechanical transportation systems.  
**Requirements/functions:** lift installations (planning, zoning), round trip time, number of lifts, waiting intervals, escalators (speed of operation)
- 72.121 List the design and installation requirements for the mechanical transportation systems related to goods, documentation and catering lifts.
- 72.125 Describe the management processes during which the services installation expert must be involved.  
**Processes:** planning (long term, short term), sequencing of installation into ducts/spaces, access (testing, commissioning, maintenance), techniques (handling, installation), components (delivery, storage)
- 72.126 Explain the need for handover documentation and training for the client's employees after commissioning and before taking over the running/maintenance of the plant.

#### Co-ordination

- 72.122 Describe the processes which allow co-ordination of building services at all stages of the building and occupation cycle.  
**Processes:** integrated design team, client, liaison (designer, main contractor), sub-contractor relationships
- 72.123 Detail the considerations relating to the space and loading requirements of service installations during design and construction stages.
- 72.124 Explain the need for fully co-ordinated drawings and details at all stages of the construction process.

# Assessment

## **Test specification for written paper Building Services, Science and Technology (6165-30-072)**

This is a written paper lasting three hours with 10 questions.  
Candidates must answer **all** questions.

<b>Topic</b>	<b>Approximate % examination weighting</b>
Building services science 4	50
Building services technology 4	50

## Practical competences

The candidate must be able to do the following:

### Water systems

- 72.1 Carry out a field survey to identify sources of water supply.
- 72.2 Carry out tests on water samples.
- 72.3 Research and prepare a report on the factors that influence the quality of untreated water supplies within the local or national region.
- 72.4 Research and prepare a report on water treatment methods and waste collection systems in the country of study.
- 72.5 Draw a driven rain index map for the region/country of study, showing exposure gradings.
- 72.6 Research those aspects of building design that are influenced by precipitation or a high humidity environment.
- 72.7 Draw a diagram to show how a mains water distribution system is piped to users from a service reservoir.
- 72.8 Carry out calculations related to stored water systems for a range of buildings.
- 72.9 Calculate flow rates at sanitary fittings for given applications.
- 72.10 Calculate pipe sizes for different systems.
- 72.11 Carry out calculations related to pressurised supply systems, open channels and ground water drainage.
- 72.12 Measure the pressure of water in a pressurised system.

72.13 Carry out calculations related to open and closed pipe systems.

72.14 Measure the flow rate of waste water in an open channel using a Parshall flume.

### Sound

- 72.15 Draw waveforms to illustrate the nature and propagation of sound waves through various mediums.
  - 72.16 Use sound wave diagrams to indicate the properties of sound.
  - 72.17 Use a sound meter to measure the levels and intensity of sound.
  - 72.18 Conduct an experiment to determine the velocity of sound using a resonance tube.
  - 72.19 Conduct an experiment to determine the velocity of sound in and the modulus of brass using Kundt's tube.
  - 72.20 Conduct experiments to determine Young's modulus of elasticity for concrete.
  - 72.21 Use a sound level meter to measure sound pressure levels and sound levels.
  - 72.22 Measure L10 levels of traffic noise using a sound level meter.
  - 72.23 Conduct an experiment to determine the way in which loudness varies with frequency.
  - 72.24 Conduct an experiment to measure the airborne sound insulation of a partition.
  - 72.25 Conduct an experiment to measure the impact sound insulation of a floor.
- Artificial lighting**
- 72.26 Produce diagrams to show the relationship between the units of illumination.

This is to confirm that the candidate has successfully completed the above tasks:

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- 72.27 Carry out calculations involving different lighting laws and methods
- 72.28 Produce diagrams to show the relationship between various illuminance factors due to daylight and permanent supplementary artificial lighting in a room or office.
- 72.29 Conduct a survey to establish the luminous values of surfaces within a room.
- 72.30 Conduct an experiment to plot a polar curve using a model lamp fitting.
- 72.31 Produce diagrams to show the relationship between wavelength, colour and the human eye.
- 72.32 Carry out calculations to establish the glare index for a lighting scheme.

**Heating and air conditioning requirements and design**

- 72.33 Calculate 'whole body' comfort checks as a design requirement using the 'Resultant temperature' method.
- 72.34 Calculate 'whole body' comfort checks as a design requirement using the 'Fanger's Criteria' method.
- 72.35 Calculate heat losses through different building components.
- 72.36 Calculate heat emission from installed systems and building components.
- 72.37 Draw heating circuit diagrams for different systems.
- 72.38 Use manufacturers' published data to quantify and cost materials and equipment for a proposed heating scheme within a chosen building.

**Air conditioning**

- 72.39 Calculate, using published data, the cooling load for a single zone system in an area of less than 300m<sup>2</sup>, in order to provide 'comfort conditioning' within a building located in the region/area of study.
- 72.40 Carry out calculations in designing an air conditioning system for a given application.

This is to confirm that the candidate has successfully completed the above tasks:

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# 72 Building Services Technology 4

## Practical competences

The candidate must be able to do the following:

- 72.98 Investigate the relationship between the design and function of building services installations.
- 72.99 Investigate and prepare a report on the main design considerations for building services installations to meet the needs of established laws, regulations and standards in the country of study.
- 72.100 Prepare a report on the uses and limitations of a range of building services installations giving consideration to maintenance costs and cost-in-use.
- 72.101 Produce an overall programme to show the stages at which consideration must be given to the influence of building services on other building components and finishes.
- 72.102 Produce a flow chart with a systematic and logical approach to the sequence of operations of installations throughout the construction of a building.
- 72.103 Illustrate, by means of annotated and dimensioned drawings and sketches, an understanding of the knowledge requirements of the unit.
- 72.104 Prepare lists of materials, components and sequences of operations illustrating an understanding of the unit.
- 72.105 Develop a safety, health and welfare policy for a specific site based on existing legislation to give consideration to installation and other site personnel, building user, general public and adjacent property for building services installations during construction and after commissioning of the building.

This is to confirm that the candidate has successfully completed the above tasks:

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Instructor name (please print)

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Completion date

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# 73 Structural Elements, Geology, Soil Mechanics and Hydraulics 4 – Summary of syllabus sections

Page 56 **Structural Elements 4**  
(Objectives 73.1 to 73.20)

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The aim of this unit is to provide an understanding of the underlying factors which underpin the design of simple structural elements.

Note: Candidates must have satisfactorily studied the unit 'Structural Mechanics' (Level 3) or its equivalent before embarking on this course of study.

This unit requires candidates to carry out the design of the following structural elements and where appropriate compare designs with those obtained using computer software packages.

Page 58 **Geology, Soil Mechanics and Hydraulics 4**  
(Objectives 73.21 to 73.79)

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The aim of this unit is to develop a basic understanding of:

- a the origins and composition of minerals and rocks
- b the structure classification and engineering properties of engineering soils
- c fluids at rest and in motion and their effects on other bodies
- d the operating principles of hydraulic machinery and pumping head calculation methods.

# Structural Elements 4

## Practical competences

The candidate must be able to do the following:

- 73.1 Carry out the design of restrained and unrestrained steel beams.  
**Design:** loadings, steel grades, ultimate bending stresses for degree of restraint, bending, shear, deflection, bearing, web buckling
- 73.2 Carry out the design of axially loaded universal columns and those subject to eccentric loading.  
**Design:** end fixity, effective length, radius of gyration, slenderness ratio, steel grades, ultimate load capacity
- 73.3 Carry out the design of slab and built up bases for axially loaded steel columns.  
**Design:** ground loadings (ultimate, permissible), plate thickness, shaft end specification, holding down bolts, fillet welds, base size (no bending)
- 73.4 Carry out the design of solid reinforced concrete slabs.  
**Design:** loadings, concrete (mixes, strength), steel (types, strength), bending, shear, deflection, bond, curtailment, steel areas (minimum, maximum), slab detail
- 73.5 Carry out the design of singly reinforced concrete beams.  
**Design:** loadings, concrete (mixes, strength), steel (types, strength), bending, shear, deflection, bond, curtailment, steel areas (minimum, maximum), links, bent up shear reinforcement
- 73.6 Carry out the design of short axially loaded reinforced concrete columns, and those subject to eccentric loading.  
**Design:** braced members, influence of end condition, slenderness ratio limits (short columns), minimum eccentricity, steel reinforcement, steel areas (maximum, minimum), link reinforcement, column details
- 73.7 Carry out the design of mass concrete and reinforced strip and pad foundations.  
**Design:** loadings from (walls, columns), limit state (bending, shear, allowable bearing capacity), critical sections (bonding, shear), steel reinforcement (concentration zones), bond, anchorage, base details
- 73.8 Carry out the design of axially loaded solid masonry walls.  
**Design:** mortar strengths, restraints, effective length, effective height, effective width, slenderness ratio, capacity reduction factor, ultimate load capacity/metre

- 73.9 Carry out the design of eccentricity loaded cavity walls.  
**Design:** ultimate loadings, effective height, effective length, effective thickness, lateral support, slenderness ratio, capacity reduction factor, eccentricity ratio, ultimate load capacity/metre
- 73.10 Carry out the design of timber joists given loadings and span conditions.  
**Design:** material (types, size, gradings, associated strengths), influence of 'K' factors, bending, shear, deflection, bearing
- 73.11 Carry out the design of axially loaded timber compression members of a typical roof truss or a vertical member of a stud wall, given length and end conditions.  
**Design:** timber grade, permissible compressive strength, end conditions, effective length, slenderness ratio, modification factor for compression, ratio of modulus of elasticity to compressive stress

## Knowledge requirements

The instructor must ensure the candidate is able to:

- 73.12 Explain the use of the relevant standard codes of practice, design handbooks and computer software applications with respect to the design in various structural materials.  
**Use:** loadings (dead, imposed, wind), pressures (earth, water), limit states, load factors, material factors, design strengths, sectional properties, stability implications, durability, fire protection  
**Materials:** structural steel, reinforced concrete, masonry walls, structural timber
- 73.13 Explain the basic factors that affect the design of simple steel beams, columns and associated slab and built up bases.  
**Factors:** steel (grades, associated strengths), universal sections (shape, size, strength, efficiency), classification with respect to behaviour at ultimate load, flexural members (restrained/unrestrained), ultimate bending resistance, ultimate shear resistance, deflection criteria (basic ratios modification factors), bearing, web buckling, compression members (braced/unbraced definitions, influence of end conditions, effective length, slenderness ratio, ultimate load capacity), base-plates (thickness, holding down (H.D.) bolts, shaft end specification welding), fire protection
- 73.14 Describe the method for designing simple steel beams, columns and associated slabs/built up bases taking into account the factors included in 73.13 above.

- 73.15 Explain the basic factors that affect the design of simple slabs, beams, columns and bases of solid reinforced concrete sections.  
**Factors:** steel/concrete (grades, types, strength), members (shape, size, strength, efficiency), flexural members (ultimate bending resistance, ultimate shear resistance), deflection criteria (basic ratios modification factors), compression members (braced/unbraced definitions, influence of end conditions, effective length, slenderness ratio, ultimate load capacity), durability, fire resistance, steel areas (maximum, minimum), reinforcement (bond, curtailment rules, member sketches)
- 73.16 Describe the method for designing simple slabs, beams, columns and bases of solid reinforced concrete sections taking into account the factors included in 73.15 above.
- 73.17 Explain the basic factors that affect the design of masonry walls.  
**Factors:** masonry units/mortars (types, qualities, grades), relationship (unit strength, mortar strength, wall strength), restraint details (simple, enhanced), influence on strength of wall (effective length, effective height, effective width), eccentric loading (effect, design considerations)
- 73.18 Describe the method for designing masonry walls taking into account the factors included in 73.17 above.
- 73.19 Explain the factors that affect the design of structural timber.  
**Factors:** material (types, size, grading, associated strengths), influence of 'K' factors (load duration, load sharing, buckling), maximum depth to breadth ratios, flexural members (bending, shear, deflection bearing), compression members (end fixity, effective length, slenderness ratio, ratio of modulus of elasticity to compressive stress, ultimate load capacity)  
**Timber:** beams, columns, struts, ties
- 73.20 Describe the method for designing structural timber taking into account the factors included in 73.19 above.  
**Timber:** beams, columns, struts, ties

# Geology, Soil Mechanics and Hydraulics 4

## Practical competences

The candidate must be able to do the following:

### Geology and soil mechanics

- 73.21 Participate in a geological field trip and record important features in a report.  
**Field trip:** duration (minimum 2 days)  
**Features:** eg examine exposed rock faces, interpret geological periods, examine (bedding, dip, strike, cline, folds, slip), rock formations (settlement, drift), obtain rock samples for examination (field, laboratory), examine in-situ rock (weathering, erosional process, depositional features)  
**Report:** specific headings
- 73.22 Examine geological maps and investigate the features of the area.  
**Features:** bedding, dip, strike, cline, folds, faults, slip
- 73.23 Participate in a soil site investigation borehole exploration and label soil samples to the recommended method of description.  
**Description:** relative density, colour, structure/texture, adjectival constituents, principle soil type, additional information (eg historical burial site, disused lime pit), sample types (disturbed, undisturbed), sampling methods, water table, borehole log
- 73.24 Examine and identify a range of minerals and rock types.  
**Minerals (rock forming):** quartz, mica, feldspars, calcite  
**Rocks:** igneous (granite, basalt, dolerite, andersite, gabbro, rhyolite, syenite), sedimentary (limestone, sandstone, mudstone, shale, conglomerate), metamorphic (slate, schist)
- 73.25 Carry out a visual inspection to identify and describe various soil types.  
**Description:** relative density, colour, structure/texture, adjectival constituents, principle soil type
- 73.26 Determine in a laboratory the properties of a range of soil samples.  
**Soils:** gravels, sands, clays, silts  
**Properties:** moisture content, density, specific gravity, particle size distribution
- 73.27 Carry out tests to establish the engineering properties for a range of soils.  
**Tests:** shear box, unconfined compression, vane  
**Soils:** sands, clays, silts
- 73.28 Carry out compaction tests on soils.  
**Soil:** sand  
**Test:** proctor

### Hydraulics

- 73.29 Carry out experiments or associated calculations to find basic fluid properties.

**Properties:** mean density, relative density, specific weight, viscosity

- 73.30 Use instruments in the field/laboratory to measure fluid pressure intensities and solve problems involving fluid pressures.  
**Instruments:** piezometer, manometer, pressure gauge, electrical transducer
- 73.31 Carry out calculations to find the pressures and forces on submerged surfaces due to fluids at rest.  
**Pressure:** hydrostatic, centre of pressure  
**Submerged surfaces:** eg retaining walls, valve gates
- 73.32 Carry out experiments to verify Archimedes Principle.
- 73.33 Examine the stability factors of floating bodies.  
**Floating bodies:** eg cylinders, model boats  
**Factors:** centre of gravity, metacentre, metacentric height
- 73.34 Carry out experiments to demonstrate various types of flow.  
**Types of flow:** steady uniform, steady non-uniform, laminar, turbulent, indicator (Reynold's number)
- 73.35 Use equations to solve problems associated with fluid flow.  
**Equations:** continuity, Bernoulli, momentum
- 73.36 Solve problems involving gravity flow in pipe networks for specified energy loss positions, taking into account various factors.  
**Pipe networks:** methods (head balance, gravity balance)  
**Energy loss positions:** entry, mid pipe, pipe exit  
**Factors:** friction losses, Darcy's Law
- 73.37 Solve problems associated with sudden valve closure.
- 73.38 State the operating principles of hydraulic machinery and carry out pump head calculations.
- 73.39 Use equations to calculate flow depths in open channels for specified sections and Manning coefficients.  
**Equations:** Chezy, Manning  
**Depths of flow:** normal, critical, hydraulic jump
- 73.40 Examine various methods for the measurement of fluid flow in pipelines and open channels using equations.  
**Methods:** venturi meter, orifice plate  
**Equations:** Bernoulli energy, coefficient of discharge (Cd)

## Knowledge requirements

The instructor must ensure the candidate is able to:

### Geology and soil mechanics

- 73.41 Describe the composition, properties and occurrence of commonly encountered minerals and rocks and comment on their origins.  
**Minerals (rock forming):** quartz, mica, feldspars, calcite  
**Rocks:** igneous (granite, basalt, dolerite, andersite, gabbro, rhyolite, syenite), sedimentary (limestone, sandstone, mudstone, shale, conglomerate), metamorphic (slate, schist)
- 73.42 Explain the denudation and deposition of rock material by natural agencies and the development of relevant landforms.  
**Natural agencies:** weathering (erosional processes, depositional features), glacial/fluviative (profiles of landforms)
- 73.43 Describe various types of geological maps and explain the structural implications with regard to major excavations and foundation design.  
**Structural implications:** bedding, dip strike, cline, fold, faults, slip, settlement, drift, difficulty of excavation, fragmentation
- 73.44 Describe the principle soil classification methods and explain fundamental soil properties.  
**Classification methods:** particle size analysis, consistency limits, A-line clays/silts  
**Properties:** dry, bulk, saturated, submerged densities, voids ratio, porosity, moisture content, specific cavity, use of soil model
- 73.45 Describe the nature of soil stresses and the movement of water through soils.  
**Soil stresses:** pressure (total, effective, neutral)  
**Movement of water:** soil permeability, hydraulic gradient, flow of water through soils, simple flow nets for single sheet pile cofferdam
- 73.46 Explain the shear strength of soils and the mechanics of soil friction and cohesion.  
**Shear strength:** importance of shear strength, Mohr's circle, shear failure for various soil types ( $C$ ,  $\phi$ ,  $C/\phi$ ), shear strength envelope, formula for shear strength, shear testing with different drainage conditions
- 73.47 Explain the reasons for soil compaction.  
**Reasons:** difference between soil compaction/consolidation, influence of compaction on soil properties, test for relationship between moisture content/soil density, optimum moisture content, compaction (plant, methods for cohesive/non cohesive soils)

- 73.48 Explain the basic principles of soil consolidation.  
**Principles:** Teraghi's model, consolidation (magnitude, rate), application to simple pad foundation given various load increases/soil properties
- 73.49 Describe the nature of lateral pressure which can exist within a soil mass.  
**Nature:** Rankine theory of active/passive pressures, Coulomb wedge theory, method of determining lateral forces on a structure (calculations, drawings), influence of ground water
- 73.50 Describe the various methods of site investigation.  
**Methods:** trial pits, hand auger, rotary boring, percussion rig boring  
**Site investigations:** scope, safety implications, limitations, sampling methods (disturbed, undisturbed), observations, borehole logging, soil description, sample labelling, site testing methods (vane, standard penetration, plate bearing tests), compilation of a site investigation report (sections), recommendations (bearing capacity, settlement)

### Hydraulics

- 73.51 Explain basic fluid properties.  
**Properties:** mean density, relative density, specific weight, specific volume, viscosity, kinematic viscosity, vapour pressure, surface tension, capillarity
- 73.52 Explain fluid pressure.  
**Fluid pressure:** pressure intensity, absolute pressure, gauge pressure, atmospheric pressure
- 73.53 Explain how pressure varies with depth in a liquid.
- 73.54 Describe the various methods of using instruments to measure fluid pressure.  
**Instruments:** piezometers, manometers, pressure gauges, electrical transducers
- 73.55 Explain the principle of uniform and varying pressure intensities on submerged surfaces.
- 73.56 Explain the force exerted by a liquid on a submerged plane area and its resultant position.  
**Force:** hydrostatic pressure  
**Resultant position:** centre of pressure
- 73.57 Explain hoop/circumferential tension due to liquid pressure.
- 73.58 Explain the principle of Archimedes.
- 73.59 Explain the stability of submerged bodies.  
**Stability:** stable, unstable, neutral, equilibrium

- 73.60 Explain the principle factors relating to the stability of floating bodies.  
**Factors:** centre of gravity, metacentre, metacentric, height
- 73.61 Explain the factors involved in fluid flow.  
**Factors:** viscosity, boundary layer, velocity, pressure, density  
**Flow types:** steady, unsteady
- 73.62 Explain flow patterns.  
**Flow patterns:** one/two/three dimensional
- 73.63 Explain the factors affecting velocity distribution across a flow.  
**Factors:** friction losses, boundary condition
- 73.64 Explain laminar and turbulent states of flow and how they may be determined.  
**Determination:** Reynold's number
- 73.65 Explain the use of equations for analysing fluid flow.  
**Equations:** continuity, Bernoulli, momentum
- 73.66 Explain the value of pipelines compared with open channels.
- 73.67 Explain the basics of pipe flow head loss.  
**Losses:** pipe entry, mid pipe length, pipe exit
- 73.68 Explain the principle of Darcy's Law.  
**Principle:** pipe friction losses
- 73.69 Explain pipe fittings.  
**Fittings:** on/off sluice valves, control valves, air release valves, desilting valves
- 73.70 Explain methods of solving pipe networks.  
**Methods:** head balance, gravity balance
- 73.71 Explain the factors affecting unsteady flow rates.  
**Factors:** sudden valve closure, slow valve closure
- 73.72 Explain methods of reducing unsteady flow.  
**Methods:** pipe strength, valve closure time periods, flap valves, surge tanks
- 73.73 Explain the operating principles of hydraulic machinery.  
**Machinery:** hydraulic presses/lifts, hydraulic ram, pumps (reciprocating, centrifugal)
- 73.74 Explain pumping head calculations  
**Calculations:** suction head, delivery head, pipe flow losses
- 73.75 Explain the equations used for finding the depth of flow in open channels.  
**Depths:** normal, critical  
**Equations:** Chezy, Manning
- 73.76 Explain the principles of Drowned and Backwater curves.
- 73.77 Explain the principle of hydraulic jump.
- 73.78 Explain measurement of pressure in pipe flow.  
**Devices:** venturi meter, simple orifice plate
- 73.79 Explain the methods of measuring of flow rates in open channels.  
**Methods:** weirs, velocity area gauging

# Assessment

## **Test specification for written paper Structural Elements, Geology, Soil Mechanics and Hydraulics 4 (6165-30-073)**

This is a written paper lasting three hours with 10 questions.  
Candidates must answer **all** questions.

<b>Topic</b>	<b>Approximate % examination weighting</b>
Structural elements	30
Geology and soil mechanics	40
Hydraulics	30

# 73 Structural Elements 4

## Practical competences

The candidate must be able to do the following:

- 73.1 Carry out the design of restrained and unrestrained steel beams.
- 73.2 Carry out the design of axially loaded universal columns and those subject to eccentric loading.
- 73.4 Carry out the design of solid reinforced concrete slabs.
- 73.5 Carry out the design of singly reinforced concrete beams.
- 73.6 Carry out the design of short axially loaded reinforced concrete columns, and those subject to eccentric loading.
- 73.7 Carry out the design of mass concrete and reinforced strip and pad foundations.
- 73.8 Carry out the design of axially loaded solid masonry walls.
- 73.9 Carry out the design of eccentricity loaded cavity walls.
- 73.10 Carry out the design of timber joist given loadings and span conditions.
- 73.11 Carry out the design of axially loaded timber compression members of a typical roof truss or a vertical member of a stud wall, given length and end conditions.

This is to confirm that the candidate has successfully completed the above tasks:

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Instructor name (please print)

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Completion date

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# 73 Geology, Soil Mechanics and Hydraulics 4

## Practical competences

The candidate must be able to do the following:

### Geology and soil mechanics

73.21 Participate in a geological field trip and record important features in a report.

73.22 Examine geological maps and investigate the features of the area.

73.23 Participate in a soil site investigation borehole exploration and label soil samples to the recommended method of description.

73.24 Examine and identify a range of minerals and rock types.

73.25 Carry out a visual inspection to identify and describe various soil types.

73.26 Determine in a laboratory the properties of a range of soil samples.

73.27 Carry out tests to establish the engineering properties for a range of soils.

73.28 Carry out compaction tests on soils.

### Hydraulics

73.29 Carry out experiments or associated calculations to find basic fluid properties.

73.30 Use instruments in the field/laboratory to measure fluid pressure intensities and solve problems involving fluid pressures.

73.31 Carry out calculations to find the pressures and forces on submerged surfaces due to fluids at rest.

73.32 Carry out experiments to verify Archimedes Principle

73.33 Examine the stability factors of floating bodies.

73.34 Carry out experiments to demonstrate various types of flow.

73.35 Use equations to solve problems associated with fluid flow.

73.36 Solve problems involving gravity flow in pipe networks for specified energy loss positions, taking into account various factors.

73.37 Solve problems associated with sudden valve closure.

73.38 State the operating principles of hydraulic machinery and carry out pump head calculations.

73.39 Use equations to calculate flow depths in open channels for specified sections and Manning coefficients.

73.40 Examine various methods for the measurement of fluid flow in pipelines and open channels using equations.

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature \_\_\_\_\_

Candidate name (please print) \_\_\_\_\_

Instructor signature \_\_\_\_\_

Instructor name (please print) \_\_\_\_\_

Completion date \_\_\_\_\_

# 74 Architectural Design 4 – Summary of syllabus sections

Page 65 **Architectural Detailing 4**  
(Objectives 74.1 to 74.21)

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The aim of this unit is to enable candidates to gain competence in the:

- a preparation of detailed architectural drawings
- b preparation of specialist and fitting out drawings
- c identification of the legal considerations involved.

Page 66 **Computer Aided Design (CAD) 4**  
(Objectives 74.22 to 74.62)

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The aim of this unit is to enable candidates to complement the traditional skills and principles covered in Architectural Detailing 4.

# Architectural Design 4

## Practical competences

The candidate must be able to do the following:

- 74.1 Carry out a survey of a multi-storey building and of a development site, recording all necessary measurements and data.  
**Multi-storey:** minimum 3 storeys
- 74.2 Plot survey information to scale to produce an 'as existing' drawing.
- 74.3 Produce a detailed cross-section through a typical local multi-storey structure from foundation level to roof, showing all constructional details to enable the building to be approved, costed and constructed.  
**Multi-storey:** minimum 3 storeys
- 74.4 Produce plans and elevations of a multi-storey structure to enable the building to be approved, costed and constructed.  
**Multi-storey:** minimum 3 storeys
- 74.5 Produce a detailed scale drawing of a complex component.  
**Component:** eg staircase, built-in kitchen unit.
- 74.6 Produce a services drawing for a simple electrical and mechanical engineering services system.
- 74.7 Produce a material schedule for typical components.  
**Components:** eg doors, windows, kitchen units, ironmongery, lintels
- 74.8 Produce a finishes schedule.
- 74.9 Produce a drawing sheet checklist.
- 74.10 Prepare a report on the national/local regulations controlling building construction.
- 74.11 Produce estimates for design schemes.  
**Estimates:** cost per m<sup>2</sup>, approximate estimate for feasibility purposes
- 74.12 Identify and describe the use of equipment required to undertake a survey.  
**Equipment:** tapes, level, staff, theodolite, camera, folding rule, binoculars, pen knife, torch, inspection chamber keys, folding ladder, plumb bob
- 74.13 Describe the techniques of surveying and recording information.  
**Techniques/recording information:** surveys (building, chain, traverse), recording/booking of measurements
- 74.14 Describe the selection of the appropriate scale for the plotting of survey drawings and identify plotting techniques.  
**Plotting techniques:** manual, computer-based
- 74.15 Identify the building elements that should be included in setting out drawings.  
**Elements:** site, foundations, frame, structure, components, dimensions, tolerances, modular coordination
- 74.16 Describe the use and purpose of furniture and fixture details.  
**Use/purpose:** manufacture, location
- 74.17 Describe the use and purpose of construction component details.  
**Use/purpose:** manufacture, fixing
- 74.18 Describe the systems used for the costing of buildings at the design stage.  
**Systems:** cost per m<sup>2</sup>, approximate estimating for feasibility purposes
- 74.19 Explain the basic electrical and mechanical engineering services requirements for a building.  
**Services:** lighting, heating, water, drainage, air conditioning, ventilation, ducting, lifts, escalators, fire-fighting equipment, security equipment, telecommunications
- 74.20 Identify the component parts of building services drawings.  
**Component parts:** pipe/cable runs, ducts, fittings, controls, symbols
- 74.21 Describe the methods/formats for producing schedules both manually and by the use of computers.  
**Methods/formats:** spreadsheets, databases, matrices

## Knowledge requirements

The instructor must ensure the candidate is able to:

- 74.12 Identify and describe the use of equipment required to undertake a survey.  
**Equipment:** tapes, level, staff, theodolite, camera, folding rule, binoculars, pen knife, torch, inspection chamber keys, folding ladder, plumb bob

# Computer Aided Design (CAD) 4

## Practical competences

The candidate must be able to do the following:

### File management

- 74.22 Prepare directories for use with a particular job and sequentially list the contents of the directories.
- 74.23 Copy, rename and delete files in both the operating system and within the CAD programme.
- 74.24 Operate a CAD programme.
- 74.25 Prepare at least three typical prototype/template drawings.  
**Prototype/template drawings:** eg A4, A3, A2
- 74.26 Set up a drawing size appropriate to the job to be drawn.
- 74.27 Apply 'system variables' to show different presentation methods.  
**System variables:** eg attdia, aperture, tilemode, UCSICON, dimaso, skpoly
- 74.28 Use 'drawing aids' within the CAD programme to show different drawing methods and speed drawing.  
**Drawing aids:** isometric style, snap, grid, ortho, object snap

### Drawing techniques

- 74.29 Apply absolute, relative and polar coordinate entry methods to execute a series of drawings.
- 74.30 Use keyboard and pointing devices create a drawing.
- 74.31 Create appropriate layers with different colours and linetypes.
- 74.32 Remove unused blocks, symbols, layers, levels, linetypes and text styles.
- 74.33 Enter text using different styles derived from standard fonts.
- 74.34 Enter text using different orientations and sizes.
- 74.35 Import text from a word-processed document.
- 74.36 Modify existing drawn items.  
**Modify:** eg extend, trim, chamfer, fillet, scale, change colour, change linetype characteristics
- 74.37 Mirror drawn items both with and without mirroring text.
- 74.38 Reverse the effect of one or more commands.

### Blocks and symbols

- 74.39 Create a library of blocks or symbols to be used both on a single drawing and also for use in other drawings.
- 74.40 Insert blocks and symbols into a drawing to a specified position at different scales and rotations.
- 74.41 Insert a bitmap image into a drawing.

### Dimensioning

- 74.42 Modify and update system variables settings.  
**System variables:** eg associated dimensions, dimension font (type, size), text position, arrow sizes, tick sizes
- 74.43 Dimension a drawing to show various information.  
**Information:** horizontal, vertical, aligned, angular, radius, diameter, rotated

### Display of drawing

- 74.44 Display the entire drawing on the screen.
- 74.45 Demonstrate the 'pan' and 'zoom' facilities by moving to different parts of the drawing.
- 74.46 Create views of particular parts of the drawing and subsequently restore those views as required.

### Plotting

- 74.47 Prepare a plotter or printer for use.
- 74.48 Produce a hard copy of the drawing on the plotter or printer to an appropriate scale.
- 74.49 Produce a plot file of the required drawing.

## Knowledge requirements

The instructor must ensure the candidate is able to:

### File management

- 74.50 Describe the techniques for setting up directories and folders.
- 74.51 Describe the procedures for copying, renaming and deleting files within the operating system.
- 74.52 Describe the procedure for copying, renaming and editing files within the CAD system.
- 74.53 Explain the purpose of standard drawing sheet sizes.
- 74.54 Explain the importance of system variables and how they are set up.
- 74.55 Describe the purpose of system variables and how they are set up.

**Drawing techniques**

74.56 Explain the different methods of entering coordinate information.

**Methods:** absolute, relative, polar

74.57 Describe the purpose of a User Coordinate System and its relationship with reference to the World Coordinate System.

74.58 Describe the methods used to enter drawing commands.

**Drawing commands:** lines, circles, arcs, polygons

74.59 Explain how to extend, trim, stretch, break and scale drawn items.

74.60 Explain how to edit line properties.

**Blocks and symbols**

74.61 Describe the purpose and use of the use of blocks and symbols.

74.62 Describe how to obtain information about drawn items.

## **Test specification for written paper Architectural Design 4 (6165-30-074)**

This is a written paper lasting three hours with 10 questions.  
Candidates must answer **all** questions.

<b>Topic</b>	<b>Approximate % examination weighting</b>
Architectural detailing 4	50
Computer aided design (CAD) 4	50

# 74 Architectural Design 4

## Practical competences

The candidate must be able to do the following:

- 74.1 Carry out a survey of a multi-storey building and of a development site, recording all necessary measurements and data.
- 74.2 Plot survey information to scale to produce an 'as existing' drawing.
- 74.3 Produce a detailed cross-section through a typical local multi-storey structure from foundation level to roof, showing all constructional details to enable the building to be approved, costed and constructed.
- 74.4 Produce plans and elevations of a multi-storey structure to enable the building to be approved, costed and constructed.
- 74.5 Produce a detailed scale drawing of a complex component.
- 74.6 Produce a services drawing for a simple electrical and mechanical engineering services system.
- 74.7 Produce a material schedule for typical components.
- 74.8 Produce a finishes schedule.
- 74.9 Produce a drawing sheet checklist.
- 74.10 Prepare a report on the national/local regulations controlling building construction.
- 74.11 Produce estimates for design schemes.

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature \_\_\_\_\_

Candidate name (please print) \_\_\_\_\_

Instructor signature \_\_\_\_\_

Instructor name (please print) \_\_\_\_\_

Completion date \_\_\_\_\_

# 74 Computer Aided Design (CAD) 4

## Practical competences

The candidate must be able to do the following:

### File management

- 74.22 Prepare directories for use with a particular job and subsequently list the contents of the directories.
- 74.23 Copy, rename and delete files in both the operating system and within the CAD programme.
- 74.24 Operate a CAD programme.
- 74.25 Prepare at least three typical prototype/template drawings.
- 74.26 Set up a drawing size appropriate to the job to be drawn.
- 74.27 Apply 'system variables' to show different presentation methods.
- 74.28 Use 'drawing aids' within the CAD programme to show different snap and grid arrangements.

### Drawings techniques

- 74.29 Apply absolute, relative and polar coordinate entry methods to execute a series of drawings.
- 74.30 Use keyboard and pointing devices create a drawing.
- 74.31 Create appropriate layers with different colours and linetypes.
- 74.32 Remove unused blocks, symbols, layers, levels, linetypes and text styles.
- 74.33 Enter text using different styles derived from standard fonts.
- 74.34 Enter text using different orientations and sizes.
- 74.35 Import text from a word-processed document.

- 74.36 Modify existing drawn items.
- 74.37 Mirror drawn items both with and without mirroring text.
- 74.38 Reverse the effect of one or more commands.

### Blocks and symbols

- 74.39 Create a library of blocks or symbols to be used on both a single drawing and also for use in other drawings.
- 74.40 Insert blocks and symbols into a drawing to a specified position at different scales and rotations.
- 74.41 Insert a bitmap image into a drawing.

### Dimensioning

- 74.42 Modify and update system variables settings.
- 74.43 Dimension a drawing to show various information.

### Display of drawing

- 74.44 Display the entire drawing on the screen.
- 74.45 Demonstrate the 'pan' and 'zoom' facilities by moving to different parts of the drawing.
- 74.46 Create views of particular parts of the drawing and subsequently restore those views as required.

### Plotting

- 74.47 Prepare a plotter or printer for use.
- 74.48 Produce a hard copy of the drawing on the plotter or printer to an appropriate scale.
- 74.49 Produce a plot file of the required drawing.

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature

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Candidate name (please print)

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Instructor signature

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Instructor name (please print)

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Completion date

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# 75 Construction Mathematics 4 – Summary of syllabus sections

Page 72    **Construction Mathematics 4**  
(Objectives 75.1 to 75.61)

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The aim of this unit is to further develop mathematical skills learnt at diploma level and apply them to Structural Analysis and Civil Engineering.

# Construction Mathematics (applied/diagnostics) 4

## Practical competences

The candidate must be able to do the following:

- 75.1 Differentiate the trigonometric, logarithmic and exponential functions.
- 75.2 Display the skill to differentiate products, quotients, functions of a function and implicit functions of the above type.
- 75.3 Express  $\tan x$ ,  $\cot x$ ,  $\sec x$ , and  $\operatorname{cosec} x$  in terms of  $\sin x$  and  $\cos x$  and work out their differentials.
- 75.4 Determine the differential coefficients of the functions  $a^x$ ,  $\log_{10} x$ ,  $1_n(ax+b)$ ,  $\log_{10}(ax+b)$  ( $a+\sin x$ ) and  $\sin(ax+b)$
- 75.5 Work out indefinite and definite integrals of functions involving  $\sin ax$ ,  $\cos ax$ , and  $e^{ax}$
- 75.6 Use Trapezoidal and Simpson's Rules to do numerical integration.
- 75.7 Calculate the mean and root mean square values of sinusoidal functions between given limits.
- 75.8 Define  $e$ , obtain its series expansion and calculate the value of  $e$  to four decimal places to show its rapid convergence.
- 75.9 Obtain the power series for  $e^x$  and  $e^{-x}$  and deduce the expansion for  $e^{kx}$  where it has positive or negative values.
- 75.10 Differentiate the power series to verify that  $\frac{d}{dx}(e^x) = e^x$
- 75.11 Sketch the graphs of  $e^x$ ,  $e^{-x}$ ,  $ae^{bx}$ ,  $ae^{-bx}$  where  $a$  and  $b$  are positive and use log-linear graph paper to plot straight line graphs for  $e^x$ ,  $e^{-x}$  and  $ae^{bx}$
- 75.12 Apply Taylor's Theorem to expand a given function  $f(x)$  about a point in powers of  $(x-a)$
- 75.13 Use Maclaurin's Theorem to determine series for  $\sin x$ ,  $\cos x$ ,  $1_n(1+x)$  and deduce series for  $1_n(1-n)$  and  $1_n \frac{1+x}{1-x}$
- 75.14 Use series expansions to evaluate definite integrals.
- 75.15 Calculate the sum, difference and the product of two  $3 \times 3$  matrices and then generalise the operations to  $m \times n$  matrices.
- 75.16 Evaluate a  $3 \times 3$  determinant.
- 75.17 Define the cofactor of an element of the determinant, transpose and inverse of a matrix and determine the inverse of a non-singular  $3 \times 3$  matrix.
- 75.18 Solve simultaneous linear equations with three unknowns using matrices and determinants.
- 75.19 Define a scalar and a vector, represent a vector in two and three dimensions and determine its magnitude and direction.
- 75.20 Perform addition and subtraction of vectors and carry out multiplication of a vector by a scalar.
- 75.21 Solve vector equations.
- 75.22 Determine the position vector of a point which divides the position vectors of two points in a given ratio.
- 75.23 Define a scalar product of two vectors and calculate the angle between them.
- 75.24 Determine the equation of a straight line parallel to a vector and passing through a point with a given position vector.
- 75.25 Determine the equation of a straight line passing through two points with given position vectors.
- 75.26 Establish geometrical results using vectors.
- 75.27 Define probability, state the two rules of probability and calculate probabilities for mutually exclusive independent and dependant events.
- 75.28 Identify and explain the concepts of Binomial, Poisson and Normal Distributions.
- 75.29 Calculate probabilities using Binomial, Poisson and Normal Distributions.
- 75.30 Use the appropriate software to analyse the data.

## Knowledge requirements

Instructors must ensure that candidates are able to:

### Calculus

75.1 State that  $\frac{d}{dx}(\sin x) = \cos x$  and that  $\frac{d}{dx}(\cos x) = -\sin x$ .

75.2 State that  $\frac{d}{dx}(e^x) = e^x$  and  $\frac{d}{dx}(1_n x) = \frac{1}{x}$ .

75.3 State the rules for differentiating a product and a quotient of two simple functions.

75.4 Differentiate various combinations of any two of the functions  $x^n$ ,  $\sin x$ ,  $\cos x$ ,  $e^x$ ,  $\log_e x$ .

75.5 State the function of a function rule for differentiation.

- 75.6 Determine the differential coefficient of the reciprocal of a function.
- 75.7 Determine differential coefficients of products of any two of the functions  $x^n$ ,  $\sin nx$ ,  $\cos nx$ ,  $e^{nx}$ ,  $\log_e nx$ .
- 75.8 Define  $\tan x$ ,  $\cot x$ ,  $\sec x$ ,  $\operatorname{cosec} x$ , in terms of  $\sin x$  and  $\cos x$  and hence determine their differential coefficients.
- 75.9 Show that  $\frac{d}{dx}(a^x) = a^x \ln a$   
and that  $\frac{d}{dx}(\log_{10} x) = \frac{1}{x} \log_{10} e$ .
- 75.10 Determine the differential coefficients of  $\ln(ax+b)$  and  $\log_{10}(ax+b)$ .
- 75.11 Determine the differential coefficients of functions of the type  $(a+\sin nx)$  and  $\sin(nx+a)$ .
- 75.12 Determine indefinite integrals of functions involving  $\sin ax$ ,  $\cos ax$ ,  $e^{ax}$ .
- 75.13 Evaluate definite integrals involving the functions in 75.12.
- 75.14 Calculate the approximate value of integrals using Trapezoidal Rule and Simpson's Rule.
- 75.15 Calculate the mean and root mean square of sinusoidal functions between given limits.

### Algebra

- 75.16 Define  $e$  as the limiting value of the function  $(1 + \frac{1}{n})^n$  as  $n$  tends to infinity.
- 75.17 Apply the Binomial Theorem to the function  $(1 + \frac{1}{n})^n$  as  $n \rightarrow \infty$  to obtain a series expression for  $e$ .
- 75.18 Calculate the value of  $e$  to four decimal places and hence show that the series converges rapidly.
- 75.19 Expand  $(1 + \frac{1}{n})^{nx}$ ,  $n \rightarrow \infty$  to obtain a power series for  $e^x$  and for  $e^{-x}$ .
- 75.20 Deduce from 75.19 the expansion of  $e^{kx}$  where  $k$  has positive or negative values.
- 75.21 Verify that  $\frac{d}{dx}(e^x) = e^x$  by differentiating the power series term by term.
- 75.22 Sketch the graphs of  $y = e^x$ ,  $y = e^{-x}$ ,  $y = ae^{bx}$  and  $y = ae^{-bx}$  where  $a$  and  $b$  are positive.
- 75.23 Use log-linear graph paper to plot straight line graphs for  $y = e^x$ ,  $y = e^{-x}$  and  $y = ae^{bx}$ .

- 75.24 Determine whether experimental results are related by a law of the type  $y = ae^{bx}$  and estimate the values of the constants from the log-linear graph.

75.25 State Maclaurin's Theorem.

75.26 Determine series for  $\sin x$ ,  $\cos x$ ,  $\ln(1+x)$  and  $(1+x)^n$  using Maclaurin's Theorem.

75.27 Deduce series for  $\ln(1-x)$  and  $\ln \frac{1+x}{1-x}$ .

75.28 State Taylor's Theorem.

75.29 Use Taylor's Theorem to expand a given function  $f(x)$  about a point in powers of  $(x-a)$ .

75.30 Use series expansions to obtain approximate values of definite integrals.

### Matrices and determinants

75.31 Calculate the sum and difference of two  $3 \times 3$  matrices.

75.32 Determine the product of two  $3 \times 3$  matrices.

75.33 Generalise the operation in 75.31 and 75.32 to  $m \times n$  matrices.

75.34 Evaluate a  $3 \times 3$  determinant by expansion about any row or column.

75.35 Verify the effect on the sign of a determinant is the interchange if any two rows or any two columns.

75.36 Deduce that the value of a determinant is zero if two rows or two columns are identical.

75.37 Verify the effect of extracting a common factor from any one row or column.

75.38 Verify that the value of a determinant is unaltered by the addition or subtraction of multiples of rows or columns.

75.39 Define the minor and cofactor of an element of the determinant of a matrix.

75.40 Define the transpose and adjoint of a matrix.

75.41 Define the inverse  $A^{-1}$  of a matrix  $A$  and determine  $A^{-1}$  for a non-singular  $3 \times 3$  matrix  $A$ .

75.42 Express a set of three linear equations in the form  $AX = b$  and solve them by means of matrices.

### Vectors

75.43 Define a scalar and a vector.

75.44 Represent a vector in two and three dimensions and determine its magnitude and direction.

- 75.45 Perform addition and subtraction of vectors.
- 75.46 Perform multiplication of a vector by a scalar.
- 75.47 Solve vector equations.
- 75.48 Determine the position vector of a point which divides the position vectors of two points in a given ratio.
- 75.49 Define a scalar product of two vectors and determine the angle between them.
- 75.50 Determine the equation of a straight line parallel to a vector and passing through a point with a given position vector.
- 75.51 Determine the equation of a straight line passing through two points with given position vectors.
- 75.52 Establish geometrical results using vectors.

### **Statistics**

- 75.53 Define probability both in 'classical' and 'empirical' sense.
- 75.54 Define mutually exclusive events and distinguish between independent and dependent events.
- 75.55 State addition and multiplication rules of probability.
- 75.56 Perform calculations relating to total and compound probability.
- 75.57 Identify the probability Distributions: Binomial, Poisson and Normal.
- 75.58 Explain the concept of Binomial Distribution and calculate probabilities using Binomial Distribution.
- 75.59 Explain the concept of Poisson Distribution and calculate probabilities using Poisson Distribution.
- 75.60 Explain the concept of Normal Distribution and calculate probabilities using Normal Distribution.
- 75.61 Use the appropriate software to analyse the data.

# Assessment

## Test specification for written paper Construction Mathematics (6165-30-075)

This is a written paper lasting three hours with 10 questions.  
Candidates must answer **all** questions.

<b>Topic</b>	<b>Approximate % examination weighting</b>
Calculus	20
Algebra	20
Matrices and determinants	20
Vectors	20
Statistics	20

# 75 Construction Mathematics (applied/diagnostics) 4

## Practical competences

The candidate must be able to do the following:

- |       |  |                          |       |  |                          |
|-------|--|--------------------------|-------|--|--------------------------|
| 75.1  | Differentiate the trigonometric, logarithmic and exponential functions.  | <input type="checkbox"/> | 75.13 | Use Maclaurin's Theorem to determine series for $\sin x$ , $\cos$ , $1_n(1+x)$ and deduce series for $1_n(1-n)$ and $1_n \frac{1+x}{1-x}$                | <input type="checkbox"/> |
| 75.2  | Display the skill to differentiate products, quotients, functions of a function and implicit functions of the above type.  | <input type="checkbox"/> | 75.14 | Use series expansions to evaluate definite integrals.  | <input type="checkbox"/> |
| 75.3  | Express $\tan x$ , $\cot x$ , $\sec x$ , and $\operatorname{cosec} x$ in terms of $\sin x$ and $\cos x$ and work out their differentials.  | <input type="checkbox"/> | 75.15 | Calculate the sum, difference and the product of two $3 \times 3$ matrices and then generalise the operations to $m \times n$ matrices.                  | <input type="checkbox"/> |
| 75.4  | Determine the differential coefficients of the functions $a^x$ , $\log_{10}x$ , $1_n(ax+b)$ , $\log_{10}(ax+b)$ ( $a+\sin x$ ) and $\sin(ax+b)$  | <input type="checkbox"/> | 75.16 | Evaluate a $3 \times 3$ determinant.   | <input type="checkbox"/> |
| 75.5  | Work out indefinite and definite integrals of functions involving $\sin ax$ , $\cos ax$ , and $e^{ax}$   | <input type="checkbox"/> | 75.17 | Define the cofactor of an element of the determinant, transpose and inverse of a matrix and determine the inverse of a non-singular $3 \times 3$ matrix. | <input type="checkbox"/> |
| 75.6  | Use Trapezoidal and Simpson's Rules to do numerical integration.   | <input type="checkbox"/> | 75.18 | Solve simultaneous linear equations with three unknowns using matrices and determinants.   | <input type="checkbox"/> |
| 75.7  | Calculate the mean and root mean square values of sinusoidal functions between given limits.   | <input type="checkbox"/> | 75.19 | Define a scalar and a vector, represent a vector in two and three dimensions and determine its magnitude and direction.                                  | <input type="checkbox"/> |
| 75.8  | Define $e$ , obtain its series expansion and calculate the value of $e$ to four decimal places to show its rapid convergence.  | <input type="checkbox"/> | 75.20 | Perform addition and subtraction of vectors and carry out multiplication of a vector by a scalar.  | <input type="checkbox"/> |
| 75.9  | Obtain the power series for $e^x$ and $e^{-x}$ and deduce the expansion for $e^{kx}$ where it has positive or negative values.   | <input type="checkbox"/> | 75.21 | Solve vector equations.  | <input type="checkbox"/> |
| 75.10 | Differentiate the power series to verify that $\frac{d}{dx}(e^x) = e^x$  | <input type="checkbox"/> | 75.22 | Determine the position vector of a point which divides the position vectors of two points in a given ratio.  | <input type="checkbox"/> |
| 75.11 | Sketch the graphs of $e^x$ , $e^{-x}$ , $ae^{bx}$ , $ae^{-bx}$ where $a$ and $b$ are positive and use log-linear graph paper to plot straight line graphs for $e^x$ , $e^{-x}$ and $ea^{bx}$ | <input type="checkbox"/> | 75.23 | Define a scalar product of two vectors and calculate the angle between them.   | <input type="checkbox"/> |
| 75.12 | Apply Taylor's Theorem to expand a given function $f(x)$ about a point in powers of $(x-a)$  | <input type="checkbox"/> | 75.24 | Determine the equation of a straight line parallel to a vector and passing through a point with a given position vector.                                 | <input type="checkbox"/> |
|       |  |                          | 75.25 | Determine the equation of a straight line passing through two points with given position vectors.  | <input type="checkbox"/> |
|       |  |                          | 75.26 | Establish geometrical results using vectors.   | <input type="checkbox"/> |

- 75.27 Define probability, state the two rules of probability and calculate probabilities for mutually exclusive independent and dependant events.
- 75.28 Identify and explain the concepts of Binomial, Poisson and Normal Distributions.
- 75.29 Calculate probabilities using Binomial, Poisson and Normal Distributions.
- 75.30 Use the appropriate software to analyse the data.

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature

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Candidate name (please print)

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Instructor signature

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Instructor name (please print)

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Completion date

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# Appendix A

## Assessments

Two assessment methods are used in the 6165 Advanced Technician Diploma in Construction programme – written questions and practical assessment.

### Practical assessment

Each unit (assessment component) in this programme has one or more practical assessments which are derived from the practical competences that make up the first part of each syllabus section. The competence checklists (tick boxes), given at the end of each unit, serve as the marking criteria for these assessments and should be used to record the outcome of each candidate's performance. The use of local materials, tools, equipment or practice is allowed within the specifications of the 'range' supporting each competence statement. The results of the assessments must be documented and available for audit by the visiting verifier. ALL assessments must be successfully completed.

The assessments may be carried out at any time agreed by the instructor and the candidate.

The competence checklists in this publication are intended to be photocopied so that each candidate has a personal record of his/her practical assessments.

### Preparation, supervision and marking

It is essential that the instructor ensures all necessary preparations are carried out. This will involve ensuring:

- the candidate is ready to demonstrate his or her practical skills
- every candidate understands what is involved
- any necessary materials, tools or equipment are present.

Marking of the practical performance is determined on outcomes as defined by the practical competences. Each tick box will show either 'yes – the candidate achieved this' or 'no – the candidate did not achieve this'. Candidates must be successful in all competences included in the checklist before it can be 'signed off' and its results transferred to the summative record.

All assessments require supervision to ensure that the results reflect only the work of the individual candidate concerned. All assessment documentation and material must be kept in a file for each candidate until the results have been agreed by the visiting verifier and until confirmation of the result has been received from City & Guilds.

### Records, results and certification

As the practical assessments for each component are successfully completed, the achievement must be recorded. A model of a summative record is given at the end of this section. When all components for an award have been recorded, the result must be sent to City & Guilds. Each candidate's achievements should be transferred from the summative assessment record to the entry form.

Practical components are entered onto Form S which must be countersigned by the visiting verifier and then sent to City & Guilds. The visiting verifier will want to see evidence to support the results being entered. Actual forms are supplied by City & Guilds.

### Question paper assessments

The knowledge requirements in the sections of each unit are tested by question papers which are set and marked by City & Guilds. At the Certificate and first year Diploma levels (levels 1 and 2) of this programme, candidates will sit multiple choice question papers. At the higher levels, all question papers will require short written answers.

Entries for these examinations must be made in accordance with the timetable for entries given in the 'Directory' and must be sent in on Form S.

### General information

An advantage of this programme is that candidates who successfully complete a component of assessment for a single unit may, if they wish, claim a Certificate of Unit Credit. This may be beneficial for those candidates who only wish to complete part of this programme.

Candidates wishing to gain the full award (Certificate, Diploma or Advanced Diploma) must successfully complete all components. We recommend that their practical results are sent at the time of, or shortly before the date of the written examinations.

### Visiting verifier

The operation of this programme requires the appointment of a visiting verifier. **The visiting verifier must countersign the results of the practical assessments on Form S.** The visiting verifier should also be able to inspect records and candidates' work to verify the results before submission.

## 6165-30 Advanced Technician Diploma in Construction (Applied) Practical competence assessment record

Candidate's name and number \_\_\_\_\_

Centre name and number \_\_\_\_\_

Assessment reference	Date completed	Instructor signature	Instructor name
<b>161 Site Surveying 3</b>			
161 Site Surveying			
<b>162 Materials and Construction Technology 4</b>			
162 Materials Technology			
162 Construction Technology			
<b>163 Construction Management 4</b>			
163 Construction Management			
And any two of the following			
<b>171 Tendering, Estimating and Quantity Surveying 4</b>			
171 Tendering and Estimating			
171 Quantity Surveying			
<b>172 Building Services, Science and Technology 4</b>			
172 Building Services Science			
172 Building Services Technology			
<b>173 Structural Elements, Geology, Soil Mechanics and Hydraulics 4</b>			
173 Structural Elements			
173 Geology, Soil Mechanics and Hydraulics			
<b>174 Architectural Design 4</b>			
174 Architectural Detailing			
174 Computer Aided Draughting			

Assessment reference	Date completed	Instructor signature	Instructor name
<b>175 Construction Mathematics 4</b>			
175 Construction Mathematics			

\* The syllabus units containing the above components can be found in either the 6165 Technician Awards in the Construction Industry – certificate level or the 6161 Awards in the Construction Industry – certificate level.

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