# $\underset{2024-25}{\text{ASSESSED COURSEWORK}}$

Instructions: This assignment will contribute to 30% of your final mark for the course. Marks will be awarded for performing the task correctly using Excel, and appropriate interpretation and comments on the results. For each task and question, you should create an Excel worksheet to organise the information needed to carry out the task.

General Style and Content: The report should be a single PDF file consisting of the main text body (commentaries, interpretation) and graphical outputs, and an appendix to explain how the tasks are carried out with Excel commands. The PDF file should be created from a word processing package such as Microsoft Word or LaTeX. There should be a page header that includes your name and HWU ID.

**Appendix:** The main body of the report should not contain any Excel command, and there must be an Appendix which specifies briefly how the results for each section were obtained using Excel. Some specifications include menu commands and/or screenshots.

Length: The main body of your report should be **NO more than five sides of A4 including graphs and tables**. Note that the main report does not include the title page and the Appendix.

**Submission:** The assignment should be submitted through Canvas. It should not be submitted by email or handed in as a paper copy.

Collaboration: Students are encouraged to discuss among themselves the appropriate methods to be used, but your submitted report must be **your own work**. In particular, copying a section of your report, either graphical outputs or commentaries, from other students' report is a serious disciplinary offence. It is also an offence to allow another student to copy your work, so your assignment files should never be made available to other students.

**Deadline:** The deadline for submission is **5pm on Thursday 17th April**; assignments may be submitted early. Any report submitted within 5 working days after the deadline will receive a deduction of 30% in the final mark. Reports that are submitted more than 5 working days past the deadline will not be marked.

# Background

Suppose you are an engineer who works on evaluating the mechanical properties of various construction materials to ensure their suitability for structural applications. This project involves examining a random sample of 150 different materials, specifically focusing on concrete, wood, and steel. The primary goal is to analyse how these materials respond to different reliability tests, which are crucial for understanding their performance under different conditions.

Two reliability tests are designed to assess the mechanical properties depending on the material type:

• Load Testing (Concrete and Steel)

For steel and concrete samples, the focus is on determining their load-bearing capabilities. Load testing involves applying a constant load to the material and measuring its deflection, strain, or stress. The data collected are useful for verifying design assumptions, validating construction quality, and identifying possible defects and damages in structural elements.

• Humidity Testing (Wood)

Wood samples are tested to assess their deformation under humid conditions. Humidity testing involves exposing the material to high humidity to observe its deformation profile and dimensional changes. The data collected could reveal deformation characteristics of materials and how they affect its practical use in construction.

It is expected that load testing would reduce the loading capacity of the material (concrete or steel) by a certain amount. In the humidity test, wood samples are exposed to different levels of humidity and their levels of deformation are observed and recorded.

#### Data

The data collected are available in the Excel worksheet "Materials data template.xlxs". The data consist of 150 instances (50 concrete, 50 steel, and 50 wood) and 9 variables. The description for each variable is delineated as follows:

Variable Name	Description
UID	Unique identifier
Material	Material type, i.e., Wood, Concrete, or Steel
Load Stress Tested (Yes/No)	Whether underwent loading test
Humidity Stress Tested (Yes/No)	Whether underwent humidity test
Load1	Loading capacity kN before loading test
Load2	Loading capacity kN after loading test
Temperature	Temperature exposure (fixed 23 degrees)
Humidity	Percentage level of humidity exposure
Deformation	Size of observed shape deformation (mm)

The Excel file "Materials data template.xlxs" contains a worksheet for each task and question of the assignment. These worksheets must be used to answer the questions, and Excel commands or screenshots should be attached in the Appendix of your report.

#### **Tasks**

#### Task 1 - Sampling for Reliability Testing

Suppose that you would like to sample a subset of 25 concrete materials (out of the 50) and 25 steel materials (out of the 50) to undergo load testing. You wanted the selection to be random so that each individual piece would have an equal likelihood of being included in the load testing. Describe a sampling procedure that could achieve this.

[1 mark]

## Task 2 - Investigation of Loading Capacities before Load Testing

1. Calculate the descriptive statistics for the loading capacities (Load1) for each material, i.e., Concrete, Steel, and Wood, respectively. Produce boxplots to visualise Load1 for each material. Comment on these statistics and plots.

[4 marks]

2. It is claimed that the mean loading capacities (Load1) of concrete and steel are not the same. You wish to test if the claim was true with your observed data.

Conduct a two-sided t-test to check whether there is a statistically significant difference between the mean loading capacities (Load1) of concrete and steel, assuming that the population variances are equal. You should set the significance level at 5%.

Clearly state your hypotheses and the assumptions needed for the test, interpret the results, and state your conclusions. Based on your summary statistics and plots in part 1, explain whether the assumptions have been reasonably met.

[5 marks]

3. Suppose now you decided to conduct a two-sided t-test on the mean loading capacities (Load1) of concrete and steel, assuming that the population variances are **NOT equal**. By doing some research on Welch's t test, state the formula for the test statistic used and the equation to calculate the degrees of freedom.

Perform this test in Microsoft Excel and interpret the results. Are the results consistent with your conclusion derived in part 2? You should set the significance level at 5%.

[4 marks]

#### Task 3 - Investigation of Loading Capacities after Load Testing

1. First, separate all 150 materials into two groups: the treatment group where Load Stress Test = Yes, and the control group where Load Stress Test = No. Create a new variable for each group with the variable name Differences, and the variable should contain the difference between Load1 and Load2 (i.e., Load1 - Load2).

Produce dotplots for the variable Differences for both the treatment group and the control group. Comment on the dotplots.

(Hint: You may wish to round the values of differences before producing a dotplot.)

[4 marks]

2. It is claimed that performing a stress test reduces the loading capacity of steel by at most 7 kN. You wish to test if there is any evidence against this claim.

For the treatment group, select only the material **steel**. Perform an appropriate one-sided t-test for the difference between Load1 and Load2. You should set the significance level at 5%.

Clearly state your hypotheses and the assumptions of the test, interpret the results, and state your conclusions.

[4 marks]

## Task 4 - Relationship between Deformation Level and Humidity

1. Select only data corresponding to Humidity Stress Test = Yes. Using those data, create a scatter plot for the variables Deformation against Humidity. Comment on the scatter plot and the potential relationship between the variables.

Use least squares regression to obtain a linear equation for Deformation in terms of Humidity (i.e., find  $\alpha$  and  $\beta$  such that Deformation =  $\alpha + \beta \times$  Humidity.

[3 marks]

2. Plot the residuals of the linear regression model over the fitted values. Comment on the residual plot and explain whether the assumptions for a linear regression model have been reasonably met.

[5 marks]