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1 Introduction

1.1 Remote Laboratories

Remote laboratories enable students to access physical laboratory apparatus through the internet, providing a supplement to their studies and existing hands-on experience. Students carry out experiments using real equipment, but with much greater flexibility since access can occur from anywhere and at any time. Their interaction with the remote equipment is assisted by the use of data acquisition instrumentation and cameras, providing direct feedback to students for better engagement. Traditional engineering laboratories require students to be physically present in order to work with equipment, which may limit student flexibility. Conversely, remote laboratories let students work in their own time and even repeat experiments for better learning outcomes.

Of course students cannot actually touch and feel the equipment in a remote laboratory, but they can still perform most other tasks relevant to their learning. Sometimes, separation from potentially hazardous equipment is preferable from a safety point of view. Due to the increased use of remote operation in industry, where machinery and entire plants are often controlled from a distant location, students may directly benefit from learning how to remotely control equipment. Furthermore, remote laboratories provide the opportunity to access a wider range of experiments as costly or highly specialised equipment may not be locally available. This presents the opportunity to share laboratory facilities between institutions.

Significant research and pilot studies have been undertaken in Australia and by several groups around the world into the educational effectiveness of using remote laboratories. These studies have consistently shown that, if used appropriately in a way that is cognizant of the intended educational outcomes of the laboratory experience, remote laboratories can provide significant benefits. Indeed, multiple research studies have demonstrated that whilst there are some learning outcomes that are achieved more effectively through hands-on experimentation (e.g. identification of assumptions, specific haptic skills), there are other learning outcomes that are achieved more effectively through remotely accessed laboratories (e.g. processing of data, understanding of concepts).

1.2 Loaded Beam - The Rig Apparatus

The Loaded Beam rigs are designed to allow students to study and further their understanding of tensile and compressive forces in structural beams. Structural beams are typically made of wood, steel, or reinforced concrete. The beam used within the Loaded Beam rig is made of polyurethane elastomers - which become stiffer as deflection and impact velocity increase.

The rig consists of three pistons above the beam, which are pneumatically controlled to push down on the beam using a compressed air source. Below the beam and directly underneath the point where the two pistons apply the input loads, there are two probe sensors to measure the descending displacement of the beam. The left end of the beam is fixed or held down by another pneumatically controlled flat piston to hold the beam in position for input loads.

Students develop and verify their mathematical models of beam loading against the real-world data coming from the Rig under a variety of load scenarios using the aforementioned pistons.

The Loaded Beam Rig thus allows students to:

- Characterize the behavior of the beam under tensile and compressive loads
- Acknowledge the stress distribution across the beam
- Acquire the appropriate data of applied forces versus load rate on the beam
1.2.1 Pistons

There are three pneumatic pistons used within the rig. The LHS piston is used to constrain the beam in both the horizontal and vertical axes when Piston B is used. Piston A provides a mid-span load while Piston B provides an end-span load.

The pistons used are SMC CD85 series with associated SMC pneumatic regulators, pressure gauges and relays.

1.2.2 Sensors

The sensors used are RDP Group LDC2000A spring-return linear displacement transducers. The LDC2000A’s use the Linear Variable Differential Transformer (LVDT) principle, providing robust and reliable position data and long sensor life.

1.2.3 Data Acquisition

Data acquisition and control is implemented using a LabJack UE9, linked to the Rig Server PC via an Ethernet connection. The control software from which users drive the Rig is written in LabVIEW and is hosted on a remote machine running Windows Server 2003.

1.2.4 Webcams

Two Apple iSight webcams are connected to the Rig Server PC and stream data over the network, they enable visual feedback of the rig in action – one is aimed at the mid-span section whilst the other provides a complete visual overview of the rig.
2 Rig Session

The following section outlines the procedure for using the Loaded Beam Rig, which is similar to other Remote Laboratory Rig types used in the past. The software that runs the Remote Laboratories and provides access to the rigs through a web browser is called Sahara.

For the purpose of using the rig, it is assumed that users have access to a workstation that meets the system requirements. Users should refer to Labshare's Generic Rig Access Guide for this information.

After logging in with a username and password, the user will be directed to the "Rig Selection" page. Selecting the generic "Loaded Beam Horizontal" or "Loaded Beam Vertical" rig under Rig Types will randomly allocate the user to an available rig. However, if the user wishes to access a particular rig, then this can be selected in the Specific Rigs section. Once a rig is selected, a popup window will appear, asking if the user wishes to join in the queue for the chosen rig. By clicking the "Queue" button, the user now has an access to the selected Loaded Beam rig.

If the rig is "In Use" status, the user will be put in waiting list to access the rig until current user and any other previously queued users are finished. The user's position in the queue may be forfeited if the user navigates away from the queue page.
2.1 Using the Rig Page

If the rig is free, the user will immediately be taken to the rig page where the user can access the Loaded Beam rig control software. Each user has a designated session timeframe to conduct a desired number of experiments. A countdown timer at the top left of the page indicates how much time the user has left on the rig. This may be automatically extended if no other users are waiting to use the rig. The rig session starts as soon as the user is directed to the “Rig Session” page. If the user does not utilize the rig session within the timeline that is given, the rig session may be forfeited.

As the user clicks on the green “Launch” button at the left of the screen, a new window – LabVIEW control application will be automatically launched from its remote location. Note that it may take a couple of seconds for the user’s remote connection to be established. Next screenshot indicates the user interface that is properly launched to use.
Once finished with the experiment, the user can exit by closing the control software window or pressing the red “Terminate” button under Rig Control of the Loaded Beam Session page. This will allow the rig to shut itself down and close the control software properly.

If the user has finished using the rig completely back in the Loaded Beam Session page, then the session can exited by pressing the “Finish Session” button. A popup window will appear asking the user for a confirmation of exit.

Selecting “Yes” will close the current remote connection to the rig and redirect the user to the Rig Selection page. It is important that the user exits the current rig session properly before logging out of the Remote Labs web page to allow other users to access the rig.
If data has been saved during any of the rig experiment runs, these files can be accessed and collected from the “Data Files” link (circled in red) on the Rig Selection page.
This page consists of a collection of all the data files a user has collected from the rigs, listed in chronological order. Selecting one of the files will prompt a popup window where the user is asked to download the data to the current local drive or open the data file with a recommended program.

To exit the Remote Labs page itself, the user can click on the “Logout” button at the top right of the screen. Once again, a popup window will appear asking for a confirmation of exit. Once successfully logged out, the user will be directed back to the main login page of the Remote Labs.
3 Rig Control Software

This section describes how to use the Loaded Beam rig control software created in LabVIEW.

Once the user’s connection to the remote environment is established, the control software is automatically launched and will begin its initialization procedure. During this process, the status bar at the bottom right of the control application will indicate “Rig Resetting, please wait”.

The video feed the Rig Session page indicates what is happening to the rig in real-time where the beam indicates no load application.

Once the initialization is complete, the status bar on the control application will read “Reset Complete, ready for experiment” and grayed-out ‘Test Selection’, ‘Run’ and ‘Set (N)’ sections will be available to use as shown in the next screenshot.
A visual model of the Loaded Beam is displayed on the left portion of the control application. Below the visual model, there is a “Test Selection” section where the user can select a test option to do the experiment. Two graphs on the right of the control application are updated in real time when running the selected test. The top graph indicates a force applied on the beam, and the bottom graph indicates displacement of load applied on the beam directly above Displacement Sensor(s) A (blue) and/or B (red) in real time. Below the displacement graph, there are three buttons – “Run” to carry out the selected load testing, “Abort” to stop the control application to carry out the selected load testing, and “Save Data” to save and collect data after the testing of the selected load has been carried out.

To start, the user needs to choose one type of Loaded Beam test. Then the user can set a number for the load on Piston A up to 100 N and/or Piston B up to 50 N. Also, the user can select different “Load Rate” from the drop down list located next to the visual model for the experiment. When all variable are selected and the user is sure of those selections, “Run” button can be clicked to perform the selected test. Both video screens and the visual model on the control application should indicate that the force is being applied on the beam.

The selected testing and the corresponding data will show up on two graphs on the right side of the control application. Testing can be repeated as many times as the user wishes to perform the experiment within the given session timeframe.
3.1 Experiment Data File Transfer

By clicking the “Save Data” button, an ASCII file will be created where data is automatically recorded – as indicated in the status bar. Then the user can choose to open and/or save the data elsewhere.

All data saved during an experiment run are automatically copied to a server where it can be accessed via the rig page under “Session Files”.

For user convenience, all files are named with the following convention:

\(<TEST \#>_<YYYYMMDD>_<Timestamp>.txt\)

The saved test data consists of 10 columns:

<Time (s)> <LHS State> <A State> <A Force Set (N)> <A Force Measured (N)> <A Displacement (mm)> <B State> <B Force Set (N)> <B Force Measured (N)> <B Displacement (mm)>
Any additional files for subsequent runs are stored here consecutively. To save a copy to the current local drive, the user can simply click on the file – a popup window will appear asking the user for the details of where to save the file.

Once finished using the rig and collected all the data needed, the user can exit the Loaded Beam control software by clicking on the red “Terminate” button under Rig Control on the web page. The button will change to yellow as the rig initiates its shutdown procedure including the automatic exit of the control software as shown below.
4 FAQ & Troubleshooting

Any questions regarding the nature of assessment tasks should initially be directed to the relevant academic. If the user encounters any difficulties during the course of using the rigs, the “Contact Support” button should be used to request assistance and report an incident. The following popup will appear to enter the username and a valid email address. Then the user is to select a category from the drop down list, briefly stating the nature of the request in a few words as a purpose. Then, the detailed description of the incident should be noted in the feedback textbox.

Users are strongly encouraged to leave feedback and comments of their experience with the rigs to help improve the system, as well as any suggestions for additional features to be included in the future.

For any enquires or assistance, contact the Labshare helpdesk at:

helpdesk@labshare.edu.au