



Application of Web Published Virtual Instruments in Delivering Engineering Instructions and Performing Experimental Research

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I. Introduction

In this paper the special utility of the LabVIEW Virtual Instruments published as HTML files is documented and discussed. The Virtual Instruments (LabVIEW programs) created using the software's web publishing tool can be used to complement the effectiveness of the classroom instructions and extend the reach of engineering researchers in more effectively conducting laboratory and field experimentation. The Virtual Instruments (VIs) created as web documents can be placed on a web-server and made available to users at remote locations. These files can enhance the collaborations and interactions among individuals at these stations. For example, the created VIs for a course can be accessed and executed by multiple instructors delivering other sections of the course at various physical locations on and off campus. One of the most valuable features of LabVIEW is its attractive and easy to use user-interface. Through the "controls" and "indicators" available in this user-interface, various parameters, such as beam and loading conditions, can be altered to yield the computed results such as the displacements and stresses instantaneously in any desired form. Using special features available in LabVIEW, the published HTML programs can be set-up in a form that can either be executed by users on the server-side or remote-side. This choice can be altered with ease at any time. The development of two sample VIs created as web documents, for an undergraduate and a graduate engineering mechanics course are included and discussed in the paper to clearly illustrate the power and utility of this type of Virtual Instruments.

LabVIEW Virtual Instruments published as HTML files also seem to have a great potential application in the area of experimental research. Using these files, the investigators have the opportunity to remotely monitor the health of structural members in the field or laboratory without actually needing to be present at the experimental site for the entire duration of the experiment. This capability of LabVIEW is specifically valuable for experiments needing a significant amount of completion time. The author is currently seeking funding for obtaining the needed data acquisition instrumentation to fully investigate this capability of LabVIEW related to performing field/lab experimentation over the web.

II. Virtual Instrument for Enhancement of a Mechanics of Materials Course

In several earlier publications of the author the computing and programming features of LabVIEW were explored in determining the theoretical solution of a number of problems using some of the classical approaches in Mechanics¹⁻³. In Fall 2014, the author utilized two specially designed LabVIEW Virtual Instruments (VIs) to enhance and complement a Mechanics of Materials course. These VIs were prepared as web published HTML files so that they can be run by the author remotely in various classroom locations. The VIs were utilized at the later part of the course after the students were exposed to some of the important course fundamentals such as; determination of internal reactions, construction of shear and moment diagrams, calculation of normal and shearing stress, and utilization of stress transformation equations.

One of the more important advantages of LabVIEW over other software tools is its convenient and user-friendly interface¹. Through using this interface, the problem input can conveniently be modified to calculate and display the results in any desired format. By utilizing the developed LabVIEW Virtual Instruments in the classroom, the faculty was able to interactively run the VIs for a variety of load and beam conditions and quickly generate the corresponding results in a visual form. This enabled the students to better understand the behavior of beams subjected to loads and recognize the factors considered in the design of beams. Arriving at such results using other means is more difficult to achieve. Use of modules such as the ones developed in this project can effectively promote students' interest, enhance classroom interactions, and elevate students' understanding of the important course concepts.

Screenshots of the front panel of two developed VIs utilized in the course are presented in Figures 2 and 4. The depicted VIs were designed by the author with a help of a student engaging in Undergraduate Research. These programs were later converted to HTML files using a procedure presented in the next section of the paper. The idea related to the utilization of the LabVIEW Virtual Instruments prepared as HTML files was introduced by the author in an oral presentation format at the 2014 EMI (Engineering Mechanics Institute) conference held Aug. 5-8, 2014 in Hamilton, Ontario, Canada.

The VI presented in Figure 2 is capable of determining the distribution of shear force, bending moment, slope, and deflection along the length of the beam for any combination of the applied concentrated and distributed loads. This VI additionally computes the maximum normal and shearing stresses induced on the beam to ensure that these stresses do not exceed the allowable limits. In case of failure, a visual indicator placed on the VI's front panel alerts the designer. This failure indicator can be seen at the bottom of the screenshot in Figure 2. An added feature of this VI allows the user to click on a link created at the bottom of the front panel to make a call to a second VI depicted in Figure 4 to compute the "principal" normal and shearing stresses acting at any point on the beam's cross section. This VI is capable of computing the normal and shear stresses on any desired inclined plane located anywhere on the beam. The programming used in the two VIs presented in Figures 2 and 4 are performed by calling a number of other subVIs designed by the author. In the development of several of these subVIs, various computing and programming features of MATLAB were utilized. The block diagram of the two main VIs presented in Figures 2 and 4 are provided in Figures 5(A) and 5(B). The specific details involved in the actual programming of these VIs are not the main focus of this paper and therefore are not included here.

Creation of Web Published LabVIEW Virtual Instruments

Prior to the utilization of the VIs described in the previous section, these VIs were converted into HTML files so that they can be accessed and ran by the author in various classroom locations on campus. The four stages involved in the conversion of a LabVIEW Virtual Instrument into a HTML file are shown in Figure 1. These stages are briefly outlined below.

- (1) Initiating the publishing process by selecting the Web Publishing Tool from the Tools menus.
- (2) Indicating the location of the "VI" residing on the server in the Web Publishing Tool dialog box as shown, so that this program can be accessed over the web.

- (3) Selecting an optional title, header, and footer for the HTML files to be generated. At this stage, the author is provided with an opportunity to view the HTML file before actually publishing it.
- (4) Indicating the location of the LabVIEW “HTML” file on the web server to be linked to the “VI” file already selected in step 2. Once this is selected, the URL address of the created HTML file will be displayed at the bottom of the dialog box. To complete the process, next the “Save to disk” and the “OK” buttons in the next appeared dialog box should be selected consecutively.

Once the Virtual Instrument is published using the above indicated steps, it can remotely be accessed over the web using the URL address indicated in step (4) above. Figure 2 shows the discussed LabVIEW web document created for enhancing a Mechanics of Materials course as seen on the remote site. To run this VI, the users need to click on the web server link at the bottom of the file as indicated in Figure 2 and request control of VI. Once the request is made, the users can remotely run the VI file residing on the server. The screenshot of the front panel of the VI located on the server site is provided in Figure 3. Included on this figure is a message in the middle of the screen indicating that the control has been transferred to the user at the remote site. Note that for any user to be able to access and run this VI, the file must be open on the server.

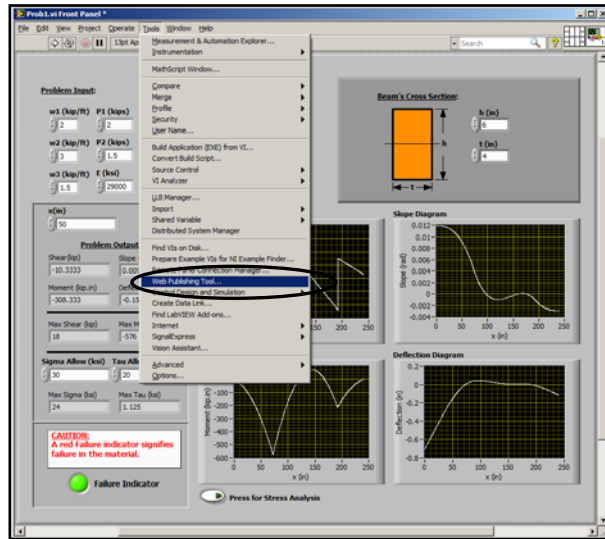
On the server site the owner of the VI has several options to further control the access to the VI. These options can be revealed by clicking on the URL address at the bottom of the VI as shown in Figure 3. As observed, the owner can elect to:

- (a) “Regain” the control of the VI after it has been used by a user at the remote site, so that it can be run again on the server site.
- (b) “Switch” the controller, so that another user located at a different site can run the file. Note that any number of users can access the file at the same time, but only one user at a time can actually run the VI.
- (c) “Lock” the file so that a user cannot run the file at a particular site (i.e., only allow viewing).
- (d) “Unlock” the file to grant access again to that user.

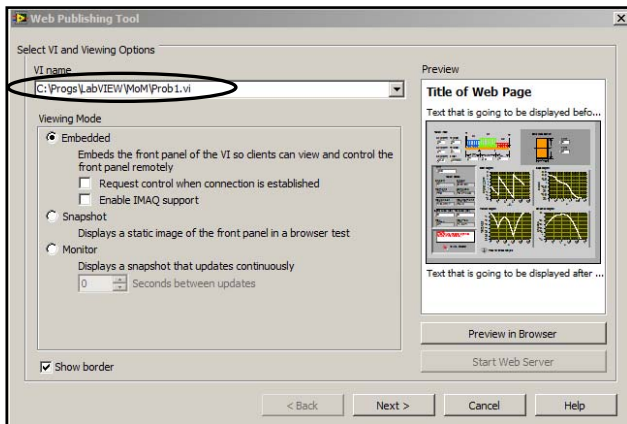
To view and run the published VIs on the remote site, the users only need to install on their computers the LabVIEW Run-Time Engine for the particular web browser they are using. This Run-Time Engine can be downloaded free of charge from the *National Instruments* website.

Assessment of the LabVIEW Modules Used in the Course

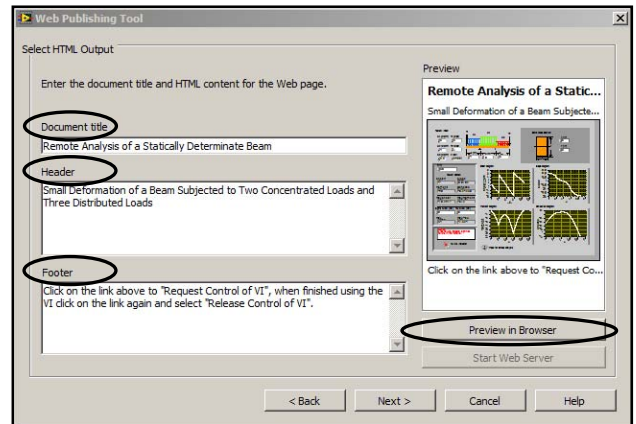
The developed LabVIEW modules were utilized in two sections of the Mechanics of Materials course taught in Fall 2014 at Georgia Southern University. The author accessed and ran these modules residing on a server in his office from two separate classroom locations on campus. In the two sections, a survey was also conducted at the end of the semester to measure the effectiveness of the modules in enhancing the delivery of some of the important concepts covered in the course. Full assessment result for rating each component of the modules is provided in Table 1. As observed, the responses have been overwhelmingly positive and validate the effectiveness and utility of the created modules in further enhancing the course.



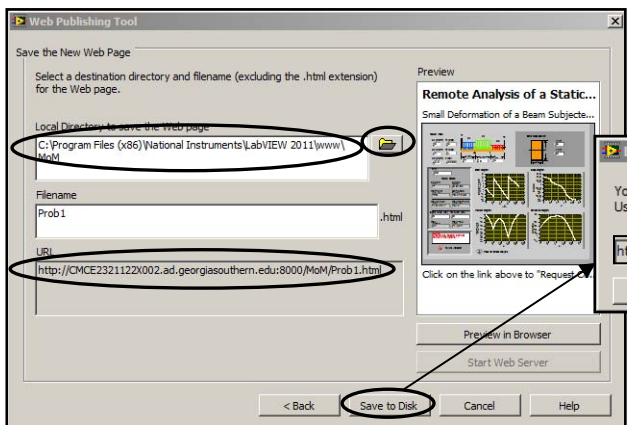
(1)



(2)



(3)



(4)

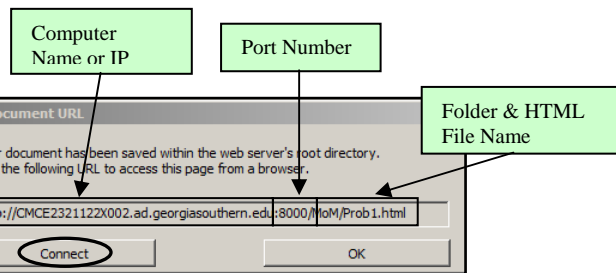


Figure 1. Four Stages for Publishing a LabVIEW Virtual Instrument on the Web

Remote Analysis of a Statically Determinate Beam - Internet Explorer

http://cmce2321122x002... Remote Analysis of a Statical... x

Remote Analysis of a Statically Determinate Beam

Small Deformation of a Beam Subjected to Two Concentrated Loads and Three Distributed Loads

Using the three options shown, the users at the remote site can "Run", "Continuously Run", or "Stop the Execution" of the VI.

Problem Input:

w1 (kip/ft) P1 (kips)
 2 2

w2 (kip/ft) P2 (kips)
 3 1.5

w3 (kip/ft) E (ksi)
 1.5 29000

a (ft) b (ft) c (ft)
 6 10 4

Beam's Cross Section:

h (in) 6
 t (in) 4

Problem Output:

Shear (kip) Slope (rad)
 -10.3333 0.00907

Moment (kip.in) Deflection (in)
 -308.333 -0.15426

Max Shear (kip) Max Moment (kip.in)
 18 -576

Sigma Allow (ksi) Tau Allow (ksi)
 30 20

Max Sigma (ksi) Max Tau (ksi)
 24 1.125

CAUTION:
 A red Failure indicator signifies failure in the material.

Failure Indicator

Press for Stress Analysis

A call can be made to another VI to perform the stress analysis on the beam.

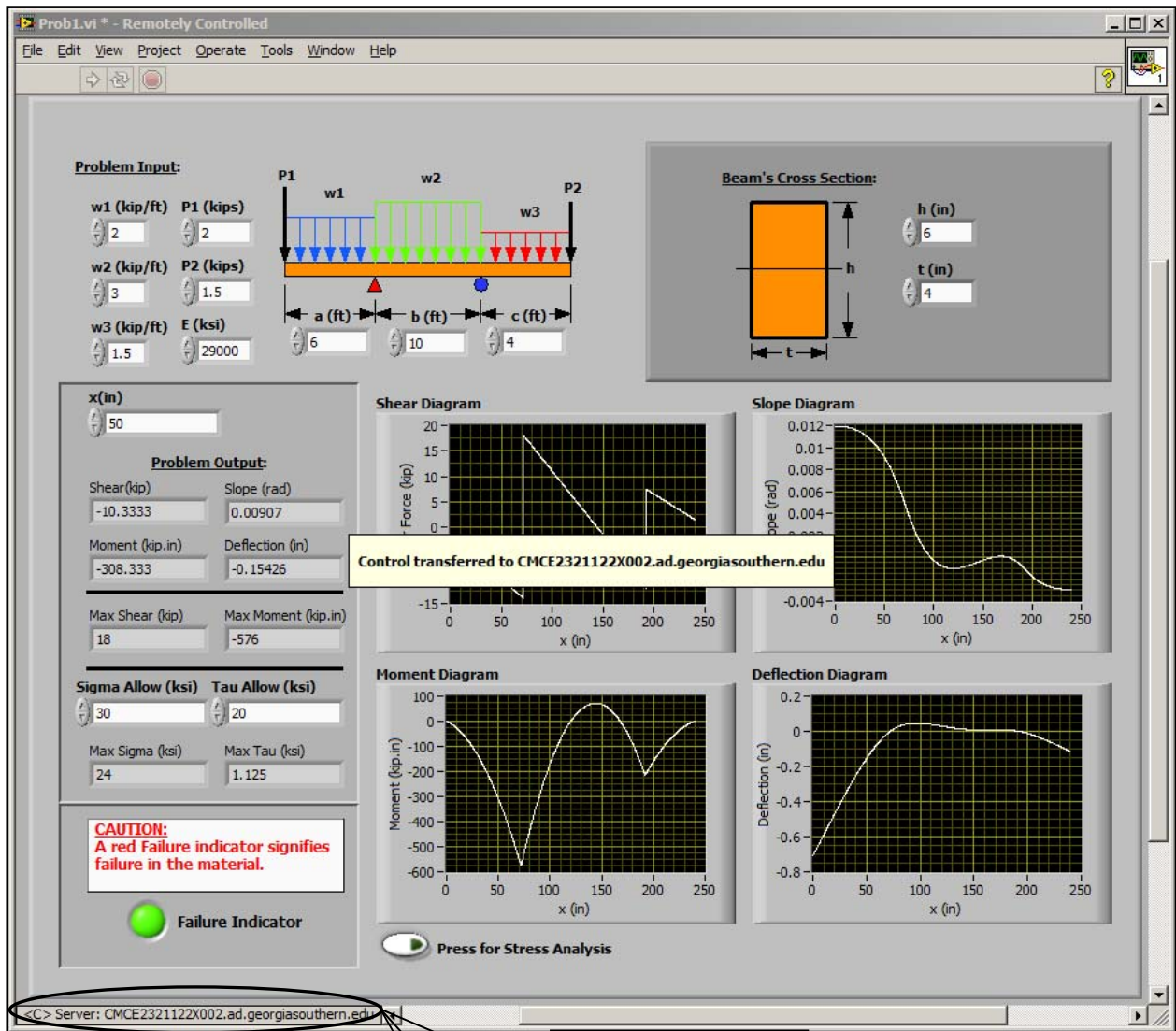
Click on the link above to "Request Control of VI", when finished using the VI click on the link again and select "Release Control of VI".

Request Control of VI
 Release Control of VI
 Show Last Message
 Show Control Time Remaining
 Close Panel

Request Control of VI
 Release Control of VI
 Show Last Message
 Show Control Time Remaining
 Close Panel

Other options available on the remote site are shown on the right side. These choices can be revealed by clicking on the URL address shown at the bottom of the VI above.

Figure 2. Web Published LabVIEW Virtual Instrument for Analyzing a Beam as Viewed on the Remote Site



Four main options available on the server site:

- (a) **Regain Control**
- (b) **Switch Controller**
- (c) **Lock Control**
- (d) **Unlock Control**

These choices can be revealed by clicking on the URL address shown at the bottom of the VI above.

Regain Control

Switch Controller

Show Last Message

Lock Control

Switch Controller

Show Last Message

Unlock Control

Switch Controller

Show Last Message

Figure 3. Front Panel of the LabVIEW Virtual Instrument Residing on the Server Site for Analyzing a Beam

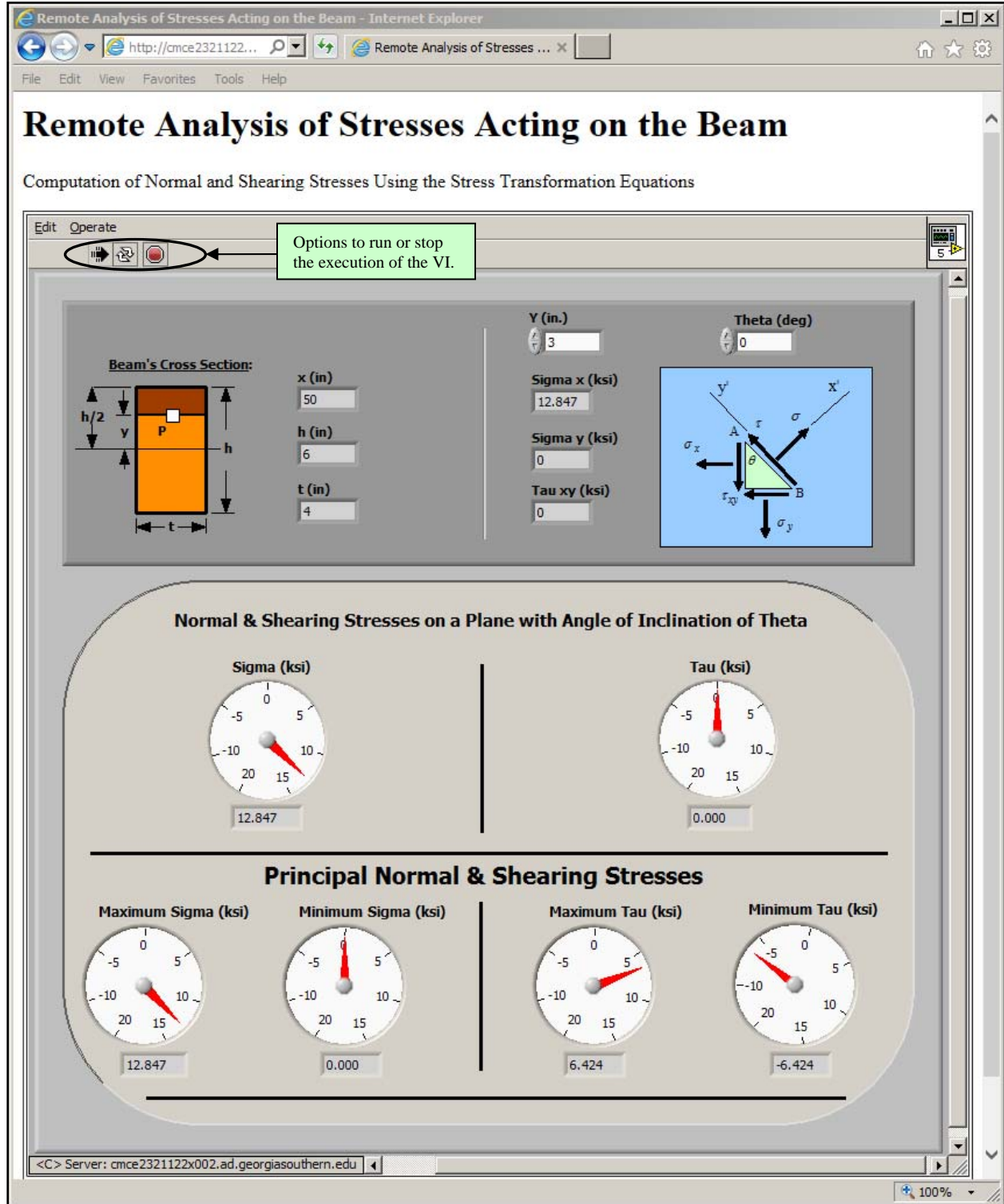
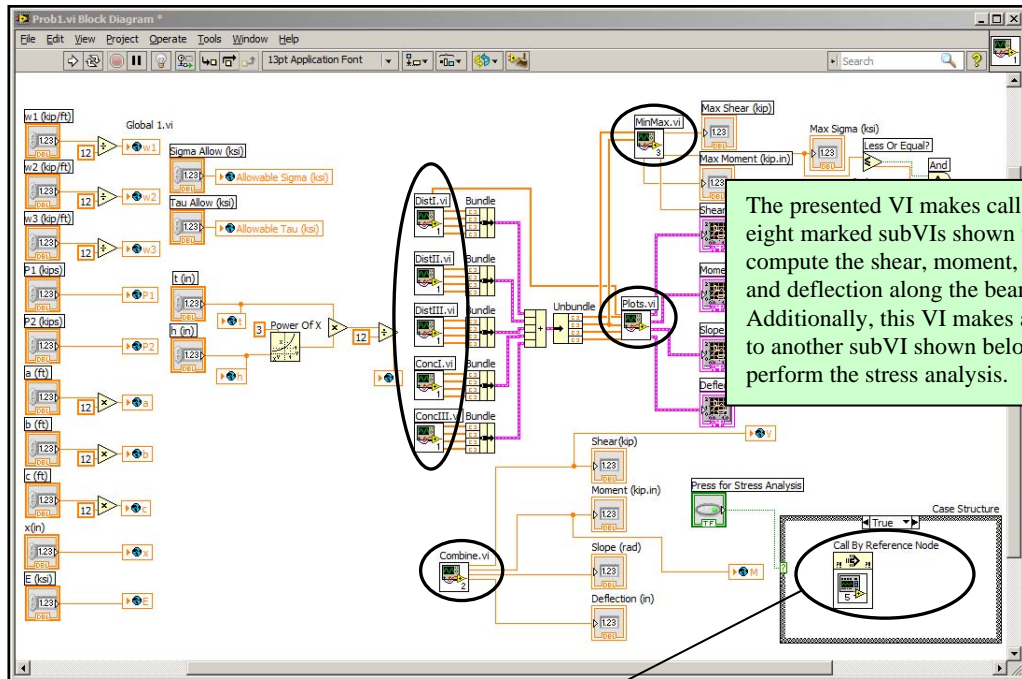


Figure 4. Web Published LabVIEW Virtual Instrument on the Remote Site for Performing the Stress Analysis on the Beam

(A)



The presented VI makes calls to eight marked subVIs shown to compute the shear, moment, slope, and deflection along the beam. Additionally, this VI makes a call to another subVI shown below to perform the stress analysis.

(B)

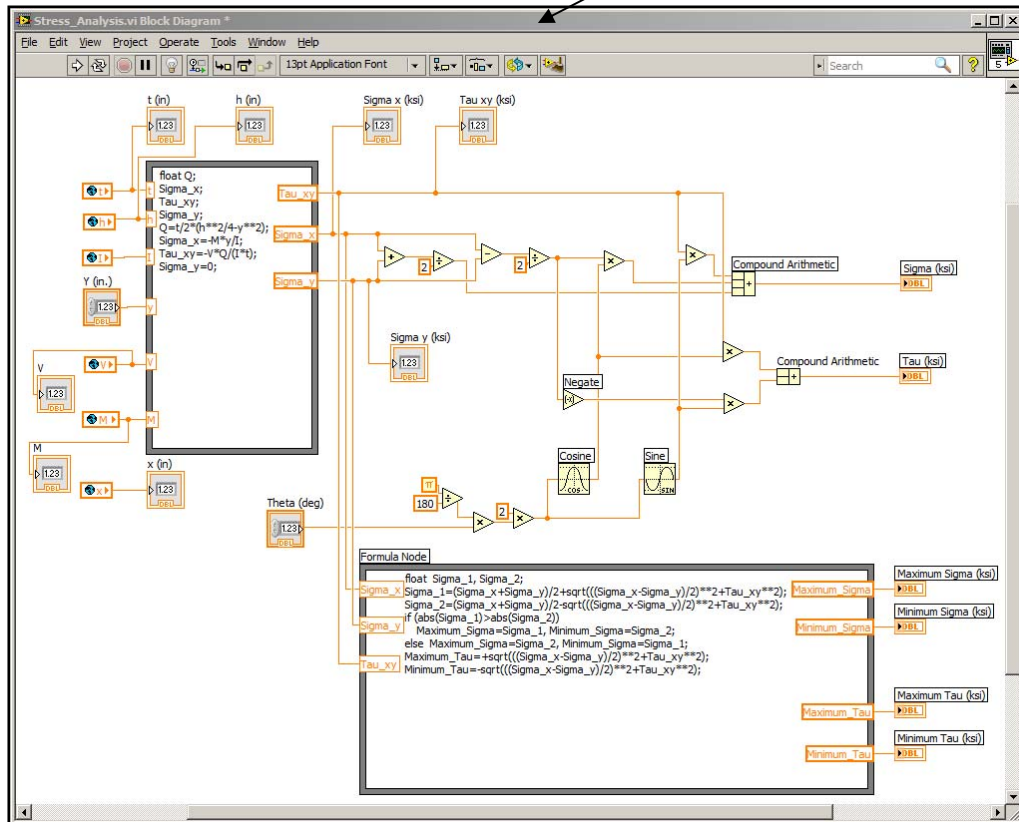


Figure 5. Block Diagrams of the Two Developed LabVIEW Virtual Instruments; one for Analyzing the Beam (5A), and the other for Performing the Stress Analysis at a Point (5B)

ENGR 3233 – Mechanics of Materials
Utilization of LabVIEW in Enhancing a Mechanics of Materials Course
Student Evaluation Sheet – Fall 2014

Please rate the effectiveness of utilization of the LabVIEW module such as the one presented in this lecture in further complementing a Mechanics of Material course on a scale of 1-5 as described below.

(1) Strongly Disagree (2) Disagree (3) Neither Disagree or Agree (4) Agree (5) Strongly Agree

1. The created module help students better understand:
 - (a) The Shear & Bending Moment Diagrams for beams.
 - (b) The deformation of the beams subjected to various loads.
 - (c) The Bending & Shear Stress Calculations.
 - (d) The Stress Transformation.
 - (e) The factors influencing the design of beams.
 - (f) The importance of various principles/concepts discussed in the Mechanics of Materials course.

2. Overall the utilization of the LabVIEW module is a helpful addition to the course and enhances the students' understanding of some of the key course topics.

Section A

	Strongly Disagree (1)	Disagree (2)	Neither Agree or Disagree (3)	Agree (4)	Strongly Agree (5)	Total Responses
Question #1 (a)	0 (0%)	0 (0%)	1 (7.7%)	7 (53.8%)	5 (38.5%)	13 (100%)
Question #1 (b)	0 (0%)	0 (0%)	2 (15.4%)	7 (53.8%)	4 (30.8%)	13 (100%)
Question #1 (c)	0 (0%)	0 (0%)	5 (38.5%)	6 (46.1%)	2 (15.4%)	13 (100%)
Question #1 (d)	0 (0%)	1 (7.7%)	2 (15.4%)	9 (69.2%)	1 (7.7%)	13 (100%)
Question #1 (e)	0 (0%)	0 (0%)	0 (0%)	7 (53.8%)	6 (46.2%)	13 (100%)
Question #1 (f)	0 (0%)	0 (0%)	1 (7.7%)	8 (61.5%)	4 (30.8%)	13 (100%)
Question #2	0 (0%)	0 (0%)	3 (23.1%)	6 (46.1%)	4 (30.8%)	13 (100%)

Section C

	Strongly Disagree (1)	Disagree (2)	Neither Agree or Disagree (3)	Agree (4)	Strongly Agree (5)	Total Responses
Question #1 (a)	0 (0%)	0 (0%)	0 (0%)	7 (36.8%)	12 (63.2%)	19 (100%)
Question #1 (b)	1 (5.3%)	0 (0%)	3 (15.8%)	7 (36.8%)	8 (42.1%)	19 (100%)
Question #1 (c)	0 (0%)	2 (10.5%)	1 (5.3%)	7 (36.8%)	9 (47.4%)	19 (100%)
Question #1 (d)	0 (0%)	0 (%)	1 (5.2%)	9 (47.4%)	9 (47.4%)	19 (100%)
Question #1 (e)	0 (0%)	0 (0%)	2 (10.5%)	11 (57.9%)	6 (31.6%)	19 (100%)
Question #1 (f)	0 (0%)	1 (5.3%)	1 (5.3%)	10 (52.6%)	7 (36.8%)	19 (100%)
Question #2	0 (0%)	0 (0%)	2 (10.5%)	7 (36.9%)	10 (52.6%)	19 (100%)

Table 1. Student Assessment Results for the Evaluation of the Developed LabVIEW Modules Conducted in Two Sections of the Mechanics of Materials Course

III. Virtual Instrument for Enhancement of an Advanced Mechanics Course

In one of the earlier publications of the author³, a LabVIEW Virtual Instrument was developed for solving a more advanced problem dealing with nonlinear bending of beams. This VI was specifically designed to determine all possible deflected shapes of a flexible cantilever beam subjected to an end inclined load. All numerical computations in this VI for producing the final results were performed by making calls to nine other user-defined subVIs developed by the author. The actual theoretical formulation and programming details regarding this problem were covered in the earlier publication³ and therefore are not included here. The front panel of the web published version of this file however has been created and provided in Figure 6. Observed in this figure is one of the possible deflected configurations of the beam, along with the distributions of slope, shear, moment, and axial force along the length of the member for a prescribed set of beam and loading parameters. This VI can be used as a great tool for design of beams, since the users can run this program for a variety of beam and loading condition and determine an optimal solution. The produced HTML version of the VI greatly enhances the utility of this module since it can be accessed remotely by instructors teaching advanced courses in solid mechanics, or by other investigators interested in the problem of large deformation of beams. Since until the present time no advanced mechanics courses have been offered at the author's institution, no assessment data related to the actual utility of this particular VI in the classroom could be provided. Web published LabVIEW Virtual Instruments such as the one presented here can be developed for other more complicated problems and shared with users at remote sites.

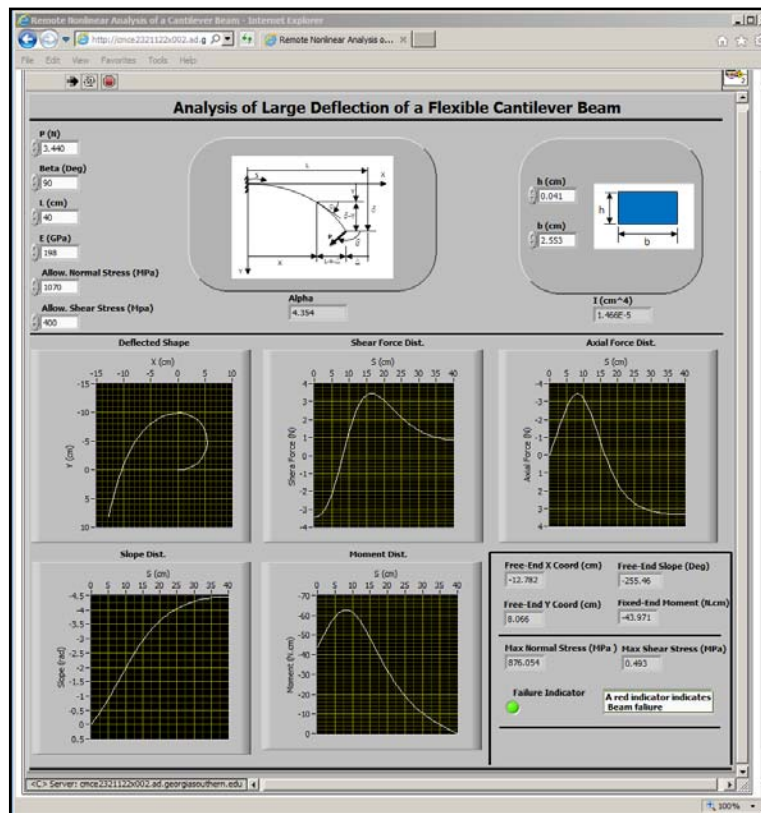


Figure 6. Front Panel of the Web Published LabVIEW Virtual Instrument for Analyzing the Nonlinear Behavior of a Cantilever Beam Subjected to an End Load

IV. Summary & Conclusion

In the presented paper the procedure for creating web published LabVIEW Virtual Instruments and the utility of these special VIs were discussed using two sample HTML files. These special VIs are particularly useful and effective due to the fact that they can simultaneously be accessed and interactively run by various users at remote locations with ease. The LabVIEW published HTML files can effectively enhance the collaborations and interactions between investigators located at various sites. The web publishing capability of LabVIEW seems to have a great potential application in conducting laboratory and field experimentation. Using this capability, the progress of the lab or field experiments requiring a significant amount of completion time can be monitored remotely without having to be present at the experimentation site. The author plans to further investigate this capability of LabVIEW in his next research. A fund request has been submitted for acquiring the data acquisition instruments needed for this research. The investigator also hopes to be able to compare this method of analysis to other available approaches to possibly choose the optimal method for remotely conducting lab or field experimentations. This research can have a great potential in monitoring and evaluating the health of structural members.

Acknowledgement

The author would like to thank Mr. Ryan Mooney, an undergraduate Mechanical Engineering Technology student at Georgia Southern University for his assistance in developing an initial version of the VIs for the first example included in the paper. This was done in spring of 2009. As discussed in the paper, the initial version was prepared in a form not accessible over the web.

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