LABORATORY PLANNING GUIDE

L13 Structural Engineering Laboratory

Content

G.U.N.T. Gerätebau GmbH, Hanskampring 15-17, 22885 Barsbüttel, Germany
Phone: +49 40 670854-0, E-mail: sales@gunt.de, Web: www.gunt.de

Covered subjects according to the curriculum of Structural Engineering

Major topics of learning content:

- bending tests, load tests, compression tests
- investigation of member forces in the plane, statically determinate truss
- familiarisation with a Gerber beam
- application of the method of sections and the conditions of equilibrium to calculate the support forces for
  - point load, distributed load and moving load
- determination of the internal reactions under static load
  - shear force curve
  - bending moment diagram
- determination of the lines of influence under moving load
- comparison of the calculated and measured reactions for static and moving load
- mechanical principles of the parabolic arch
- differences between statically determinate and statically indeterminate arches
- measurement of the deformations of the arch under load
- measurement of the support reactions on the statically indeterminate arch under load
- calculation of the support reactions
- influence of load on reaction forces and deformation of the arch
- familiarisation with three-hinged arches (unsymmetrical and symmetrical)
- investigation of the influence of the load on the horizontal thrust in the supports
- familiarisation with a suspension bridge
  - under dead-weight, additional weight, evenly and unevenly distributed loads
- calculation of the supporting cable force
- comparison between calculated and measured values of the supporting cable force
- observation of the effect of internal moments in the roadway under uneven load
  - for a stiff roadway and for an elastic roadway
- determination of the catenary of a free-hanging cable
  - under dead-weight only and with additional weights
  - with a symmetrical setup (chain wheels at same height)
  - with an unsymmetrical setup
- measurement of the sag
- determination of the buckling force for the case of an:
  - elastic joint and elastic fixed end support
- investigation of the buckling behaviour under the influence of:
  - of additional shear forces and pre-deformation
- relationship between load application and deformation on the frame
- differences between statically determinate and statically indeterminate frames
- familiarisation with the first-order elasticity theory for statically determinate and indeterminate systems
- application of the principle of superposition
- application of the principle of virtual work on statically determinate and statically indeterminate frames
  - determination of a deformation by the principle of virtual forces
  - determination of a load by the principle of virtual displacement
- comparison of calculated and measured deformations
- measurement of the bar forces in various single plane trusses

- dependency of the bar forces on the external force
  - magnitude, direction, point of application
- comparison of measuring results with mathematical methods
  - method of joints, Ritter's method of sections, Cremona diagram
- basic principle: measurement of forces using strain gauge measurement
- distribution of forces in the single plane truss dependent on the use of a surplus bar
- torsion of a bar
- shear modulus of elasticity and second polar moment of area
- angle of twist dependent on clamping length and torque
- influence of rigidity on torsion
  - round bar with full cross-section
  - tube
  - tube, longitudinally slotted
  - square tube
- calculation of angle of twist
- comparison of calculated and measured angle of twist
- elastic deformation of truss under point load
- calculation of support reaction and bar forces
- principle of work and strain energy
- application of Castigliano's first theorem to calculate the deformation at a defined point
- verification of the calculated deformation possible by the principle of virtual work
- elastic lines for statically determinate or indeterminate beams under load
- determination of the elastic line of a beam by
  - the principle of virtual work (calculation)
  - Mohr's analogy (area moment method devised by Mohr; graphical representation)
- determination of the
  - maximum deflection and angle of inclination of the beam
- comparison between calculated and measured values for angle of inclination and deflection
- experimental development of the core principle of "freeing" in statics
- calculation of the support forces for a given position of the clamp weight and for a known angle of inclination
- application of the 1st and 2nd equilibrium conditions in statics
- and full compensation of the support forces by cable forces
- how does the clamp weight position affect the support forces
- how the angle of inclination affects the support forces
- free vibration in a vertical and horizontal bending beam
- determine the natural frequency according to Rayleigh
- how clamping length and mass affect the natural frequency
- investigation of deflection for statically determinate & indeterminate straight beams
  - cantilever beam
  - single-span beam, dual- or triple-span beam
  - formulation of the differential equation for the elastic line
- deflection on a cantilever beam
  - measurement of deflection at the force application point
- deflection of a dual-span beam on three supports
  - measurement of the support reactions and deformations
- influence of the material (modulus of elasticity) and the beam cross-section (geometry) on the elastic line
- Maxwell-Betti coefficients and law

- determination of lines of influence
  - arithmetically or qualitatively by way of force method (Müller-Breslau)
- calculation of the reactions arising from the static conditions of equilibrium
- application of the method of sections to calculate the internal forces and moments
  - under a point load and under multiple point loads
- calculation of the shear force diagram and the bending moment diagram
- comparison of calculated and measured values for shear force and bending moment
- generate plane stress states in various models under compressive load

Main concept

The laboratory is designed for accommodation of 24 students + 2 laboratory staff:

- 2 - 4 students form a team and work together at a workstation / training system
- 12 different workstations
- 12 laboratory tables and storage space required for alternating use
- 4 workstations are equipped with a PC
- Each workstation is equipped with a manual containing technical information, basic theory, experiment instructions, evaluation help and safety advice.
- Student teams are scheduled to change workstations from lab session to lab session in order to perform the entire range of experiments within the course duration.
- Average time per experiment: 90 to 120 minutes.
- 2 workstations for laboratory staff (with PC and internet access)
- 1 printer for common use
- 1 cupboard for small parts, consumables, tools, paper etc.

Initial training provided for laboratory personnel

Trainer: Specialized engineer of G.U.N.T. Gerätebau GmbH, Germany.
To be conducted immediately after installation and commissioning of the equipment.
General topics to be covered for any of the educational systems:

- Basic familiarization with the system.
- Functions and components.
- Overall system configuration aspects.
- Start-up and operational aspects.
- Conduction experiments, including evaluation and calculation.
- Using the system with and without the software (where applicable).
- Trouble shooting and maintenance aspects.
- Hands-on, practical familiarization aspects.
- Seminar participants with the delivered system.
- Details of the manuals.
- Safe operation and preventive maintenance.

Requirements / Utilities

Power supply:

- 230 V / 50 Hz / 1 phase – at least 12 power sockets distributed according to lab lay-out

Laboratory computer network:

- 2 internet connections for staff
- 4 internet connections for students

Location:

- Laboratory space min 80 m²
- This laboratory should be installed on the ground floor

Schedule of requirements

Item No.	Description	Quantity
Item 1	Frame for load testing, 400kN	1 pcs.
Item 1.1	Standard accessories for load testing	1 pcs.
Item 1.2	Hydraulic loading device, 2x200kN	1 pcs.
Item 1.3	Dial gauges	1 pcs.
Item 1.4	Plane frame with strain gauge for member forces measuring	1 pcs.
Item 1.4.1	Multi-channel measuring amplifier	1 pcs.
Item 1.5	Hydraulic loading device, 1x200kN	1 pcs.
Item 2	Mounting frame	6 pcs.
Item 2.1	Lines of influence on the Gerber beam	1 pcs.
Item 2.2	Parabolic arch	1 pcs.
Item 2.3	Three-hinged arch	1 pcs.
Item 2.4	Forces on a suspension bridge	1 pcs.
Item 2.5	Investigation of simple stability problems	1 pcs.
Item 2.6	Deformation of frames	1 pcs.
Item 2.7	Forces in various single plane trusses	1 pcs.
Item 2.7.1	Multi-channel measuring amplifier	1 pcs.
Item 2.8	Forces in an overdeterminate truss	1 pcs.
Item 2.8.1	Multi-channel measuring amplifier	1 pcs.
Item 2.9	Torsion of bars	1 pcs.
Item 2.10	Dial gauges	1 pcs.
Item 2.11	Deformation of trusses	1 pcs.
Item 2.12	Methods to determine the elastic line	1 pcs.
Item 2.13	Cable under dead-weight	1 pcs.
Item 2.14	Equilibrium in a single plane, statically determinate system	1 pcs.
Item 2.15	Free vibrations in a bending beam	1 pcs.
Item 3	Forces in a Howe truss	1 pcs.
Item 3.1	Multi-channel measuring amplifier	1 pcs.
Item 3.2	Truss beam: Warren girder	1 pcs.
Item 4	Deformation of straight beams	1 pcs.
Item 5	Beam on two supports: shear force & bending moment diagrams	1 pcs.
Item 6	Forces in a simple bar structure	1 pcs.
Item 7	Photoelastic experiments with a transmission polariscope	1 pcs.
Item 7.1	Set of 5 photoelastic models	1 pcs.