MASSACHUSETTS

INSTITUTE OF TECHNOLOGY,

BOSTON, MASS.

DEPARTMENT

OF

CIVIL ENGINEERING.

BOSTON:
PRESS OF H. G. COLLINS, 15 MILTON PLACE.
1892.

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THE DEPARTMENT OF CIVIL ENGINEERING.

Six years ago, in recognition of the tendency toward specialization, which is so marked in all branches of engineering, the course in Civil Engineering at the Institute was rearranged and essentially modified by the introduction of options in the fourth year. As important changes in the course and extensive additions to the equipment of the department have since been made, it seems now proper to publish a detailed statement of the progress and present condition of the department and of its means and methods of instruction.

The educated engineer, whatever branch of the profession he may follow, is constantly called upon to make application of the principles of mathematics, mechanics, and physics, of the laws governing the stability of structures, the resistance of materials, or the flow of water, in dealing with problems involving the development of natural resources, the construction or improvement of channels of transportation, or the maintenance of the public health. These subjects must, therefore, be included in any sound course of instruction in Engineering. But the rapid development of the technical sciences and the specialization of the various departments of Civil Engineering have so enlarged its field as to make it impossible, in any course of four years, to cover adequately and thoroughly all branches of the profession, and have rendered it desirable that the student should be allowed some freedom of choice as to the particular line of work to be pursued in the application of these general principles. To meet this requirement, three options are offered to the students in the fourth year: first, one in which more attention than usual is devoted to Hydraulic and Sanitary Engineering; second, one in which particular attention is given to Railroad Engineering and Management; and, third, one in which special attention is given to Geodesy. The first of these options may be regarded as a general course in Civil Engineering, since it includes in the third year a considerable amount of instruction in railroad engineering, and in the fourth year a brief and elementary course in geodesy and astronomy. This option, therefore, besides being suitable for students intending to engage in hydraulic or sanitary engineering, is particularly adapted to those who wish to make their course as general as possible, either with the intention of continuing their studies after graduation, or from inability to decide which branch of the profession they wish ultimately to pursue; the second option is designed for students who desire to engage in the location, construction, or management of railroads; while the third is designed for students who wish to engage in State or government surveys, or who may desire to pursue advanced astronomical or mathematical work after graduation.

It must not be supposed, however, that any of these options fits a student only for the special line of work peculiar to it. On the contrary, the course is arranged on such a broad basis, and the training gained in the different studies is such, that a graduate in any option is qualified to engage in work in either of the other lines, although, of course, to less advantage, at first, than in his chosen branch.

Attention should here be called to the fact that since the introduction of these options into Course I., the rapid development of sanitary engineering, and the closer relations which have come to exist between the sanitary engineer, the chemist, and the biologist, have led to the adoption of a specific course in Sanitary Engineering (Course XI.) in which certain purely engineering studies of Course I. are replaced by work in Chemistry and Biology. As a special circular has been issued relating to this course, it is sufficient to say here that it is designed for students who have determined, from the beginning, not to engage in railroad, bridge, or geodetic work, but who desire to devote themselves to problems involving the health of communities, such as sewerage and water supply.

The following is the

SCHEDULE OF THE COURSE IN CIVIL ENGINEERING,

(the first term being the same as in all the other courses of the Institute.)

FIRST YEAR.

FIRST TERM.	SECOND TERM.
Algebra.	Plane and Spherical Trigonometry.
Solid Geometry.	General Chemistry.
General Chemistry.	Qualitative Analysis.
Chemical Laboratory.	Mechanical Drawing; Descriptive Geometry.
Mechanical and Freehand Drawing.	Freehand Drawing.
Rhetoric and English Composition.	Political History since 1815.
French.	French.
Military Drill.	Military Drill.

SECOND YEAR.

FIRST TERM.	SECOND TERM.
Surveying; Chain, Compass, and Transit. Plotting from Notes. Topographical Drawing. Analytic Geometry. Physics. Descriptive Geometry. Elements of Astronomy. American History. English Literature. German.	Surveying and Drawing; Level, Pocket Instruments, and Solar Compass. Differential Calculus. Physics. Physical Geography. Mechanism. English Literature and Composition. German.

THIRD YEAR.

FIRST TERM.	SECOND TERM.
Railroad and Highway Engineering. Railroad Field Work and Drawing. Stereotomy. Surveying; Stadia and Sextant. Integral Calculus. Mechanics; General Statics. Physics: Heat. Physical Laboratory. Structural Geology. German. Political Economy. Business Law.	Railroad and Highway Engineering. Railroad Field Work and Drawing. Theory of Structures. Surveying: Plane Table. Applied Mechanics: Strength of Materials. Physical Laboratory. Historical Geology. German. Political Economy and Industrial History. Business Law.

FOURTH YEAR.

FIRST TERM.

OPTION 1.	OPTION 2.	OPTION 3.
Theory of Structures. Bridges and Roofs. Hydraulics Strength of Materials. Sanitary and Hydraulic Engineering. Hydraulic Field Work. Elements of Practical Astronomy. Metallurgy of Iron. Bridge Design. Elements of Dynamo Machinery.	Theory of Structures. Bridges and Roofs. Hydraulics. Strength of Materials. Railroad Engineering. Railroad Management. Railroad Signals. Metallurgy of Iron. Bridge Design. Elements of Dynamo Machinery.	Theory of Structures. Bridges and Roofs. Hydraulics. Strength of Materials. Geodesy and Astronomy. Method of Least Squares. Hydraulic Field Work. Physical Laboratory.

SECOND TERM.

OPTION 1.	OPTION 2.	OPTION 3.
Theory of Structures. Bridges and Roofs. Thesis Work. Hydraulic Engineering. Sanitary Science and the Public Health. Sanitary and Bridge Design. Engineering Laboratory. Elements of Geodesy. Machinery and Motors.	Theory of Structures. Bridges and Roofs. Thesis Work. Railroad Engineering. Building Construction. Railroad and Bridge Design. Engineering Laboratory. Machinery and Motors.	Theory of Structures. Bridges and Roofs. Thesis Work. Hydraulic Engineering. Geodesy. Differential Equations. Field Work and Laboratory.

The instruction is given by lectures and recitations, practice in the field, and exercises in the drawing room. The constant aim is not only to make the student thoroughly familiar with the principles on which all sound engineering must be based, but to illustrate the application of those principles in such detail that he may clearly appreciate their use, and their relation to practical work. While it is recognized that most matters of mere practical detail are best and most quickly learned through experience in actual work, and while it is believed that the particular province of a higher school of engineering is to develop in the mind of the student first of all a clear perception and a proper appreciation of what may be called the theoretical side of engineering, yet it is deemed equally essential that the practical application of these principles shall be so clearly pointed out and so frequently illustrated and enforced that the student shall be able to make intelligent and prompt use of his knowledge whenever occasion arises. It is believed that only by teaching theory and practice together can proper results be obtained, and the student be made clearly to see their connection. In many cases (as in bridges) the study of details affords the best possible opportunity for the application of principles, and much time is therefore devoted to it; and in each branch of instruction it is sought to acquaint the student with matters of fact and of detail to an extent sufficient to enable him to enter at once upon the practice of his profession, and to render him capable of filling any position that would be offered to one just completing a four years' course.

In accordance with these ideas, much time is devoted to Design, and the student is allowed to carry out his own ideas whenever practicable, and encouraged to devise his own solutions to problems proposed. The designs of the student are afterwards criticised, and errors or possible improvements pointed out.

Excursions are made to such engineering works in the vicinity as may illustrate or lend interest to the work in hand; and by the study and comparison of executed works, in addition to the training in design, the student becomes acquainted, as far as the time will allow, with the practice of the day.

In class-room work mere lecturing is avoided where practicable. Text-books are used so far as they are available, and in many cases printed or lithographed notes have been prepared by the instructors, specially adapted to the needs of their classes. The students are thus largely relieved of the necessity of taking notes in the classroom.

In surveying field work the classes are divided into small parties of from two to five students, and an instructor is assigned to each party. The work is thus carried out under careful supervision, and without loss of time. In order to secure further economy of time, each class devotes an entire day in each week to field work, during favorable weather.

The work in the drawing room is, as far as possible, original, and, except in the first year and in topographical drawing, there is no drawing for practice in manual execution alone. Every drawing made by the student is either a plan of a survey made by the class, the solution of some problem, or the drawing of some design made by himself. He therefore learns how to execute and what to execute at the same time, after having acquired, in the first year, the principles of drawing and the use of the instruments.

In arranging the course, one object in view has been to give the student as broad and liberal a training and to lead him to as many points of view as may be consistent with due compactness and thoroughness. To this end, general studies, in composition, history, literature, political economy, and business law, extend through the first three years of the course. Further, in addition to the main professional subjects, briefer courses are offered in allied branches of science, and in cognate professional subjects not strictly within the option chosen. Such, for instance, are the courses in physical geography and geology in the second and third year; in the elements of astronomy and geodesy, and in sanitary science, in the fourth year. Care is taken to impress upon the students the fact that, like other professional men, the civil engineer, in order to attain success, must be broad and not narrow, that he must be able to write and to speak correctly, and that an active interest in questions of the day and a knowledge of political economy and of sciences outside of his strictly professional work may be of the greatest value to him; while, on the other hand, a habit of writing or speaking carelessly, or from a narrow point of view, may impede or limit his progress, notwithstanding great professional ability.

SURVEYING AND TOPOGRAPHY.

The work in these branches extends through the second and third years, and is followed by Geodesy in the fourth year. During the second year one day per week throughout the year is devoted to field work and drawing, together with class-room exercises. Great stress is laid on the early acquirement of rapid and accurate habits in the use of instruments and the keeping of neat field notes; and for this purpose the classes are divided, for work in the field, into small divisions, so that each student shall be constantly engaged, and shall have practice in all the manipulations. The field work comprises the use of the chain, compass, transit, level, clinometer, hand level, aneroid barometer, solar compass, and the solar attachment to the transit; the adjustments of these various instruments; the astronomical determination of the meridian; levelling for profiles and contours; and practice in surveying without instruments. By dividing a large class into a number of sections, and assigning each to a separate portion of the work, problems of considerable interest and magnitude are sometimes undertaken. So far as possible, fresh problems are given each year. The results of the field work are plotted in the drawing room, and the student is instructed in the methods of computing areas, latitudes, and departures; in the various problems involved in land, city, and underground surveying, and in the methods used in the public land surveys of the United States.

The field work of the third year includes the use of the stadia, sextant, and plane table, and the operations involved in topographical and hydrographical surveying.

The department possesses a large and constantly increasing equipment, in which almost all the principal instrument makers are represented.

TOPOGRAPHICAL DRAWING

is taught in the second and third years. In the second year the student is made familiar with the various conventional signs and methods of representing topography, the standards used being those of the United States Coast and Geodetic Survey. In the third year this knowledge is applied in making a map of a railroad location.

GEODESY.

Students taking the general option receive, in the first term of the fourth year, a short course in Practical Astronomy, embracing an elementary discussion of the methods of determining latitude, longitude, time, and azimuth, together with the theory of the usual astronomical instruments. This is followed, in the second term, by a brief course in Geodesy, embracing a discussion of the figure of the earth, and of the methods of measuring base lines and of carrying on a geodetic survey.

Students in the geodetic option pursue these subjects in much greater detail, taking also the course in Least Squares.

SUMMER COURSE IN GEODESY, TOPOGRAPHY, AND GEOLOGY.

In the early part of the vacation following the third year, students in Civil Engineering have the privilege of attending a summer course, which offers about four weeks of continuous field practice, thus affording more extended training in this direction than it is possible to give during the school year. Students taking the geodetic option are required to attend this course, but it is also open to all civil engineering students who have completed the third year, and to any other students who are properly qualified.

The object of this course is to furnish the special field training essential for students desiring to enter the government surveys, or to engage in extended topographical work of a similar nature. It is not attempted to complete any particular piece of work, but to instruct the student, by actual practice, in the various steps incident to the progress of a complete geodetic survey, such as the measurement of a base line, the methods of erecting signals, the proper selection of stations, the extending of a system of triangulation, and the filling in of details.

Practice in topographical surveying by different methods occupies a considerable portion of the time, and emphasis is laid upon the economical adaptation of methods and instruments to different scales of topographical work. The plane table, the transit and stadia, the aneroid barometer, and pocket instruments of various kinds are used and compared, and attention is paid to the freehand sketching of contours, for the purpose of bringing out special geological features.

Hydraulic field work constitutes an important part of the work of the summer course, and consists in measuring the flow of some stream of considerable size, using various methods and instruments, including floats and current-meters of several kinds. The results of the observations are plotted and the computations of discharge worked out by the students during their fourth year. In this way, previous classes have measured the flow of the Connecticut River at South Deerfield, Mass., of the Schoharie Creek at Schoharie, N. Y., and of the Delaware River at Water Gap, Penn.

Field work in geology, and in the study and interpretation of topographical features, constitutes another important part of the summer course. The class-room study of geology often fails to prepare for intelligent field work, and the aim of this portion of the course is to enable students to acquire correct perceptions through their own examination of natural features. The detailed study of several simple types of surface leads to the study of a diversified district, which the student is taught to analyze into the topographical elements of which it is composed, and to examine with reference to its geological structure, thus ascertaining to what extent and in what ways the superficial topography reveals the internal or concealed structure of hills and other features. By carrying on this work hand in hand with the topographical surveying, the student gains an insight into the true significance of the surface features which the topographer has to represent.

RAILROAD ENGINEERING.

This subject is taught in the third year to all students in the department, while in the fourth year advanced courses are given to students choosing the second or railroad option.

The class-room work in the third year comprises a series of sixty exercises, and treats of the survey, location, construction, and equipment of railroads. It includes the topics of reconnaissance, preliminary work, location, curves and turnouts, the calculation and measurement of earthwork, the setting of slope stakes, the theory of easement curves, the construction of culverts, trestles, and masonry, and the subject of track, comprising ballast, ties, rails, frogs, switches, crossings, turn-tables, etc.

The students are thoroughly drilled in the mathematical work involved in the subjects of curves, turnouts, spirals, and earthwork, and are taught the use and construction of earthwork diagrams of various kinds.

In addition to the work in the class-room, the students make each year the reconnaissance, preliminary, and location surveys for a railroad two or three miles in length, upon such ground as may best illustrate the problems occurring in practice. Field practice is also given in a variety of problems involved in running in curves and spirals, and in setting slope stakes. In order to carry on this work without waste of time, one entire day in each week is devoted to field work, in the fall and spring, while the weather permits. In the drawing room, maps and profiles of the railroad survey are prepared by the students, who are instructed in the methods of using the map and contours to fit the line properly to the ground. Additional practice in this direction is also given by furnishing the students with lithographed contour maps of a certain district, upon which they are required to locate a suitable line connecting two given points.

The advanced courses given in the fourth year comprise one on Railroad Engineering and one on Railroad Management, together with lectures on Railroad Signals. The course in Railroad Engineering, which includes three exercises a week during the entire year, treats with considerable detail of the economics of location, that is, of the effects of grades, curves, and length upon the cost of operation, and the resulting principles which should be borne in mind in determining location. It further deals with the subjects of train resistance, brakes, rolling stock, motive power, signals, yards, stations, tunnels, steep inclines, and street railways of various kinds. The work in the drawing room consists of the preparation of designs, such as for a station yard or a water tank, or in working up the results of tests on brakes or on train resistance. Particular attention is given in this course to the arrangement of tracks at stations, a matter in regard to which great confusion of mind and much uneconomical practice exist among railroad men.

The course in Railroad Management consists of thirty lectures, and is designed to give the student a broad, general view of the history of railroads and of the methods of organization, the duties of the different officers, and the methods of keeping railroad accounts; together with a discussion of "the railroad question," including the subjects of fares, freights, pooling, discrimination, the Interstate Commerce Law, and the governmental control of railroads. This course is general as well as technical, and is dependent upon the course on Political Economy, as well as upon the Railroad Engineering of the preceding year.

The course in Railroad Signals has been given by Mr. George W. Blodgett, electrician of the Boston and Albany Railroad, and consists of six lectures, together with excursions to several points of interest. The students are in this course made acquainted with the methods of operating block signals, the construction of interlocking signals and switches at junctions, crossings, and terminal points, and other similar matters.

HIGHWAY ENGINEERING.

The instruction in this branch of engineering is given mainly in the second term of the third year, and consists of a series of lectures treating of the location, construction, and maintenance of town and county roads, and of city streets and pavements. Students desiring it may also, during the fourth year, devote some time in the drawing room to problems connected with the subject, or to work in the laboratory. During the past year, for instance, a series of tests has been made to determine the specific gravity, porosity, and relative durability of different kinds of paving bricks.

Through means furnished by Col. Albert A. Pope, of Boston, an instructorship in this branch is maintained, and the equipment of the department in books and apparatus is being rapidly increased.

DESCRIPTIVE GEOMETRY AND STEREOTOMY.

The principles of mechanical drawing and the use of instruments are taught to all students in the first term of the first year. This is followed by a thorough course in Descriptive Geometry, extending to the middle of the second year. In the third year a course in Stereotomy, or stone cutting, is given, in which the principles already learned are applied to the various problems arising in the construction of walls, arches, abutments, wing walls, and other masonry structures. The remainder of the drawing in the course, except that already referred to in describing the work in Surveying and Railroad Location, is given in connection with the instruction in Bridges, Sanitary or Hydraulic Engineering, or Railroad Engineering, and consists in making complete or sketch designs and working drawings of structures of various kinds.

THEORY OF STRUCTURES.

In this course, which is required of every regular student, and which extends from the middle of the third year to the end of the fourth year, the principles of the equilibrium and strength of the various structures met with in the practice of the civil engineer are discussed, and illustrated by numerous examples. It embraces a study of the analytical and graphical methods of determining the stresses and proportioning the parts of structures of wood, stone, and metal, such as bridges, roofs, stone and iron arches, piers, abutments, and retaining walls.

BRIDGES AND ROOFS.

Parallel with the course in the Theory of Structures is the course in Bridges and Roofs, which is devoted to the practical construction and designing of bridge and roof structures, together with a series of drawing-room exercises in Bridge Design, in which the student is required to make complete designs and working drawings of one or more structures of this kind. In these courses the student is made familiar with the different shapes of iron used at the present time, and with the methods of designing and properly proportioning connections. The plate girder is first taken up, and is followed by a study of framed structures of iron and wood, stone arches, floors and roofs for buildings, etc. The department is well supplied with blue prints received from the different bridge companies, illustrating the most recent American practice, and with an extended series of sheets showing European practice. Special efforts are made to call attention to faulty methods of construction, and to impress upon the student the importance of a sound knowledge of principles as a basis for good design. The student is taught the importance of carefully proportioning even the smallest details in such structures; and is shown that elaborate and precise computations of strain-sheets are to a large extent illusory, unless an equal degree of attention and care is devoted to the arrangement and proportions of each detail of connection. Further, continual attention is directed to the economical aspects of construction, and to the importance of economy in material, ease of manipulation in the shop, and facility of erection. Visits of inspection are occasionally made to important structures in the neighborhood, and to the shops of the Boston Bridge Works, where, through the courtesy of the proprietor, Mr. D. H. Andrews, students have an opportunity to become acquainted with the actual manipulation of the iron.

This course also includes the subject of Foundations.

HYDRAULICS AND HYDRAULIC ENGINEERING.

This course embraces the subjects of theoretical hydraulics and hydrometry, and of hydrology, water supply, water power, rivers and canals, coast and harbor works, irrigation, pumps, and hydraulic motors. The course in Hydraulics embraces the principles of hydrostatics, and of the flow of water through orifices, over weirs, in open channels, and through pipes; and the practical application of these principles is enforced by numerous examples. In Hydrometry the methods of measuring the quantity of water flowing in open channels or in pipes are considered. Floats and current-meters of different patterns have been provided for the use of the classes, and the students are taken in small parties to points on the Charles River or elsewhere, where the flow of the stream is measured. Occasional visits are also made to Lowell and Lawrence, and similar measurements made in the mill flumes. The subjects of rainfall and the flow of streams are specially considered with reference to the conditions existing in different parts of this country, and to their application in the study of the questions of water supply and irrigation. Under the head of water supply are considered the sources, purity, and necessary quantity of water, the methods of collecting, storing, filtering, raising, and distributing it for domestic purposes, with the practical details involved in such work. A study is also made of the control and improvement of rivers, the construction of locks, dams, and canals, and the utilization and distribution of water as a motive power.

Under coast and harbor works are briefly considered the design and construction of harbors, breakwaters, and jetties, the maintenance of channels, and the protection of coasts. Under irrigation, the conditions existing in our Western States are specially regarded, and the student is made acquainted with the results of experience in other countries. Should the student select the subject of hydraulic design, he is required to plan in detail the arrangement of a water supply or sewerage system for some town, or to design cross-sections for a sewer, aqueduct, dam, or other similar work.

The work of the class-room is supplemented by a series of exercise in the Hydraulic Laboratory, where the student becomes familiar with the measurement of water by weirs, orifices, nozzles, etc., and with the details of efficiency tests of pumps, turbines, and other hydraulic motors.

SANITARY ENGINEERING.

The instruction in this subject is given by a course of lectures, supplemented by work in designing. The object sought is to equip the student with such special knowledge as shall fit him to deal intelligently with certain questions relating to the health of individuals and communities, and to properly plan works of sewerage and drainage. A brief course in Sanitary Science, in the second term, affords the student some insight into the modern theories of disease, the biological methods employed in detecting the presence of disease germs, and the relations between works of water supply or sewerage and the health of communities. The matter of water supply, properly included in the practice of the sanitary engineer, is fully treated in connection with Hydraulic Engineering.

Under the head of House Drainage are studied the material and arrangement of drain, soil, and waste pipes, and the connecting fixtures, the advantages and defects of various forms of traps, results of experiments upon siphonage, examples of faulty plumbing, the modes of testing work, sanitary inspections, and the disposal of sewage by sub-surface irrigation.

Under Sewerage of Cities and Towns are considered the various systems employed in this country and abroad for the removal of sewage, special methods in use for its treatment and ultimate disposal, the proportioning and construction of main, branch, and intercepting sewers, with their appendages in the way of man-holes, catch-basins, flush-tanks, etc., tests of material employed, and custom in the apportionment of cost. Attention is directed to the history of sanitary work and legislation, and the results effected through their agencies, as well as to the consideration of such problems as the pollution of streams and the disposal of manufacturing waste.

In connection with the work in the drawing room, the preparation of detailed drawings is required for some assigned project in house drainage, sewerage, or other sanitary work, accompained by such specifications and estimates of cost as the case may admit.

APPLIED MECHANICS AND STRENGTH OF MATERIALS.

The instruction in these subjects begins at the middle of the first term of the third year, and extends to the middle of the fourth year. The course includes statics, dynamics, and the theory of beams, shafts, and columns; followed by a study of the strength and physical properties of the materials used in engineering, such as the various kinds of wood, stone, iron and steel, cement, etc. This is accompanied by exercises in the engineering laboratories, where each student has practice in testing iron, wood, and cement.

MECHANICAL ENGINEERING SUBJECTS.

The civil engineer has frequently to do with machines of various kinds, such as pumping engines, locomotives, etc., and should possess some knowledge of machinery. A course in Mechanism is, therefore, given in the second year, and one in Machinery and Motors in the fourth year. These courses are designed to give the student sufficient knowledge to serve any immediate needs, and upon them he may base more extended studies, should his future work require.

THE ENGINEERING LABORATORIES.

The objects to be acccomplished by these laboratories are first, to give the students practice in such experimental work as engineers are, in practice, called upon to perform; second, to afford some experience in carrying on original investigations in engineering subjects, with such care and accuracy as to render the results of real value to the engineering community; third, by publishing, from time to time, the results of such investigations, to add gradually to the common stock of knowledge. These laboratories are situated in the Engineering Building, where they occupy the two lower floors, 50 x 150 feet each. They include,

First: the laboratory for testing the strength of materials;

Second: the hydraulic laboratory;

Third: the steam laboratory.

Of these, the first two are the only ones of which extensive use is made by the students in Civil Engineering, and the third need not be here described.

THE LABORATORY FOR TESTING THE STRENGTH OF MATERIALS.

This laboratory is furnished with the following apparatus: an Olsen testing machine of fifty thousand pounds' capacity, for determining tensile strength, elasticity, and compressive strength; a testing machine of the same capacity for determining the transverse strength and stiffness of beams up to twenty-five feet in length, and of framing joints used in practice; machinery for the measurement of the strength and twist of shafting; for testing the tensile strength of mortars and cements; for testing the strength of ropes; for testing the effect of repeated stresses upon the elasticity and strength of iron and steel; for determining the strength and elasticity of wire; for determining the deflection of parallel rods when running under different conditions; also accessory apparatus for measuring stretch, deflection, and twist. Besides the above-stated apparatus, a horizontal Emery testing machine of 300,000 pounds' capacity is now (June, 1892) being constructed for this laboratory by William Sellers & Co., of Philadelphia. It will contain all the essential features of the 800,000 pounds testing machine at the Watertown arsenal, built by Lieut. Albert H. Emery. The new machine will be suitable for testing a compression specimen eighteen feet long, and a tension specimen twelve feet long, and will enable the department of Applied Mechanics to undertake and carry out a kind and amount of experimental investigation not otherwise possible, and to obtain a large number of results of value in practical engineering work such as could not be obtained by means of machines of smaller capacity.

THE HYDRAULIC LABORATORY

has been planned to give facilities for substantially all kinds of experimental hydraulic work which are practicable indoors. It contains the following apparatus: —

(1) A closed steel tank five feet in diameter, and twenty-seven feet high, connected with a standpipe ten inches in diameter, and over seventy feet high. The tank is arranged for openings or connections at eight different points, and on two different floors, with specially designed gates for controlling the discharge. Water is fed to the tank either directly from the city supply, or from a storage pit whence it is drawn, in such volume as needed, by a steam and a rotary pump. By means of valves and overflows on the supply pipe, the head in the standpipe can be maintained with great steadiness at any desired height.

(2) Apparatus, in connection with the tank, for performing a great variety of experiments on the discharge through orifices and mouth-pieces, which may be free or submerged.

(3) The main overflow pipe, over seventy feet high, arranged as a vertical stack of soil pipe, with numerous connections for experiments in trap siphonage.

(4) A six-inch Swain turbine, so arranged that its efficiency can be tested under different heads and gate openings. This wheel receives water from a separate storage tank, to which water is supplied by a centrifugal pump.

(5) A Pelton water motor, upon which similar tests of efficiency can be made. Such tests are also made upon the various pumps with which the laboratory is fitted.

(6) Several weirs, with hook gauges, for measurements of the flow of water, either for independent tests or in connection with the flow through orifices, or the testing of motors.

(7) A cylindrical steel tank of about 280 cubic feet capacity, which affords a direct and accurate means of measuring very considerable volumes of water, in determining the discharge coefficients of small weirs, orifices, mouth-pieces, and nozzles.

(8) A system of pipes arranged for the insertion of diaphragms, branches, and other special pieces, in experiments for determining loss of head. These pipes may be connected either to receive the water from the tank under steady pressure regulated by the stand-pipe, or to receive a greater pressure directly from the pumps.

The demands of the students' thesis work have led to the construction of several pieces of apparatus original in design, and admitting of widely varied, delicate, and valuable experiments. Among such apparatus may be mentioned one piece consisting of an adaptation of the Pitot tube to the measurement of the velocity at any point of a jet, for the study of variations in velocity. A simple modification allows accurate measurement of the shape of the jet, whether it be from a standard orifice, or from a mouth-piece.

In connection with the apparatus here outlined, the laboratory is equipped with a variety of mercury gauges for the measurement of pressure, one having a specially graduated Brown & Sharpe scale seven feet long, with vernier attachment; with apparatus for weighing directly the discharge of water during experiments; and with a large number of standard orifices, mouth-pieces, diaphragms, branches, etc., of the most accurate workmanship. Many special pieces of apparatus which have been used in experimental work by Mr. James B. Francis, Mr. John R. Freeman, and other hydraulic engineers, have been courteously placed at the disposal of the department. Through the courtesy of the makers, a 12-inch Hercules turbine has also been temporarily loaned to the department.

The engineering laboratory also contains a foundry rattler for determining the relative durability of various paving materials.

The Engineering Library, open to teachers and students, contains a good collection of engineering works, now numbering about 3,500 volumes. New books of value are added as soon as they appear, and the library receives regularly over eighty technical periodicals.

THESIS WORK.

Before receiving his degree, each student is required to present an acceptable thesis, embodying the result of some original investigation or design, accompanied in the latter case by the necessary computations, drawings, and estimates. The following are the titles of the theses presented by the class of 1892:—

Project for a System of Signals for the Old Colony Railroad between Boston and Quincy.

Comparative Tests of the Durability and Physical Properties of Road Materials.

Design for a Movable Bridge.

Design for a Cantilever Bridge.

Design for a Standpipe.

Experimental Study of the Resistance of Riveted Joints to Bending.

Plan for the Sewerage of a Certain District in West Roxbury.

Experimental Study of the Effect of Notching the Ends of White Pine Beams.

Plan for abolishing a Grade Crossing on the Old Colony Railroad at Avon, Mass.

An Investigation of the Coefficient of Discharge of Water through Nozzles.

A Project for Laying out and Subdividing a Tract of Land in West Newton.

A Study of the Measurements of the Flow of Streams made by the U. S. Geological Survey.

Measurements of the Size of the Jet of Water discharged from a Standard Orifice.

A Discussion of Base-Line Measurements with Steel Tapes.

A Comparative Study and Discussion of Earthwork Tables and Diagrams.