Physical Culture of Beams and Girders

Beam Testing Apparatus of Massachusetts Institute of Technology Has Played Important Part in Modern Building Construction—How a Beam in a Laboratory Is Made To Do the Work of a Beam in a Skyscraper

Boston, May 8.—What is essentially the most important part of the construction of any big modern building takes place before either the carpenter, mason or contractor begin their visible operations. This is the testing of the material to be used in order to see how well it will perform its part in the new structure; old Davy Crockett's famous maxim, "Be sure you're right, then go ahead," might be applied directly to this preliminary investigation of the steel, iron or masonry that is to become the flesh, bone and sinew of any large and important modern building. All this, however, goes on quietly, often before the general public knows that the new structure is contemplated, and it is only within comparatively recent years that it has been reduced to what is practically an accurate science by means of which the contractor is able to know in advance the exact strength and endurance of each part of his building. The beam that supports a certain amount of floor area, for example, has its known maximum of endurance and is never expected to support a weight that will even approximate the breaking point. And every other part of the building is similarly tested.

Without such tests the modern skyscrapers would have been impossible because no man could have said how well the lower part of the structure would have withstood the weight of the many stories superimposed upon it. Every stick and stone, of course, is not tested individually. But representative samples of all forms of building materials are nowadays being constantly put on the rack, their strength and endurance tested under just the conditions in which this strength and endurance will be demanded by the actual building, and in just the shapes and sizes in which they are thus to become important and often invisible factors in the making of modern cities. In many cases therefore the birthplace of a modern building is the mechanical laboratory of a modern school of technology, and the new science of testing might almost be called a physical culture course for inanimate building materials.

In order to make these tests, it is necessary to reproduce within the limits of a single laboratory—for the laboratory is nowadays as important in so-called practical achievements as it is in strictly scientific investigations—conditions, for example, that will be represented in reality by the weight of a big city skyscraper resting on foundations of steel imbedded in concrete. The problem is one that has required considerable human ingenuity. Until some ten or twenty years ago it had never been attempted and although building material was then tested, the tests were conducted on a small scale, with small samples of material, and the strength of larger sought by a decidedly deceptive process of arithmetical computation. These small specimens, moreover, were not always true samples, for the timber merchant could, if he were so inclined, pick out a flawless specimen which could hardly be duplicated by a real beam or girder of the same timber; while the ideal test of any material is, of course, a test made on a piece of the exact dimensions that are to be used in the building. The means of such a test were finally supplied by a machine constructed by Professor Lanza of the Massachusetts institute of technology. Professor anza's testing apparatus, together with other testing mechanism recently constructed in this country and abroad, revolutionized the knowledge of building materials available for architects and constructors—whether of office buildings, aqueducts, railroad bridges or ocean vessels—and has therefore played a very important part in the evolution of modern construction. A portion of it may still be seen in the Institute laboratory where it was originally put in operation and where its timbers now serve as the frame for its direct descendant. The machine is used in testing beams, girders and trusses, of the size used in actual construction, and can load them with a weight of 100,000 pounds and test them to the point of failure. And the apparatus for measuring the deflection of a piece of material undergoing a test is so sensitive that it notes even the difference produced by the weight of a human hand laid on the material when near the limit of its endurance—an achievement in accuracy that comes very near estimating the weight of the straw that broke the camel's back.

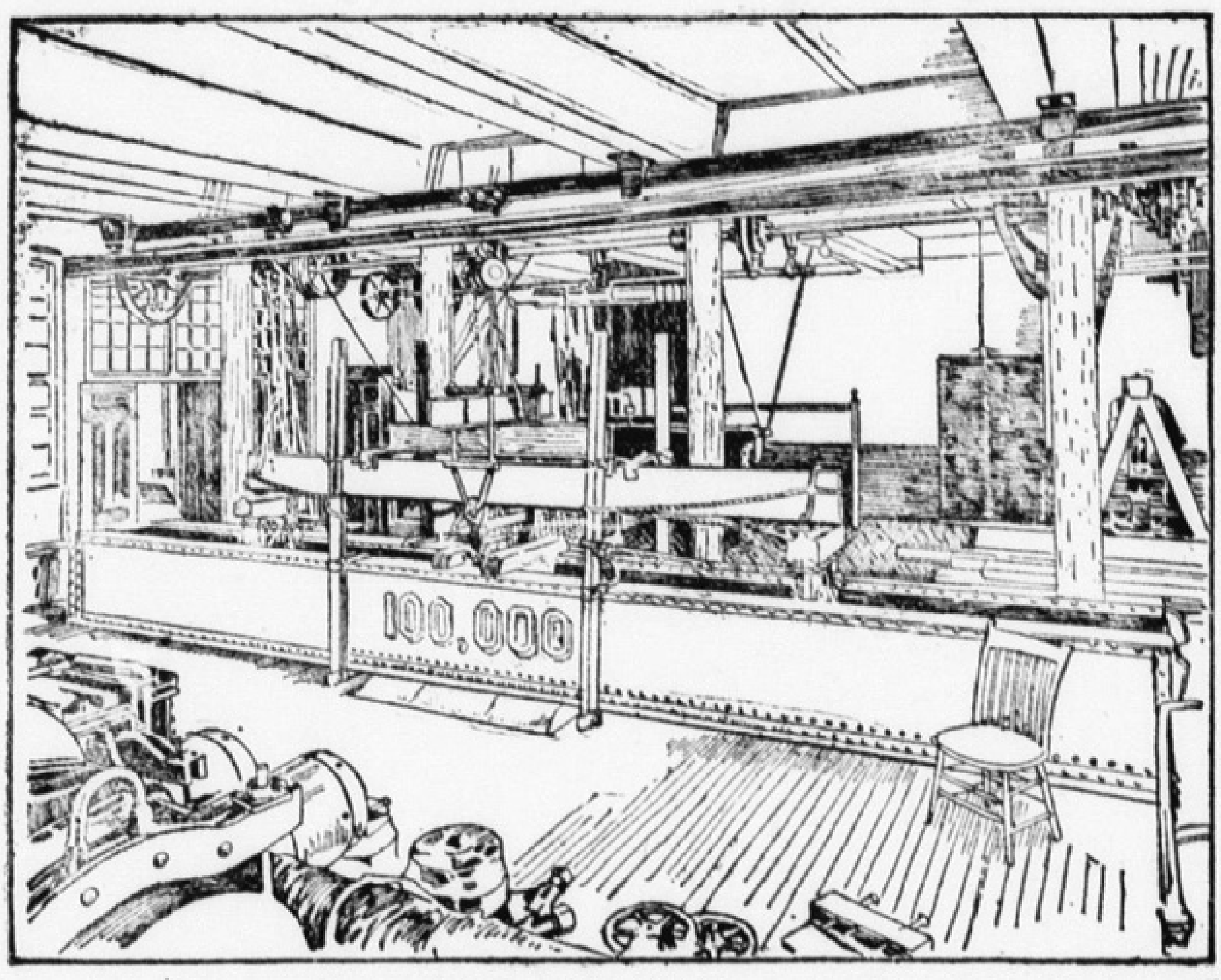
This particular piece of modern apparatus is designed to estimate the amount of downward pressure that will be carried by any given specimen of building material. It consists of a stalwart framework which supports the end of the material under investigation, just as it would be supported in an actual structure. But the weight is applied, not by piling pound after pound on top but by adding pound after pound to a mass of metal in the room below, each addition to the weight of the load being communicated to a scale beam, the effect on the material being watched by a delicate instrument especially contrived for that purpose. And in this way the stoutest beam or truss can be finally made to succumb to its maximum downward pressure and the bending moment and character of the break accurately noted. Hour after hour sometimes passes before the attainment of this breaking point, but when the snap of the breaking timber has resounded through the laboratory, the students and laboratory assistants who conduct the tests know that they have found the strength limit of a typical piece of that particular timber. In the case of a truss a similary experiment shows not only the strength of the big timber pieces composing its familiar triangle but also the strength of its steel or iron fastenings at the corners; and the Institute laboratory has thus done yeoman service in finding the best modern method of fastening together these all important timber triangles. And all round this big testing apparatus are other ingenious apparatus for reproducing all other conditions of present day building.

It may be wondered why former methods of construction have never demanded a similar mechanism. The answer lies partly in the fact that no material is ever used to the limit of its endurance and that it is only with the erection of the lofty buildings of our own time, together with the greater use of steel and iron as well as wood, that the question of what is actually the limit of a given piece of building material has become of vital importance. The great buildings of the past were stone structuers and when wood was used it was used only in comparatively low buildings. Many of the beams from these old buildings, however, come finally to the big testing apparatus of the Tech laboratory simply to add to our general knowledge of how wood wears in actual service. An old house, for example, is being torn down somewhere in the vicinity of Boston and some of its timbers are sent to their laboratory to see how they will compare, after a century or more of service, with the kind of timber fresh from the modern timber forest. And the old timber usually stands the test admirably. In the same fashion, during the recent digging of the new subway tunnel under Boston harbor the excavators found an old corduroy road some 20 feet under the surface of modern Boston. Some of the old logs, wet and slimy from their long immersion in the mud were transported to the Institute where they were dried and placed on the testing apparatus. From an old State street market there came also two beams of white pine which had been in use for over a century and which proved to be nearly as good as new, barring a few places where dry rot had set in owing to contact with damp flooring.

These historical reminiscences naturally speak highly of timber as a long lived building material. But all timber, even when the specimens come, one might at first imagine, from the same place, is not of the same value. A timber beam grown on the sunny side of a Carolina mountain is a much stouter specimen than an apparently similar beam which grew on the shady side of the same mountain.

Most of the tests made with this especially important piece of technology apparatus have what might be called a three-fold purpose. The material is sometimes furnished by the producers, wishing to obtain an accurate statement of the character of their product. The test itself, for every beam, truss or girder is numbered and the results recorded, is an addition to the general scientific knowledge of the character of building material. And the test is finally, perhaps, one should say primarily, a part of the education of the Institute of Technology student. So important a part, indeed, is played in modern life by this question of the character of various building materials, that the student of nearly every form of modern engineering is more or less interested in the processes of testing different materials of construction and an actual participation in the work of the stalwart beam tester—as well as in that of the various other mechanisms that pull or twist material to its final limit of endurance—is an important incident in the training of a majority of the students.

During the last few years similar tests have been frequently applied to irons imbedded in concrete—a new form of support that has come into use with the development of concrete-steel structures—and there are now some 40 or 50 pieces of material of this kind kind waiting for examination on the big testing machine. These pieces are to be subjected to heat, while loaded with the weights of the apparatus, and then deluged with cold water as a means of studying their strength and endurance when exposed to the test of a great fire. And still more interesting perhaps are the long-time tests that have been going on for years in the same laboratories in order to study day by day the slow process of wear and tear to which old Father Time himself subjects all forms of building material.



Apparatus that can load a beam with 100,000 pounds of downward pressure.