SCIENCE

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GOVERNMENT TIMBER TESTS.

In reply to many inquiries regarding the comprehensive timber tests inaugurated in the Forestry Division of the Department of Agriculture, the following brief statements regarding the objects and methods of the work have been prepared by B. E. Fernow, chief of the division, in the hope that thereby an interest in this investigation, a work of national importance, may be spread.

It will be admitted by all who have to handle wood in building, engineering, and manufacturing, that our knowledge regarding the properties of our various timbers is not very satisfactory, and that while attempts more or less systematic have been made to determine these properties, and knowledge gained from experience exists among those who have handled certain classes of wood for certain purposes, there does not exist much reliable published information for general use.

The reason for this deficiency may be explained from the fact that wood, being a non-homogeneous material, varies very largely in its qualities. Not only does there exist a wide range of qualities in the same species if grown under different conditions, but the quality varies in the same tree from the butt to the top, and from the heart to the bark.

To arrive, then, at any satisfactory results in an experimental determination of the properties of wood, it is necessary to derive them from test material of known origin, and, furthermore, to establish any laws which will be generally applicable in referring quality to physical appearance, structure, and origin of material, it is necessary to examine and test carefully a very large number of test specimens.

The difficulty for private enterprise to secure the test material in sufficient quantity, and with a full knowledge of its origin, in fact the magnitude of an investigation of this kind, renders it pre-eminently an undertaking for a government agency. This has also been recognized by the Prussian Government; but the United States Department of Agriculture can boast of having inaugurated such elaborate work one year earlier.

The object of this work in general will be readily perceived from the foregoing statement.

Besides more reliable data regarding the properties of our principal timbers, there is to be gained from this investigation a means of determining quality by the examination of physical appearance and structure, and of establishing an inter-relation between quality and conditions of growth.

To define the objects of the work more in detail, some of the questions which it is expected ultimately to solve may be formulated as follows: —

What are the essential working properties of our various woods and by what circumstances are they influenced? What influence does seasoning of different degree have upon quality? How do age, rapidity of growth, time of felling, and after-treatment change quality in different timbers? In what relation does structure stand to quality? How far is weight a criterion of strength? What macroscopic or microscopic aids can be devised for determining quality from physical examination? What difference is there in wood of different parts of the tree? How far do climatic and soil conditions influence quality? In what respect does tapping for turpentine affect quality of pine timber?

It is also proposed to test, as opportunity is afforded, the influence of continued service upon the strength of structural material, as, for instance, of members in bridge construction of known length of service. This series of tests will give more definite information for the use of inspectors of structures.

There are four departments necessary to carry on the work as at present organized, namely: the collecting department, the department of mechanical tests, the department of physical and microscopic examination of the test material, the department of compilation and final discussion of results.

The collection of the test material is done by experts (Dr. Charles Mohr of Mobile, Ala., for southern timbers). The trees of each species are taken from a number of localities of different soil and climatic conditions. From each site five trees of each species are cut up into logs and disks, each piece being carefully marked, so as to indicate exactly its position in the tree; four trees are chosen as representative of the average growth, the fifth or "check tree" the best developed specimen of the site.

Disks of a few young trees, as well as of limbwood, are also collected for biological study. The disk pieces are eight inches in height and contain the heart and sapwood of the tree from the north to the south side of the periphery. From fifty to seventy disk pieces and from ten to fifteen logs are thus collected for each species and site.

A full account of the conditions of soil, climate, aspect, measurements, and determinable history of tree and forest growth in general accompanies the collection from each site.

The disks are sent, wrapped in heavy paper, to the Botanical Laboratory of the University of Michigan, at Ann Arbor (Mr. F. Roth, in charge), to be studied as to their physical properties, their macroscopic and microscopic structure, rate of growth, etc. Here are determined, (*a*) the specific weight by a hygrometric method; (*b*) the amount of water and the rate of its loss by drying in relation to shrinkage; (*c*) the structural differences of the different pieces, especially as to the distribution of spring and summerwood, strong and weak cells, open vessels, medullary rays, etc.; (*d*) the rate of growth and other biological facts which may lead to the finding of relations between physical appearance, conditions of growth, and mechanical properties. The material thus studied is preserved for further examinations and tests as may appear desirable, the history of each piece being fully known and recorded.

The logs are shipped to the St. Louis Test Laboratory, in charge of Professor J. B. Johnson. They are stenciled off for sawing and each stick marked with dies, corresponding to sketch in the record, so as to be perfectly identified as to number of tree, and thereby its origin, and as to position in tree. After sawing to size, the test-pieces are stacked to await the testing. One-half of every log will be tested green, the

other half after thorough seasoning. A determination is made at the time of testing of the amount of water present in the test-piece, since this appears greatly to influence results.

From each tree there are cut two or three logs, from each log three or four sticks, two of standard size, the other one or two of larger size. Each standard stick is cut in two, and one end reserved for testing two years later after seasoning. The standard size for the sticks is 4 × 4 inches and 60 inches long for cross-breaking tests. There will, however, be made a special series of cross-breaking tests on a specially constructed beam testing machine, gauged to the Watertown testing machine, in which the full log length is utilized with a cross section of 6 by 12 up to 8 by 16 inches, in order to establish the comparative value of beam-tests to those on the small test-pieces. It is expected that, on the average, 50 tests will be made on each tree, besides 4 or 5 beam-tests, or 250 tests for each species and site.

All due caution will be exercised to perfect and insure the accuracy of methods; and, besides the records, which are made directly in ink into permanent books, avoiding mistakes in copying, a series of photographs, exhibiting the character of the rupture, will assist in the ultimate study of the material, which is also preserved.

Such work as this, if done as indicated, and well done, will never need to be done over again. The results will become the standard, the world over. The strength and value of a given species or even stick will then no longer be a matter of opinion, but a question of established fact, and we will learn not only to apply our timbers to the use to which they are best adapted, but also what conditions produce required qualities, thus directing the consumer of present supplies and the forest grower of the future.

The American Association for the Advancement of Science, in its Section of Mechanics and Engineering, has created an Advisory Board to assist in securing improved methods, and the co-operation of other authorities will be welcomed to make this a truly national work.

So far the work has been confined to southern pines and oaks (which, thanks to the courtesy of the Louisville and Nashville Railroad Company, could be obtained free of transportation charges); the scant appropriations available, and other unfavorable conditions, making such limitation necessary.

The work will be extended and its progress pushed in proportion to appropriations made by Congress, which depend upon the interest which the work may arouse among those to be benefited by it.

FIRE-RESISTING MATERIALS.

TESTS were held on Oct. 15, in two buildings erected in a vacant lot on Park Street, Boston, Mass., for the purpose of demonstrating the efficiency of slow-burning construction, and also of various materials designed to retard free combustion. In addition to asbestos paper and ordinary lath and plaster, the materials manufactured by the following companies were used, being contributed by their representatives,—King's Windsor Cement Dry Mortar Company, Clinton Wire Cloth Company, New Jersey Wire Cloth Company, Magneso-Calcite Fire-Proof Company (who manufacture a fire-proof paper), Boston Fire-Proofing Company (who manufacture porous terra-cotta lumber), New York Eastern Plaster Board Company (manufacturers of cellular blocks of plaster of Paris mixed with fibrous vegetable matter), Stark, Edson, & Co. (manufacturers of albamural, which is a fire-proofing material in general appearance similar to kalsomine).

The buildings were constructed of two-inch tongued and grooved spruce plank placed upright and held by a grooved plate at the top. They were covered by flat plank roofs tinned on the upper side.

The larger building was 12 x 16, divided into four cells, with a fire door in each partition and one at the eastern end. The other building measured 12 x 12, being divided into three cells, and situated three feet from the larger building. Scuttles about two feet square were placed in the roof over each cell, but they were opened when the fire was started. The entrance at the front of each cell was provided with doors made of two-inch plank tinned on the edges and on the side toward the fire.

For the purpose of obtaining approximate temperatures in the buildings at the test, four links furnished by Mr. Morris Martin of the United States Electric Fire Alarm Company were hung on steel wire in the upper part of each cell, and the melting points of these links were stated to be as follows: lead, 626°; antimony, 842°; aluminum alloy, 1,292°; brass, 1,850°. Each of the cells was lined with fire-retarding material.

After the buildings had been thoroughly examined by those present, the fuel was placed in each cell, consisting of kiln-dried hickory wood piled to a depth of nearly four feet, and also piled to the depth of over five feet in the space between the two buildings. This wood was thoroughly wet with kerosene oil, and the fires were lighted at 12.21 P.M., simultaneously in each cell. Although the fires burned very fiercely, the buildings resisted the flames admirably, and it was considered that up to 1.30 P.M., or an hour and ten minutes after the fires were started, any burning of the buildings could have been extinguished with a pail of water.

The heat of the fire was too severe to allow near enough approach to make very careful or accurate observations of the interior until after the fire was extinguished by the fire department, who applied a hose stream upon the fires, beginning at 1.52 P.M. After the fires were extinguished, careful observations were taken of the conditions of each cell as it was at the time, and later further examinations of the floors were made after the ashes had been removed.

There were shutters placed upon the ends of the buildings. The wooden shutter covered with tin was somewhat injured and the wood badly charred. The shutter covered with one-eighth of an inch magneso-calcite, before the tin was applied, was in excellent condition. The fire doors in the partitions in the larger building all yielded during the fire. The immediate cause of their failure appeared to be the use of screws in attaching the hinges, and in this respect as well as others they all differed from what is known as the standard tin-covered fire doors, which require that all attachments to the doors shall be made by bolts and not by screws.

The doors in the partition were held in position, after the hinges gave way, by the mass of fuel piled on either side. The doors covered with asbestos paper or with magneso-calcite, before applying the tin, were somewhat distended by the gas generated by the heated wood, which could not escape readily, as was the case in the doors not covered except by the tin, where the gas could escape at the seams.

The doors at the front of the cells were tinned only on the edges and the side toward the fire, and were able to resist the heat of the fire for only about an hour, the cause of the failure in each case being the conduction of the heat along