TECH NOTES

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Information on the In-Grade Testing Program, Impact on Design Values

Introduction – What was In-Grade?

The In-Grade Testing Program was one of the largest materials testing programs of a single product – dimension lumber – ever to be conducted in North America. 70,000 pieces of full-size structural lumber in dimension grades were pulled from hundreds of U.S. and Canadian mills. Lumber was tested to destruction to scientifically measure its performance characteristics.

Because the softwood lumber was pulled directly from mill production and tested in its actual grade, size and species, the project became known as the "In-Grade" program. This 12-year research program was conducted by the U.S. Department of Agriculture Forest Products Laboratory in cooperation with the North American softwood lumber industry.

The more than a decade of testing and analysis yielded a wealth of new data on the structural performance of softwood lumber and on why lumber performs in certain ways. This data ultimately resulted in the development of American Society for Testing Materials (ASTM) Standard D 1990 for the computation of design values based on tests of full-size pieces of lumber.

New design values resulting from Standard D 1990 were published by the North American lumber industry in late 1991. For the most part these new 1991 values created only minor changes in the way lumber is used; however, architects, engineers, and building officials were required to become familiar with a new format for design values (BASE VALUES), along with some modifications to species groupings.

During 1996, ASTM Committees directed minor revisions to Standard D 1990. These revisions resulted in minor increases to some of the 1991 Western Lumber BASE VALUES. The 1996 increased design values are published in WWPA's **TECH NOTE No. 5**, the **Western Lumber Grading Rules '97**, and in the 1997 **Design Value Supplement** to the **National Design Specification (NDS) for Wood Construction**. They are expected to become adopted by the forthcoming International Building Code (a merging of the major model building codes) by the year 2000.

Background

Current framing practices in wood frame construction evolved from the first "light-frame" buildings of the mid-1800s. Over time, steady improvements occurred in building technology. Today, light-frame wood construction is used throughout the world as a practical, economical, earthquake-resistant structural system.

The first significant tests of lumber's strength capabilities began in the late 1920s. Researchers recorded the pounds per square inch required to bend short-length samples of clear (without knots) 2x2 wood to specified limits. The results for each species were mathematically projected to create basic theoretical values for dimension lumber.

Lumber has certain natural characteristics, such as knots, that can affect its strength. Such characteristics were factored into the clear-wood design values and the impact computed. The amount of clear wood in the cross section plus other characteristics, such as the slope of the wood's grain, governed the strength of each grade.

History shows that design values based on the clear-wood approach (ASTM Standards D 2555/D 245) performed well. The long-term performance of lumber in wood-frame buildings has been what it was predicted to be. But design values are at the core of structural lumber safety and associated liabilities, thus new research, using state-of-the-art technology, was inevitable. The In-Grade program began in 1978.

What Did In-Grade Do?

The In-Grade Testing Program was initiated to verify the existing softwood lumber design values and to provide a more scientific basis for wood engineering procedures.

Rules-writing agencies like WWPA, in cooperation with the USDA Forest Products Laboratory, tested thousands of pieces of lumber in the grade, size and species to which the design values are applied.

Lumber samples were tested in bending, tension and compression parallel to grain. Detailed information was recorded for each specimen including growth characteristics, stiffness, ultimate strength and failure modes. In addition, specific-gravity values for many samples were obtained. Relationships of mechanical properties in terms of moisture content, size and grade were also developed.

What was tested?

In the United States, Douglas Fir-Larch, Hem-Fir and Southern Pine were sampled as species groups, while some other species were sampled as individual species. For marketing and manufacturing reasons, many of the individual species were grouped together after testing. Design values for each species group are derived from the set of species in the group which was not statistically different from the lowest species.

What were the results?

For the most part, design values for Western Lumber existing prior to 1991 were found to be relatively accurate when compared to new data. However, some of the differences between the earlier design values and the results of the In-Grade Testing Program were significant.

Some specific results include:

- An increase in the bending and tension parallel-to-grain strength, in the narrow widths (e.g. 2x4) of the highest grades (Selects Structural, No. 1 & Btr., No. 1).
- An increase in compression parallel-to-grain values for most grades and sizes.
- A reduction in bending values in some grades of the wider widths (e.g. 2x10, 2x12, etc.)
- A slight reduction in some MOE values for some species and grades.

Some of the broader, perhaps more significant results for Western Lumber were:

Fewer Species Groups

- In-Grade allowed an accurate analysis of the relationships among species. Instead of ten Western Lumber species groups, the number was reduced to six for increased ease of design.

Recognition of No. 1 & Btr.

- In-Grade testing of the No. 1 & Btr. combination resulted in the assignation and recognition of design values for the No. 1 & Btr. grade in Douglas Fir-Larch and Hem-Fir.

New Tables and Formats

- In-Grade design values for Western, North Eastern and Canadian dimension lumber are published as BASE VALUES, which are first adjusted for size and then for conditions of use. The ADJUSTED VALUE becomes the design value that is applied to a piece for its particular end use.

Did the Grading Rules change?

The grading rules were not affected by the In-Grade Testing Program.

In-Grade affected the design values that are applied to dimension lumber grades. And the procedure for working with those values changed because new values are published as BASE VALUES, which must be adjusted for size as well as conditions of use.

What is the impact of 1996 changes to ASTM D 1990

Design values resulting from ASTM D 1990 procedures are subject to rounding and data-grouping sensitivity procedures which can have a minor impact on resulting BASE VALUES. When the 1996 changes to ASTM D 1990 were applied to Western Lumber BASE VALUES some design values increased slightly, others, remained the same; there were no decreases. Information regarding these changes and the increased design values is provided in WWPA **TECH NOTE No. 5**.