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Structural Applications of Lumber in Construction

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Abstract: ***In this Review paper we will focus on the various lumber species & growth rates. We will see the percentage of moisture content required in lumbers taking the perspective of their durability and sustainability. Strengths and various treatments carried out on wood to make them better in chemical resistances are elaborated. We have reviewed the fire resistance characteristics required to make the structure fire-proof. It also includes the approach of reduce, reuse and recycle of waste lumber for various purposes. Cross-laminated timber connections and the Suitability of various species as per conditions at the site are also elaborated.***

Keywords: Wood, Designing, Saturation, Strengths, Moisture, Fire resistance

1. Introduction

Spruce-Pine-Fir and Douglas-Fir are the two main species of lumber mainly used for wooden construction. Those are easily and cheaply available in those regions. We will see species of lumber. For better performance of lumber, it is necessary to have moisture content within some range which increases durability and strength of a material. In addition to MC, some chemical treatments on the wood are also included in this study. Suitability of proper use of material considering purpose and design requirements is also included.

2. Lumber

Wood and its derivative products are widely used by people for hundreds of purposes. The tall buildings as a whole or for some parts are widely constructed by using lumber. As wood is a natural resource, it has an inclination that lumber is good for the environment. Due to its flexibility and availability in various sizes, it has various benefits over conventional materials used for construction purposes.[1]

3. Species

Various species are available for commercial use in the construction industry. Some of them are as follows:

a) Spruce-Pine-Fir
b) Douglas Fir
c) Baldcypress
d) Cedar
e) Hemlock
f) Redwood
g) Basswood

Figure 1: Standardised Lumber planks

Spruce-Pine-Fir (SPF) and Douglas fir(DF) are some of the widely used and easily available species. These are available in various standard sizes as 2x, 4x, and 6x nominal dimensions.

4. Growth rates

The spruce tree's maximum attainable height and rate of growth during its 500year life, it will reach between 160 and 220 feet, with a 5’ per year growth rate until it reaches maturity. Douglas-fir is a medium-size to large size evergreen tree, It has a height of about 70–330 ft. tall and up to 8 ft in diameter. Experts say the growth rate of DF trees at 24 inches a year.

5. Moisture content

As a natural, wood can lead to fungal degradation. So the protection of wood from moisture is much necessary, it is most important to take the view of designing for durability. We can say the wood is dry if its Moisture Content (MC) is 19% or less.[2] These lumbers are considered dry at the time of manufacturing. Those are kiln-dried lumbers. The average fiber saturation point for wood where all fibers of

the wood are saturated is 28% MC. This is the maximum limit of MC after which the decaying of lumber starts.

6. Strengths

When species tested in the United States testing program, the following results are obtained considering 12% moisture content while testing:

Table 1: Results of the testing

Species	Spruce	Douglas Fir
Moisture Content	12%	12%
Specific Gravity	0.44	0.48
Compression parallel to grain (lb/sq.in)	5650	7230
Compression perpendicular to grain (lb/sq.in)	730	800
Shear parallel to grain (lb/sq.in)	1490	1130
Side Hardness(lb)	660	710
Modulus of Elasticity (x10^6 lb/sq.in)	1.23	1.95

It has been concluded that DF is stronger than Spruce species, so preferred for high rise buildings and structures where better strength is required. [3]

7. Wood Treatments

Other than controlling only moisture content and manufacturing into standard dimensions, additional treatments on woods to increase durability is necessary. Wood can be attacked by fungi and bacteria. Quenching is the method in which chemicals such as hydroxyl groups are quenched to prevent the attack by fungi, bacteria, and insects. These also provide fire resistance to lumber. Chromated copper arsenate (CCA) of greenish tint shade is used. It imparts to timber, CCA is a chemical that is much common for many decades. In the pressure treatment process, the solution of CCA in an aqueous state is applied using a vacuum method and pressure cycle, and the treated wood is then stacked for drying.

8. Fire resistance

It has resulted that timber structural members may still give better performance at high temperatures when compared to steel members. In construction using cross-laminated timbers instead of normal dimensional lumbers provide enough time for evacuating the building occupants or the fire to be extinguished.

9. The ‘3R’ approach

Minimizing the waste material and reuse of the construction waste production is always preferred. Reduce, Reuse and Recycle of materials in good condition is always necessary.[4] Lumbers which are in better condition after demolition can be used directly without further treatment at non-structural uses. Others can be used at structural requirements as well after required special treatments.

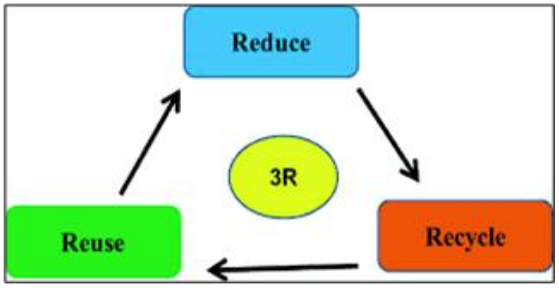

Figure 2: The ‘3R’ approach

10. Cross Laminated Timber connections

From the tests, it has been concluded that the connection joint by using connector bolts and sawn board is much weak concerning their strength and stiffness. While the sheet of fibreboard glued from both sides and applying screws from both the faces gives more strength to CLT joints. [5]

11. Suitability

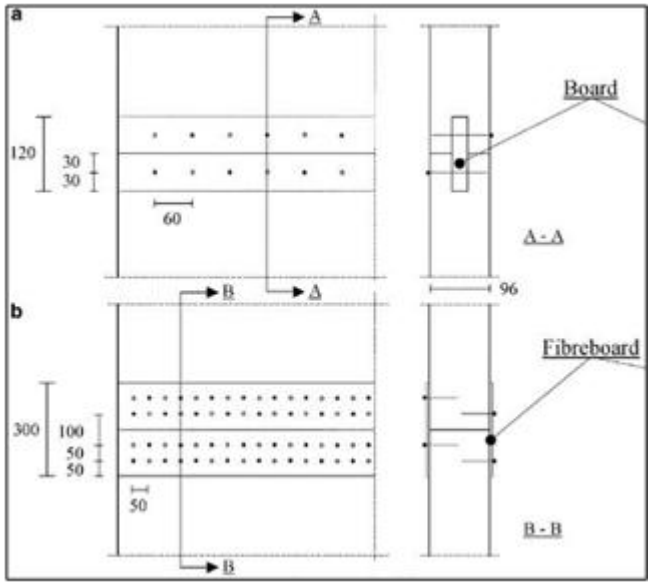

Figure 3: CLT joint connections

For non-structural or decorative purposes, lumbers of negligible strengths can be used. SPF is used for single and multi-family constructions and commercial constructions. It has low strength to weight ratio, so it is a widely used material. DF is generally adopted at special conditions requiring high strengths due to its less availability and pricing compared to other materials.

12. Conclusion

From comparative studies, it is concluded that Spruce and Douglas fir are two main species for wood construction. DF is more strong than spruce species. It is necessary to keep the moisture content under 19% to achieve better durability. Other than maintaining water content in the material it is necessary to perform various chemical treatments on wood to better perform it under severe conditions. Fire protection should be considered while constructing wooden houses. It is necessary to use waste material wherever possible to minimize the cost of material and reduce wastage.

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