Building codes are critically important in the use of wood products for construction. The codes contain regulations that are prescriptive or performance related for various kinds of buildings and construction types. A prescriptive standard might dictate that a particular type of material be used in a given application. A performance standard requires that a particular building or building component meets a specified strength or fire-resistance characteristic based on code-approved testing procedures. For the wood products industry, a change in a prescriptive or performance standard in a building regulation could affect the use of millions of feet of lumber or panel products.

BUILDING CODES
Obstacle or Opportunity?

By Alberto Goetzl and David B. McKeever

In buildings where the code may require the use of noncombustible materials, wood products are clearly disadvantaged. In contrast, if a 1-hour or 2-hour fire rating performance standard is dictated, then wood products or an assembly of wood products in combination with gypsum or some other material can effectively compete. With few exceptions, building codes allow a wide variety of wood products to be used in residential construction applications. Wood framing accounts for better than 90 percent of all homes built in the United States.

While wood products dominate the residential construction market, they are less commonly employed in nonresidential buildings such as schools, offices, stores, hotels, healthcare facilities, and other types of commercial or industrial structures. Steel and masonry products have traditionally dominated this market. The limited use of wood framing in new nonresidential buildings can be attributed to numerous reasons, including traditional material preferences and building practices, design considerations, or, in some circumstances, costs. Building codes also tend to be more restrictive for nonresidential buildings than for residential construction. Depending on their use, the codes establish height and area limitations for nonresiden-

The International Building Code
Long-Sought Changes Coming to Fruition

The first-ever *International Building Code*, a national, model building code for the United States, is scheduled for publication in 2000. It is being written by the International Code Council (ICC), formed in 1994 by the three existing U.S. model building code organizations: the Building Officials and Code Administrators (BOCA) International, the nation's oldest professional organization for construction code officials, founded in 1915; the International Conference of Building Officials (ICBO), founded in 1922; and the Southern Building Code Congress International (SBCCI), founded in 1940.

Building codes serve to protect the public's life, health, and welfare in the built environment. In the United States, this is accomplished by adoption of a code through state statute or local government ordinance. Enforcement is provided by state agencies or local governments, as determined by state law. Model building codes are popular because cities, counties, and states generally lack the resources to write and maintain their own up-to-date, comprehensive regulatory documents.

The genesis of the new code can be traced back to the American Institute of Architects (AIA). In the early 1970s, the AIA implemented a policy calling for both short- and long-term modifications to U.S. building code development processes. Their short-term goal was merely to reorganize the three existing model code documents around a common code format. In this manner, similar requirements would be located in the same chapters in each of the three model codes. Their long-term goal was more ambitious and initially thought by many to be wishful thinking on the part of AIA. It called for development and publication of a single set of construction-related codes through the cooperation of the three model code groups.

Showing its resolve to produce nationally applicable model documents, the ICC produced several elements of its family of construction-related codes. The first to be promulgated was the *International Mechanical Code* in 1995. Rapidly following were the *International Plumbing Code*, the *International Private Sewage Disposal Code*, and an *International Zoning Code*. Finally, in late 1996, ICC began what was believed to be its most difficult task, creating a unified building code, by establishing code development committees to meld the three distinctly different regional building codes into a single model code.

The result of this effort is the *International Building Code*. The new format has taken a majority of its provisions from the existing model codes, although modifications during the development process have resulted in an improved, state-of-the-art building code. Over the 3-year development period, AF&PA's American Wood Council shared its expertise with the drafting committees. In addition to being asked to draft Chapter 23 (Wood) provisions, AWC provided comments on all provisions affecting wood and participated actively in all code hearings, successfully advocating on behalf of the wood products industry.

The final hearing of the ICC will take place September 12 to 16, 1999, to approve the *International Building Code*. Publication is expected in the first quarter of 2000.

More Information Available On-Line From The American Wood Council

The American Forest & Paper Association's American Wood Council (AWC) is the industry's trade group that keeps track of building code changes in the United States and in key wood products export markets. Through its field staff, AWC works with model, state, and local code officials to ensure that wood products are continually accepted in the marketplace and advocates changes in building regulations to expand the safe use of wood products in construction. AWC has developed "Code-Conforming Wood Design" software that provides building designers with an easy tool to retrieve detailed code-conforming building height and area allowances and an abundance of other useful information. The program can be accessed or downloaded on-line at no charge at the AWC website: http://www.awc.org.

tial buildings that can be constructed using combustible materials, such as wood products. However, the codes are increasingly recognizing the safety and structural integrity of wood systems even in nonresidential applications. This article describes an analysis of building codes and wood use that reveals that wood-frame construction could be employed in a much larger share of nonresidential buildings.

We estimate that existing building codes would have permitted the use of wood-frame construction in just over half of all nonresidential buildings in 1995, but it was actually used in only about 17 percent of nonresidential buildings. This suggests that there are significant opportunities for wood framing that might be exploited through increased outreach and promotional activities to architects and builders of nonresidential buildings. Additional sales of wood products to this particular construction market segment could exceed $2 billion.

In 1995, the U.S. Department of Commerce (12) reported the value of all construction put in place at $534 billion. Of that amount, new residential construction accounted for $235 billion or 44 percent of the total, while new nonresidential building construction was $184 billion or 34 percent. This contrasts dramatically with the statistics on wood products consumption. Although consumption estimates vary somewhat by source, they indicate that the market for wood products could expand significantly if greater advantage were taken of opportunities to employ wood systems in nonresidential buildings. According to the Western Wood Products Association (13) new residential construction accounted for 38 percent of softwood lumber consumption in 1995, while nonresidential construction accounted for just 14 percent. Similarly, APA-The Engineered Wood Association (1) estimated that new residential construction accounted for 50 percent of domestic structural panel demand in 1995, residential repair and remodeling for 25 percent, and nonresidential construction for 12 percent. In a Forest Service study (8) researchers found that nonresidential buildings accounted for just 7 percent of softwood lumber consumption and 8 percent of structural panel consumption in 1996. These statistics show that wood products usage in nonresidential building construction clearly lags behind the residential sector.

Cost factors, architectural design, and local building practices and regulations each impact the use of wood products in nonresidential buildings. Several studies have explored the comparative costs issue of wood-frame construction versus steel and concrete, e.g., Spelter's analysis reported in the *Forest Products Journal* in 1998 (11). Architectural design is less easily analyzed, although designers tend to have a less favorable view of wood for large buildings (6). In general, few impediments exist to using wood systems in building designs. If anything, wood provides added design flexibility, and wood materials can be adapted to design specifications or vice versa. Local customs or trade practices can also influence the choice of materials. But as a practical matter, some architects and building planners may also be reluctant to specify wood structures because of building regulations. Maximum allowable height and area allowances for wood-frame construction may lead to the perception that the use of wood framing is too restrictive. To examine this issue systematically, we investigated the actual and potential use of wood building products in nonresidential building construction as influenced by the height and area provisions of existing model building codes.

The methodology used for this investigation was similar to that used by McKeever and Adair and, in fact, relied on the same data set (9). Their earlier analysis developed wood-use factors and estimates of wood products usage in nonresidential building construction by building use and construction type. They also estimated the total volume of wood products that *could have been used* if *all* nonresidential buildings had been constructed with wood in 1995. For our investigation, we sought to isolate the effects of building codes on wood products use. So where the earlier analysis looked at the question from the standpoint of potential wood use if all nonresidential buildings were constructed with wood-framing, our analysis filtered out the effects of any building code height and area limitations in order to focus on the potential wood use in nonresidential buildings where it would be feasible to use wood. We sought to determine the following:

- the value of nonresidential building construction that could have utilized wood framing in the context of applicable codes, by building use;

- the value of nonresidential building construction that actually used wood framing, by building use;

- the value of wood products employed in nonresidential building construction, by building code region and building use;

- the potential market value of wood products that could have been used within code constraints, by code region and building use.

This investigation produced extraordinarily detailed estimates about wood products use and potential use in nonresidential buildings, only some of which are presented here. More importantly, as building regulations evolve, the approach taken here could be applied to track changes in product use in the nonresidential building sector over time. Some background on the nation's system of building codes helps to put our approach into perspective.

Overview of Model Building Codes

The process of building code adoption and enforcement is little understood outside the building community. While 17 states have promulgated statewide building codes, most states, including those that have statewide regulations, have assigned building code adoption and enforcement to counties and municipalities. Thus, there are literally thousands of building code jurisdictions in the United States. In the majority of cases, local and state building regulations reference one or more of three model building codes: the *Standard Building Code* (SBC), *Uniform Building Code* (UBC), or *National Building Code* (NBC) (2). The codes are published and updated by three independent building code organizations, and each contains measures and standards to regulate construction in the geographic areas where they most commonly apply. The NBC is adopted mostly in the northeastern and midwestern states; the UBC is applied throughout the western states; and the SBC is applied in most of the southern states. Each model code specifies height and area limitations for several types of construction. For this analysis, *protected combustible construction* for each building use group was investigated. Protected combustible construction refers to buildings where the structural frame, bearing walls, floor construction, and roof construction is fire rated to a specified fire endurance time, e.g., l-hour construction. Buildings with exterior wood framing would fall into the category of protected combustible construction and the height and area limitations for this category would essentially define the size for these wood-frame buildings. For example, the model codes generally limit protected combustible construction to four stories or less.

With the availability of more precise testing procedures and better engineering information, building codes have increasingly recognized the safety, technical integrity, and strong structural performance attributes of wood building systems. The code organizations are in the process of consolidating the three model building codes into one *International Building Code* to provide greater consistency and simplicity in building regulations in the United States. When fully implemented after the turn of the century, the new *International Building Code* will replace the existing model codes, where local jurisdictions choose to adopt it (7).

Methodology and Data

This analysis was based on the same F.W. Dodge[1] (Dodge) data (4) and relied on similar methodology as was used by McKeever and Adair (9) in 1995. The main data set consisted of approximately 2,500 buildings drawn randomly from Dodge's tracking system of construction projects completed, started, or planned for the 3-year period 1993 to 1995. From this sample, estimates of the value and incidence of construction by building use, construction type (based primarily on framing materials used), and region were developed. Buildings were identified as being constructed principally of wood, concrete, or steel components. An additional subset of 500 buildings from the larger Dodge database was used to develop detailed wood products usage estimates by

[1] F.W. Dodge, a subsidiary of McGraw Hill, is one of two large vendors of private construction data services. Among its services, F.W. Dodge collects and publishes reports on nonresidential construction activity. The other private data source is Construction Market Data, Inc. of Norcross, Ga. (3).

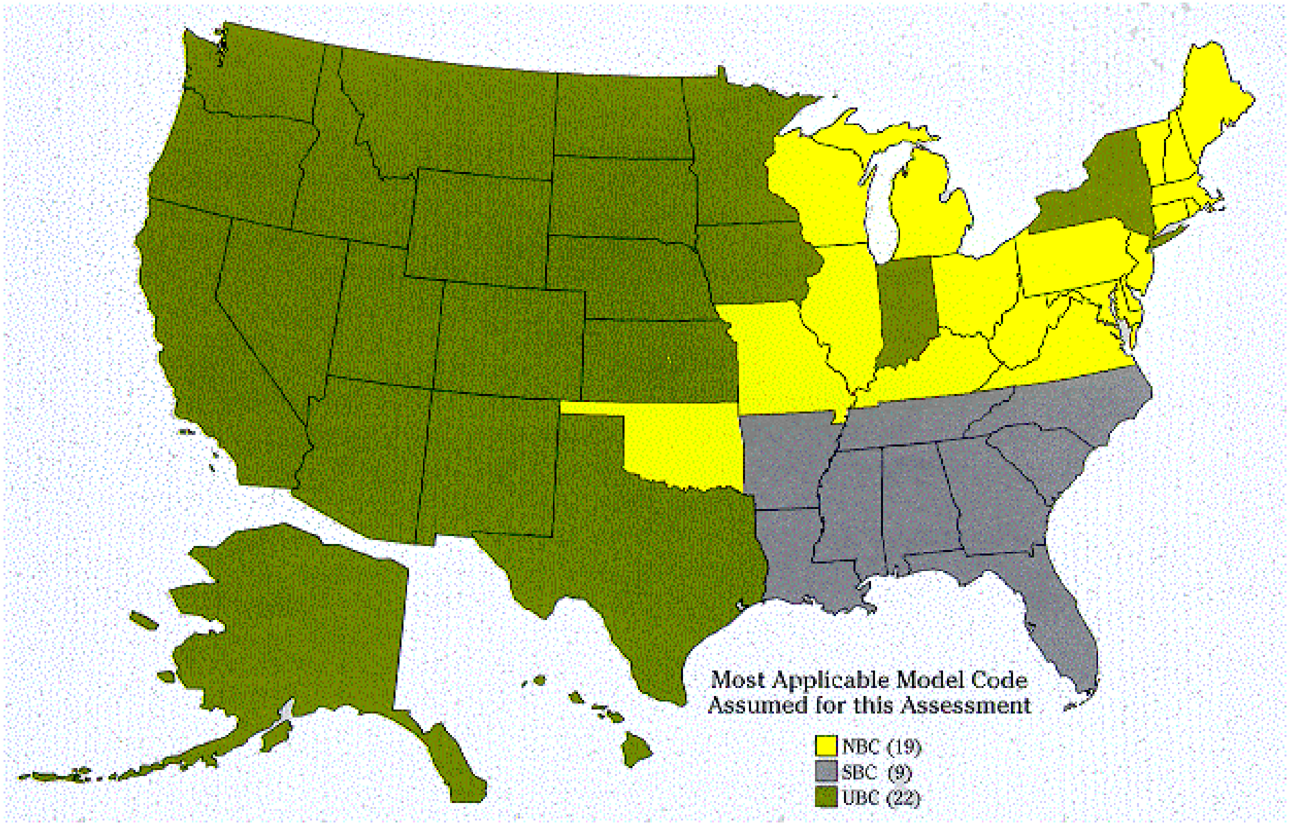

Figure 1.-Model building code regions.

building use, construction type, region, and building component (foundation, floors, walls, roofs, and siding). The sample data were then extrapolated regionally and nationally using published Department of Commerce (12) estimates of the value of new nonresidential buildings put in place in 1995.

For our building code analysis, we redefined regions based on the applicability of the three model building codes. Each building in the data set, which included information on geographic location, was assigned to a building code region. Buildings were then grouped by size classes conforming to the area and height allowances provided for in the three model codes. Figure 1 displays how the states were assigned to each model building code region. Model codes were initially assigned to each state as reported in *Wood Design & Building* magazine (5). Where two *or* more codes apply, and where individual states have developed their own code, AF&PA's American Wood Council field staff provided guidance on the most appropriate model code to assign to that state for this analysis.

The model building codes cover a wide range of building use groups (called *occupancies* in code parlance), such as residential, business, educational, factory, industrial, mixed use, etc. Within each of the building use categories, the codes contain detailed definitions and examples of the types of buildings that are covered. Although not precisely matched, the Dodge data set was closely aligned to the building use or occupancy groups in the model codes. The Dodge data set identified buildings as falling into one of 13 building categories: offices, stores, educational buildings, dormitories, industrial buildings, warehouses, auto service and repair stations, hotels, religious buildings, healthcare facilities, amusement buildings, public buildings, and "other" buildings. For purposes of this analysis, auto service and repair stations were grouped with stores; amusement buildings were grouped in the other category and assumed to have the same building code constraints as public buildings. Thus, we analyzed 11 building use groups. (This analysis differed from McKeever and Adair who grouped buildings into nine building types.) For each use group, a corresponding category from the model codes was selected, and the applicable height and area limitation for that building category was assigned.

Table 1 shows the height and area limitations for l-hour protected combustible construction by building use under each of the model building codes. The maximum allowable area ranges from a low of 15,000 square feet up to a maximum of 202,000 square feet, depending on the particular model code, the building use group, the number of stories,

TABLE 1.–Area and height allowances for protected combustible (wood-frame) construction, by building use.

Building use, and number of stories	Model code[a]					
	SBC		UBC		NBC	
	Unsprinklered	Sprinklered	Unsprinklered	Sprinklered	Unsprinklered	Sprinklered
	(ft^2)					
Office						
1-Story	27,000	81,000	28,000	84,000	38,250	68,850
2-Story	54,000	114,000	56,000	112,000	76,500	137,700
3-Story	N/A[b]	81,000	56,000	112,000	105,570	151,470
4-Story	N/A	N/A	N/A	N/A	N/A	201,960
Education						
1-Story	24,000	72,000	23,350	70,650	38,250	68,850
2-Story	48,000	96,000	47,100	94,200	N/A	137,500
3-Story	N/A	72,000	N/A	N/A	N/A	N/A
4-Story	N/A	N/A	N/A	N/A	N/A	N/A
Industrial						
1-Story	30,000	90,000	31,500	94,500	38,250	68,850
2-Story	N/A	60,000	63,000	126,000	76,500	137,700
3-Story	N/A	N/A	63,000	126,000	105,570	151,470
4-Story	N/A	N/A	N/A	N/A	N/A	N/A
Stores						
1-Story	18,000	54,000	28,000	84,000	25,500	45,900
2-Story	36,000	72,000	56,000	112,000	51,000	91,800
3-Story	N/A	54,000	56,000	112,000	N/A	100,980
4-Story	N/A	N/A	N/A	N/A	N/A	N/A
Hotels						
1-Story	21,000	63,000	15,750	47,250	25,500	45,900
2-Story	42,000	84,000	31,500	63,000	51,000	91,800
3-Story	63,000	126,000	31,500	63,000	70,380	100,980
4-Story	N/A	84,000	N/A	N/A	N/A	134,640
Religious						
1-Story	15,000	45,000	15,750	47,250	22,313	40,163
2-Story	N/A	30,000	31,500	63,000	N/A	80,325
3-Story	N/A	N/A	N/A	N/A	N/A	N/A
4-Story	N/A	N/A	N/A	N/A	N/A	N/A
Public						
1-Story	15,000	45,000	15,750	47,250	22,313	40,163
2-Story	N/A	30,000	31,500	63,000	N/A	80,325
3-Story	N/A	N/A	N/A	N/A	N/A	N/A
4-Story	N/A	N/A	N/A	N/A	N/A	N/A
Dormitories						
1-Story	21,000	63,000	21,000	63,000	25,500	45,900
2-Story	42,000	84,000	42,000	84,000	51,000	91,800
3-Story	63,000	126,000	42,000	84,000	70,350	100,980
4-Story	N/A	84,000	N/A	N/A	N/A	134,640
Health/Inst.						
1-Story	22,500	45,000	7,800	23,400	19,125	34,425
2-Story	N/A	30,000	15,600	31,200	N/A	68,850
3-Story	N/A	N/A	N/A	N/A	N/A	N/A
4-Story	N/A	N/A	N/A	N/A	N/A	N/A
Warehouses						
1-Story	18,000	54,000	21,000	63,000	22,313	40,163
2-Story	56,000	36,000	42,000	84,000	44,625	80,325
3-Story	N/A	N/A	42,000	84,000	N/A	88,358
4-Story	N/A	N/A	N/A	N/A	N/A	N/A
Other						
1-Story	15,000	45,000	15,750	47,250	22,313	40,163
2-Story	N/A	30,000	31,500	63,000	N/A	80,325
3-Story	N/A	N/A	N/A	N/A	N/A	N/A
4-Story	N/A	N/A	N/A	N/A	N/A	N/A

[a] SBC = 1997 Standard Building Code; UBC = 1997 Uniform Building Code; NBC = 1996 BOCA National Building Code (2).

[b] Where N/A is noted, building codes do not permit protected combustible construction without special exception.

and whether or not sprinkler systems are used. Not surprisingly, the allowances are greater when sprinkler systems are utilized. An underlying assumption in this analysis is that all buildings are constructed with adequate open space to achieve the maximum allowable areas. This is an important assumption

TABLE 2. – Estimated nonresidential building construction activity, 1995.

Building use group	Value of construction put in place[a]	Estimated aboveground floor area[b]	Estimated number of projects[c]
	(1,000 $)	(1,000 ft^2)	
Stores	42,654,000	876,000	19,510
Offices	25,613,000	333,700	13,583
Education	24,029,706	245,836	6,660
Public	21,974,000	179,000	9,873
Warehouses	17,901,042	403,356	13,105
Industrial	16,111,958	363,044	7,057
Health/Inst.	15,560,000	133,400	6,220
Hotels	7,112,000	103,400	2,048
Other	6,071,000	94,200	3,983
Religious	4,326,000	57,500	3,635
Dorms	2,997,294	30,664	899
Total	184,350,000	2,820,100	86,574

[a] U.S. Department of Commerce (12).
[b] McKeever and Adair (9).
[c] Derived from F.W. Dodge data set (4).

Table 3. – Actual and potential wood-frame construction market under analyzed code assumptions, 1995.

Building use group	Potential under existing codes	Actual construction	Actual as % of potential	Construction market potential[a]
	(million $)	(million $)	(%)	(million $)
Offices	17,435	2,805	16.1	14,630
Stores	15,211	882	5.8	14,329
Education	12,231	1,123	9.2	11,108
Public	12,217	1,666	13.6	10,551
Industrial	10,433	57	0.5	10,376
Warehouses	10,370	537	5.2	9,833
Religious	4,016	1,366	34.0	2,650
Other	3,910	494	12.6	3,415
Health/Inst.	3,520	1,435	40.8	2,084
Hotels	2,782	1,750	62.9	1,032
Dormitories	1,337	286	21.4	1,050
Subtotal	93,462	12,403	13.3	81,059
Exempted Buildings[b]	4,483	4,483	—	—
Total	97,945	16,886	17.2	81,059

[a] Represents the difference between potential construction value and actual construction value.
[b] Wood-frame buildings that exceeded the maximum allowable area specifications of the model codes.

because the building codes require a certain amount of what is referred to as *open perimeter* around buildings. This is to ensure that the local fire department has adequate room to access and maneuver around the building should it be necessary to do so. For example, the SBC requires a minimum 30-foot setback for protected combustible construction. The UBC requires a 40-foot setback. Builders can build to the maximum allowable area and height allowances provided they plan an adequate open perimeter around the building. In general, the height and area allowance essentially dictates a maximum building size that could be constructed with wood framing without any design modifications. In some circumstances, regulations allow buildings with wood framing to exceed the prescribed size limitations provided that certain design criteria are met, e.g., when firewalls separate building units and/or property line setbacks are sufficiently large. Therefore, the area and height limitations shown in Table 1 should be viewed as generally representative, but not hard and fast rules of the codes.

Project data were sorted by number of stories and area, and grouped according to area allowances applicable in the respective code region, by building use. This part of the analysis separated buildings that could be constructed without sprinkler systems from those where sprinkler systems were presumed to be required because of their size, if wood framing were to be employed. The incidence of wood framing by region and size class was subsequently determined. The data were extrapolated by code region based on Department of Commerce (12) estimates of value of construction (similar to the procedure used by McKeever and Adair (9)). Estimates of the number of buildings, total floor area, and construction value were derived for all buildings (Table 2) and for wood-frame buildings (Table 3) by building use group. Buildings that potentially could have been constructed using wood framing under existing codes were identified. Buildings that actually were constructed with wood framing were also identified.

Wood products use factors developed by McKeever and Adair (9) were recalculated based on product usage in wood-frame buildings versus buildings framed in other materials (concrete and metal), by building use, and by code region as defined in this analysis. Based on these recalculated wood products use factors, estimates of lumber and structural panel consumption by code region, building use, and size class were generated. The economic value of the wood products consumed was then estimated using the annual 1995 average *Random Lengths* composite prices for softwood lumber and structural panels (10), and representative unit prices of other wood products. Some publicly traded company annual reports include average product pricing. These served as a source of unit value for nonstructural panels and engineered wood products.

The Potential for Wood Use in Nonresidential Construction

Published estimates as to the number of nonresidential building projects constructed each year vary by source. Based on our analysis, we estimate that approximately 87,000 nonresidential building construction projects were undertaken nationwide in 1995. This is a calculated, weighted estimate derived from average building size and construction values reported in the Dodge data set. The 87,000 nonresidential buildings constructed in 1995 represented an estimated 2.8 billion ft^2 of floor area. (Total aboveground floor area was derived by McKeever and Adair (9)). Table 2 shows the estimated number of projects, value of construction, and floor area by building use group in the analysis.

According to the Department of Commerce, the value of nonresidential building construction in 1995 totaled approximately $184 billion (Fig. 2). Based on this analysis, approximately half (51%) of the value of construction would have met the allowable size

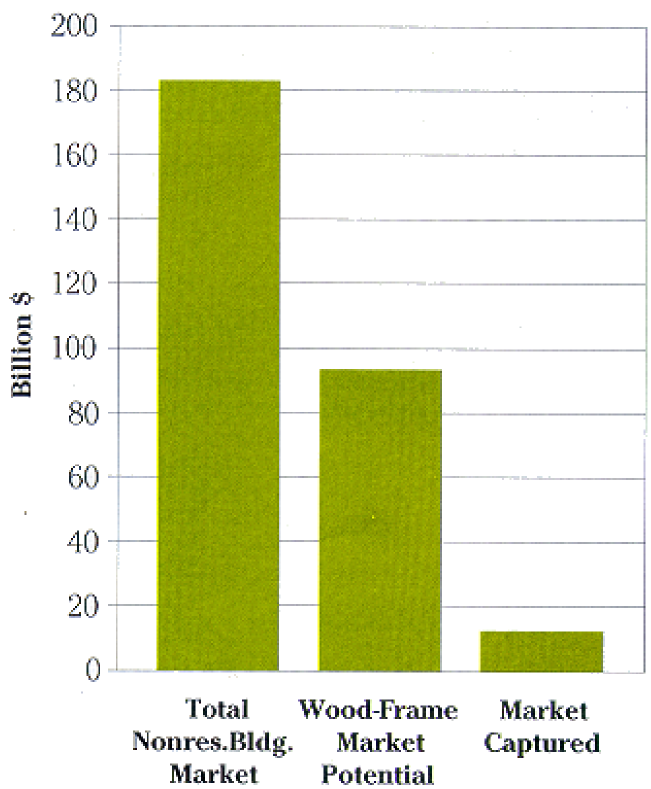

Figure 2.-Wood-frame market potential and actual market share relative to the value of new nonresidential construction, 1995.

criteria to permit wood-frame construction under existing building codes. Thus, we estimate that the potential nonresidential construction market that could have utilized wood framing in 1995 was about $93 billion. The value of buildings that *actually* used wood framing was just over $12 billion, or about 13 percent of the potential construction market for wood-framed buildings, not including buildings qualifying for wood-frame construction under unlimited area provisions of the codes (Table 3; Fig. 2). Including wood-frame buildings that were assumed to be constructed conforming to unlimited area provisions of the codes would raise the market share to just over 17 percent. These results suggest that substantial opportunities exist for promoting wood use in nonresidential construction markets.

A closer look at the data reveals that, of the 11 building use groups included, wood-frame construction has penetrated industrial buildings the least. Less than 1 percent of industrial buildings that would have been eligible for wood-frame construction actually used wood in 1995. In contrast, wood framing captured a good portion of the potential opportunity for hotels and health/institutional buildings (includes nursing homes and other types of health-related facilities). In fact, health/institutional buildings were the one category that showed a considerable number of wood-frame buildings that were larger than the assumed height and area allowances for protected combustible construction in the model codes. In these situations, other code provisions allowing larger building areas likely applied. As noted earlier, certain provisions of the model codes theoretically permit wood framing to be used in larger nonresidential buildings provided specific design criteria and open perimeter requirements are met. According to this analysis, only about 2 percent of the value of new nonresidential building construction, and 4 percent of the construction value of wood buildings, fell into this category and most was in the health/institutional type of buildings.

While industrial buildings showed the lowest percentage market penetration for wood framing, offices and stores showed the greatest dollar gap between actual wood-frame construction and potential (Table 3). Together, the model codes would have allowed over $28 billion of additional wood-frame

TABLE 4. – Actual and potential nonresidential construction market share for exterior wood frame buildings, 1995.

Total value of new nonresidential building construction:	**$184.4 billion**
Construction value of buildings that potentially could have been constructed using wood framing under existing codes:	
Unsprinklered Buildings	**$ 43.9 billion**
Sprinklered Buildings	**49.5 billion**
Subtotal	**$ 93.4 billion**
Exempted Buildings[a]	**4.5 billion**
Total	**$ 97.9 billion**
Potential as percent of total construction value:	**50.1 %**
Construction value of buildings that were actually constructed using wood framing under existing codes:	
Unsprinklered Buildings	**$ 9.3 billion**
Sprinklered Buildings	**3.1 billion**
Subtotal	**$ 12.4 billion**
Exempted Buildings[a]	**4.5 billion**
Total	**$ 16.9 billion**
Percent of potential wood-frame construction market captured:	**17.3 %**
Percent of potential unsprinklered buildings captured:	**21.2 %**
Percent of potential sprinklered buildings captured:	**6.3 %**

[a] Approximately 4 percent of the construction value of all nonresidential buildings (2 percent of all wood–frame buildings) were larger than the normal area and height allowances in the codes. Special code provisions allowing larger buildings likely applied in these projects.

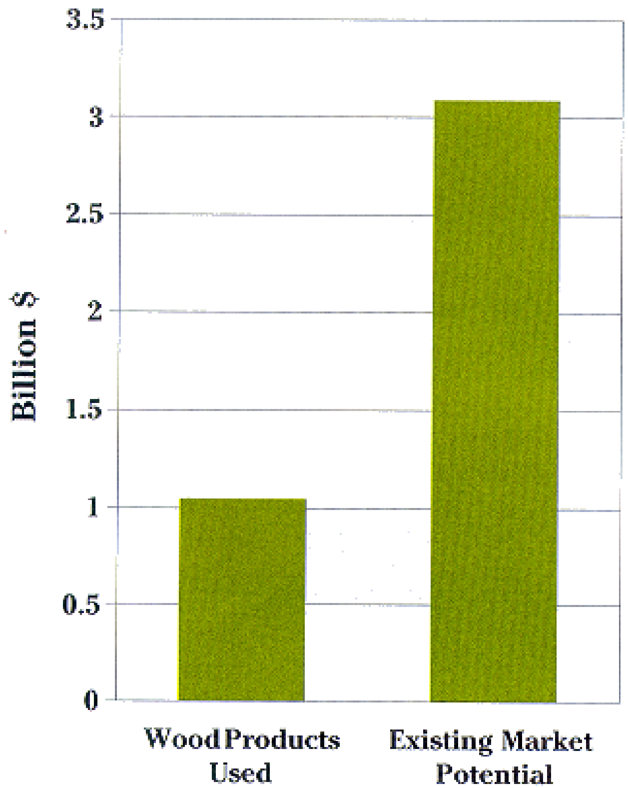

Figure 3.-Estimated value of wood products shipments for nonresidential building construction compared to the potential market.

construction of stores and offices over what was actually built with wood framing. Other significant opportunities clearly exist in school, public, and religious building construction. On a regional (i.e., code region) basis, the greatest opportunities for increasing wood products usage in nonresidential buildings are in the western states where the UBC is the most often referenced code.

Sprinklered versus Nonsprinklered Construction

Sprinkler systems have an additional impact on height and area allowances in the model codes. Our analysis identified buildings that would require sprinkler systems under the model codes if constructed with wood framing. Where sprinkler systems would be required, wood framing captures a much smaller market share than building sizes where sprinkler systems are not required. Wood framing captured just 6 percent of the total potential opportunity where sprinkler systems would be required, compared to 21 percent where they would not be required (Table 4). Over 17,000 additional buildings with 650 million ft.^{2} of floor area could have been built using wood framing if sprinkler systems had been employed. Some analysts have suggested that cost may be a consideration for using nonwood systems since sprinkler systems can add in excess of $1 per square foot to the cost of construction. On the other hand, it can also be argued that sprinkler systems provide designers and building occupants a higher comfort level with wood buildings. Thus, a sprinkler regulation could be viewed as an incentive for using wood-frame construction. Without the sprinkler system, a designer might elect to use non-wood materials.

Wood Products Usage

McKeever and Adair (9) estimated that 1.46 billion board feet of lumber and 1.17 billion ft^2, 3/8 inch basis, of structural panels were used in nonresidential building construction in the United States in 1995. An estimated 12.9 million ft.^{2}, 3/8-inch basis, of nonstructural panels, 55.3 million board feet of glulam products, 58.5 million lineal feet of wood l-joists, and 1.0 million ft.^{3} of structural composite lumber were also consumed. These volumes represented approximately $1 billion of wood products sales, based on average f.o.b. mill prices (Table 5). Had all opportunities for wood-frame construction under the model building codes been realized, an estimated 5.7 billion board feet of lumber, 2.6 billion ft.^{2}, 3/8-inch basis, of structural panels, and considerable incremental volumes of other wood products would have been used. The potential value in terms of product shipments would have been over three times as much, or about $3.1 billion (Table 5, Fig. 3).

Opportunity Knocks

According to the Department of Commerce, nonresidential building construction increased at an average annual rate of nearly 10 percent between 1993 and 1997, and at an inflation-adjusted rate of 6 percent. The 1990s have been a particularly good construction decade, and there is every indication that this construction sector will continue to do well in the future. Most nonresidential building construction is occurring in rapidly growing suburban areas.

Our analysis provides new insights into the nonresidential building construction market, and clearly shows considerable unrealized opportunities for using wood products in nonresidential buildings. It appears that forest product companies and industry associations should be encouraged to increase marketing and promotion efforts in the nonresidential building sector. The forest products industry, spearheaded by AF&PA's American Wood Council, has a long history of working with building code officials

Table 5. – Estimated actual wood products consumption, and potential consumption under building code constraints in nonresidential building construction, 1995.

Product	Units of measure for volume	Representative unit price per thousand[a]	Actual Volume[b]	Actual Estimated value	Potential Volume	Potential Estimated value
			(million)			
Lumber	Board feet	$ 337	1,464.4	$ 493.5	5,720.8	$1,932.9
Structural panels	ft.^{2}, 3/8-inch	369	1,165.4	430.0	2,628.5	964.2
Nonstructural panels	ft.^{2}, 3/8-inch	300	12.9	3.9	31.6	9.4
Glulam products	Board feet	1,000	55.3	58.5	116.1	125.3
I-joists	Lineal feet	550	58.5	30.4	100.6	67.1
Structural composite lumber (LVL)	ft.^{3}	1,555	1.0	1.6	2.7	3.9
Total		–	–	$1,017.9	–	$3,102.8

[a] Based on *Random Lengths* composite prices (11) and company annual reports.
[b] Includes increment for waste per McKeever and Adair (9).

to ensure that model codes protect health and human safety, while permitting the use of wood products. As testing procedures evolve, and better technical information becomes available, engineered and conventional wood are likely to be found safe and suitable in a greater variety of building situations. With the evolution of the *International Building Code,* the forest products industry has other opportunities to effect positive change in code applications. However, even under existing codes, if all market opportunities for using wood-frame technology in nonresidential building construction were realized, wood products sales would increase dramatically.

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