Chapter 1

Literature Review

Introduction and Justification

The infrastructure of the United States represents an opportunity for the forest products industry. This market includes the highway, railroad, marine and inland waterway, and the electric systems. At one time wood products were a primary building material in the US infrastructure, but in many areas wood product's market share has been lost to other materials such as concrete and steel. In other segments of the infrastructure, wood products have maintained a steady or increasing market share. One question is why are alternative materials to wood products now dominating in some areas of the infrastructure market, while wood products are maintaining a strong market share in other infrastructure markets? An example of loss in market share is with timber bridges. From 1986 to 1992, only five states (Indiana, Michigan, New York, Rhode Island and Wisconsin) had small increases in the number of timber bridges. All other states implementing timber bridges had decreases in their numbers. In 1982, the National Bridge Inventory listed over 70,000 bridges constructed of a main span of timber, while in 1992, the Federal Highway Administration reports that there were less than 46,000 timber bridges. This represents a decline of timber bridge implementation of over 33% in ten years (US Department of Transportation, Federal Highway Administration 1992). Table 1 shows that there was a decrease in the number of timber bridges from 1986 to 1992 of over 24%, while concrete bridges increased by over 9%. During this same period the total number of all bridges increased by 5.2%, and this data indicates a large drop in the market share of timber bridges. Other highway infrastructure can be constructed with wood, but are predominantly built with alternative materials. Examples of these products are highway noise barriers and sign posts. Table 2 shows the percentage of materials used in noise barriers. Tables 3 and 4 show the percentage of materials used in sign posts for single post and multiple post installations respectively.

Other infrastructure markets have been dominated by wood products. The United States railroad system predominantly uses wood for crossties (RTA 1986) and this market is seeing a growing trend in the use of treated wood ties (Micklewright 1994). Table 5 shows crosstie installation from 1900 to 1980. Although wood crossties dominate the market, alternate materials are being used for cross-tie construction, such as concrete (Buckett et al. 1987) and steel (Railroad

Track and Structures 1987). The differences in market share for wood products used in the different infrastructure markets identifies one justification for this research.

The expenditures for construction and maintenance on highways amount to 60 billion dollars annually. The yearly volumes of all wood except timber piling utilized in highway construction averaged over 7,400 board feet actual volume measure of wood per million dollars of construction cost. This equates to over 444 MMbf of wood in actual measure used in highway construction. The railroad expenditures on construction and maintenance of track amount to over 7.4 billion dollars annually (US Department of Transportation, Federal Highway Administration 1993). The annual crosstie demand is approximately 15 to 18 million crossties (Reynolds 1994). Utility companies spend over 500 million dollars annually on wood poles and the 3,227 electric companies in the US invest in over 2 million new poles each year. Currently in the US these companies maintain over 12.5 million miles of distribution and transmission lines (Ng 1994). The estimated loss of wood in marine structures exceeds 500 million dollars annually, which can be replaced with wood that will last longer if treatments and construction are performed correctly. The US Army Corps of Engineers spends over 300 million dollars per year on harbor improvements (National Strategic Planning Study 1991). The wood products used in highway structures represent less than one percent of all sawtimber produced in the US. The crosstie utilization represents approximately twelve percent of the hardwood lumber production in the US. Poles and pilings represent approximately one percent of softwood sawtimber harvested (Powell et al. 1993). The American Pulpwood Association estimated total construction spending in the US to exceed 450 billion dollars in 1996. They said 125 billion dollars were expected to be spent in the transportation sector which was approximately twenty-five percent of all construction spending (Cordova 1995).

All four infrastructure markets are defined as industrial markets. In industrial markets the buying and selling units are organizations represented by several different individuals. Persons in the industrial organizations make purchase decisions based on the organization's goals and not only on the individual decision maker's needs and wants (Muth and Hendee 1980). Purchase decisions in infrastructure markets can not be predicted with accuracy based on the individual's demographics and attitudes. This may be due to the organizational structure and the changes in goals from the individual to the organization. In the industrial market, it is organization leadership and norms that often decide the direction of the purchase decisions. This may cause market research on industrial purchase decisions to be based on these influences instead of those used in consumer markets such as demographics. Therefore, marketing efforts must be tailored to fit the industrial organization. For this study, differences in the infrastructure organization buying preferences for the separate infrastructure markets (such as highways versus utilities) can be examined and compared. This also means that the research methods and materials used in this study must be tailored to fit the infrastructure industrial buying centers.

This study will assist wood products manufacturers in determining how infrastructure decision makers choose materials for infrastructure construction. The material expenditures in infrastructure markets are an enormous potential market for the wood products industry. Therefore, knowledge about the market and how purchase decisions are made concerning construction materials in the four infrastructure markets will greatly benefit the wood products industry. In order to increase market share, the forest products industry needs to understand how to meet the needs and wants of these industries. These needs and wants are often determined by the perceptions these organization decision makers have about the various construction materials. The industrial organization norms and leadership may have influence over the individual decision maker in the firm, so this individual's perceptions may be swayed by these organizational factors. These perceptions relate directly to the current use or non-use of different materials, for instance wood products. The ideas, perceptions and attitudes of the industrial decision makers need to be determined so that the manufacturer can better target efforts in the infrastructure market.

Study Objectives

This project investigated current consumers of wood products in four US infrastructure markets. It identified how infrastructure materials are chosen, and determined the perceptions of various materials in different infrastructure markets. The ultimate goal was to determine the markets for wood in the infrastructure of the United States. Specific objectives of this research were:

1) Identify the factors important in the material choice decision in selecting infrastructure materials.

2) Determine the perceptions of wood in various infrastructure applications by different levels of decision-makers.

3) Develop strategies for increased wood use in infrastructure markets across the US.

Literature Review

Industrial Marketing and Infrastructure:

Choffray and Lilien (1980) state that industrial marketing is the marketing of products or services to industrial and institutional customers for their use in the production of goods and services. Demand in industrial markets is derived from the demand by the final consumers. Day and Herbig (1990) state that the individual consumer is his/her own decision maker and can be individually targeted from his/her demographics and attitudes. Therefore the likelihood of this persons purchase of products can be readily predicted with accuracy. Further defining industrial marketing, Berkowitz (1986) states that it is different from consumer marketing due to the complexity of organizational buying. Buying center decisions can be influenced by a variety of individual factors in a buying situation such as characteristics of the product, those of the firm, whether the decision concerns the product or brands selected, or the supplier selected (Berkowitz 1986). The most apparent difference between individual consumers and industrial buying centers is that buying and selling units in industrial marketing are organizations represented by several different individuals.

> "Decision making in industrial buying centers is typically done in groups, by people with vested interests that are threatened by change, and consideration of these changes increase their perceived risk. Thus, in the industrial context, we can rarely focus on the single decision maker...." (Day and Herbig 1990).

Industrial purchasing decisions involve several individuals or decision participants who work together as a decision-making unit, or buying center, inside the framework of an organization (Choffray and Lilien 1980). Muth and Hendee (1980) state that a buying center is a social system of decision makers oriented to common goals within an industrial organization. The social system specifies the range of tolerable behavior for individuals and therefore fixes the effectiveness of adoption strategies and purchase decisions by individuals in the social system. The structure of the social system most influences the norms of the organization, the purchase of frequently used or familiar products and the diffusion of new products. This structure is defined by who leads, how they lead, and why they lead. Although the buying center makes decisions as a group, individuals within the infrastructure buying center are important because their input does have an affect on the buying decisions made by the buying center.

> Lehman and O'Shaughnessy (1974) state that "a key figure in the process (the industrial buying process) is the purchasing agent, whose evaluation of suppliers and products is likely to influence - if not determine - the company's final choice."

The purchasing agents may have their individual buying characteristics, but they should behave totally different as consumers in an organization than they do as individual consumers making decisions solely for themselves. Within the industrial buying center, each individual subverts many of his own preferences to the group effort This person creates a second persona who may have totally different consuming and reasoning habits than when he/she consumes as a private individual. It could be said that the purchasing agent within the organizational buying center is an individual who adopts characteristics similar to that of the consumer he is required to be by the organization (Lehman and O'Shaughnessy 1974).

By these defining characteristics, the United States infrastructure can be defined as an industrial market. First, the decision makers in infrastructure design, construction or maintenance operate in buying organizations to meet the needs of the organization and not their own individual needs. Second, the needs of the infrastructure organizations are complex because of the collective input by the decision makers or purchasers. Therefore, purchase decisions in infrastructure markets are not easily predicted as are decisions made by an individual for personal consumption. Third, the ideas, norms and therefore decisions in infrastructure markets are heavily influenced by organizational structure. Decisions are made by these decision makers based on the structure of the organization and not by these people based on their individual consumer needs.

Choffray and Lilien Say (1980) say that consumer marketing analysis has led the way in scientific applications to marketing research, but industrial marketing research is becoming more prevalent. Industrial marketing managers are discarding traditional rules of thumb used and developed for individual consumer marketing to adopt a more tailored systematic approach required for industrial marketing. Manufacturers in the infrastructure market need more defined, industrial marketing methods instead of using consumer marketing methods.

Factors Affecting Purchase Decisions in Infrastructure Organizations:

Crow and Linquist (1985) state that the larger the firm, the more likely purchase criteria and guidelines exist. Therefore, these buyers have less individual flexibility in the purchasing decision. Both size and industry type were shown to be significant in determining the influence of participants in the buying center. Table 6 shows the purchasing procedure by industry size and table 7 shows the size versus industry effects on purchasing power. A specific example of a social system controlling individual purchasing decisions is in government agencies or non-profit organizations. In a survey performed by Berkowitz (1986), it was found from comments to unstructured questions that many end users in non-profit and government organizations have less power to control the purchase decision than in the private sector. Often times government purchases are made by generic name on a contract basis to government specifications. The government bureaucracy and regulations restrict the purchase decisions to the point where an individual has little power in a purchase decision (Berkowitz 1986). Organizations in infrastructure markets such as state departments of transportation have many branches and divisions. Therefore, the individuals decisions as to what materials will be used in construction of infrastructure will be limited by the organization structure and needs. More likely, decisions for infrastructure construction will be governed by manuals such Ritter's (1990) *Timber Bridges: Design, Construction, Inspection, and Maintenance*.

Within the organizational buying center, Day and Herbig (1990) state that the criteria used to make choices among alternative products is often transient, unstable, and depends upon current membership of the buying center. One manager may have the final buying authority, but the individual is not acting for his/her own benefit but as an agent for the firm and therefore this persons options are limited by the company regulations and specifications. One conclusion drawn by the authors is that the higher the percentage ownership of a firm by one person, the closer the tactics involved approach a consumer entity. If one views the product adopting industrial company or unit as an individual decision maker and ignores the social and institutional dynamics in the organizational buying center of said unit, a change begins to occur in the industrial marketplace. From this, Day and Herbig (1990) conclude that the greater number individual companies acting as users that exist for any particular industrial product, the closer the adoption curve and adopter behavior should approach that of a consumer product.

This consumer effect seen in large companies with many purchasing regulations and in markets with many individual companies may be seen in the infrastructure market. Prime examples of this effect are railroad and in utilities industries. Each of these industries has a large number of members, so the overall market behavior may be very much like individual consumers in the long run with characteristics defined by the firm as an individual.

Industrial Products: How are they defined?

> Onkvisit and Shaw (1989) state "Opportunities can be needlessly lost due to the failure to properly define a product. The wise marketer must define the product in terms of the present and potential benefits desired by the customers - the more benefits, the better. The effective marketing of any product or service must thus begin with the precise definition of the product."

The authors go on to state that there are different benefits that industrial marketers must offer for competitive marketing. What are the complete set of benefits found in the infrastructure markets? Since products in the industrial markets are frequently produced to a set standard, the complete benefit bundle must include: the product itself, the distribution system, the pricing, and the promotional efforts of the marketer. A better bundle has strategic advantage since it provides industrial consumers with more reasons to purchase the product other than the product alone. Infrastructure marketers will want to offer the best benefit bundle to the customer in order to remain competitive.

When compared to a more specialized product, Onkvisit and Shaw (1989) state that the commodity generally consists of a smaller benefit bundle. The authors also state that better pricing control and flexibility can be achieved only when a commodity is transformed into a specialized product. Relating this to infrastructure construction, products may be viewed as undifferentiated commodities. As a result, the commodity manufacturer of infrastructure materials usually must conform to market forces and prices beyond his/her control. Some good examples of this are utility poles, railroad crossties, wood posts for highway signs, or formwork plywood used in highway construction. Because of product standardization, infrastructure construction material producers must define themselves in terms of their pricing, distribution and promotional efforts and less in terms of the product.

> Onkvisit and Shaw (1989) state "Conventionally and conveniently, a product is often - much too often - defined only in terms of its physical attributes (e.g., length, width, color, weight, and materials used). This narrow definition is shortsighted and misleading because consumers are usually less interested in these physical characteristics and more in functions and benefits derived from or associated with such physical characteristics."

The explicit characteristics are those that deal with appearances or the product's physical attributes. In infrastructure construction this could mean strength characteristics or the life-span of the materials. The implicit characteristics are those which for the most part are intangible, but can be just as important, if not more so, than tangible or explicit characteristics. These may be related to ones perceptions of a product, which may dictate whether one purchases or uses a product regardless of whether the product meets the needs of the consumer (Onkvisit and Shaw 1989). Infrastructure marketers must not only define the product with factors outside the products itself, but with benefits provided by a product's implicit and explicit characteristics. In infrastructure construction this could mean strength characteristics or the life-span of the materials.

> "Because of consumers concern with implicit performance, a manufacturer or marketer must look beyond the products physical configuration. Consumers buy a product not just for what it does but also for what it means", state Onkvisit and Shaw (1989).

In infrastructure markets, these implicit values could deal with aesthetics (varying to different degrees from person to person, or from industry to industry), with training about the product, or with environmental concerns that may or may not be factually based.

More (1983) states that different members of the buying center frequently have different adoption criteria, uncertainties, risks, and information needs. Examples of these differences in infrastructure markets would be the differences between engineers and purchasing agents in a company. The engineer may have strict buying criteria on product tolerances and specifications, while a purchasing agent may be more concerned with the cost of the products and less with the specifications.

Onkvisit and Shaw (1989) explain several criteria against which almost all products can be judged. First, market demand must be large enough to make a reasonable profit possible. For any product to be successful, it must satisfy a real need. Successful products have unique characteristics that set them apart from other products produced by the company and other products on the market. A company can acquire strategic advantage by adding a product which has unique features. New products should be given different positioning in order to compete. This new position should allow a market advantage, while minimizing cannibalization of the companies current products.

Infrastructure construction materials are no different and these criteria should be useful for marketers. In the infrastructure market, the products are mainly commodities and therefore should be differentiated on some characteristic other than that of the product itself. The distribution, promotion, or pricing methods should be the differentiating factors in infrastructure markets. When new companies try to enter the market, they should position themselves differently to compete and not through their product alone (i.e., competing through improved distribution, promotion or pricing).

In a study of how product characteristics affect the rate of product acceptance in an industrial organization, Onkvisit and Shaw (1989) identified seven product variables: relative advantage, compatibility, observable, trialability, complexity, perceived risk and price. First, relative advantage is the perceived desirability or the benefit derived from a product relative to other products. The product must be seen as more attractive or useful than other products for it to be accepted. The product's attributes used in differentiation from other products must also be perceived as good and significant. In infrastructure markets, concrete may be seen as having a relative advantage over wood in many applications for highway construction. In other infrastructure applications, such as railroad crossties and utility poles, wood may have the relative advantage over concrete. How individuals in infrastructure organization buying centers perceive these relative advantages is one focus of this study.

The second characteristic cited by Onkvisit and Shaw (1989) is production compatibility, which is defined as fitting a new product into the companies existing production structure through sharing of equipment, facilities, labor, and raw materials. Production compatibility allows the company to avoid costly investments related to the production of a new product with uncertain demand. Economies of scale will be improved, thus lowering overall fixed costs per unit. Products should be compatible with the experiences, values, lifestyles, religious beliefs, and attitudes of consumers in target markets as well as with other products in their possession. Incompatibility may cause the products to necessitate the changes in thinking and attitude, which may cause a slow diffusion of product acceptance.

Incompatibility could be a large cause of loss in market share for wood products in many infrastructure markets. For example, a highway engineering and construction firm may specialize in concrete and steel construction in highway infrastructure. Therefore, the use of wood products in design and construction may require the design engineers to receive further training in wood structures, while they are already highly trained in the use of concrete or steel. Therefore the added costs of training and implementing a material outside their specialty may be incompatible with the firm's goals.

Marketing consistency in infrastructure markets could mean using the current distribution methods in place for the materials such as concrete or wood products. It could also mean implementing promotions such as trade associations or publications. Building new distribution methods or promotional methods for infrastructure products could be costly in time and financial resources.

Onkvisit and Shaw (1989) state that successful products take into account the market demographics. The United States can be broken down into several distinct geographic regions. Geographic customs should be defined for these regions and products should be marketed to fit these customs. Consumption patterns among consumers vary from one region to another. Demand for products can change with the change in regions; each region may have different customs and climates that cause a product to be used. In infrastructure, the customs may change from state to state or from region to region. This change in infrastructure market demographics could be caused by many differences in the decision makers in infrastructure including predominant years of experience, education level, and/or political affiliation or leaders.

Onkvisit and Shaw (1989) state that the United States has five geographic regions each with different descriptions: the East is described as having cosmopolitan travelers; the South is mainly politically conservative; the Midwest, which is considered the average or typical American; the Southwest, being very traditional; and the West, composed primarily of liberals. Each of these regions have different consumption and media patterns. These differences may even be seen in materials used in infrastructure. For example, the US Department of Agriculture, Office of Transportation (1989) states that over two-thirds of timber bridges in the United States are located in the central and south-central United States. This concentration of timber bridges could be influenced by political reasons, education levels/strengths of the bridge designers or because there may be more timber bridge promotional efforts by manufacturers in the Midwest. Close attention should be paid by infrastructure marketers to the geographic locations and the three important aspects of population density, mobility, and customs.

Next, Onkvisit and Shaw (1989) state that there may be legal considerations that must be accounted for the product to be a success. A new or existing product can not be produced and sold without considering its legal implications in terms of consumer safety, monopoly, patent protection, and patent infringement. Other legal considerations in industrial markets are often dealing with the natural environment. The Environmental Protection Agency (EPA) has large regulatory and legal power over many industrial businesses. If operations are not conducted to the EPA's legal standards, production may be halted and the business could fail.

> Onkvisit and Shaw (1989) state that "because the market is dynamic, changes in regulations and related industries should be anticipated and expected. These changes make existing products obsolete and new products necessary."

This could be occurring with the wood products in infrastructure. Concrete is perceived to be a better new product under the current environment of the infrastructure industry. People don't like to see trees used unnecessarily. This may be the perception in the infrastructure decision makers. More likely, the transport infrastructure market perceives the wood products as unable to meet the required demands. Wood is not perceived as being as good a material in highway bridge construction as concrete or steel (Smith and Bush 1995).

Onkvisit and Shaw (1989) give three main characteristics dealing with the individual product characteristics that affect industrial acceptance are observability, trialability, and complexity. Observability is concerned with whether the use of a new product is publicly visible or not. A product will have a better chance of being consumed if it is socially or publicly consumed rather than privately consumed. This public use increases visibility and identification, therefore allowing easier communication about the products features/functions among consumers.

The infrastructure represents how we are either transported or communicate. We are examining products or materials to be used in the infrastructure and its markets. Infrastructure products such as guardrail posts, sound barriers, docks, railroad tracks, and utility poles will be highly visible in a community. Because of this observability of the infrastructure, both the decision makers and the community will form definite ideas and opinions about the performance of the products.

Observability allows future consumers to see what occurs with the products, while trialability allows a consumer to implement a product with low investment risk. Consumers are more likely to try a product if they do not have to commit themselves to a long period of time or substantial investment. If a product can be tried in small quantities, then consumers will be more likely to try and accept it later. Consumers who are forced to buy large quantities initially see the possible adverse consequences of making a mistake as too great a risk for most innovative purchases.

In infrastructure markets, trial use of the materials is relatively easy. Designers have easy access to products made of different materials throughout the US for testing before making the decision as to which material to use. A prime example of making materials in infrastructure observable is the US Forest Service Timber Bridge Initiative program which began in the late 1980s. The initiative not only made timber easily observable as a bridge building material, but it made the trialability less costly as well.

Onkvisit and Shaw (1989) define complexity as the relative difficulty or ease of understanding the operation of the product. The authors further state that a complex product or one that is difficult to understand or use may cause acceptance of the product to be delayed. This has been shown to occur in many infrastructure products which need a great deal of designing and engineering for implementation. Examples are sound barriers, bridges, railroad tracks, and marina infrastructure products. Because many structures are highly complex in design, making them more complex by changing material types may become difficult. The infrastructure decision makers will tend to stay with materials they understand to avoid making the decision more complex.

Onkvisit and Shaw (1989) state that perceived risk or inherit disadvantages in the form of product risks are also seen as a cause for products not to accepted. The risks include physical, functional, social, psychological, legal and financial risks. The risks may range from serious physical harm from the product to annoyance when the product fails. The more complex a structure was, the greater the risk associated with that structure. Infrastructure decision makers would tend to use with materials they understand to avoid making infrastructure more complex, thereby decreasing their risk in designing the structure. In infrastructure markets, the decision makers will want to reduce the risk as much as possible because of the inherent risk already associated with many of the structures. As with all industrial markets, decision makers in the infrastructure market would reduce risks as much as possible by using standard specifications and time tested materials in construction.

The final characteristic of industrial and infrastructure products is defined by Onkvisit and Shaw (1989) as pricing. Price is perhaps the most immediately seen and widely used product characteristic for product purchase decisions, especially if the product is a commodity. High price is a deterrent to adoption or use of a product, whether old or new. New products usually need higher prices because of the small volume and the lack of economies of scale, but mass production makes it possible for the prices to decline. This decline in prices will then stimulate more product sales. Low price can speed up the trial phase and adoption process of products since the negative consequences of making a mistake are minimized.

Products: Success or Failure

Cooper (1990) states that successful products are superior and give the consumer unique benefits not offered by competitive products. These benefits may be in the product itself, or may be part of the product bundle, including better pricing, distribution benefits or promotion benefits. The successful products meet consumer needs better, have higher quality, solve a problem the customer has with competitive products, reduces the consumers total costs, and are innovative.

Urban et al. (1987) give several reasons why products fail. First, the authors state that the market could be too small, causing insufficient demand for the product. This is not the case in most parts of the infrastructure market, such as the railroad or highway construction markets which cover the United States. There are smaller markets where infrastructure market size could be a problem for product success. An example could be the marine and inland waterway construction material's market of the non-coastal US Although there is construction on inland waterways, the interior US may not have enough waterway construction to sustain a materials producer that works only in this market area. The producer must be versatile and address other infrastructure markets to survive.

A second reason the Urban et al. (1987) give causing products to fail is that product capabilities may not match the product requirements needed by the consumers. Related to this is the fact that products often fail because they do not offer better performance than other products on the market. For example, in the railroad construction market, the concrete crosstie is beginning to compete with the wood crosstie. The concrete crosstie has been shown to perform well, but there have been some problems. Railroad companies often want to replace individual worn-out wood crossties in a track system and not the entire track system. The concrete tie has been tried as a replacement for the worn-out wood crossties, but they have failed because the concrete ties have a higher strength in bending and more secure fastening systems. Therefore, the concrete ties which are interspersed within a wood track system will receive disproportionate parts of the train loads which will cause these ties to fail. The failure could occur in the fastening system (the rail seat plates or the fastening screw) or in the tie itself (the crosstie could crack and cause the rail to loose gauge). Concrete crossties do not meet the railroad companies' need in the wood crosstie replacement market and they will not succeed in this market without improvements (Burns 1987).

A third reason Urban et al. (1987) gives for product failure is that the products do not generate the expected channel support. An example of this in the infrastructure market is seen in the highway guardrail market. Punches (1993) states that metal guardrail posts are smaller than wood guardrail posts. These smaller metal posts are more easily arranged on a truck, and therefore more metal guardrail posts than wood posts can be delivered per load. Material transportation costs can be very high. Therefore, this could cause the decision makers to choose metal posts because they can ship more per load and lower transportation.

A fourth reason given by the authors for product failure are changes in key environmental factors causing difficulties for a product in a market-place. Specifically, there are four main areas that could be causing difficulty for the wood products industry in the infrastructure market. First, problems with the natural environment may be causing a supply problem for the wood products in the infrastructure market. Some individuals perceive forest products to be in short supply, so these individuals are putting the wood they cut in the highest value products, which are not necessarily infrastructure products. This has started occurring in the utility pole industry (Wright 1979), where trees which could be poles are put into higher value saw-logs. The railroad industry may also see a crosstie supply problem. In some instances, trees are not being allowed to grow to the size needed for 7 inch thick crossties (Reynolds 1994). The second area of concern in the legislation preventing timber harvesting. The endangered species in the South (red-cockaded woodpecker) and the Northwest United States (spotted owl) has caused shortages in the supply of needed timber for infrastructure products. The third area for concern is with decision makers in the infrastructure construction market. These individuals may perceive the use of wood products to be harmful to the environment. They perceive it as a mis-use of natural resources or harmful because many of the wood products must be chemically treated. The fourth area causing wood product's manufacturers concern in the infrastructure market is that decision makers may perceive the wood products as inferior to alternate materials like concrete and steel.

Copper (1988) states that winners and losers in industrial markets are often determined by deciding factors that tend to occur much earlier in the new product development process, and often before product design and development even begins. These early stages often receive the least amount of management attention and resources. Three main objectives should be accomplished in pre-development activities. First, idea generation should be done extensively to come up with the most useful product ideas that can fit the company and the market. Second, product definition should occur to properly define the winning new product, its market positioning, benefits to be delivered, and its design. Third, in depth product evaluation should be performed, to weigh the project from a marketing, technological, manufacturing, and financial standpoint. This last step will then allow the firm to decide whether to push the project into development. Choffray and Lilien (1980) have similar ideas, stating that major causes of product failures are: poor sales and competitive environment assessment; deficient prior market research; deficient engineering and marketing skills; and lack of integration of the new product/technology into the company's experience base.

To be competitive in the infrastructure market, the wood products industry must differentiate their products from the competition in the minds of the consumers. The wood product companies marketers must position their products to meet alternate needs of the consumers or position the wood products as better than the alternate materials. To compete a product must have good core benefits and be positioned differently from the competition. To position wood products properly, marketers must understand the dimensions used by infrastructure designers to view construction materials. The number of dimensions, the names of these dimensions, the positions of competition and the gaps where wood products can fill the gaps must be known. The wood products industry must know how to put together a product and marketing plan so designers and purchasers in the infrastructure market perceive the products exactly as intended.

Industrial Products Categories:

Difficulties can arise in finding classification categories for industrial products that buyers perceive as homogenous. In industrial markets, the different product types must be taken into consideration to help marketers form a competitive strategy for their products. Lehman and O'Shaughnessy (1974) classify industrial products into four main categories based on problems likely to be encountered if the product is purchased. The type I product is a routine product which is frequently ordered and used. There is little problem learning how to use these products and there are few problems associated with them. Examples of these products in infrastructure could be railroad crossties, electricity distribution poles, and/or highway guardrail posts.

Type II products are procedural problem products where the buyer is confident the product will perform as expected, but personnel must be taught how to use the product. Examples of these products are wood products used to construct highway noise barriers. Sterling (1984) states that because wood highway noise barriers are complicated structures with special needs in construction, the personnel may have to be instructed on the proper construction methods. The wood used in the construction may shrink and swell with changes in the wood moisture content. Therefore, gaps could form in the noise barrier which lessen its ability to abate noise. Special instruction is required to inform construction workers on how to properly build the wood noise barriers in order to minimize the noise causing gaps.

Type III products may have performance problems concerned with the technical outcome of the product. Buyers will usually favor suppliers that offer technical support and training with these products. Examples of these products in infrastructure could be complicated structures such as bridges, salt storage buildings and/or marina facilities. These structures are technical in their application and the persons building or installing them may desire technical support or training about the structures.

Finally, type IV products are deemed political problem products because they frequently necessitate large capital outlays. Usually there are more departments affected because of their separate financial responsibilities with the product and a greater number of changes that will need to be introduced to accommodate the product. When the whole course of the solution can not be solved in advance, problems can often result from difficulties in getting the people from different departments to coordinate their purchase decisions through feedback. Finally, the more departments involved, the greater the number of people involved in the buying decision and the more political problems that could arise. An example of type IV products in transportation infrastructure could be bridges. One department in an organization (for example, the office of the chief engineer in a state department of transportation) may favor the use of concrete bridges, while another department (the office of bridge engineer in the same state department of transportation) may favor using steel or wood in the same application. Because both offices have responsibility for the bridge construction, there is an opportunity for political conflict.

Each of these four product types have different characteristics which determine the acceptance of the product. Knowing these characteristics may help infrastructure material manufacturers develop strategies to help their products compete and fit the needs of the infrastructure organization. Table 8 shows the seventeen attributes used by purchasing agents in industrial situations. Using these attributes, industrial product manufacturers may best target the needs of industrial consumers. As expected with type I products that are used normally and frequently, reliability of delivery and price are the most important attributes for product/supplier selection. Type II products require training of personnel, therefore technical service and ease of use are very important attributes. Type III products require personnel training and technical training, therefore the buyer will judge the product/supplier firm on whether it can do the required job. This causes reliability of delivery, flexibility, and technical service to be rated very high. Finally, type IV products often have political problems within the organization. With Type IV products, people from different departments within the organization want to be sure their firm is receiving the best product from a reputable firm for the least cost. Often, these people have different wants, needs or agendas for the firm's resources as well as differing levels of authority which can cause political problems. Therefore, pricing, supplier/product reputation, and reliability data are the most important product/supplier selection attributes with type IV products (Lehman and O'Shaughnessy 1974). An infrastructure marketer will have to determine what type of product he/she is selling, and then can use these characteristics to promote and sell the product.

Product Life Cycle and the Industrial Products:

The product life cycle curve (PLC) concept describes the evolution of a product over time and is measured by its sales or percent market saturation. The PLC has four main stages: the introduction stage, a period in which the product is commercially launched; the growth stage when the sales start to "take off"; the maturity stage when sales stabilize under competition by new substitutes; finally, the decline stage which is the time when the product is near the end of production and consumption in a market (De Kluyver 1977).

Maturity Stage for Infrastructure Products:

Hiam and Schewe (1992) maintain that strategies in the mature stage are used to profitably prolong this phase in a products life cycle. This is the stage when market shares for products are well established and market growth is slow. Strategies used in the mature stage are the following: maintenance strategy, emphasizing maintenance and reinforcement of the product's market position; defensive strategy, which uses price cuts and promotional activities to defend against other products in the market; and innovation at maturity, which is the combination of defensive and maintenance strategies to minimize market share losses and maintain the highest profitability.

The defensive and offensive strategies are the two main strategies used by marketers in the maturity stage. Defensive strategy is used to maintain a products market share and keep it from being taken by substitute products. This is accomplished mainly by cutting production costs and eliminating weaknesses of the product. Other means of maintaining market share are improving packaging, changing promotional efforts, or changing pricing as consumers become less responsive to promotion efforts (Hiam and Schewe 1992). Infrastructure marketers have mainly been implementing the defensive strategy for market competition. Promotional efforts are implemented with mass media such as the journal published by the Railway Tie Association, *Crossties*, or through personal sales relationships. Prices in infrastructure markets must be kept at market price because the products are commodities. Finally, market share is maintained by producing the lowest cost products that meet infrastructure construction standards.

Offensive strategies are mainly accomplished through finding new markets and untapped market segments, new product uses, and ways to get consumers to increase their use of the product. As products reach maturity, marketers must either use an offensive strategy to force growth of these products, or they can look for new products that will compensate for the anticipated decline and death of the existing product. Life cycles apply to whole groups of similar products, and not any one particular product or brand. Products may need to be very new or innovative in order to compete, and not just improvements or extensions on products in a mature category (Hiam and Schewe 1992). This strategy would be difficult in infrastructure markets because of the strict guidelines for construction. An example is the composite utility poles produced using laminated veneer lumber or the reconstituted railroad crossties produced from ground wood ties.

Industrial Product Life Cycles:

De Kluyver (1977) hypothesizes that the industrial product life cycle behavior is correlated with the degree of product newness. He states that products with a high degree of innovation require a longer period of time to become adopted in the market because of the learning time involved. This author continues by stating that there are three main types of product life cycles for industrial products. Type I PLC curves have innovative maturity. These products have a temporary delay in the growth pattern caused by being highly innovative. Therefore, they do not see large market growth early on and appear to have a mature stage. This could be caused by the consumer learning that needs to take place because the product is highly innovative, as stated by Day and Herbig (1990). Other reasons for relatively slow adoption of the product is to allow all the defects to be improved upon in the innovative idea. The type II PLC curves are more traditional in their growth over time and are referred to as growth maturity. In these curves, maturity comes when expected after a long period of steady growth. Type III PLC curves are deemed decline maturity curves and have a relatively low degree of product innovation. They reach their peak monthly sales volume rather quickly. Decay rate levels off and there is a relatively long maturity stage before decline begins (De Kluyver 1977).

Infrastructure construction products may best fit the Type III PLC curve. De Kluyver (1977) states that low innovation products (such as commodities) are more familiar to the industry and may have anticipated rapid adoption if the product offers substantial economic advantages. This probably causes the growth stage to be fairly short for successful infrastructure materials. As well as being low technology, these materials are expected to have a long service life of sometimes more than fifty years. With such long service lives and very stable markets for infrastructure materials (for instance, with railroad crossties or utility poles) it is difficult to see the need for innovative products. Therefore, infrastructure materials should be considered at the maturity phase as type III PLC products.

Infrastructure Products Review:

In this literature review, product descriptions will be given for each wood product, followed by the current market size and current marketing practices. Competitive products will be described, including their advantages and disadvantages as compared to wood products. New wood product designs and opportunities for wood products in each infrastructure area will be discussed.

The Highway Infrastructure Market:

The US Highway system consists of 3.9 million miles of roads and streets, which utilizes wood in structures such as sound walls, guard rail posts, sign posts, salt sheds, formwork and falsework, and pedestrian bridges. There are approximately 577,000 bridges in the highway system, with 270,000 of these on the federal-aid system (Smith 1994). The main consumers of wood products in the highway transportation system are local, state, and the federal government. The ownership breakdown for highway systems is: local governments 75 percent, state governments 21 percent, and the federal government 5 percent.

Highway construction and maintenance are financed by a variety of ways, including direct user fees, license fees, tolls, taxes and local property assessments. The 1990 census estimated that the 1988 funding collected by all governments for highway use amounted to $69 billion. The percentage breakdown for fund collection was: federal government 48.1 percent; state government 49.7 percent; and local government 2.2 percent. The distribution of funds was: capital improvements 48.1 percent; maintenance 22.7 percent; and all others 24.2 percent. The areas of primary interest to the wood products industry include capital improvements and highway maintenance (National Transportation Strategic Planning Study 1991).

Products

Highway Guardrail Systems:

Guardrail systems are protective structures constructed parallel to roads and highways. They are constructed primarily using steel or wood posts driven into the ground at ten to fifteen foot centers with railing attached at the top usually made of steel beams with W cross-sections or triple V cross-sections, wood timbers or steel cable. The main purpose of guardrail systems is to guide vehicles from traveling off the road or intended path of travel. The market size for guardrail systems includes the entire United States highway system. Anywhere that a road hazard would warrant the use of a guardrail, for instance a road along the edge of a hill or close to buildings, is an opportunity for the use of wood guardrail posts. The highway engineer in charge of construction will specify the material type to be used or the state government may have certain specifications for the type of guardrail system to be implemented. Highway engineers will specify materials according to past experiences and policies of the state governments. Table 9 shows the amount spent on highway guardrail systems (all material types) between 1974 and 1992.

Bowlby (1992) estimates the current cost per unit of guardrail system to be $20 for steel and $11 for wood. Punches (1993) states that a possible market for wood in guardrail systems would be the blocks connecting guard railing to the post. Currently, most states either use wood blocks on wood posts or steel blocks on steel posts. Wood blocks are cheaper than steel blocks, and installation difficulty and expense are the same. The main competition for wood in guardrail systems is the steel post. Table 10 shows the comparison of wood versus steel posts used in guardrails.

Highway Noise Barriers:

Highway Noise Barriers are protective walls constructed parallel to roads and highways. The purpose of these barriers is to reduce the level of noise to areas adjacent to the highway and to break the line of sight between vehicles on the highway and area residents. Noise barriers have two major designs; vertical walls or earth berms. Masonry, concrete, earth, metal, wood, vegetation and combinations of materials have been used in barrier construction.

By the end of 1980, more than 189 miles of noise barriers had been constructed in 31 states and Puerto Rico, and 85% of these barriers had been built in nine states (Cohn 1981). By the end of 1986, more than 450 miles of noise barriers had been built in the United States at a cost of more than 300 million dollars (Weiss 1988). In this study Weiss states that future construction of noise barriers is expected to be tens of miles annually. At an average cost of 12 dollars per linear foot, this represents a market for wood products valued at $3,453,000 annually (Weiss 1988). Table 2 contains the total length of each barrier type in place in the United States as of 1990. The total expenditures on different noise barrier types as of 1981 is found in table 11. The states that implement the noise barriers can be seen in table 12. California has the most noise barriers because of its high population, while Minnesota comes in second due to noise barrier initiative programs.

Cohn (1981) further states that the principle decision makers for noise barrier construction are highway engineers. Teams consisting of design engineers, planning engineers, and environmental engineers make specifications/material decisions. Nearly three fourths of the 27 states surveyed by the author in his study of highway noise barriers allow some form of community involvement primarily through the public hearing process.

The principle criteria explained in Cohn's study used to determine the height and length of highway noise barriers is the Federal Highway Administration's design noise level. Other states have the requirement that the line of sight between the source and receiver of the noise be broken. Most states will not install a noise barrier unless it will result in a noise reduction of at least 10 decibels, although some states use 5 decibels as the noise reduction criteria. A decibel (dBa) is the unit for expressing the relative intensity of sounds on a scale from 0 dBa as the average least perceptible sound, to 130 dBa, the average pain level (Mish and Morse 1994). Cohn (1981) presents several criteria to consider when constructing a noise barrier. First, it should be aesthetically pleasing. The effectiveness of the barrier can be as greatly influenced by aesthetics and landscaping as by acoustical performance. Second, community acceptance is a critical factor. If a community does not want the barrier in place, the barrier will not perform the objective of noise reduction no matter how technically effective. Third, the cost should be optimized. The last factor to consider is a noise barrier must reduce noise to the desired level to be effective.

Signs and Sign Posts:

Signs are constructed along roads, highways, and interstates to give directions, inform and warn motorists. Typically, signs are composed of the following pieces: sign blanks, sign faces, and sign posts. Cunard (1990) states in his study on the maintenance and management of street and highway signs that most widely used sign blank materials are wood (usually plywood), and aluminum. The Federal Highway administration estimates that more than 58 million traffic signs are in use and worth 6 billion dollars. This is an average of 15 signs per highway mile. Today an estimated 250 million dollars are spent on street and highway signs annually. Because of the wide range of supply points for wooden sign posts and plywood used for the sign blanks, there was no estimate attainable for the volumes of these wood materials used in sign construction. Tables 3 and 4 give the percentages of different sign post materials used in cities, states, counties and other government jurisdictions. The qualifications for sign post material is that it must first meet AASHTO standards. Second, it must be rigid enough to resist twisting in the wind or collapsing under the weight of snow and ice. Third, the post must be designed to break away or bend over when hit by an automobile. Fourth, signs must be constructed from readily available material which is inexpensive to install and maintain (Cunard 1990).

Formwork/Falsework Description:

Falsework is described as any temporary construction used to support the permanent concrete structure until it becomes self-supporting. It could include steel or timber beams, girders, columns, piles, foundations, modular shoring frames, post shores, and adjustable horizontal shoring. Formwork is any temporary structure or mold used to contain and support the plastic or fluid concrete in its designed shape until it hardens. Formwork is usually supported by the falsework, which acts as a frame or skeleton bracing system. Formwork is usually composed of plywood sheathing backed with supporting studs, wall and bracing systems. One of the main formwork components is plywood. The first benefit of plywood in concrete formwork is it can be used many times; some panels can be overlaid 200 times or more. Second, plywood produces a smooth finish on the concrete and it can be easily bent to form curves. If desired, plywood panels are available in various surface textures for imparting different textures to the concrete. Third, plywood stiffness reduces design deformation during pouring. Finally, plywood insulating qualities help provide consistent curing conditions (APA 1993). A large portion of formwork and falsework in infrastructure is used in building concrete bridges and other roadway structures (Duntemann et al 1991). Table 13 shows the different types of plywood formwork and their volumes produced in the United States as rated by the APA.

The main competition for wood products comes from steel and aluminum materials used in formwork and falsework. Steel panels and beams for formwork and falsework have been very successful. The steel falsework serves the same purpose as wood timbers, but allows greater spans or heavier loads than is possible with wood timbers. Steel form framing members can last long periods of time with reasonable care and are very suitable for reuse. Much like the steel formwork/falsework, aluminum alloys have proven successful in formwork applications. Although aluminum has a higher initial cost, it has a long service life and is very lightweight, reducing handling costs. Glass-Fiber-Reinforced Plastic is another material competing with wood in formwork applications. The formwork is a combination of materials made up of about one-third glass fiber. This glass-fiber-reinforced plastic material is expanding in the formwork market because it is lightweight, is easily molded into shape, and can impart a seamless surface to the concrete. It is capable of producing a high quality concrete finish and it can be readily fabricated into complex or nonstandard shapes, and it can be readily reused. The main problem with glass-fiber-reinforced plastic is that it can not be fabricated in the field (Hurd 1981)

The Railroad Infrastructure Market:

The second market for wood products in infrastructure is the railroad, which uses wooden ties and timber bridges as major structures. The rail freight industry is composed of private companies with tracks ranging in size from 1 to 23,000 miles. The railroad transports 25 percent of the freight tonnage in the US There are over 500 railroad freight companies owning 160,000 miles of rail line, employing over 213,000 people, and acquiring combined revenues of over $30 billion. Table 14 classifies the rail freight industry.

Class I railroads include companies with revenue greater than $255.9 million. Class I railroads account for only two percent of the total railroads in the US, but operate 73 percent of the total railroad mileage, have 89 percent of the employees, and generate 90 percent of the freight revenue. Class II railroads include those companies are considered regional railroads. These companies operate in specific regions in the US and generate revenues between $20.5 million to $255.8 million. Class III railroads are local, in-line hauls or switching and terminal railroads.

These companies generate less than $20.5 million in revenues (Association of American Railroads 1995).

The passenger rail service is mainly controlled by the National Railroad Passenger Corporation known as Amtrak. Amtrak operates 220 trains each day and transports 21.5 million inter-city travelers and 10 million commuters annually. Amtrak operates on over 24,000 miles of track in the US and provides inter-city travel to 487 stations nationwide. Amtrak owns only 700 miles of track, operating the rest of its 23,300 miles on freight company rail lines (National Transportation Strategic Planning Study 1991).

Railroads in the United States are predominantly owned by individual companies which have exclusive rights to the tracks and facilities. Although the rail transport system use has been declining over the last fifty years, the railroad is still a dominant method for transporting many bulk items, such as coal and other raw materials. The total transport of freight reported by the US railroads in 1990 was over 1 trillion ton-miles and more than 1.6 billion tons of freight. The tremendous amount of freight moved each year puts stress on the track system and the yearly expenditures on track are a major market for the wood products industry.

There is little public knowledge concerning the physical condition of the US rail freight system because it is mainly held by the private sector. New crosstie installation has declined in the past few years, but Class I railroads continue to spend significant amounts on maintenance of way, structures, and on capital expenditures for railroad way and structures. Maintenance of way and structure expenditures include keeping the railroad tracks free of vegetation and debris, as well as maintaining the tracks by adding ballast, replacing decayed and broken crossties, and maintaining bridges, road crossings, and railroad signals. Class I railroads spend 4.4 billion dollars on maintenance of way and structures and 2.7 billion dollars on capital expenditures for railroad way and structures annually. The smaller Class II and Class III railroads are expected to spend over 11 billion dollars over the period from 1990 to 2020, with over 25 percent of this expected to be spent on rail rehabilitation including tie replacement (National Transportation Strategic Planning Study 1991).

Railroad Crossties:

Together, the rail freight and rail passenger industries have a great need for crossties to maintain and build track. The purpose of the wood crosstie is: first, to connect it to lines of transverse rail and hold them to correct gage; second to bear the load transmitted by the rails; and third, to transmit and distribute the load with diminishing intensity along the tie length to the ballast beneath (RTA 1986). Today, virtually all hardwoods except the very low density hardwoods such as cottonwood and willow are acceptable as tie material. Practically all known conifer species are acceptable crosstie material (Gross 1979). Any log 12 inches in diameter or larger will make a crosstie, and the side lumber products are tremendously important to the saw mills producing crossties. Today crosstie production is big business, with millions of dollars invested in crossties every year. Reynolds (1994) states that the current annual crosstie demand is approximately 15 to 18 million crossties per year, with the highest demand on hardwood cross and switch ties which account for 90 percent of production. Table 5 gives the approximate installations for crossties over the last eighty years. Most wood crossties are produced by small to medium sized mills, cutting from 50 to 200 crossties per day. Table 15 illustrates the volumes of treated crossties produced in the United States in 1993. Table 16 shows the different costs associated with production of different grades of wood crossties.

The maintenance of way activity by the Class 1 railroads has slowed considerably since the major track and crosstie replacement of the 1970's, with several factors influencing this trend. First, the system is in good condition and does not require material replacement. Second, redundant and uneconomical lines are being divested by Class 1 railroads, so there are fewer miles of track to maintain. Third, new material technology is prolonging the service lives of many track components. Fourth, the recent creation of many smaller local and regional railroads has reduced the share of track owned by the Class 1 railroads. These smaller railroads have less traffic and travel at slower speeds, so their track maintenance requirements are not as great as Class 1 railroads. Therefore, these smaller railroads spend less on crosstie replacement than Class 1 railroads. Finally, major rail maintenance work has historically occurred in waves with the most recent work in the 1940s and the 1970s. It has been predicted that the next substantial cross-tie replacement cycle will occur in the next decade (National Transportation Strategic Planning Study 1991).

The steady increase in gross train-car weights has lead railroads to consider alternate materials for wood ties. Now the 125 ton car with 39 ton axle loads is becoming a reality (Buckett et al. 1987). The increased burden supported by rail track will require a more thoroughly engineered track than in place today. Engineered wood products such as laminated veneer lumber ties, the reconstituted wood Cedrite tie (McIntosh 1994), or concrete ties may be the future competition for solid wood cross-ties. Steel rail ties are also beginning to take a small place in the crosstie market. The major advantages of steel ties is that specified cants and rail seat configurations can be formed into the tie. Another advantage is the ties downward cavity shape, which serves to confine the ballast and minimize track vibration (Railroad Track and Structures 1987).

Why have wood crossties performed so satisfactorily? First, wood ties have a high strength to weight ratio. This is demonstrated by the fact that less than 0.5 percent of all wood ties removed from track are classified as broken. Second, wood is fibrous and resilient, so it is especially effective in withstanding impact loads. Third, wood crossties are highly resistant to fatigue: a crosstie can be loaded to 50 percent of its load carrying capacity for millions of cycles without any measurable loss of strength or permanent damage. Fourth, in contrast to other tie materials, wood crossties rarely experience sudden failure. Fifth, creosote pressure treated ties have a long life, lasting 30 to 40 years. Sixth, wood is a renewable resource, unlike other materials. Finally, wood is the most economically feasible material for crossties (RTA 1986).

The Marine Infrastructure Market:

The US has the world's largest port system, with roughly 2,500 ports, sub-ports and other facilities. The third form of infrastructure addressed is the marine and inland waterway system using many piles and lumber in wood construction. The waterborne infrastructure system consists of channels, piers, wharves, cargo handling equipment, storage facilities and connections to other modes of transportation. These structures require tremendous amounts of wood products including lumber, timbers, and pilings to build and maintain. Marine applications of wood, especially pilings, represent a large market for wood products. The channels, including locks and dams, will require lumber, timbers and plywood panels for the formwork and falsework used in their construction.

The operators of marine and inland ports are from both the public sector and the private sector. The public sector is operated by the US Navy and the Army Corps of Engineers. The Army Corps of Engineers has the primary responsibility for keeping the US waterways clear and navigable, so they represent a large market in both inland waterways and marine ports construction. The private sector of marine infrastructure is operated by individuals who own the ports and sub-ports, or people that lease these marine facilities from the owners. These marine infrastructure systems and there owners and operators represent a large market for the wood products industry.

The first market for the wood products industry is in building more spacious marine and inland waterway terminal facilities for cargo handling, storage and transportation system interfaces (moving cargo from ship to truck or ship to rail). The building of these structures will mean large use of wood pilings, lumber and wood structure panels in structures as well the use of formwork and falsework for concrete construction. The second market for the wood products industry relates to the age and size of locks in relation to growth of inland waterway traffic. As the inland waterway traffic grows, the need for expansion of the lock system will increase, requiring more formwork and falsework to build the concrete locks and dams (National Transportation Strategic Planning Study 1991). The third market for wood products in water transport is building and repair/maintenance of recreational docks, piers and wharves. The annual economic loss of marine structures caused by wood destroying organisms exceeds $500 million in the United States, not including damage to structures along inland waterways (Helsing et al. 1984).

More than 40 percent of the US marine terminals are located in 15 port cities with 500,000 or more people. The US Army Corps of Engineers is constantly building and improving the US harbors, and these expenditures represent a large market for wood products including formwork, falsework, piling, lumber and structural panels. Table 17 shows the total amount spent over the period of 1985 to 1990 on harbor improvement construction. The major funding for publicly owned facilities varies by source and type of facility. The main sources of funds for capital investment include commercial market instruments, direct subsidies, public-private ventures, user charges and state lotteries. Privately owned terminal facilities generally are operated by the owner or are leased to a private operator (National Transportation Strategic Planning Study 1991). The main species used for marine wood pilings are southern yellow pine and Douglas fir. Table 18 reports the amounts of wood pilings treated in 1993.

The Utility Infrastructure Market:

The fourth market to be addressed is the electricity infrastructure market. This market is a large user of wood poles and cross arms. The consumers in this utility market are: public electric utilities, investor owned electric utilities, Federal electric utilities, and cooperative borrowers. This industry utilizes over 2 million new poles every year at a cost of around $200 to $400 per pole with installation costs as high as $2000 per pole. This equates to a $600 million market annually for the wood products manufacturers (Ng 1994).

Wood utility poles are structures used to support the electric distribution lines. The poles range in length from 30 feet to over 100 feet and from 10 inches to over 20 inches in diameter. There are 2,022 state and local publicly owned electric utilities in the US There are 254 investor-owned and 10 federally owned electric utilities in the US Finally, 941 cooperative borrowers electric utilities operate in the United States. As of 1991, these companies had over 11 million miles of overhead distribution lines and 1.5 million miles of overhead transmission lines in service. It is assumed that 95 percent of these lines are supported by wood utility poles with an average distance of between 350 and 400 feet between poles. This equates to between 138 to 158 million poles currently in service (Ng 1994). Table 19 has data on the production of treated poles in the United States in 1993.

Over 70 percent of the annual production of wood poles in the US have traditionally come from the southern pine forests, and historically these have come from mature pine stands (Wright 1979). Southern yellow pine is preferred over all other species for utility poles for several reasons. First, the supply of southern yellow pine has a wide range and currently is reproducing at a faster rate than it is being harvested. Second, southern yellow pine occurs in dense, pure stands readily accessible to transport methods, making its harvest economical. Third, southern yellow pine may be harvested year round in many locations. Fourth, it is one of the strongest off all conifers. Fifth, it can be found reasonably straight and with good form. Finally, because southern yellow pine has a thick sapwood ring, it is very easy to treat (Williston and Screpetis 1975).

The southern yellow pine pole market may be reaching some difficulties with supply. At the present time, the southern pine forest is producing about 60% pulpwood and 40% sawtimber. About 15% of the sawtimber or about 6% of the total southern pine forest is suitable for pole production. Competitive supply pressure has increased and will push pine timber prices higher. Southern yellow pine prices are projected to rise faster than the inflation rate. Management practices have caused the percentage of pole quality southern pine to drop steadily over the years. As natural stands of pole quality timber are harvested, poles generally are not being re-grown on a planned cycle. An important factor in southern pine pole supply is the trend of utilities' demands for longer and larger poles (Wright 1979). A management problem with growing southern pine poles is the rotation time necessary to produce the pole sized timber. The trees large enough to produce poles for utility purposes require 35 to 40 years for growth on scientifically managed land, while plantation pine is usually grown only on a 25 to 30 year rotation. The longer growing time needed to grow southern pine poles and the potential loss of wood volume by growing poles for this longer time means a lower return on investment. The need and equal market for smaller trees, along with the shorter investment time makes the shorter rotation economically efficient, so fewer pole length pines are produced. The southern yellow pine pole quality timber is the most highly valued part of any forest crop and is equally suitable for utilization in wood product uses which are more economical. Greater concentrations of wood products plants in the South and increasing use of southern pine for sawtimber and plywood are causing some extension in rotations on forest industry lands, but poles will not be grown unless they can compete in price with other forest products (Wright 1979).

Some competing pole materials have begun to make take part of the utility pole market, although the estimate of competing materials is less than 5 percent. When choosing a utility pole material, Taylor (1988) recommends in his study of concrete versus wood poles that the material first be plentiful and uniform. Second, the family of poles should be designed for the loads which are planned for the system. Third, the utility poles should be built from material that will endure longer than the life of the utility line. Finally, quality control of the pole material should be carefully monitored during the pole manufacture process.

There are now four basic types of concrete poles on the market: (1) cast concrete poles which is a cast pole using reinforcing rods for strength; (2) prestressed cast concrete poles which are similar to cast poles except the reinforcing wires are under tension when the pole is cast; (3) spun concrete poles which have a reinforcing rod cage which is placed in the mold and the mold then rotated (like a centrifuge) for uniform distribution of the concrete; (4) prestressed spun concrete poles which are similar to a spun concrete poles except the wires are under tension (prestressed) while the mold is being spun (Taylor 1988). Table 20 shows the cost comparisons for different pole materials.

Other Wood Products in Transportation:

Salt storage buildings are a wood product to be addressed in this study. The second largest end use for salt in the US is for highway deicing. In 1990, over 11,300,000 short tons of ice were used in highway deicing. A large problem with utilizing this large amount of salt is how to properly store the salt, especially with present and future EPA guidelines concerning industrial water runoff and water quality. A problem with using concrete and steel to build salt storage buildings is that the salt will corrode the structure. Salt on roads has been associated with corrosion of motor vehicles, bridge decks, unprotected steel structures, and reinforcement bar and wire used in road construction, and salt storage buildings are corroded the same as other highway structures (Kostick 1992). A viable solution to the salt corrosion problem is to construct the salt storage buildings from wood materials. Some promotional literature distributed by Advanced Storage Technology, Inc. (1988) of Elmira, New York, claims the following benefits with wood constructed salt storage buildings: first, they protect against environmental problems; second, they provide a safer working environment; third, wooden salt storage buildings can be an aesthetically pleasing structure that can be painted any color; fourth, the buildings require little maintenance; and fifth, non-corrodible wood used in construction. Wheeler Consolidated, Inc., also claims that wooden salt storage buildings will not pit or rust, and are not affected by temperature, alkali soils, or acids.

Other infrastructure structures of concern to the wood products industry are small bridges used in off-road transportation, specifically pedestrian foot bridges and small vehicle bridges. Promotional literature distributed by Wheeler Consolidated, Inc. (1988) makes the following claims about small timber bridges: first, construction is faster in any weather; second, the bridges are more easily maintained than bridges made from other material; third, the wooden bridges can be visually pleasing; and fourth, wooden bridges are durable (especially if made from pressure treated wood). A few possible markets for these smaller bridges are: public parks and recreation areas with trails and small roads, golf courses, and private developments such as farms, estates or communities.

Summary

In summary, the infrastructure market is very large with expenditures of 60 billion dollars per year for highway construction, 7 billion dollars per year for railroad track maintenance/crosstie replacement, 500 million dollars per year for marine structures replacement and 500 million per year for utility pole installation/replacement. This large market has many opportunities for the wood products industry in construction of highway guardrails, highway signs, highway sound barriers, road salt storage buildings, railroad structures/crossties, bulkheads, wharves, docks, piers, and utility poles. The wood products industry needs information about this infrastructure market to best compete.

Detailed information has been given about the construction of infrastructure in the United States. Information about market losses/gains and infrastructure construction gives the wood products industry direction for the infrastructure market possibilities. It has been determined that some forest products are maintaining market share in transportation markets, while others are losing market share in transportation markets. The product life cycle for industrial products has been examined and it has been determined that wood products in infrastructure markets are at the mature level. This means that the wood products industry needs devise new ways to extend the mature stage or start a new growth period. The wood products industry could accomplish this largely through changes in the marketing mix, which means changing the promotion, pricing and distribution methods as well as the product. If no changes are made, the wood products industry could see wood products continue to loose market share in the infrastructure market. The infrastructure market has been described as an industrial market because purchase decisions are made in an industrial buying center setting for the benefit of the organizations production or service. Unlike consumer marketing, individuals within the industrial market are making the purchase decisions for the good of the organization based on that organizations norms and leadership. The wood products industry will need to recognize the infrastructure market as an industrial market to best direct their marketing efforts.

This literature review brings information to the forest products industry which is important for several reasons. First, it has been shown that the infrastructure market can use wood products in construction, but the wood products are losing market share in some areas such as in highway bridge construction. In other areas, the wood products are maintaining market share, such as railroad track and utility construction. There are four main hypothesis that produced from these findings. First, it is hypothesized that many decision makers in the transportation industry are not educated in using wood products in design and construction. This lack of education could cause the decision makers to have a poor perception of wood products in transportation design and construction. Second, these decision makers are building structures that must provide safe, efficient transportation of people and freight. If the designs are not standardized and the structure that the decision maker designed or constructed fails, that decision maker has little defense. Design standards act as the decision makers' safety net. Therefore, it is hypothesized that those decision makers in industries without standards for wood products designs in transportation structures probably will have a lower perception of wood in design and construction. Third, greater experience in a transportation area will lead to a larger amount of experience with different materials. Therefore, it is hypothesized that a decision maker with greater work experience in a transportation area will have a different perception of wood than a decision maker with smaller work experience. Finally, wood products are declining in use in the highway system, while decision makers are using about the same amount of wood products in railroads and utilities. Therefore, it is hypothesized that the different markets will have varying perceptions of wood as a construction material.

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