CHAPTER TEN

INTERNATIONAL RESEARCH AND DEVELOPMENT FOR INFRASTRUCTURE MATERIALS

In the past decade, international competition in construction technologies and materials has become more intense. During this same period, U.S. industry began to lose its competitive edge in a number of domestic and international markets. The U.S. also became a "foreign" market for some industrialized countries marketing advanced technologies and materials here. More and more countries will penetrate U.S. technology and materials markets, and our reliance on imports will increase, unless a national commitment is made to change our approach to materials R&D. The following discussion characterizes the orientation and funding of infrastructure materials R&D in Japan, Britain, and Germany, and identifies whatever differences exist. Also, a brief description of specific materials R&D efforts in Europe and Japan is given.

JAPAN

In Japan, materials R&D is user- and applications-oriented. R&D efforts focus on clients' needs, and research is done accordingly. Japanese construction and trade industries conduct construction-specific research, and maintain large laboratory facilities. This is in stark contrast to the U.S. where construction companies do little or no R&D, and the designer knows better than the client what is best. Japanese universities also conduct R&D that is separate from, but complementary to, the work being done at construction company laboratories. Duplication of effort usually is avoided.[46]

46 Halpin, supra note 5, task 3, chapter 2.

New materials are a primary focus of Japanese construction R&D. These include materials used for subsurface ground stabilization and for the construction of bridges and buildings. Because ocean development is important for future land expansion in Japan, the Ministry of International Trade and Industry (MITI) identified advanced construction materials as an integral part of the country's future "marine community program" and overall infrastructure.[47]

One of the keys to the success of Japanese innovation is government support of private sector R&D. Government support comprises a host of government measures that have an important bearing on private sector investment decisions. Prominent among these measures are a policy designed to improve a firm's accessibility to technological information, and fiscal incentives designed to encourage R&D investment, modernization of plants, and technology exports. The MITI and the Science Technology Agency (STA) coordinate R&D efforts, and compile and disseminate data on world economic trends, trade, and industrial developments. Other government agencies set up to facilitate the flow of technical information are the Japan Patent Information Center (JAPATIC) and the Japanese Industrial Technology Association (JITA). JAPATIC was formed in 1971 to serve as a clearinghouse for patent information of both Japanese and foreign origin. The access to this information fosters the transfer of licensing of inventions and helps expedite the innovation process.[48]

Although the Japanese government's information policy certainly helps encourage innovation, perhaps the most far-reaching measures enacted are the fiscal incentives. These include tax credits on a firm's R&D expenditures, accelerated depreciation of plant and equipment, and tax exemptions on sales of technology products overseas.[49]

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47 Strategic Analysis, Inc., New Structural Materials Technologies: Opportunities for the Use of Advanced Ceramics and Composites (Contractor Report to OTA, December 31, 1986), p. 177.

48 Gee, supra note 3, at pp. 148-152.

49 Ibid., pp. 153-154.

Another key to Japanese success in technological innovation is their willingness to assimilate, adapt, and improve on R&D conducted elsewhere. In the course of adapting and perfecting other countries' technologies, the Japanese develop new innovations and new markets. For example, the Japanese are producing innovative egg-shaped concrete waste treatment digesters using design methods based on prestressed concrete technology developed by a West German firm. Also, the Japanese have been very successful in moving technologies quickly from the research stage to the marketplace. This is due, in part, to the fact that in many cases the basic research was done elsewhere; development simply involves adapting the technology to Japanese standards. In contrast, the U.S. is not normally so well informed about R&D efforts abroad.[50]

EUROPE

Each European country has its own approach to conducting and funding R&D. The British and German approaches are described here.

Britain

As in the United States, British R&D efforts tend to be product oriented. Also, a variety of public and private institutions, including government, universities, associations, materials suppliers, and private commercial laboratories conduct materials R&D. Approximately 60 percent of British R&D is funded by the private sector, and 40 percent by the public sector. Materials and component manufacturers finance the majority of private sector R&D efforts, which are aimed at securing a competitive advantage. sl Consequently, the fragmented nature of the

50 Halpin, supra note 5, task 3, chapter 2.

51 "Strategy for Construction R& D," building and Civil Engineering EDCs, United Kingdom, no date.

British research community is similar to that found in the U.S. There is no organization in Britain that carries out the function of the MITI in Japan.[52]

Much of the research in Britain is driven by the fact that infrastructure is in need of repair, and actual funding levels have been declining over the past several years. Areas of great R&D interest include waste disposal, sewage treatment, and public transportation. Improvements in materials and better nondestructive testing techniques will support R&D advances in these areas, and enhance Britain's competitive position in the international construction market. Materials R&D will focus on improving durability and ease of construction and maintenance.[53]

Germany

The German government does not operate its own research laboratories but depends on a number of private, nonprofit research institutions and associations for R&D. However, the government, through the Federal Ministry for Education and Science, is the main funding source and as such controls the direction of R&D activity for these nonprofit organizations. The key organizations are the Germany Research Society, the Max Planck Society for the Advancement of Sciences (the largest research establishment in Germany), the Fraunhofer Society for the Advancement of Applied Research, and the Confederation of Industrial Research Associations. These nonprofit institutes often operate as intermediaries between the government and industry, aggregate needs of the private sector, and disseminate R&D results to industrial firms.[54]

Most engineering and construction research is conducted in the private sector by either manufacturers, large contractors, or institutes receiving support from the public or private see- ,

52 Halpin, supra note 5, task 3, chapter 3.

53 Ibid.

54 Gee, supra note 3, at p. 158s

tor. The role of government ministries, such as the Construction Ministry, the Transportation Ministry, and the Ministry of Research and Technology, is to coordinate and identify national research needs and disseminate research results. For example, a 1981 German government report, "The Future Tasks in Construction Research," identified primary research areas for the construction industry. These included development and improvement of construction materials and methods for industry, bridges, tunnels, water resources, and transportation systems. Specific projects included waterproof concrete, corrosion reduction of reinforced concrete, and improved post-tensioning methods.[55]

A unique aspect of the German engineering and construction industry is the "Gutachten" (expertise) system. This system requires that third-party experts (often, university professors who reside in the German State in which a project is designed or built) verify various aspects of the engineering and construction process. Sometimes, large materials testing facilities are used to evaluate the quality of materials and design concepts. These "Materialprufungs Anstalten" are a source of interface between industry and university faculty. The system encourages a special relationship in which conceptual ideas initially generated at the university are advanced and perfected by industry. Furthermore, university professors act as entrepreneurs and participate as individuals in the patenting process. As a full partner in the patent, a professor can receive large financial rewards and enhance her reputation. Both factors motivate university faculties to conduct R&D.[56] In contrast, U.S. patents from university research often belong to the institution (depending on local policy) rather than to the faculty members who did the work.

Like the Japanese government, the German government plays an active role in coordinating and directing R&D efforts. Both countries employ a wide participative system for R&D planning. Representatives from government, industry, and nonprofit institutions become

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[55] Halpin, supra note 5, chapter 4.

[56] Ibid.

involved in the planning process through numerous advisory groups and committees.[57] Also like the Japanese, the Germans survey international R&D efforts and disseminate this information to the private sector. Furthermore, considerable attention is devoted to facilitating innovation at all stages of the process. Special linker organizations, such as the Garching Instrument Company, and the Arbeitsgruppe fur Patentverwertung (A RPAT), act to narrow information gaps between research and commercialization. Garching, a for-profit organization, is the primary link between the Max Planck Society and industry. It negotiates agreements with industry, acts as licenser for patents, engages in prototype development, and sometimes performs marketing. ARPAT, which is one of the Fraunhofer Society institutes, acts as a licensing and patent rights broker but does not participate in negotiations between principal parties. The activities of the Garching Instrument Company and ARPAT have no equivalents in the U.S.[58]

Besides these activities, the German government stimulates innovation through fiscal measures, which include a variety of tax benefits, such as credits, allowances, and accelerated depreciation, for R&D investments and expenditures. In addition, the government offers public grants to assist companies in introducing innovations into the commercial market. The innovation may be either a product or a process, and, in addition to being technologically new, it must have good commercial promise. Furthermore, the government has made risk capital more easily available to small- and medium-sized companies. One approach used is to provide credits and guarantees to equity investment companies in order to encourage them to invest in technological innovation projects of small- and medium-sized firms. Another approach is to share risks with a private venture capital company for a limited period of time.[59]

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57 Gee, supra nOte 3, at p. 157.

58 Gee, supra note 3, at p. 158.

59 Ibid.

European community

While each European country has its own approach for conducting and funding R&D, the European Community (EC) realizes that maintaining international competitiveness will depend on cooperation among member countries. Accordingly, in 1985, EC created the Basic Research in Industrial Technologies for Europe (B RITE) program. The central objective of the program is to provide an incentive toward the creation of a technological base that Community industries can draw on to maintain international competitiveness over the next decade. Nine major technological areas are given priority: 1) problems of reliability, wear, and deterioration of materials and systems; 2) laser technology and powder metallurgy; 3) joining techniques; 4) new testing methods, including nondestructive, on-line, and computer-aided testing; 5) computer-aided design and manufacturing and mathematical modeling; 6) polymers, composites and other new materials; 7) membrane science and technology; 8) catalysis and particle technology ogy; and 9) new technologies applied to articles made from flexible materials.[GO] Total funding for the 103 selected research projects is 120 million ECU, 50 percent of which is provided by the EC and 50 percent by the industrial companies participating in the program .61 Several of the selected projects will address infrastructure-related issues. They include Electrochemically - based Techniques for Assessing and Preventing Corrosion of Steel in Concrete; Deterioration Prevention in Reinforced Concrete Structures Subject to Hostile Environments; and Improvements of the Lifetime of Woven and Nonwoven Synthetic Materials for Geotextiles, Packaging and Agriculture.[62] Funding levels for these projects are not known at this time.

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60 commission of the European Communities, “Basic Research in Industrial Technologies for Europe,” information package, no date.

[61] Commission of the European Communities, "BRITE - The Community Programme of Research in Industrial Technologies - Gets Under Way,” Press Release, Bruxelles, February 4, 1986.

[62] Complete List of projects Under the First Tranche of the BRITE program me, European Community, no date.

EUREKA is another European initiative to improve productivity and competitiveness of Europe's industries and economies through closer cooperation among enterprises and research institutes in the field of advanced technologies. It was created in 1985 at the European technology conference. To date, 19 European countries, including the Commission of the European Communities, participate in this initiative. Seventy-two cooperation proposals were adopted as EUREKA projects, which cover a wide range of advanced technologies. These technologies include manufacturing, computing, communications, materials, biotechnology, and advanced forms of transport. Implementation of the projects will cost ECU $3.2 billion over a period of 2-10 years. Two advanced materials projects approved in 1986 are CARMAT 2000 and Light Materials for Transport Systems. The $60 million CARMAT 2000 project will evaluate new materials for car structures over a four-year period. The other approved project, Light Materials for Transportation Systems, is funded at $15 million and will last four years. Little information is available on this project.[63]

CEMENT AND CONCRETE

According to the National Materials Advisory Board (NMAB), cement and concrete research and development are declining worldwide, except for Japan. A 1980 NMAB report states that cement and concrete R&D efforts in the U.S. suffer from a lack of intellectual and financial support from pertinent industries and government agencies. In Britain and France, the status of cement and concrete R&D is similar to that in the U.S. In Britain, the Cement and Concrete Association will be cut to one-third of its size, and redirected towards contract research. And, in France, the primary cement industry research institute, CERILH, is closing. In contrast, Japanese building contractors have substantial R&D budgets, and are given

63 Strategic Analysis, Inc., supra note 47, at pp. 32-33.

additional support from the Japan Building Contractors Society, the central coordinating agency, and the Japanese government.[64]

The U.S. cement industry is plagued by obsolete manufacturing facilities, and lags far behind many industrialized nations in the design of efficient plants. Consequently, the U.S. has to rely on new technologies developed primarily in Europe and Japan to modernize existing plants. For example, Germany and Japan are leaders in developing new types of cement kilns.

Another recent trend in the cement industry is the increasing number of acquisitions of U.S. cement companies by foreign companies. In 1986, two U.S. companies, Gifford-Hill and Ideal Basic Industries, were purchased by European companies. Also, Martin Marietta phased out all of their cement operations in 1983. Blue Circle Industries Group of Great Britain bought some of Martin Marietta's plants. About 60 percent of U.S. cement production Plants in 'he U.S. are now owned or controlled by foreign companies.

Developments in improving concrete have taken place both here and abroad. The Europeans and Japanese have done substantial work on concrete admixtures, particularly super-p1asticizers[66] and high range water reducers. U.S. efforts have focused on polymers in concrete, computer applications in modeling and design, and special concrete applications (e. g., earth-quake resistance), as well as compliance with environmental regulations.[67]

Japan has done considerable work on polymer concrete, which was first developed by Nippon Telephone and Telegraph (NTT) in the late 1960s. Since then, polymer concrete has

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64 Frohnsdorff and Skalny, supra note 9.

65 Business communications Company, Inc., supra note 12.

66 Superplasticizers are small organic molecules (no more than 20-25 atoms) used to improve the workability of concrete. The molecules help to disperse water in the concrete so that less *water* is needed.

67 Frohnsdorff and Skalny, supra note 9.

been used to make manholes for telephone lines and now accounts for over 80 percent of block manholes used by NTT. Polymer concrete is also used to make manholes for sewer systems.[68]

Underwater concrete is attracting much attention in Japan. Mitsui Petrochemical first introduced underwater concrete in 1979. Use is increasing in applications such as bridge supports and other structures exposed constantly to water. Because of the increasing demand for this material, the Japanese government formed an *ad hoc* committee (consisting of ten construction companies and auxiliary organizations of the Transportation Ministry and Ministry of Agriculture, Forestry and Fisheries) to establish product standards and create an instruction manual. The Ministries also are actively promoting the use of underwater concrete.[69]

ASPHALT[70]

The U.S. asphalt industry is confronted with a wider variety of problems caused by climate, terrain, traffic loads, and crude oil qualities, than their European counterparts. Consequently, according to the Asphalt Institute, U.S. asphalt R&D efforts are a valuable source of information to the Europeans in addressing their roadway problems.

Pavement rutting is a pronounced problem in Europe. Although there are many ways to solve the problem, the Europeans are focusing on asphalt additives. Two additives that the U.S. Asphalt Institute currently is examining are Styryl (French process) and polyethylene (Austrian process).

Finally, the Asphalt Institute mentioned that Germany, France and Holland have government organizations that support asphalt R&D.

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68 Strategic Analysis, Inc., supra, note 47.

69 Ibid., p. 172-77.

70 This section is based on information received from the Asphalt Institute, March 17, 1987.

PLASTICS

Two of the most recent technological breakthroughs in pipe production systems were developed abroad. The system developed by A.G. Petzetakis S.A. of Athens, Greece, reportedly can produce 60-inch plastic (polyvinyl chloride) pipe that is equivalent in compressive strength and stiffness to solid-wall concrete or cast-iron pipe. Aim International is marketing the Petzetakis system in the U.S. The other pipemaking system was developed by Corma, Inc., a Canadian pipe-corrugation equipment manufacturer, and Oy Uponor AB, a Finnish pipemaking and equipment company. Extrusion Technologies, Inc., has entered into the first Uponor process licensing agreement in the U.S. Both of these processes enable polyvinyl chloride pipe to compete with concrete and cast iron pipes for infrastructure applications. ’l

GEOTEXTILES

Geotextiles (synthetic fiber fabrics used in geotechnical applications) were first developed in the Netherlands in the 1950s as a result of an ambitious civil engineering construction program--Delta Works. Delta Works was initiated after the catastrophic flood of 1953, which inundated 150,000 hectares of land and killed 2,000 people. Since that time, European and U.S. interests in geotextiles have grown. Today, about 38 U.S. and at least as many European companies manufacture and/or distribute geotextiles. Some of the largest U.S. companies include Amoco Fabrics Company, Dow Chemical, du Pent and Exxon Chemicals Americas.

WASTEW.ATER TREATMENT

In the United Kingdom, 13 regional water districts have been established to conduct waste water treatment research. These water districts and a limited number of private companies contribute to the operation of the Water Research Centre, which has a staff of over 255 and

71 Modern Plastics, supra note 17, at pp. 42-44.

about 78 major studies underway. Although most of the Centre's budget comes from the 13 water districts, the national government also contributes 12 percent of the funding. The Water Research Council of Great Britain recently opened an office in Philadelphia to market British sewer and wastewater management systems and technology to U.S. waste water agencies.

A number of large U.S. municipal wastewater treatment authorities fund appreciable R&D on their own (see chapter nine). For example, the Metropolitan Sanitary District of Greater Chicago, the Los Angeles County Sanitary District, and Seattle Metro funded a total of about $3.5 million in support of R&D in 1983. However, the public pays for that R&D via user fees, and the type of R&D funded is generally limited to satisfying local needs.[72]

The Japanese rely heavily on the central government for sewer and wastewater research, planning, and design, and the government has increased its investment in municipal wastewater R&D significantly in the past six to eight years. The Japan Sewage Works Agency (JSWA) has expanded its total staff from 30 to over 900 employees, and considers municipal wastewater treatment a major focus of the Agency's research program. Unlike its U.S. counterpart, the Environmental Protection Agency (EPA), the JSWA also designs treatment works for municipalities through contract arrangements. In the U. S., design and engineering work is performed largely by private sector firms.

The Japanese also have launched a five-year, $30 million collaborative research program involving MITI, JSWA, the Japan Ministry of Construction, universities, and private companies. The goal of the program is to develop a new class of wastewater treatment technology, which, if successful, would meet pressing local needs as well as become a possible new export to the U.S. and Europe. The program supports two simultaneous research efforts: one in biotechnology for waste treatment; and the other, dubbed "renaissance, " examines a wide range of treatment approaches, including various membrane technologies. U.S. experts note that the prospects for a

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72 American Public Works Association, supra note 44.

breakthrough in wastewater treatment technology are far from certain, and that any Japanese advances likely would have to be adapted and modified for U.S. conditions. Currently, exports comprise no more than 1-2 percent of Japan's wastewater treatment equipment sales.[73]

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73 Personal communication with John Convery, U.S. Environmental protection Agency, Municipal Wastewater Research Division, Cincinnati, Ohio.