PART THREE

MATERIALS RESEARCH AND DEVELOPMENT

FOR THE NATION’S PUBLIC WORKS

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CHAPTER SIX

INTRODUCTION TO MATERIALS R&D FOR PUBLIC WORKS

The 1986 report of the National Council on Public Works Improvement (NCPW) noted that, although the basic technology of public works has changed very little in the past 50 years, "current developments in science and engineering are capable of making significant contributions to the improvement of every major infrastructure sector in the foreseeable future."[1] The Council's report concluded that new or improved materials can significantly improve the condition of our Nation's infrastructure and even minimal efforts could yield substantial benefits, However, they also found that a number of formidable institutional constraints inhibit the application of new technology in the construction industry generally, and especially in public works.

Th s part of the OTA Staff Paper evaluates the importance of materials R&D efforts to rebuilding and maintaining our Nation's public works, and identifies some of the most recent developments in materials for infrastructure, These include cement and concrete, asphalt, plastics and other synthetics, geotextiles, and paints and coatings (see chapter seven). In addition, it describes current Federal and nonfederal programs supporting materials R&D for public works (chapters eight and nine). The Federal agencies examined include the Departments of Transportation, Commerce, Defense, and the Interior; the Environmental Protection Agency; and the National Science Foundation. Federally-supported highway materials research programs of the

[1] National Council on Public Works Improvement, The Nation's Public Works: Defining the Issues (September 1986),

National Research Council also are discussed. This part also briefly describes foreign R&D programs for infrastructure materials (chapter ten). Finally, it outlines institutional issues and materials research needs that OTA staff identified during the course of preparing the paper, and discusses options for resolving those issues (chapter eleven).

This is not an exhaustive review of all aspects of materials R&D for public works. OTA Energy and Materials Program staff relied on an extensive literature survey supplemented with information obtained in meetings and telephone conversations with Federal agencies, trade associations, and companies. Several questions were impossible to address adequately within the time constraints of this survey. In particular, we were unable to quantify the size of the materials R&D needs, or the point at which R&D investment reaches diminishing returns. Instead, we provide a qualitative discussion of the materials R&D areas that would deliver the "biggest bang for the buck," and discuss ways of targeting the available R&D to make it more effective. In addition, we were unable to conduct thorough reviews of foreign R&D and of the constraints introduced by Federal contracting policies.

WHAT ARE INFRASTRUCTURE MATERIALS?

Materials may be defined as "the 'stuff' that things are made of." There are two basic classes of infrastructure materials: 1) natural or construction materials, which derive their properties in the field or in use (e.g., asphalt, concrete, cement, stone, sand and gravel, coatings); and 2) manufactured products that are fabricated from materials in a controlled environment and tend to have more consistent properties (such as pipes, gaskets, liners, membranes, filters, hoses, and precast concrete items). OTA*S primary focus in this Staff Paper is on natural and construction materials (see chapter seven).

WHAT IS INFRASTRUCTURE MATERIALS R&D?

The materials industry and its R&D projects vary widely--from "high tech" ceramics and composites to such basic materials as sand and gravel.[2] Infrastructure materials R&D includes both basic and applied research. The basic research focuses on the scientific understanding of the characteristics and properties of different materials, their performance in use, their modes of failure (e. g., fracture, deformation, delamination, rutting, slumping, corrosion, etc.), and their interaction with the environment. Applied infrastructure materials R&D examines methods of prolonging and enhancing the performance of materials in place, and of predicting and preventing failure, including the development of nondestructive testing methods. In addition, the materials industry frequently evaluates and adapts technologies or materials developed for other uses to infrastructure needs or to specific local infrastructure problems. In this latter sense, infrastructure materials R&D includes some work that in other fields might be dismissed as neither advanced nor incremental, or perhaps not even research.

Research and development on infrastructure materials currently is sponsored and carried out by a number of Federal agencies, and by State and local governments, universities and research centers, trade associations, and corporations. Based on our brief survey, OTA estimates total materials-related R&D to be $53 million to $62 million in FY86, with around $35-!$37 million coming from Federal agencies and programs (see chapter eight) and the remainder from nonfederal sources (chapter nine). Nearly half of the Federal R&D (around $17 million in FY86) is sponsored by the Department of Transportation (DOT). The second largest chunk of

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[2] The materials industry can be characterized as a "mid-day" industry--one that is essential to the basics of life, food, shelter, and transportation. At the same time, much of Federally-funded materials R&D is directed toward academic "big physics" and "high tech" projects with little application to the needs of the domestic materials industry. Statement of Dr. Rustum Roy, Pennsylvania State University, Hearings on Materials Research and Development Policy, Subcommittee on Transportation, Aviation and Materials, House Committee on Science and Technology, 98th Cong., 1st Sess., 1983, at pp. 258-67.

Federal materials R&D for public works comes from the Department of Defense, Army Corps of Engineers ($12-$13 million). Other Federal research efforts are conducted by the Environmental Protection Agency; the National Bureau of Standards, the National Science Foundation; the Department of the Interior, Bureau of Reclamation; and the Department of Agriculture, Forest Service.

Of the $18 million to $25 million spent annually on nonfederal materials R&D for public works, around 60 to 65 percent is related to highways, roads, and bridges. This is funded by State and local governments and regional transit agencies, as well as professional organizations and trade associations and their affiliated research foundations (e. g., the Asphalt Institute, American Public Works Association).

Materials are an important cost component in sewer construction and maintenance, and the larger municipal sanitary districts are a significant source of funding for materials-related research for sewers and wastewater treatment systems. Other sponsors include professional and trade associations; engineering, consulting, and construction firms; and equipment and materials suppliers. Together, these groups spend approximately $3 to $5 million annually on wastewater R&D. Another $1 million in nonfederal funds for materials R&D is devoted to water supply and treatment, primarily by local governments. Finally, around $100,000 to $500,000 in nonfederal R&D is spent annually on materials for water resource projects, waterways, and ports.

HOW DOES DOMESTIC MATERIALS RESEARCH FOR PUBLIC WORKS COMPARE TO R&D EFFORTS ABROAD?

Successful development of materials and their incorporation in public works projects require a favorable climate and appropriate incentives--both of which are lacking in the United States. Strong incentives are available in other countries to work the "bugs" out of theory and move new ideas to the marketplace (see chapter ten). In both Japan and Europe, for example, the governments encourage innovation and development through tax incentives or matching funds, and through flexible bidding concepts. Government-industry co-funding assures a company's willingness to commercialize results after research is completed. West Germany, for example, makes public grants available for the introduction of promising innovations into commercial markets. Also in Germany, special "linker" organizations facilitate innovation by expediting the flow of technical information and contributing to the stimulation of new ideas.[3]

In the U. S., industrial materials research and development are product-oriented, and aimed at maintaining a competitive edge.[4] However, the numerous materials programs and researchers, and the inadequate information flow among them result not only in duplication of efforts, but also in gaps in the materials R&D agenda. In comparison, both the Japanese and German governments have agencies that coordinate research and disseminate information.

Also, few U.S. universities have construction-related materials programs, and many civil engineers have little or no training in materials science. The opposite is true in Europe and Japan where specialty engineers receive cross-disciplinary trainings

An integrated approach to design, engineering, and construction would benefit infrastructure projects by identifying optimal materials for specific projects. An integrated approach also would help facilitate the transfer of information more readily. Although the U.S. is not presently pursuing this approach in any organized manner, other developed nations have established integrated research programs, such as Switzerland's efforts in concrete technology.[6]

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[3] Sherman Gee, Technology Transfer, Innovation and International Competitiveness, New York: J. Wiley & Sons, 1981.

[4] Nonproduct-oriented research generally focuses on software and management systems.

[5] Daniel W, Halpin, Technology in Architecture, Engineering, and Construction (Contractor Report to OTA, Tasks 1 and 2, chapters 8 and 13, March 17, 1986.

[6] Ibid., Chapter 8.