CHAPTER FOUR

CONSTRUCTION R&D PROGRAMS IN OTHER INDUSTRIES AND IN FOREIGN COUNTRIES

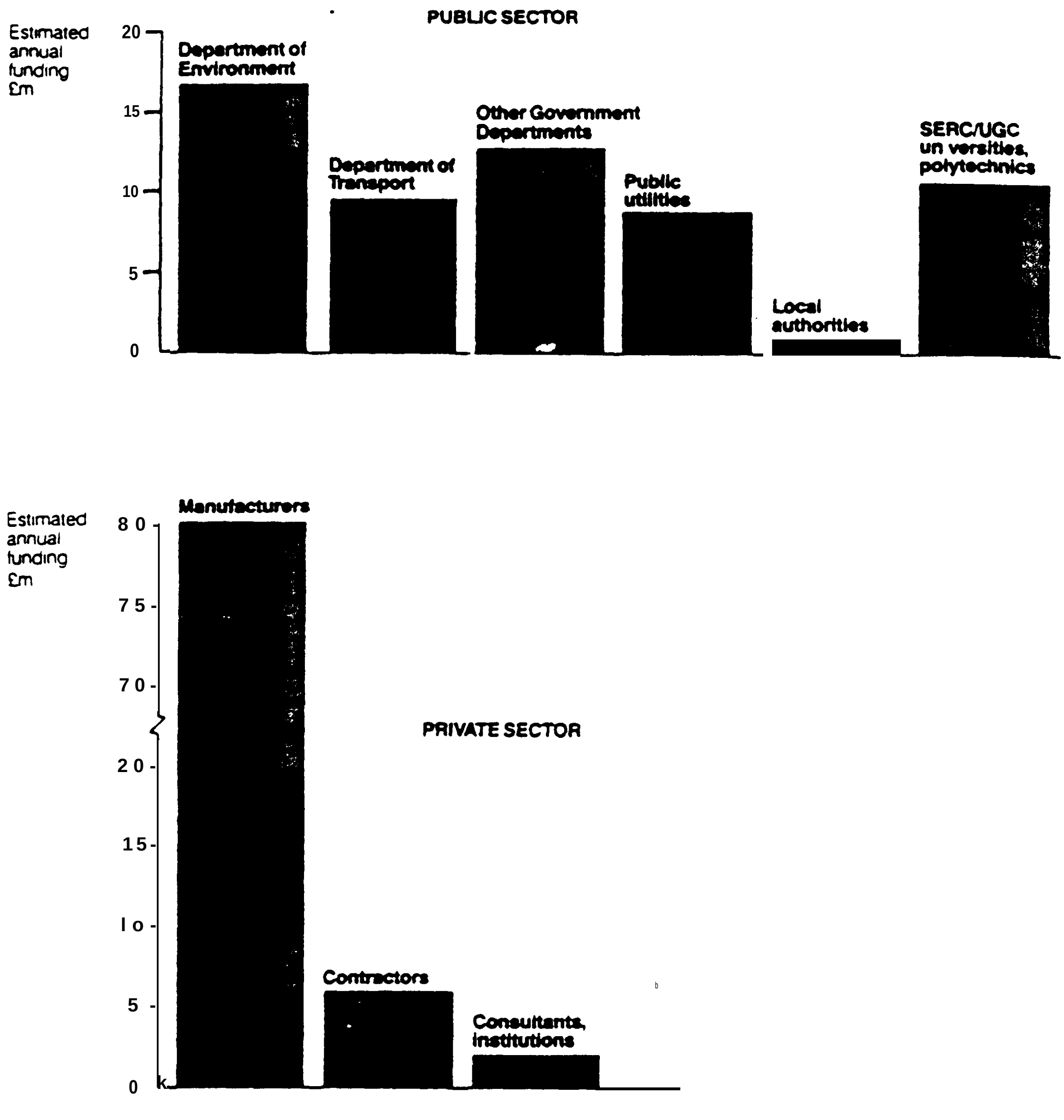
American firms have been preeminent in the world in large-scale construction for many years. Recently, however, smaller-scale construction is becoming increasingly internationalized, and American firms find themselves competing with foreign construction firms even for domestic work. R&D efforts in other industries and in foreign countries provide comparisons and potential alternatives for infrastructure construction R&D programs in the United States.

The competitiveness of U.S. firms in international markets or against foreign-based firms in U.S. domestic markets is not a primary concern of this study. Nevertheless, foreign competition has become a major driving force for new and improved technologies in many industries, and could become so for construction. This chapter presents a brief comparison of R&D and innovation of public works construction technology support in the United States with examples from other countries. That comparison highlights some institutional strengths and weaknesses of the U.S. system as well as describing alternatives.

RELATIVE EXPENDITLTRES FOR R&D IN OTHER U.S. INDUSTRIES

Privately funded R&D expenditures for several major industries are listed in figure 4-1. Electric utilities and construction have markedly lower R&D expenditure percentages than the other industries. In addition to this private support on R&D, many manufacturing industries also perform in-house, federally-supported R&D funded primarily by the Department of Defense. These expenditures are not included in figure 4-1. For example, the aircraft and mk - sdes industry received Federal funds equivalent to 12.9 percent of sales volume for R&D, while the electrical equipment industry received 2.6 percent; the machinery industry, 0.75 percent; the

Figure 4-l,-Estimated Funding for Construction related RGD in the United Kingdom



SOURCE: Daniel W. iialpin, Construction Management Consultant to OTA, "Final Report, Task I, Technology in Architecture, Engineering and Construction," Mar. 17, 1986.

chemicals and allied products industry, 1.2 percent; and the motor vehicles industry, 0.40 percent.[42]

INFRASTRUCTURE R&D PROGRAMS IN FOREIGN COUNTRIES

OTA examined construction R&D programs in two foreign countries--Japan and the United Kingdom--comparing to the extent possible the expenditures of these countries for construction R&D with those in the United States. One European Community research program, Basic Research in Industrial Technologies for Europe (BRITE), was also examined, since several projects in the BRITE program are relevant to infrastructure construction.

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In Japan, the Ministry of Construction funds nonmarketable basic research at institutes such as the Public Works Research Institute and the Building Economics Research Institute. The institutes are not connected with universities, but they employ full-time researchers as well as faculty from universities on a temporary barn.[43] The Ministry of International Trade and Industry (MITI) funds similar research for transportation.

The level of government support for construction research programs is unknown but is reportedly small compared with the amount invested by Japanese construction company laboratories.[44] The Japanese Government indirectly supports R&D Programs in the construction cOmpany laboratories through tax breaks and other institutional means.[45] For example, if a com-

42 Adapted by OTA from National Science Foundation, National patterns of Science and Technology Resources 1986, NSF 86-309 (Washington, DC: 1986), p. 55.

43 Neil M Hawkins, Associate Dean for Research, University Of Washington, Personal communication, May 28, 1987.

44 Daniel W Halpin, construction Management Consultant to the Office of Technology Assessment, “Final Report, Task 3, Technology in Architecture, Engineering and Construction, ” Mar. 17, 1986.

45 Ibid.

pany invests more in a given year in research than its largest R&D investment over the past ten years, it gets a tax deduction of up to ten percent of its total tax. If the R&D investments less than 15 percent higher than the largest R&D investment over the past ten years, 25 percent of the increased portion is deducted from its annual tax. If the annual increase is over 15 percent, the deduction is 50 percent of the increased amount. For further discussion of institutional support for R&D in Japan, see chapter five.

R&D expenditures are shown in figure 4-2 for eleven out of the 18 construction firms (worldwide) that enjoyed at least $3 billion in total contracts and at least $16.5 million in foreign business for 1985. The list includes seven Japanese firms; R&D expenditures are known for five of these firms. The five firms spend a little less than one percent of their total contract volume on R&D, in decided contrast to large U.S. firms, whose much smaller expenditures are also shown in figure 4-2. All of the largest Japanese firms have smaller total contract volume than the seven largest U.S. firms, but R&D expenditures for each of the five Japanese firms whose R&D expenditures are known are greater than for any of the U.S. firms.

Many of the types of R&D pursued by Japanese firms in recent years were "invited" by the Japanese government, and they are impressive.[46] KajimaJs R&D has included a concrete finishing robot, a rebar placing robot, wall tile inspection machine, and a five-boom crawler for tunnel work. Taisei's R&D program has included pioneering developments in abrasive waterjet methods for cutting steel, rock and concrete; new tunneling techniques based on the New Austrian Tunneling Method; microcomputer systems for shield tunnel boring machines; an underwater T.V. inspection system; robots for spraying concrete, inspecting wall tiles, and spraying paint on building exteriors; as well as development of computer software for concrete-laying robots. Takenaka has worked on robotic systems for concrete placement and finishing, a paint spraying robot, a robot tower crane fox lifting and positioning steel reinforcing bars for concrete

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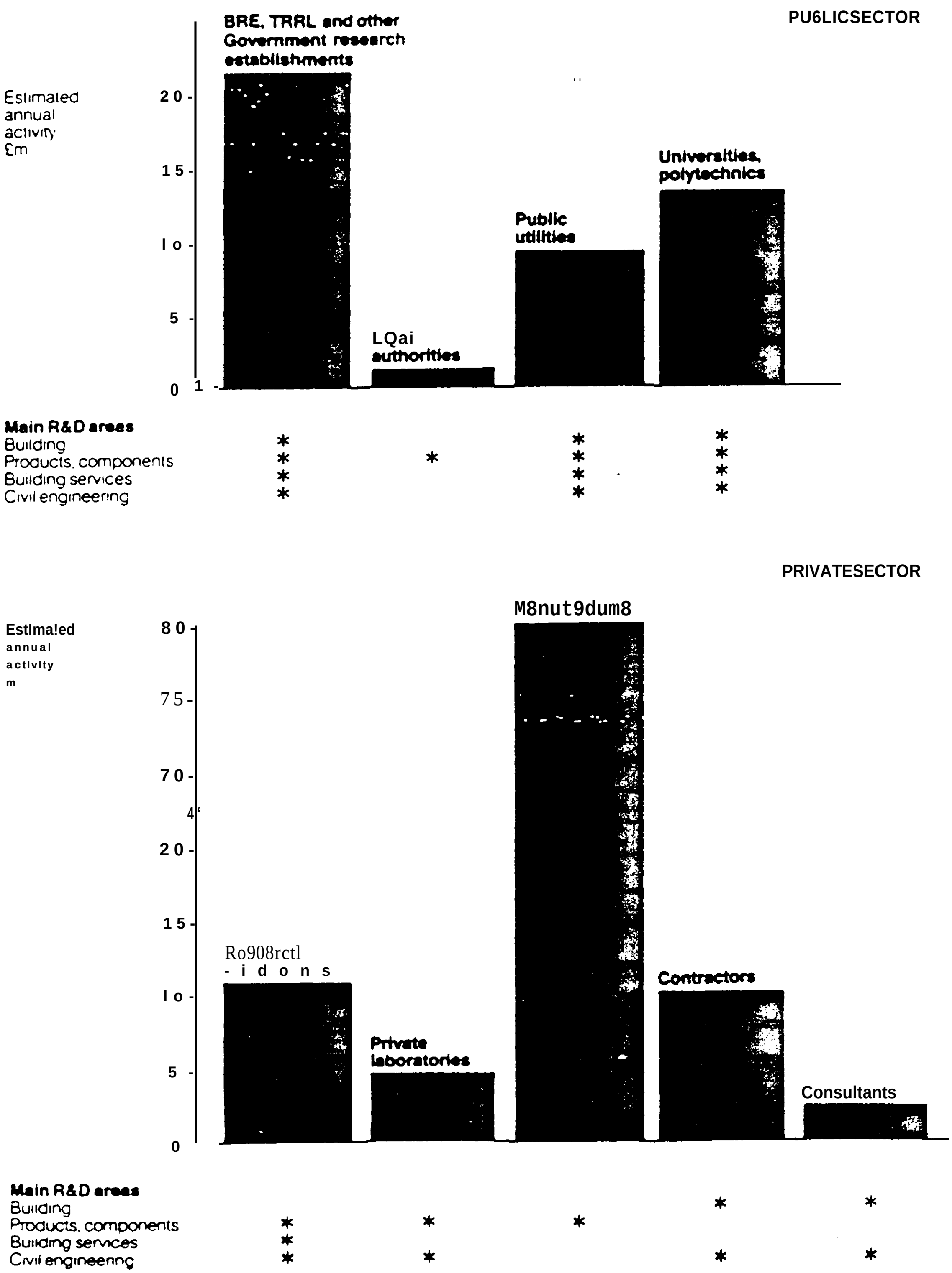
46 Neil M. Hawkins, op. cit.

Figure 4-2--Estimated construction related RGD Activity in RGD Facilities in the United Kingdom



Source : Daniel W. Halpin, Construction Management Consultant to OTA, "Final Report, Task 3, Technology in Architecture, Engineering and Constructionj" !lar. 1[7], 1986.

buildings, and a combination crane and concrete placement machine. Shimizu's R&D program has included earthquake-resistant walls; clean room technology; processing and disposal of nuclear wastes; automatic installation of ocean platforms; and robots for spraying fireproofing on structural steel in high-rise buildings, and for industrial cleaning, concrete cutting, painting with rollers, and lifting and positioning steel beams. Kumagai Gumi has worked on liquid natural gas storage, new shields and techniques for tunnel boring, novel methods for driving piling, novel methods for building walls by applying hardeners to soil, and robotics for automatic assembly of segments of tunnel lining. A smaller company, Hazama Gumi, Ltd., specializes to a greater extent in infrastructure construction, such as dams, tunnels, railways, highways, subways, airports, waterways and shipyards. Hazama Gumi has an R&D department which has developed an automatic control system for a tunnel boring machine shield using laser and computer technology. Hazama Gumi's researchers are interested in acoustic and other sensors for measuring soil properties in real time in front of the shield to allow them to optimize control of rate of material extraction and shield velocity .47

The research programs of the Japanese construction firms contrast markedly with the research programs of U.S. firms. Of the eight U.S. construction firms contacted in this study (see chapter three for details), only Bechtel appears to be doing R&D at a level of sophistication approaching that of the Japanese firms. Even at Bechtel, the amount of such research is less than at the Japanese firms. Much of what could be considered R&D at U.S. firms is software development for scheduling, cost control and other management functions. Enhancements in management functions are important, but do not fundamentally advance construction technology. From discussions to gather information for chapter three, OTA estimates that R&D at U.S. construction equipment manufacturers probably approaches the sophistication of Japanese construction R&D in some cases.

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47 James S. Albus, Chief, Robot Systems Division, National Bureau of Standards, Summary Trip Report, July 7, 1985.

United Kingdom

Public sector funding in the United Kingdom for R&D for construction in general (not just infrastructure construction) comes from a variety of sources, as shown in figure 4-1. The research is performed at several types of facilities, as shown in figure 4-2. It is not known how much of this research is evaluative or design-oriented, and how much is oriented toward development of construction technologies. According to one estimate, the British Government spends about 60 million pounds, or 0.28 percent, of the total construction turnover in the United Kingdom, on R&D for construction.[48]

According to a study of construction R&D in the United Kingdom, manufacturers fund most of the R&D in the private sector (see figure 4-1).[49] Organizations that do R&D in the private sector are shown in figure 4-2.

Total private expenditures on R&D for construction in the United Kingdom is about 90 million pounds, or 0.42 percent of the total construction turnover, according to one estimate. The same analysis estimates that the total expenditure (public plus private) for construction R&D in the United Kingdom is about 0.7 percent of the total construction turnover. Another analysis estimates 0.5 percent.[50]

The overall pattern of construction R&D in the United Kingdom seems similar to that in the United States: most of the private-sector R&D is done by the manufacturers, with construction firms doing very little. It was impossible to do an indepth comparison of United States and United Kingdom efforts in the short time span for this project.

48 Halpin, op. cit.

49 Ibid.

50 Ibid.

The BRITE Program

BRITE is a European Community (EC) program that provides one-half of the funding for 103 research projects in a variety of technological areas. Industrialists from EC that participate in the research provide the other half of the funding. The funding level provided by BRITE is 125 million ECU (approximately $125 million U.S.) for a four-year period (1985-1988).[51]

The focus of BRITE is broad, but 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, (5) computer-aided design and manufacturing, (6) polymers, composites, and other new materials, (7) membrane science and technology, (8) catalysis and particle technology, and (9) new technologies applied to articles made from flexible materials.[52]

Three of the 103 BRITE projects appear to apply directly to infrastructure construction, reconstruction, repair, or routine maintenance. Two of these are in the area of reliability, wear, and deterioration. The titles of these projects are: (1) Electrochemically-based Techniques for Assessing and Preventing Corrosion of Steel in Concrete, and (2) Deterioration Prevention in Reinforced Concrete Structures Subject to Hostile Environments. The other infrastructure construction-related projects are entitled, (1) Improvement of the Lifetime of Woven and Non-woven Synthetic Materials for Geotextiles, Packaging and Agriculture, (2) Applications in Civil Engineering. W 5A OTA was unable to determine actual funding levek for these Projects.

51 Commission of the European Communities, "BRITE The Community Programme of Research in Industrial Technologies Gets Under Way," Press Release (Brussels: Feb. 4, 1986).

52 Ibid.

53 “Complete List of Projects under the First Tranche of the BRITE Programmed,” BRITE, European Community (no date).

54 Commission of the European Communities, "BRITE: Eight More Projects Selected for Community Support,” Press Release (Brussels: June 19, 1986).

POTENTIAL R&D MODELS FROM OTHER INDUSTRIES AND COUNTRIES

R&D in other industries and countries suggests models which could potentially be applied to infrastructure construction in the United States. Several models are described here, but further study is needed to examine the models in more detail.

The first model is support by the Federal Government for R&D within private construction firms for public works construction. As described earlier in this chapter, many manufacturing industries have substantial R&D efforts funded by the government, primarily the Department of Defense. The problem with this approach as it applies to construction firms is that the firms currently do very little R&D and so would probably not have the facilities or experience to perform much federally-supported R&D, at least for a number of years. Another version of this approach is further support of projects using innovative approaches to construction, perhaps in a format similar to that in the 1982 Surface Transportation Assistance Act, described earlier. A problem here would be the definition of "innovative" and how to determine if a construction project is really innovative.

Japanese construction firms reportedly receive tax breaks for increasing their R&D expenditures, although the main incentive is in the profit margin on jobs within Japan that involve advanced technologies or processes that can then be used on the world market.[55] The same approach could be followed in the United States for its construction firms. Of course, tax breaks for U.S. firms need not follow the Japanese format exactly.

The European Community program, BRITE, is an example of a combined government industry research program, which could potentially be applied in the United States. The industries that actually participate in the research contribute half of the money, with the expectation

55 Neil M. Hawkins, op. cit.