

Development of Next-Generation Human Resources in Engineering in Japan

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1. Current Status of an Aging Society with Fewer Children and Impact on Science and Engineering

1.1 Current Status and Predictions for an Aging Society with Fewer Children

In 2005 the total population of Japan dropped below the level of the previous year for the first time since World War 2. A direct cause of population decline is a decrease in the number of births and an increased number of deaths according to aging. Looking at the number of births, there has been a decreasing trend since Japan's second baby boom in 1974. The total fertility rate reached an all-time low of 1.29 in 2004, and the decrease in the number of children is progressing more noticeably than in Europe and the USA. The proportion of elderly people indicated by the percentage of the population aged 65 years or over, rose rapidly after 1970 with the increase in life expectancy and decrease in number of children. This proportion surpassed 14%, the level regarded to constitute an "elderly society," in 1994. In October 2004 the rate reached 19.5%, with Japan's proportion of elderly people surpassing that of other developed nations.

The aging of society in Japan is characterized by its high proportion of elderly people and the extremely rapid aging rate compared to other countries. Based on comparison of Japan's expected future proportion of elderly people with that of other countries, based on estimates by the United Nations, it is projected that the aging of society in Japan will continue at a rapid pace that exceeds that of other countries (Fig 1-1).

For the world as a whole, the population will continue to grow in the future, but many developed nations and various countries in Asia are also expected to make the transition to declining populations in the near future. (Fig 1-2)

Japan will face the issues of declining population and the aging of society and decrease in the number of children before these other countries.

1.2 Impact on Science and Engineering

Over the long term the population of the country is projected to decline, along with the rapid advancement of an aging society with fewer children. Looking at the society of the country in terms of the population structure, it is

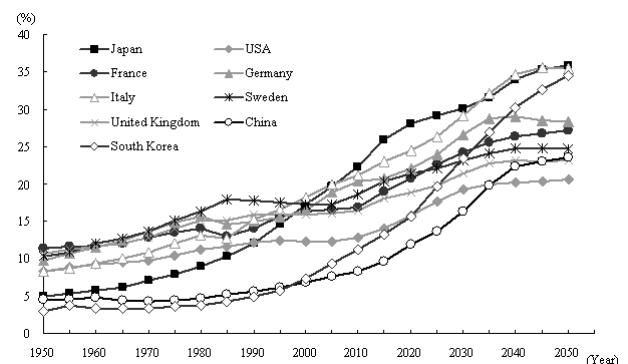


Figure 1-1 Percentage of population aged 65 and older in various countries
Source: United Nations, World Population Prospects: The 2004 Revision

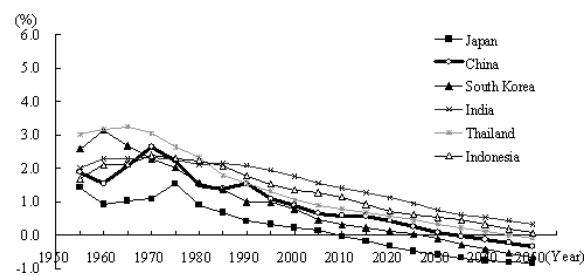


Figure 1-2 Projected annual average population expansion for Asia
Source: United Nations, World Population Prospects: The 2004 Revision
For Japan, numbers through 2005 are from the Statistics Bureau "Population Census," "October 1 Population Estimates," for 2010 and later, based on the National Institute of Population and Social Security Research, "Population Projections for Japan (January 2002 Projections)".

predicted that there will be a complete change from the structure of the past (Figure 1-3).

This kind of structural population change is expected to have large and wide-ranging effects on society.

First, as the percentage of the elderly population is increasing, it is raising concerns about the increasing burden of social security from pensions as well as health care and nursing care. In 2004 there were 3.4 people in the number of working-age population (15-64 years) for every elderly person. This is projected to drop to 1.5 by 2050.

In addition, the working population (persons aged 15 years or over who intend to work) has been declining since 1998, with decreases projected to continue in the future. Furthermore, it is projected that in 2007 the baby boomer generation (consisting of people born between 1947 and 1949) will start to retire from the labor market as they approach the age of 60. This generation has supported the country's economic growth, and mass retirement of them could have a profound impact on all facets of society, called the Year 2007 Problem.

There is fear that changes in the composition of the population could have a large impact on the ability to secure the personnel that support a science and technology-based nation. As the population ages, the percentage of middle-aged and elderly people working in specialized/technical jobs is increasing, a trend that is expected to continue in the future. In addition, the Year 2007 Problem as above is expected to have a large impact on shortage of engineers and skilled workers, particularly in the fields of science and engineering.

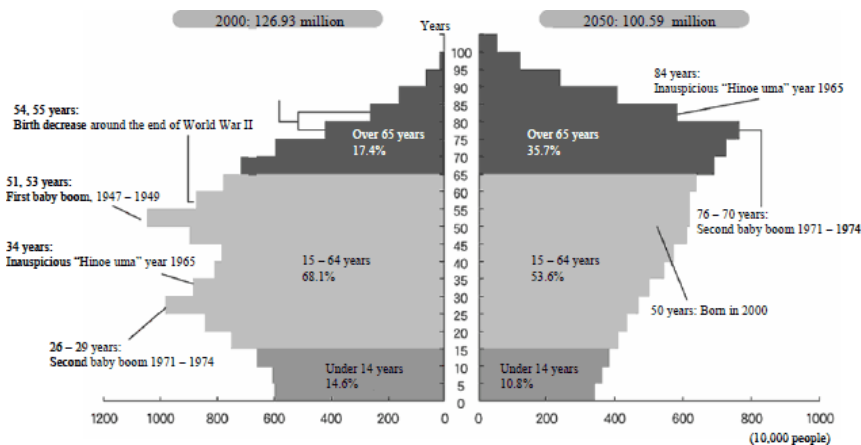


Figure 1-3 Changes in Japan's population structure by age
 Source: For 2000, Ministry of Internal Affairs and Communications' "Population Census."
 For 2050, the National Institute of Population and Social Security Research's "Population Projections for Japan (January 2002 Projections)".

Consulting engineering industry in Japan also faces the issues of aging. Since the construction investment in Japan has been decreasing year by year, most firms have restrained hiring. In recent year, the number of young engineer is decreasing and the percentage of the senior engineer is increasing. (Fig 1-4)

In addition, working conditions, such as long working hours and low wages than other intellectual industry, is not attractive for young people. There are serious concerns the shortage of engineers and the passing on of techniques and skills in the future.

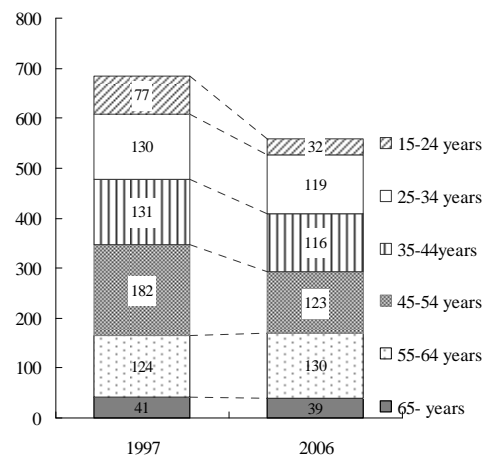


Figure 1-4 Changes in construction worker's population structure by age
 Source: The Ministry of Internal Affairs and Communications

2. Engineering education in Japan

As a nation with few natural resources and little land, wealth has been achieved through a high level of education and the high level technical abilities of the human resources. It is crucial to ensure that the younger generation with vitality and creativity enter the fields of science and engineering in order to strengthen and maintain the science and technology abilities of Japan.

The institutions for higher education in Japan consist of universities, junior colleges, colleges of technology and specialized training colleges which offer specialized courses. Since the end of World War 2, the scale of higher education in Japan has expanded remarkably, particularly in the number of private institutions. Today the scale of higher education in Japan ranks among the highest in the world.

The Third Science and Technology Basic Plan (2005-2010) approved in the Cabinet meeting in March 2006, features as a basic tenet "Emphasis on fostering human resources and competitive research environments - Shift of emphasis from 'hard' to 'soft' such as human resources; greater significance of individuals in institutions". It also points to the need to shift emphasis in science and technology policy from infrastructure building to investment in the development of excellent human resources, because human resources constitute the basis of the prowess in science and technology, and the future of creative science and technology in Japan depends on the capabilities of human resources that play an active role in the country. Therefore, the Plan features to enhance the human resource development function in Universities to develop younger generation with wide-ranging knowledge and flexible ideas. Moreover, the Plan features to promote practical education program in universities and other institutions of higher education to develop young professional engineers.

In order to satisfy diversified social needs, it has become necessary for universities and other institutions of higher education to provide opportunities for education and research in a variety of ways. The reform of the graduate school system has been vigorously promoted, leading to the establishment of new types of institutions such as those dedicated entirely to graduate courses, correspondence based graduate schools and professional graduate schools. The reform has also injected flexibility into the university entrance criteria and the duration of academic programs, and helped to diversify the methods and arrangements of education. Meanwhile, the number of graduate school students in Japan has risen about 3.5 times over the past 20 years (Fig 2-1). The ratio of students majored in engineering, science or agriculture is about 50% in Master's degree courses, 30% in Doctoral courses.

(Fig 2-2)

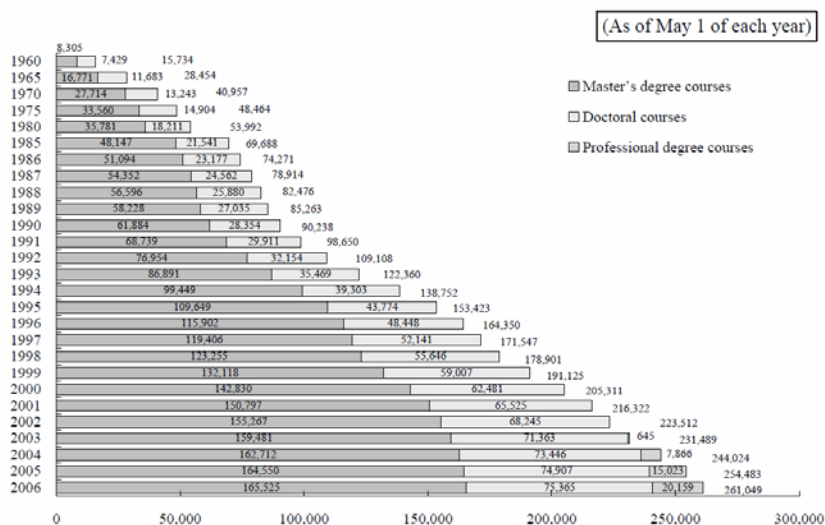


Fig 2-1 Trends in number of graduate school students in Japan

Note: The number of graduate school students enrolled in "master's degree courses" include those in master's degree courses, two-stage doctoral courses (two-year first stage) and five-year integrated doctoral courses (first and second year).

The number of graduate school students enrolled in "doctoral courses" include those in two-stage doctoral courses (three-year second-stage), in doctoral courses of medical, dental and veterinary sciences and five-year integrated doctoral courses (third to fifth year). Correspondence-based programs are excluded.

Source: Ministry of Education, Culture, Sports, Science and Technology

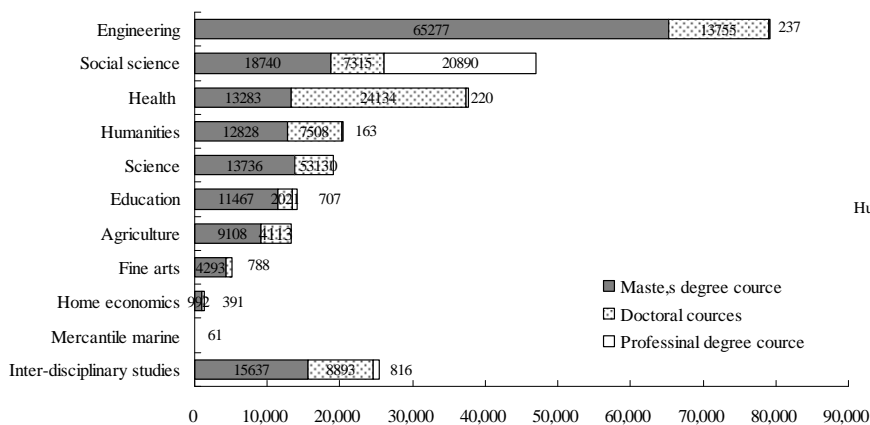


Fig 2-2(1) Trends in number of graduate school students by Major Fields of Study
 Source: Ministry of Education, Culture, Sports, Science and Technology 2008

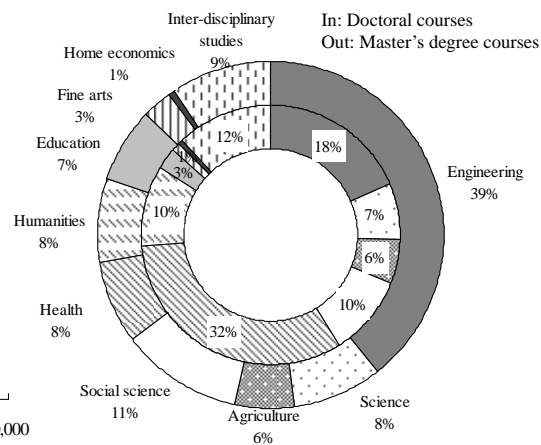


Fig 2-2(2) Percentage Distribution of graduate school students by Major Fields of Study
 Source: Ministry of Education, Culture, Sports, Science and Technology

In recent years, Japanese universities have also been promoting reform measures such as prioritized allocations of funds intended to revitalize research activities, the provision of support for young teaching staff and the introduction of arrangements for enabling flexible implementation of research programs.

Many universities are implementing measures for revitalizing research activities; including the introduction of campus-wide public invitations of research proposals with the use of president's discretionary expenses, differential budget allocations among departments and prioritized allocations of funds intended to revitalize research activities. Meanwhile, there are universities that promote the development of human resources capable of forming the basis of academic research through the provision of support to young teaching staff and graduate school students. For example, some universities seek to enhance assistance for graduate school students by earmarking funds for research assistantship (RA) intended mainly for graduates in the second stage of the doctoral program. Others have introduced a system of commending young teaching staff with innovative ideas and allocating to them research funds totaling tens of millions of yen.

To develop young professional engineer, Japanese universities, junior colleges, and colleges of technology also promote accreditation system for engineering education. Professional accreditation systems whereby an outside organization can fairly evaluate whether programs in engineering education conducted by institutions of higher education such as universities reach the levels expected by society and accredit those programs that reach such levels. The Japan Accreditation Board for Engineering Education (JABEE) established on November 1999, has examined and accredited 346 programs in engineering education.

The central government also aims to increase the supply of engineers, scientists and technicians by enhancing mathematics and science education in elementary and secondary education and by enhancing the quality of science teaching staff and student performance in science and raising the ratio of high-performing students choosing science and engineering jobs.

3. Professional Engineer in Japan

3.1 Professional Engineer in Japan

In recent years, the ratio of people engaged in specialist and technical jobs, including engineers and science researchers, to the total number of workers has been rising in Japan, with demand for human resources with higher-level knowledge growing in the labor market.

Engineers, who have capability to satisfy the social demand for efficient and safe infrastructure, have been contributed to Japan's economic development and affluent life of people. Professional Engineer, Japan; (P.E.Jp) is the authorized title of engineer by the Professional Engineer Law, and it is defined as an engineer who obtained a registration and conducts practice on matters of planning, research, design, analysis, testing, evaluation and guidance, which require advanced professional practical abilities in scientific and technological matters.

Based on the Law, obligations of P.E.Jp are following;

- Prohibited such behaviors that lose confidence on P.E.Jp
- Confidentiality
- Securing of Public Interest
- Continuing Professional Development (CPD)
- Indication of Title as P.E.Jp

The total of the certified Professional Engineer is about 61,000 in 21 technical disciplines. Among those engineers, Civil Engineers occupy about 45%, and there are much engineer is in the section of water supply & sewage, Electrical & Electronics Engineering, and Mechanical Engineering. (Fig 3-1, Table 3-1) Most of them are working in the private company, and the Professional Engineers per one company tend to increase.

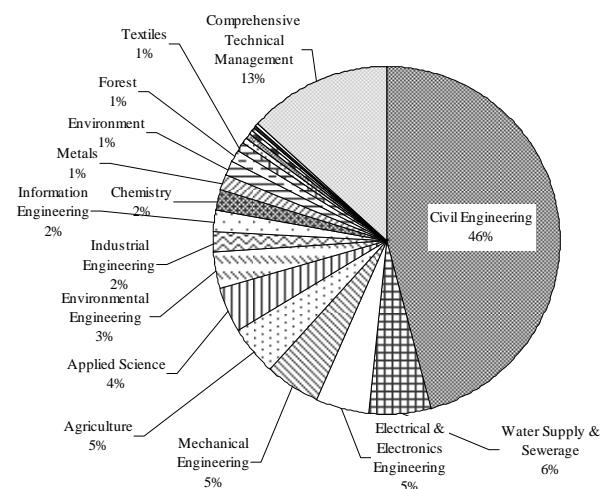


Fig 3-1 Percentage Distribution of Professional Engineer, Japan by technical disciplines

Source: Ministry of Education, Culture, Sports, Science and Technology
The Institution of Professional Engineers, Japan

The Professional Engineer Examinations are divided into First-Step Professional Engineer Examination and Second-Step Professional Engineer Examination, and these examinations are implemented according to each technical discipline. A person who has passed First-Step Professional Engineer Examination is qualified to become an Associate Professional Engineer, defined as a person who has obtained a registration and assists a Professional Engineer with respect to the practice, using the title of Associate Professional Engineer in order to acquire the necessary skill to become a Professional Engineer. A person who has passed Second-Step Professional Engineer Examination is qualified to become a Professional Engineer.

With the globalization of the economy, P.E.Jp has obtained opportunities to work not only domestic project, but also international project. Ministers at the APEC Osaka Summit held in November 1995 had a resolution that technology transfer is essential to enhance the economic growth of the APEC region, for the international mobility of engineers is indispensable. This led to the establishment of the APEC Engineer Project in the Human Resources Development Working Group of APEC, and the launch of studies on how to mutually recognize engineering qualifications. November 1, 2000, the APEC Engineer requirements were crystallized and publicly announced in the form of the APEC Engineer Manual. This is followed by the commencement of assessment and registration of APEC Engineers in the 13 recognized economies (Japan, Australia, Canada, Hong Kong, South Korea, Malaysia, New Zealand, Indonesia, the Philippines, the US, Thailand, Singapore and Chinese Taipei).

Table-3.1 Technical Disciplines and Subjects of Professional Engineer, Japan and APEC engineer

Professional Engineer, Japan		APEC engineer		
No.	Technical Disciplines	Subjects		
		Technical Disciplines		
1	Mechanical Engineering	1-1 Mechanical Design Engineering,	Mechanical Engineering	
		1-2 Strength of Materials		
		1-3 Mechanical Dynamics & Control		
		1-4 Power Engineering		
		1-5 Thermal Engineering		Mechanical or Chemical Engineering
		1-6 Fluid Engineering		
		1-7 Processing, Factory Automation & Industrial Machinery		Mechanical Engineering
		1-8 Traffic, Logistics Machinery & Construction Machinery		
		1-9 Robot		
2	Marine & Ocean	2-1 Naval Architecture	Mechanical or Electrical Engineering	
		2-2 Ocean Development		
		2-3 Marine Equipment		
3	Aerospace	3-1 Aerospace System	Mechanical or Electrical Engineering	
		3-2 Aerospace Navigation		
		3-3 Space Utilization		
4	Electrical & Electronics Engineering	4-1 Generation, Transmission, Distribution & Substation	Electrical Engineering	
		4-2 Electric Application		
		4-3 Electronics Application		Electrical or Information Engineering
		4-4 Information & Communication		
		4-5 Electrical Installations		Electrical Engineering
5	Chemistry	5-1 Ceramics & Inorganic Chemical Products	Chemical Engineering	
		5-2 Organic Chemical Products		
		5-3 Fuel & Lubricating Oil		
		5-4 Polymer Products		
		5-5 Chemical Engineering		
6	Textiles	6-1 Fiber Spinning & Textured Yarns	Mechanical or Chemical Engineering	
		6-2 Yarn spinning & Fabric Manufacturing		
		6-3 Dyeing & Finishing		
		6-4 Sewing, Manufacturing & Evaluation of Textile Products		
7	Metals	7-1 Iron & Steel Manufacturing System	Mechanical or Chemical Engineering	
		7-2 Nonferrous Metals Manufacturing System		
		7-3 Metallic Materials		
		7-4 Surface Technologies		
		7-5 Metal Working		Mechanical Engineering
8	Mining	8-1 Development and Production of Solid Resources	Geotechnical or Mining Engineering	
		8-2 Development and Production of Liquid Resources		
		8-3 Resources Recycling and Environmental Conservation		Geotechnical, Environmental or Mining Engineering
9	Civil Engineering	9-1 Soil Quality & Foundation	Civil, Structural or Geotechnical Engineering	
		9-2 Steel Structure & Concrete		
		9-3 Urban & Rural Planning		
		9-4 River, Erosion Control & Seashore, Ocean		
		9-5 Harbor & Airport		
		9-6 Construction for Electricity		
		9-7 Road		
		9-8 Railroad		
		9-9 Tunnel		
		9-10 Construction Planning, Construction Equipments & Integration		
		9-11 Construction Environment		Civil or Environmental Engineering
10	Water Supply & Sewerage	10-1 Water Supply & Industrial Water Supply	Civil, Structural or Environmental Engineering	
		10-2 Sewerage		
		10-3 Water Environment		
11	Environmental Engineering	11-1 Air Quality Control	Civil or Environmental Engineering	
		11-2 Water Quality Control		
		11-3 Waste Management		Civil, Structural or Environmental Engineering
		11-4 Air Conditioning		Structural or Environmental Engineering
		11-5 Sanitary		
12	Agriculture	12-1 Animal Industry	Environmental or Bio Engineering	
		12-2 Agricultural Chemistry	Chemical or Bio Engineering	
		12-3 Irrigation, Drainage & Reclamation	Civil, Structural, Geotechnical or Environmental Engineering	
		12-4 Agriculture & Sericulture	Environmental or Bio Engineering	
		12-5 Rural Regional Planning	Civil or Environmental Engineering	
		12-6 Rural Environment		
		12-7 Plant Protection	Environmental or Bio Engineering	
13	Forest	13-1 Forestry	Environmental or Bio Engineering	
		13-2 Forest Civil Engineering	Civil, Structural, Geotechnical or Environmental Engineering	
		13-3 Forest Products	Chemical, Environmental or Bio Engineering	
		13-4 Forest Environment	Civil, Environmental or Bio Engineering	
14	Fisheries	14-1 Fisheries & Nurseries	Mechanical, Environmental, Information or Bio Engineering	
		14-2 Fish Processing	Mechanical, Chemical, Environmental, Industrial or Bio Engineering	
		14-3 Fisheries Civil Engineering	Civil, Structural, or Environmental Engineering	
		14-4 Fishery Area Environment	Civil, or Environmental Engineering	
15	Industrial Engineering	15-1 Production Management	Industrial Engineering	
		15-2 Service Management		
		15-3 Logistics		
		15-4 Operations Research		
		15-5 Investment Science		
16	Information Engineering	16-1 Computer Engineering	Electrical or Information Engineering	
		16-2 Software Engineering	Information Engineering	
		16-3 Information System & Data Engineering	Electrical or Information Engineering	
		16-4 Information Network Engineering		
17	Applied Science	17-1 Physics & Chemistry	Mechanical, Electrical, Chemical, Geotechnical or Environmental Engineering	
		17-2 Geophysics & Geochemistry	Geotechnical or Environmental Engineering	
		17-3 Geology	Civil, Structural, Geotechnical, Environmental or Mining Engineering	
18	Biotechnology	18-1 Cell and Genetic Engineering	Bio Engineering	
		18-2 Biochemical Engineering		
		18-3 Bioenvironmental Engineering		Environmental or Bio Engineering
19	Environment	19-1 Environmental Conservation Planning	Environmental Engineering	
		19-2 Environmental Measurement		
		19-3 Nature Conservation		
		19-4 Environmental Impact Assessment		
20	Nuclear & Radiation	20-1 Design & Construction of Nuclear Power System	Structural, Mechanical, Electrical, or Environmental Engineering	
		20-2 Operation & Maintenance of Nuclear Power System		
		20-3 Nuclear Fuel Cycle		Mechanical, Electrical, or Environmental Engineering
		20-4 Radiation Application		Mechanical, Chemical, or Environmental Engineering
		20-5 Radiation Protection		Mechanical, Environmental or Bio Engineering
21	Comprehensive Technical Management		Industrial Engineering	

There are currently eleven technical disciplines in the APEC Engineer Register, and scope of applications for registration has been expanded from two disciplines such as Civil and Structural in November, 2000, followed by Mechanical, Electrical and Chemical in November 2003, and all of the rest of Geotechnical, Environmental, Industrial, Mining, Information and Bio in April 2006. (Table 3-1) There are two sorts of practitioners thought as APEC Engineer in Japan, P.E.Jp. and 1st-class Kenchikushi (Architects / Building Engineer).

3.2 Continuing Professional Development (CPD)

Every professional engineer shall have sufficient knowledge of the professional ethics and shall continue, after the acquisition of the qualification of professional engineer, professional development as one of his or her obligations so as to improve the competence of the professional engineer.

It is desirable for each professional engineer to carry out continuing professional development (CPD) programs such as participation of training courses or lectures.

Many types of CPD programs are conceivable, and every professional engineer should voluntarily choose the programs most suitable to the engineer's CPD and work on the chosen programs. However, in the case of choosing any CPD programs, it is desirable for each professional engineer to select such CPD programs, each of which can be, as much as possible, recognized as a CPD achievement by any third party. From this viewpoint, the following items will be included in CPD programs.

Table3-2 Subjects of CPD programs for Professional Engineers

A : General subjects	B : Technical subjects
(1) Ethics (2) Environment (3) Safety (4) Technical trend (5) Social trends (6) Industrial and economic trends (7) Trends of codes and standards (8) Management systems (9) Contract (10) International exchange (11) Others	(1) Latest techniques in each engineering discipline (2) Trend of science and technology (3) Applicable laws (4) Accident case study (5) Others

In response to the amendment, Association of Japanese Consulting Engineers (AJCE) and other sectors related engineering industry are promoting continuing professional development programs. Every year, AJCE carries out activities that enhance the professional capability of consulting engineers. AJCE has organized seminar regarding to the contract in international project, project sustainable management, and project risk management, etc... AJCE is also promoting these programs for not only seniors but also young professionals.



Source: Association of Japanese Consulting Engineers

4. for Next-Generation

Amid intensifying global competition for human resources and technologies concern is growing about Japan's ability to secure sufficient human resources related to science and technology in terms of both quantity and quality as the country faces problems such as the aging of society and a population decline.

Therefore, it is very important for Japan to maintain and enhance its standard of research and development and the level of international competitiveness of the country. Another critical challenge Japan must tackle at the same time is how to develop and retain human resources that form the basis of science and technology and enable them to play an active role in various sectors of society, so as to cultivate a safe, comfortable and high-quality living environment.

In order to secure sufficient human resources related to science and technology in terms of both quantity and quality, it is important to implement consistent comprehensive efforts from elementary and secondary education to undergraduate/graduate courses in universities and adult education through the following measures: enhancing science and mathematics education, cultivating a favorable working environment for young engineers, female engineers and foreign engineers, strengthening the human resource development function of universities and human resource development by industry- government-university partnership.