Thoughts on a Reduction in the Number of Civil Engineering Students

Kazuya OSHIMA
Fellow of JSCE
CTI Engineering Co., Ltd., Tokyo Branch Office, President

Trends in the Number of Civil Engineering Graduates

In May 1999, the JSCE Planning Committee investigated the distribution of civil engineering graduates within various industries. Questionnaires were sent to 161 civil engineering departments at technical colleges, junior colleges, and universities in Japan in order to learn about their curriculums, the number of students in each department, the number of graduates to date, categories of eventual employment, etc. Responses were obtained from 140 departments. Based on these results, this paper considers the need to reduce the number of civil engineering students.

Although not all of the questionnaires were returned, there was no statistical compensation. This was not done in order to avoid any possible misunderstanding of the results. Therefore, the numbers of graduates and other figures given below are smaller than the actual figures.

The post-war years have seen an expansion of civil engineering education in Japan as well as an increase in the number of civil engineering projects. Research shows that the number of students in civil engineering departments increased as the number of departments grew. As of 1999, the capacity of students in one grade of a school, college, or university was 12,779, while the number of actual entrants was 10,990. Curriculums range from architecture and urban development, to social sciences and economics, forestry and agriculture, and ocean engineering. Environmental and ecology sciences, information sciences, resources and energy, and other peripheral fields are also offered.

The number of graduates from civil engineering departments stood at 3,142 for the five years between 1950 and 1954, an average of 628 graduates per year. The number then surged to 21,481 between 1970 and 1974, an annual average of 4,296 graduates. This increase has continued, and in the last five years, from 1995 to 1999, 43,063 graduates were produced, an average of 8,613 per year. This is 14 times the number for the period between 1950 and 1954. As shown in Fig. 1, of the total number of graduates, 67% were awarded bachelor degrees and 18% Master degrees. Ph.D holders totaled 2%, or 200 per year (1995-1999).

1,588 civil engineering graduates found jobs related to civil engineering in 1950-54, or 318 per year. This number increased to 38,397 in 1995-99, or 7,679 per year, accounting for 89% of the total number of graduates. Their employers included the central government, local governments, public corporations and agencies, general contractors, construction consultants, railways, private companies such as electrical and gas utilities, and schools (teachers). Table 1 shows the trends in the number of graduates employed at various organizations. The number employed by governments and other public bodies (1. Central government; 2. Public corporations and agencies; 3. Prefectural governments; and 4. Municipal governments) has not grown since the 1980's. In contrast, the number of graduates employed by construction consultants has increased remarkably during the 1990's.

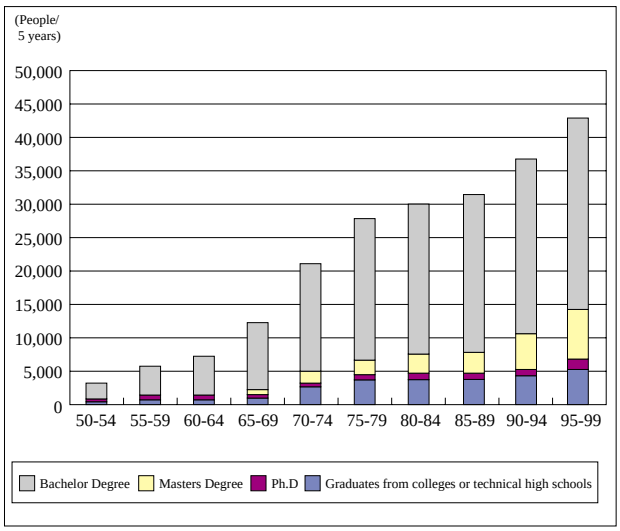
Number of Civil Engineers in the Civil Engineering Field

This section attempts to identify the number of civil engineers working in the civil engineering field for government and public bodies or as contractors and construction consultants. (Note: this survey includes only graduates from technical colleges, junior colleges, and universities.) The estimate is based on figures obtained from the civil engineering graduates survey described earlier, and assumes that the graduates worked for 40 years after leaving school and that there has been no reduction in their number resulting from job changes or deaths. As listed in Table 2, the number of civil engineers defined in this section was 29,000 in 1965 and increased to 201,000 in 2000. As of 2000, 41% of them found jobs at general contractors and other construction companies. This was the largest proportion of those surveyed. Graduates working for public and quasi-public organizations accounted for 26%, of which 4% work for

the central government, 10% for prefectural governments, 9% for municipal governments, and 3% for public corporations and agencies. Those who joined construction consultants comprised 13%, while those employed by the private sector totaled 18%, including 2% by railways, 2% by electricity and gas utilities, and 5% by manufacturing companies. Graduates with positions at universities and other schools totaled 3%.

Expenditures for civil engineering works increased sharply in the post-war rehabilitation period and in the subsequent era of high economic growth. Expenditures declined in in the years between 1973 and 1981 due to the oil crises, but have continued to grow steadily in the subsequent period of stable economic growth (Table 2).

Studies reveal a strong correlation between the number of civil engineers and expenditures for civil engineering works. For a period of 35 years starting in 1965, the investment value per civil engineer was ¥230 million



(Unit: people)

	-50	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85-89	90-94	95-99
Graduates from colleges or technical high schools	3,018	319	790	976	1,232	2,894	4,198	4,143	4,120	4,596	5,427
Ph.D	19	33	52	141	143	281	275	300	386	599	1,064
Masters Degree	14	0	163	238	1,012	1,802	2,440	2,917	3,936	5,446	7,589
Bachelor Degree	7,606	2,790	5,029	5,954	10,177	16,504	21,169	22,790	23,439	26,314	28,983
Total	10,657	3,142	6,034	7,309	12,564	21,481	28,082	30,150	31,881	36,955	43,063
Per year	-	628	1,207	1,462	2,513	4,296	5,616	6,030	6,376	7,391	8,613

Fig. 1 Trends in the number of graduates.
(Source: Civil engineering graduates survey [JSCE Planning Committee, May 1999])

Table. 1 Trends in the number of graduates by employer.
(Source: Civil engineering graduates survey [JSCE Planning Committee, May 1999])

(Unit: people)

Year / Employer	-50	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85-89	90-94	95-99	60-99 Total	60-99 Rate
1 Central government	127	51	132	349	443	664	1,095	1,218	1,449	1,614	1,258	8,090	4%
2 Public corporations and agencies	13	9	61	259	530	863	948	964	988	1,130	908	6,590	3%
3 Prefectural governments	144	68	150	626	1,558	2,702	2,413	2,848	3,165	3,869	2,708	19,889	10%
4 Municipal governments	39	22	125	324	770	2,055	2,779	2,578	2,793	2,929	2,073	16,301	8%
5 National and private universities	126	125	147	235	462	424	429	446	439	545	771	3,751	2%
6 Other schools	26	10	23	44	106	149	248	215	246	156	175	1,339	1%
7 Societies and associations	47	28	54	38	56	56	61	75	89	285	322	982	0%
8 General contractors	542	456	967	1,794	3,514	7,294	8,122	9,468	9,505	12,019	13,028	64,744	32%
9 Other construction firms	129	79	165	208	690	1,694	2,631	2,730	2,755	2,710	3,816	17,234	9%
10 Construction consultants	492	379	630	765	1,216	2,027	3,226	3,528	3,637	4,875	6,942	26,216	13%
11 Railway companies	55	19	23	150	187	291	621	343	464	780	539	3,376	2%
12 Electric or gas utilities	58	32	22	73	120	266	581	620	770	974	650	4,053	2%
13 Manufacturing companies	74	72	120	312	502	974	1,250	1,439	1,696	1,912	1,680	9,765	5%
14 Other private companies	521	238	480	456	908	1,545	2,900	2,827	3,737	3,279	3,527	19,179	10%
Total	2,393	1,588	3,099	5,633	11,061	21,004	27,304	29,299	31,733	37,077	38,397	201,508	100%

on average (real value converted by the deflator based on the standard for calendar year 1990). The investment value per civil engineer is estimated to have been ¥200 million in FY2000 (Fig. 2).

Future Prospects for the Number of Civil Engineers

Based on the results above, simple forecasts were made (see below) regarding the relationship between the number of civil engineers and civil works expenditures.

The first forecast is a scenario in which civil works expenditures remain at the same level until 2050 (Case I). If expenditures per civil engineer stay at the same level as in 2000, i.e., ¥200 million per year, the relation between expenditures and the number of civil engineers will be as shown in Fig. 3. Even assuming that the number of newly graduated civil engineers remains at the 2000 level, the market will still produce an excess of engineers, totaling approximately 96,000 in 2025 and 103,000 in 2050.

If the number of new entrants were reduced by 2% each year until 2025, the number would fall to 60% of the 2000 level. This scenario would still produce an excess of 50,000 engineers up to the year 2025, but would produce a small annual shortfall beginning in 2045.

The second scenario maintains civil works expenditures at same level until 2010, then decreases them to 60% of the current level by the year 2020 and then holds them at this level. (Case II) The result is plotted in Fig. 4.

Holding the number of new entrants to the year 2000 level would still produce more engineers than the market

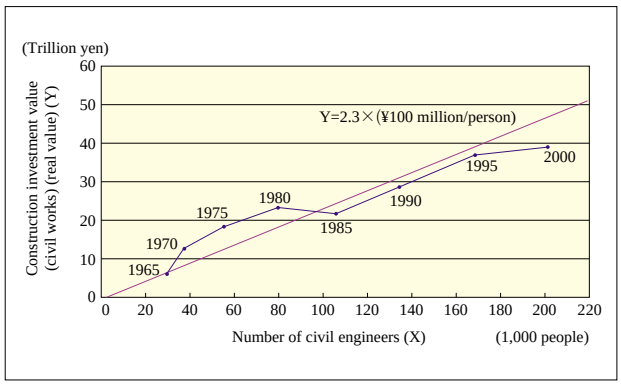


Fig. 2 Correlation between construction investment value (civil works) and the number of civil engineers

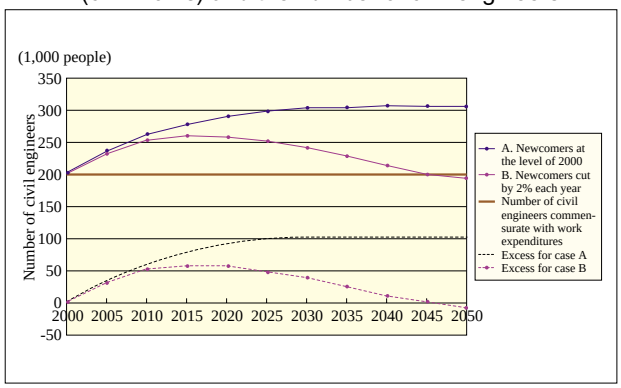


Fig. 3 Prediction of the number of civil engineers in Scenario I

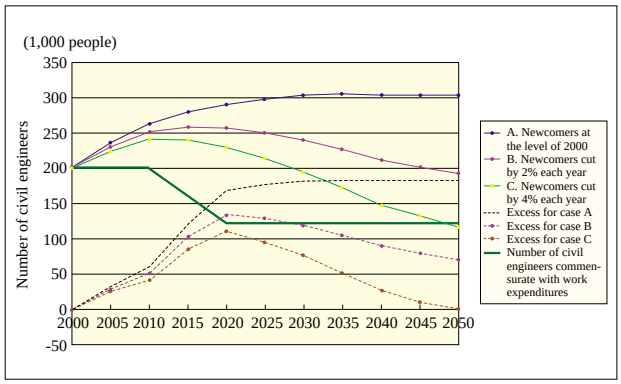


Fig. 4 Prediction of the number of civil engineers in Scenario II

Table 2. Construction investment value (civil engineering works) and the number of civil engineers

FY	Number of civil engineers (unit: 1,000 people)	Investment value of civil works (nominal, FY) (·1 billion)	Investment value of civil works (real, FY) (·1 billion)	Deflator
2000	201	40,000 (estimated to be 35,270 for 1999)	39,216	102.0
1995	168	38,027	37,391	101.7
1990	134	29,181	28,864	101.1
1985	105	20,019	21,642	92.5
1980	79	20,256	22,966	88.2
1975	55	11,864	18,280	64.9
1970	37	4,916	12,802	38.4
1965	29	2,203	6,294	35.0

Note 1: Investment values from the White Papers of Construction for 1969-1999.

Note 2: The Deflator is the public gross fixed capital formation deflator in the fiscal year terms based on the standard for calendar year 1990 (Japan Statistical Yearbook for 1999 by Management and Coordination Agency, Statistics Bureau). The deflators for FY1965 and FY2000 are estimates.

could absorb: 176,000 excess engineers in 2025, and 182,000 excess engineers in 2050. Both figures far exceed the 121,000 engineers required by predicted expenditures for civil engineering works. Even if the number of new entrants were reduced by 2% each year until 2025, which would cut the number of civil engineers to 60% of the 2000 level, there would still be 128,000 excess engineers in 2025 and 71,000 excess engineers in 2050. Even if the number of new entrants were reduced by 4% each year until 2025, which would cut the number of civil engineers to 36% of the 2000 level, there would still be an excess of 94,000 engineers in 2025 before rough equilibrium is achieved in 2050.

The author admits that the predictions above are approximations. However, given the fact that, as work expenditures fall, the industry will naturally have more difficulty in accepting newcomers, the author believes that the forecasts are reasonably acceptable scenarios with rough quantitative results.

Reduction in the Number of Civil Engineering Students

In the 21st century, unlike today, the government will most likely be forced to hold down expenditures for civil engineering works. In such a situation, it will be essential to develop infrastructure in an efficient manner, i.e., higher in quality and better maintained. This will require a change in the infrastructure development system. One way to achieve this would be by introducing a commercial market system. Such a system demands more highly capable civil engineers, but it is obviously impossible for the industry to maintain the number of accepted graduates at the current level.

There is also demand for greater productivity, or in other words, an increase in the project volume per civil engineer. The increasing number of civil engineers of advanced age will be problematic as well. These situations will make it inevitable for schools and universities to produce fewer graduates, i.e., accept fewer students.

Currently, the appropriate number of graduates from civil engineering departments is 8,000 per year. The author considers 60% of that, or 5,000, to be appropriate for the year 2025.

Assuming that the volume of public civil engineering projects drops to 60% of the current level, and that the project volume per civil engineer remains the same, the number of civil engineers needed to satisfy the project volume is estimated to be 120,000. Public-private ventures are expected to need roughly 40,000 civil engineers for a growing number of projects such as PFI projects as well as for the Asian and other international markets. Moreover, further expansion into peripheral fields such as think tanks and the information industry will need roughly another 20,000 civil engineers. Also, transfers and the creation of new jobs are expected to beef up fields plagued with a shortage of competent civil engineers for local government and local industry projects. It is said that in Japan, there are 190,000 public enterprises for civil engineering works and 50,000 enterprises for national ones. If a system of licensing for civil engineers is established, and these licensed civil engineers have a specific and high level of technological ability, then a considerable number of qualified civil engineers will be hired. If local governments, their local businesses, and other project owners join hands to enhance technological competence, it may be possible to create 40,000-60,000 new civil engineering jobs.

These estimates indicate that, in the year 2025, 250,000 civil engineers may be active in civil engineering and related markets in Japan and abroad, compared to the current 200,000. This is not a precise estimate but a rough assumption. But even if it is assumed that drastic industrial reform is carried out, the estimated figure still holds. In order to have 250,000 civil engineers in 2025, it is necessary to gradually cut the number of graduates to 5,000, or 60% of the present level, in 2025.

The estimates above assume that project expenditures per civil engineer remain unchanged in the future. This does not mean that the author assumes that the productivity of civil work projects will remain the same. The rationale for the assumption is this: in the future, software items, such as project conception, planning, design, and management, is likely to account for a greater part of the whole project, thus raising per-head expenditures. However, expenditures per head for software items will be lower than that for hardware items. Therefore, even considering the increased productivity for the hardware field, expenditures per head for an entire project seems likely to remain at about the same level as today.

As for the reduction in students, one suggested approach is simply to reduce the number of entrants or the number of departments. The other is to integrate the core departments with environmental, information, or other peripheral courses, thus achieving a virtual reduc-

tion in the number of students. A partial shift to the peripheral-course plan is another idea. In addition to these ideas, consideration should be given to the characteristics of education, such as general education, specific field-oriented education, research and study education, and license-acquisition support education (practical education). It is important to consider the balance of demand for the graduates when setting the number of students and departments. Attention should also be paid to the number of applicants and regional demands for graduates.

Whichever method is adopted, it is essential to establish a long-term plan to reduce the number of students. Specifically, an annual program covering a period of 5 years or so must be worked out and carried out with revisions and corrections as needed in response to environmental changes.

Study based on survey results by the Planning Committee of JSCE. The author hopes for discussion, consideration, and prompt action by the entire civil engineering sector as well as the educational field.