IMPACT OF INCREASE OR DECREASE IN POPULATION ON DEMAND FOR CONSTRUCTION IN TERMS OF CEMENT IN EACH PREFECTURE IN JAPAN

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ABSTRACT: Regional difference in demand for construction in Japan for recent 20 years (1990 to 2009) was examined in terms of consumption of cement for each purpose in Japan and an effectiveness of increasing rate of concrete per capita of productive age population (15 to 64 years old) was verified.   The author has already defined the increasing rate of concrete as the ratio of the consumption of cement in a year to the accumulation up to the previous year.   The purpose of consumption of cement was classified into civil engineering, private buildings and public (government and municipal) buildings. Four types of indices were employed and the values for each purpose and prefecture in each year were obtained: consumption of cement per capita, increasing rate of concrete, increasing rate of concrete per capita, and increasing rate of concrete per capita of productive age population. The coefficient of variation of each of indices for the demand for cement in each prefecture was obtained as the ratio of the standard deviation to the average value for each purpose for recent 20 years. The increasing rate of concrete per capita of productive age population was found to be the best factor for the regional difference in the demand for cement.

KEYWORDS: consumption of cement, regional difference in demand for construction, productive age population

1. INTRODUCTION: DEFNITION OF INCREASING RATE OF CONCRETE

1.1 Economic Growth Resulting in Smaller Demand for Construction

The demand for construction in the future should be forecasted so that quality of construction may be ensured with sufficient profit of the related industries. The index for demand for construction has been the amount of money, which cannot be the common index beyond the place (country) or time.

The author has proposed the amount of cast concrete as the demand for construction and also the amount of structures. The amount of cast concrete can be estimated easily by using the amount of consumption of cement. The statistics of the consumption of cement started from the beginning of the 20th century in most of all the countries.

The relationship between GDP per capita and consumption of cement per capita in all the countries in the world in 2005 is shown (**Figure 1**). It is obvious that the demand for construction may be lower with the economic growth as the developed countries.

The current consumption of cement per capita (as of 2008) in the main 15 developed countries (AT: Austria, BE+LU:

Belgium+Luxembourg, CA: Canada, CH: Switzerland, DE: Germany, DK: Denmark, FI: Finland, FR: France, IT: Italy, JP: Japan, NL: Netherlands, NO: Norway, SE: Sweden, UK: United Kingdom, US: United States) is shown (**Figure 2**). It was found that the amount of consumption of cement per capita was unequal in each country. For example, the consumption of Austria was around three times large as that of UK. That may be because the potential of the demand for construction and concrete material are unequal.
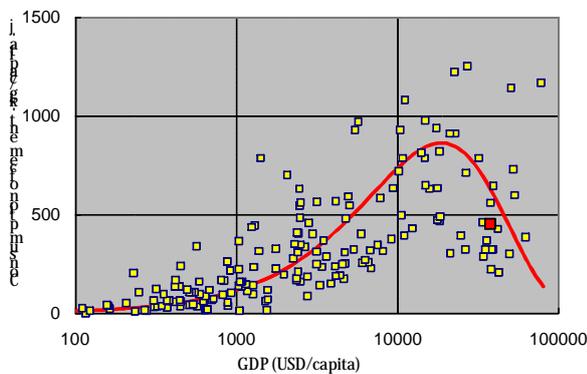

Figure 1 Relationship between GDP per capita and consumption of cement per capita in all the countries in the world in 2005
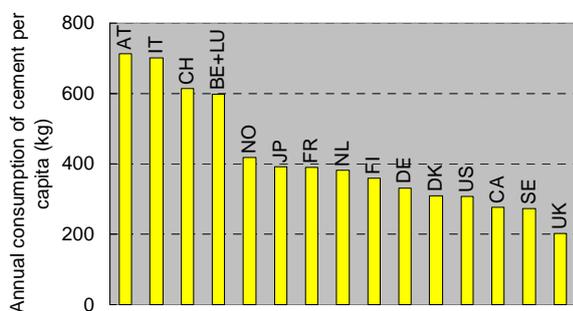

Figure 2 Annual consumption of cement per capita in developed countries (as of 2008)

Such a common index for the demand

for construction was desirable that should be beyond the difference in the potential of the demand for concrete material in each country.

It should be noted that concrete structures are not constructed as flow but as stock and that the past demand for concrete can affect the current demand largely. The accumulation of concrete structures should be taken into accounted for examining the demand for concrete construction.

The relationship between the annual consumption of cement in 2008 and the accumulated consumption of cement until the end of 2007 in the countries is shown (**Figure 3**). It was found the ratio of the annual consumption to the accumulated consumption was more equal than that of the amount consumption itself.
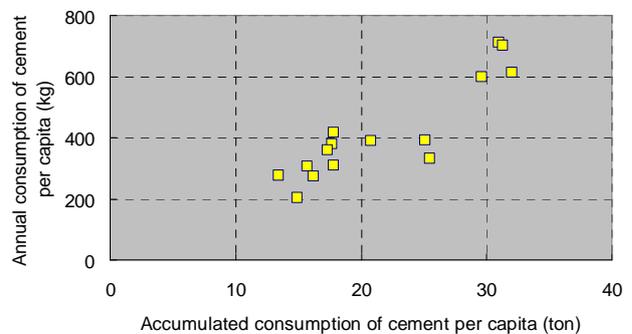

Figure 3 More equal ratio of current to accumulated consumptions of cement in developed countries (as of 2008)

1.2 Definition of Annual Increasing Rate of Concrete and Current Value

The author defined "Annual increasing rate of concrete" as the ratio of the consumption of cement in a year to the accumulated consumption of cement until before the end of the year before. The

definition was obtained by applying the concept of "ratio" described above.

The current value of the annual increasing rate of concrete in each country in 2008 is shown (**Figure 4**). For example, the value of Japan was 1.54%. That may correspond to the fact that amount of concrete structures was increased by 1.54% in Japan in 2008.
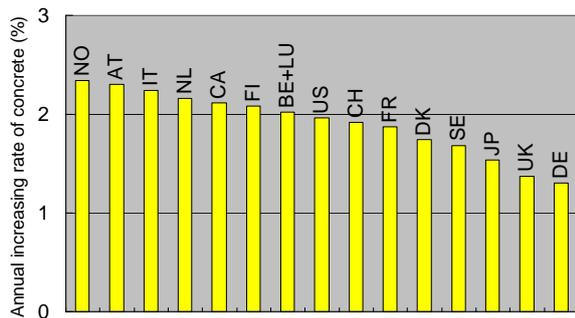

Figure 4 Annual increasing rate of concrete in developed countries (as of 2008)

The ratio of the largest to the smallest increasing rate was 1.8 while the maximum ratio of the largest to the smallest annual consumption of cement per capita was 3.5. The annual increasing rate of concrete should be a desirable index for the demand for construction for indicating the demand for construction beyond the countries.

1.3 Convergence of increasing rate of concrete

The transition of the annual increasing rate of concrete (1950 to 2009) in Japan is shown (**Figure 5**). The transition is mostly common with the developed countries. The transition of the annual increasing rate of concrete in each country in these 21 years is shown (**Figure 6**). The relationship between the annual average value of the annual increasing rate of concrete and the standard deviation is shown (**Fig. 7**). It was found that the increasing rate of Japan was remarkably large until 1990 and

has been decreasing rapidly since then. On the other hand, the increasing ratio has been stable for over ten years in most of the countries. It seems that the increasing rate has already converged in those countries.
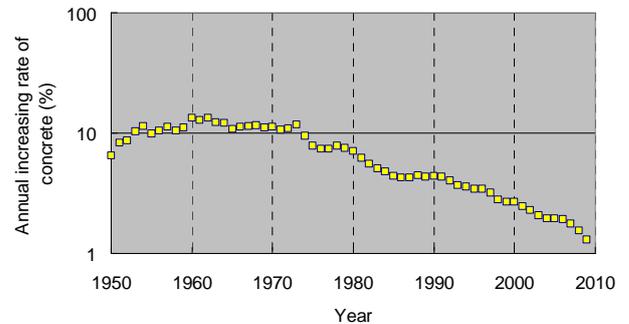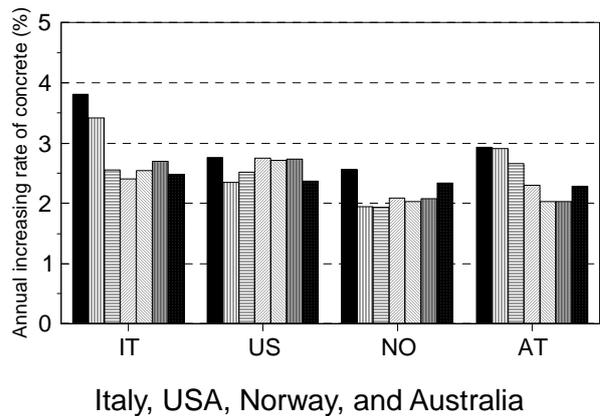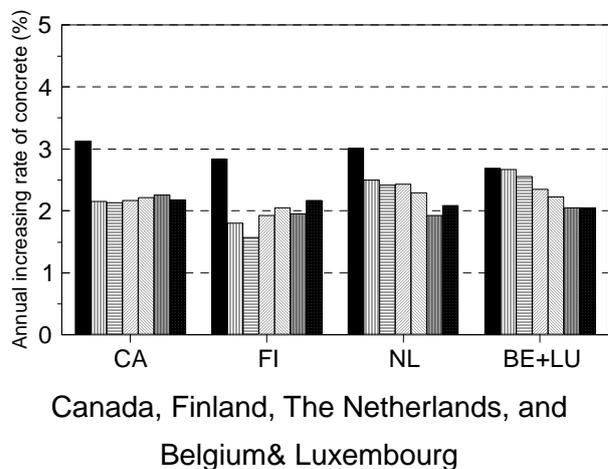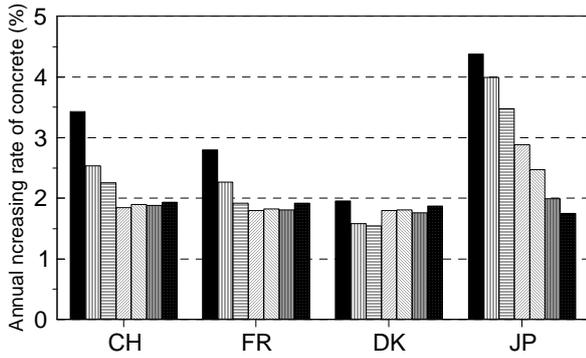

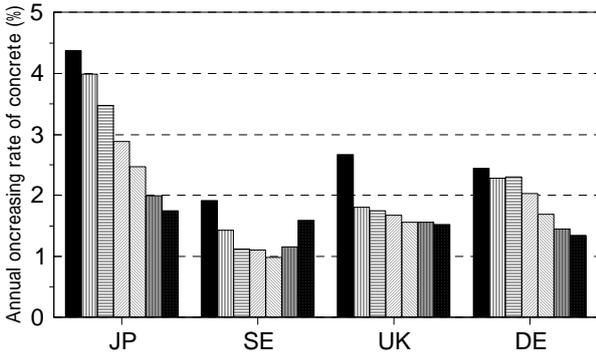**Figure 5 Transition of annual increasing rate of concrete in Japan: 1950-2009**

Italy, USA, Norway, and Australia

Canada, Finland, The Netherlands, and Belgium& Luxembourg

Switzerland, France, Denmark, and Japan

Japan, Sweden, UK, and Germany

Figure 6 Transition of annual increasing rate of concrete in developed countries (1988 to 2008): each bar in each country indicates the annual average of 1988 to 90, 91 to 93, 94 to 96, 97 to 99, 2000 to 02, 03 to 05, 06 to 08 (left to right)
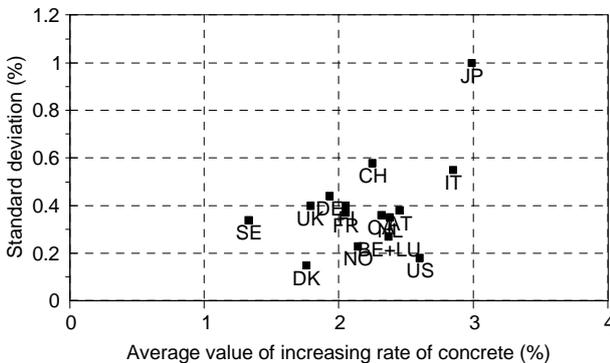

Figure 7 Relationship between annual average value of annual increasing rate of concrete and standard deviation in developed countries: 1988-2009

2. ASSUMED FACTOR FOR REGIONAL DIFFERENCE IN INCREASING RATE OF CONCRETE

The demand for cement has been decreasing in Japan since 1990 and it seems not to have stopped. The demand of cement in 2009 was approximately 50% of that in 1990. Annual consumption of cement in each prefecture in Japan is shown (**Figure 8**). Regional difference in the demand for concrete cannot be ignored. In addition to the difference in the current demand itself, the decrease in the demand for construction was not uniform (**Figure 9**). That is the case with the annual increasing rate of concrete in each prefecture (**Figure 10**).
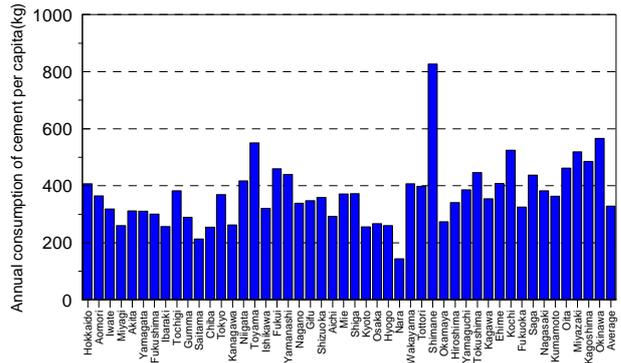

Figure 8 Annual consumption of cement per capita in each prefecture in Japan in 2009
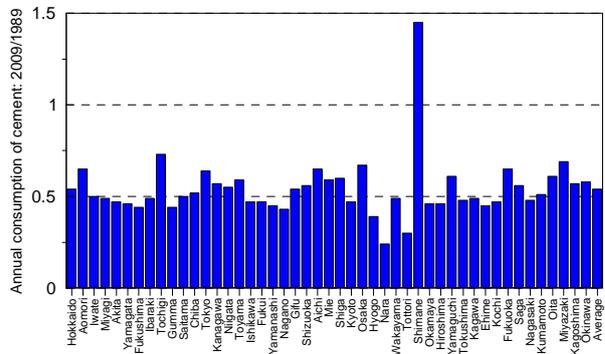

Figure 9 Ratio of annual consumption of cement per capita in 2009 to 1990 in each prefecture
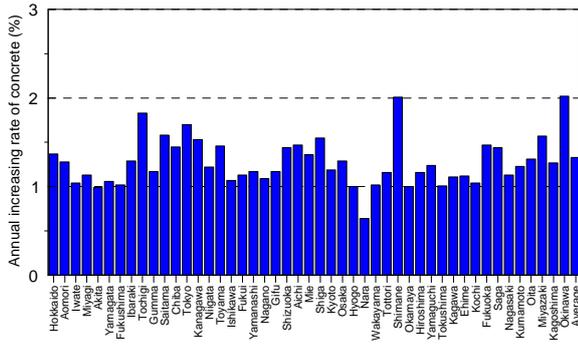
Figure 10 Annual increasing rate of concrete in each prefecture in 2009

The author assumed the increasing rate of population as the factor for the regional difference in the increasing rate of concrete between each prefecture in Japan, in which the amount of civil engineering structures or buildings have already been enough.

$$
\begin{aligned}
S_{n+1} &= (1 + \alpha)(1 + \beta) S_n \\
&= (1 + \alpha + \beta + \alpha\beta) S_n \\
&= (1 + \alpha + \beta) S_n
\end{aligned}
$$

in which α is increasing rate of population,

$\quad\quad$ β is increasing rate of concrete per person

$\quad\quad$ S_n: Accumulation of consumption of cement up to the end of the nth year

$\quad\quad$ $\alpha\beta$ is negligible because either α or β is at most a few%. Therefore, $(1+\alpha+\beta)$ should correspond to the annual increasing rate of concrete.

By assuming the increasing rate of population as the only factor for the regional difference in the increasing rate of concrete, the increasing rate of concrete per person (β) should be equal between each prefecture.

According to Motani, the economic activities should be initiated by the productive age population of 15 to 64 years old [2]. The author followed that theory and assumed that α should be increasing rate of the productive age population.

3. EFFCET OF PRODUCTIVE AGE POPULATION

The increasing rate of concrete per productive age population as β by assuming a as the increasing rate of population was obtained for each prefecture in 1990 to 2009 for each of three purposes of concrete: (1) Civil engineering structures, (2) Private buildings, and (3) Public buildings and those in 2009 are shown (**Figures 11**, **12** and **13**).
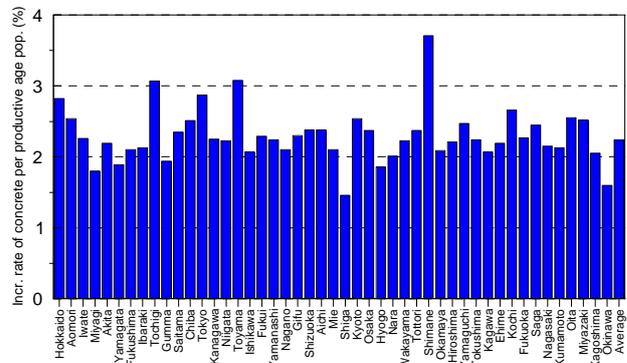

Figure 11 Increasing rate of concrete per productive age population for civil engineering structures in each prefecture in 2009; Coefficient of variation of 16.7%
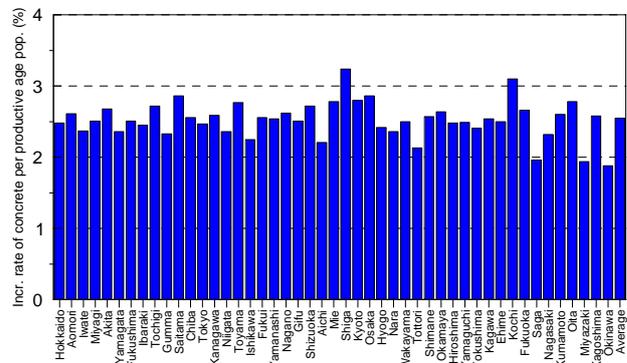

Figure 12 Increasing rate of concrete per prooductive age population for private buildings in each prefecture in 2009; Coefficient of variation of 10.3%)
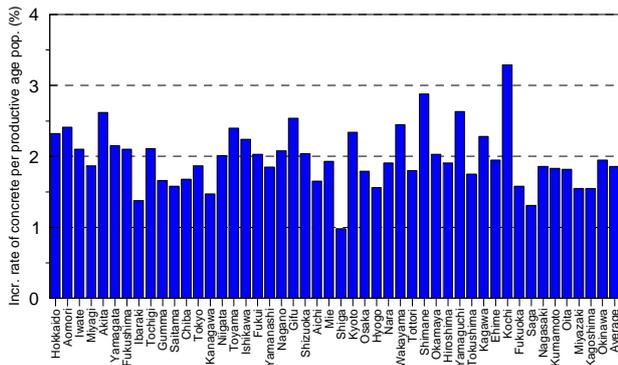
Figure 13 Increasing rate of concrete per productive age population for public buildings in each prefecture in 2009; Coefficient of variation of 21.4%

The increasing rate of concrete per capita was also obtained for each purpose of concrete, in which α should be the increasing rate of population (**Figures 14**, **15** and **16**).
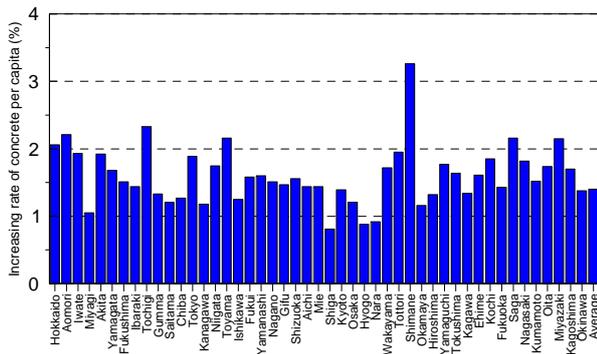

Figure 14 Increasing rate of concrete per capita for civil engineering structures in each prefecture in 2009; Coefficient of variation of 27.1%
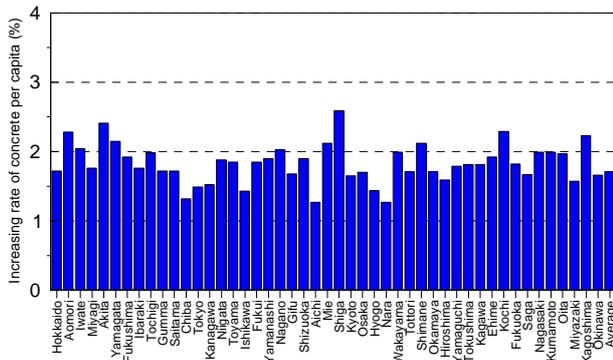

Figure 15 Increasing rate of concrete per

productive age population for private buildings in each prefecture in 2009; Coefficient of variation of 15.6%
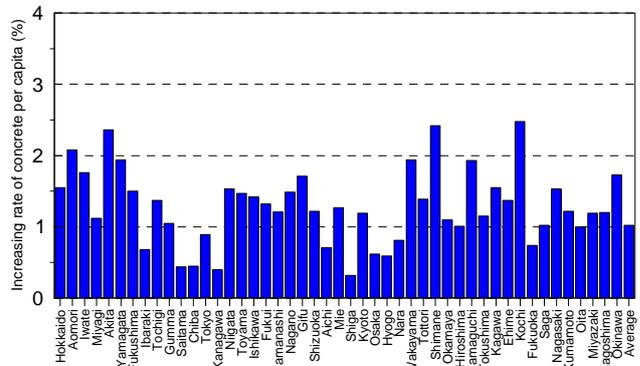

Figure 16 Increasing rate of concrete per productive age population for public buildings in each prefecture in 2009; Coefficient of variation of 40.7%

As references, the coefficient of variation of increasing rate of concrete (without consideration for per capita) and the coefficient of variation of consumption of cement per capita were obtained and compared with the those of the previous two (**Figure 17**, **18** and **19**). It is obvious that the productive age population should be better for a factor for the regional difference in the demand for cement for any purpose of concrete.
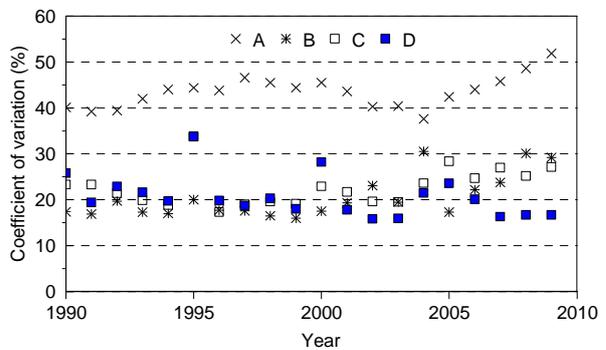

Figure 17 Coefficient of variation of each factor for demand for cement for civil engineering

structures between 47 prefectures in 1990 to
2009; A: consumption of cement per capita, B:
increasing rate of concrete, C: increasing rate of
concrete per capita; D: increasing rate of concrete
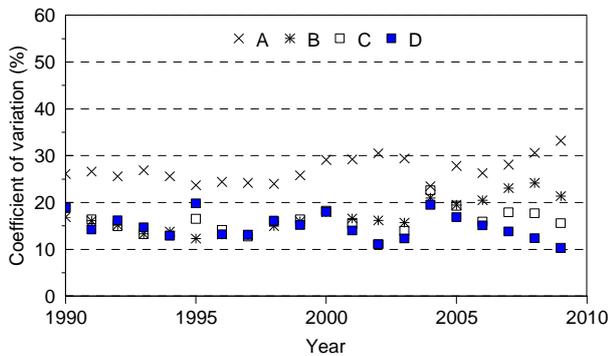pre productive age population

The history of the coefficient of variation for the increasing rate of concrete per productive age population for each purpose is shown (**Figure 20**). It is obvious that the coefficient of variation for private buildings was the smallest. That can be because the public demand for construction may reflect the increase or decrease in the population most directly.
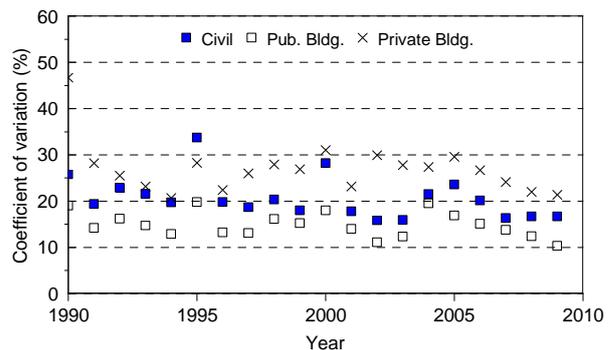

Figure 18 Coefficient of variation of each factor for demand for cement for private buildings between 47 prefectures in 1990 t0 2009; A: consumption of cement per capita, B: increasing rate of concrete, C: increasing rate of concrete per capita; D: increasing rate of concrete pre productive age population

Figure 20 Transition of increasing rate of concrete per productive age population for each purpose in 1990 to 2009

4. CONCLUSIONS

Regional difference in demand for construction in Japan for recent 20 years (1990 to 2009) was examined in terms of consumption of cement for each purpose in Japan and an effectiveness of increasing rate of concrete per capita of productive age population (15 to 64 years old) was verified. The purpose of consumption of cement was classified into civil engineering structures, private buildings and public (government and municipal) buildings. Four types of indices for the demand for cement in each prefecture were employed and the values for each purpose in each year (1990 to 2009) were obtained: consumption of cement per capita, increasing rate of concrete, increasing rate of concrete per capita, and increasing rate of concrete
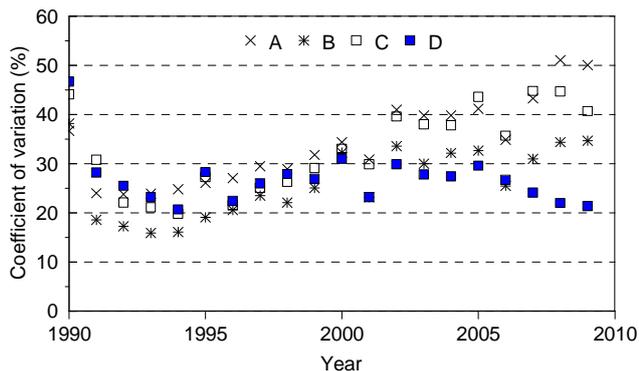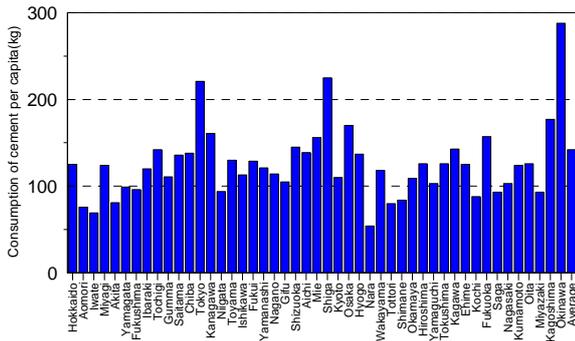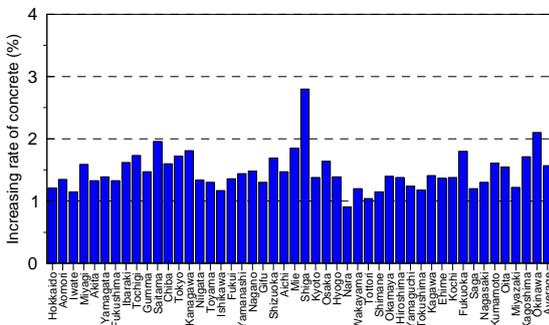

Figure 19 Coefficient of variation of each factor for demand for cement for public buildings between 47 prefectures in 1990 to 2009; A: consumption of cement per capita, B: increasing rate of concrete, C: increasing rate of concrete per capita; D: increasing rate of concrete pre productive age population
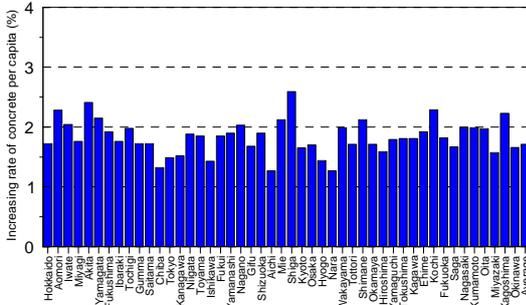
per capita of productive age population. The coefficient of variation of each type of indices that was obtained as the ratio of the standard deviation to the average value was obtained for each purpose. The increasing rate of concrete per capita of productive age population was found to be the best factor for the regional difference in the demand for cement because the coefficient of variation was the smallest.

REFERENCES

[1] CEMBURO (European Cement Association): Cement Consumption (World statistics of cement) 1920-2008.

[2] Motani, K.: Real cause for deflation, Kadokawa Publishing, 2010.

APPENDIX I: Demand for cement for civil engineering structures by each index in 2009
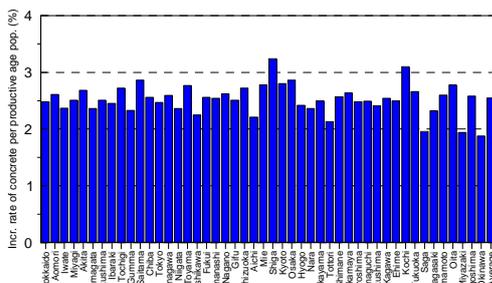

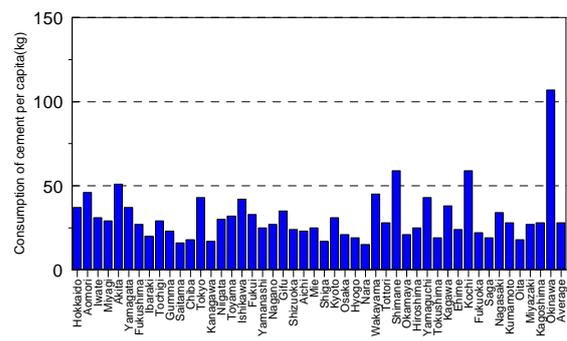Consumption of cement per capita

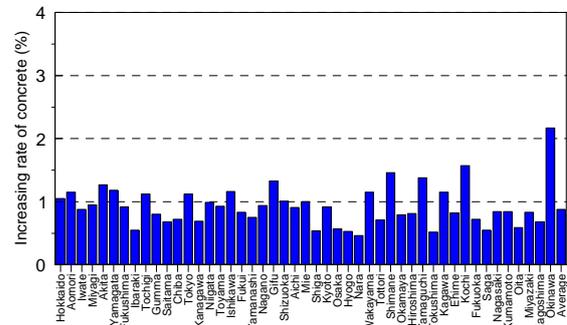Increasing rate of concrete

Increasing rate of concrete per capita

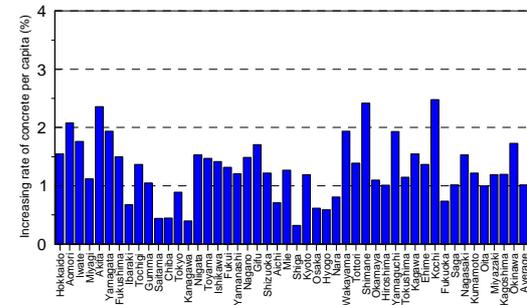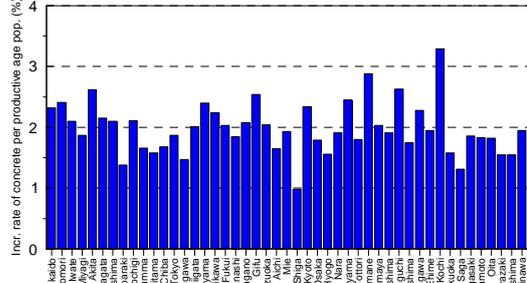Increasing rate of concrete per productive age population

APPENDIX II: Demand for cement for private buildings by each index in 2009

APPENDIX III: Demand for cement for public buildings by each index in 2009

Consumption of cement per capita

Consumption of cement per capita

Increasing rate of concrete

Increasing rate of concrete

Increasing rate of concrete per capita

Increasing rate of concrete per capita

Increasing rate of concrete per productive age population

Increasing rate of concrete per productive age population