Aiming to Interchange Effective Use of CCP Technology in Asian Countries: Setting up the Committee on Advancing the Effective Use of CCP Technology in JCOAL

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ABSTRACT

The amount of CCP (Coal Combustion Product, which includes coal ash, gypsum, and coal ash slag) increases rapidly along with new construction and expansion of pulverized coal thermal power plant in Asian courtiers in recent years. The values of annual emission are predicted to be over 300 million tons in China, about 130 million tons in India, 30 million tons Indonesia, and 10 million tons in Japan. It is reported that the amount of emission is very large and increasing rapidly. It would not be an exaggeration to say that the effective use of CCP technology has only just started in Asian countries.
In Japan, many effective technologies were developed and accumulated chiefly by the Japan Coal Energy Center (JCOAL).There is great meaning in collecting detailed information related to the actual status of CCP usage in Asian countries, transmitting effective Japanese technologies to these countries, and exchanging effective use of CCP technologies with them. Accordingly, JCOAL set up the Committee on Advancing the Effective Use of CCP Technology in Oct. 2007. In this paper, we introduce general information about the committee and its activities.

1. INTRODUCTION - ESTABLISHMENT OF THE COMMITTEE ON ADVANCING THE EFFECTIVE USE OF CCP TECHNOLOGY

Japan is going ahead with technology to make effective use of CCP. Many such techniques have been realized through the efforts of JCOAL and other organizations,

and high technical standards have been achieved in terms of practical know-how. It is both very meaningful and significant for Japan to investigate and study a framework for digitized information which can be transmitted both domestically and abroad by gathering and organizing information on technology to make effective use of CCP accumulated in Japan.

The emission of CCP has been rapidly increasing in recent years because of a rapid increase in the number of newly constructed coal-fired power plants and in the extensions of the existing ones. Quite a large amount of coal ash is reported to have been emitted in the past few years, and the amount is rapidly increasing, as indicated by the recent prediction of the annual emissions of coal ash, including over 300 million tons from China, about 130 million tons from India, 30 million tons from Indonesia and 10 million tons from Japan.

Active efforts are now being made in many countries to promote the technical development of effective CCP use, but it is no exaggeration to say that it is only the beginning.

JCOAL has active communication with Asian countries about energy and coal matters with an eye to establishing an information network on such issues. But there is almost no exchange of information on CCP because the status of effective CCP use varies from country to country. This situation has made it almost impossible for us to obtain information on what each country is doing to effectively use of CCP.

Promoting the establishment of an information exchange network on technology for effective CCP use, as in the case of the ongoing move for an information exchange network among Asian countries on energy and coal issues, is an urgent task.
In this light, JCOAL established as an internal group - the Committee for Advancing of Effective CCP Use (hereinafter, the “CCP Committee”) - in September 2007.

Fig. 1 shows the role of this CCP Committee and its position in JCOAL. The CCP Committee is under the control of the Coal Ash Use Committee, which is the main group in JCOAL that comprehensively deals with matters on coal ash and has an active relationship with the activities of the other groups. The CCP Committee should use the results of research on coal ash conducted by other groups for distribution domestically and abroad through the Committee as needed.

The CCP Committee also has a relationship with the activities of non-coal ash related

JCOAL committees. For technical training of overseas trainees conducted as part of the Clean Coal for Asia project separately underway by JCOAL, one session was held on a topic related to technology for effective CCP use for Asian trainees in FY2008. The training session produced excellent results. One of the future tasks is the integration of the database of information on the technology for effective CCP use into JCOAL's general technical information database.

For external publicity, the CCP Committee should hold symposiums and workshops on various kinds of coal ash produced in Japan. JCOAL currently communicates with foreign organizations related to CCP, such as ACAA and ECOBA, and intends to further continue and reinforce relationships and cooperation with such organizations. JCOAL particularly hopes to aggressively exchange technical information on effective CCP use with Asian countries and strengthen mutual ties.

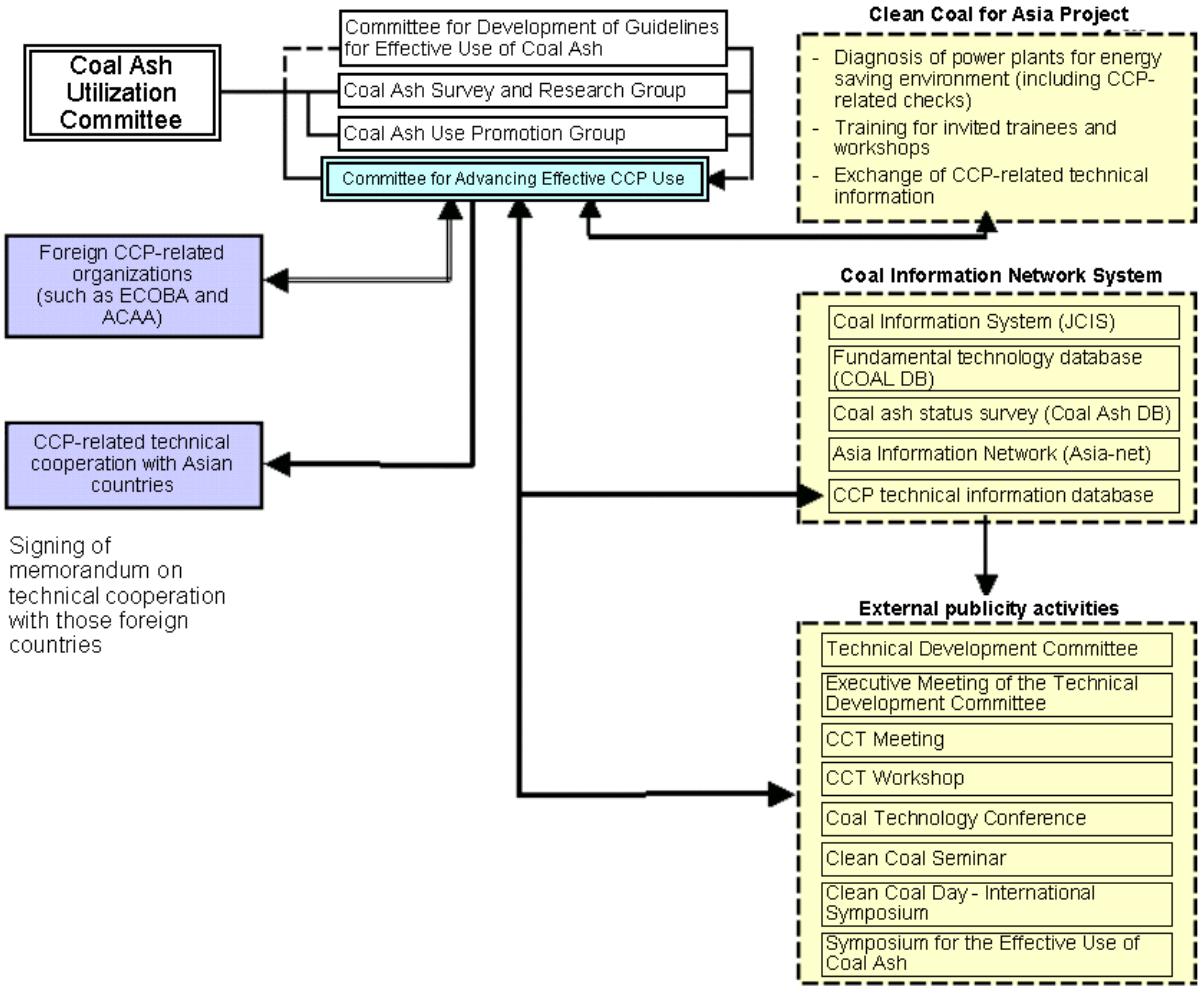

Fig. 1: Roles of the Committee for Advancing of Effective CCP Use and its position in JCOAL

3. CCP EMISSION AND EFFECTIVE USE IN JAPAN

3.1 Ratio of coal power generation in Japan

Since the petroleum crisis, thermal power plants in Japan have diversified fuel sources from the viewpoint of ensuring stable electric power supply by actively promoting conversion from petroleum-based thermal power generation to LNG and coal-based thermal power generation. The changes in the composition of power generation equipment according to the Power Supply Planning designed by the Ministry of Economy, Trade and Industry (METI) of Japan in March 2008 are shown in Fig.2.

Coal fired thermal power generation equipment currently occupies about 16% of the total power generation equipment, and it is estimated that this ratio will remain substantially unchanged for the next 10 years [1)].

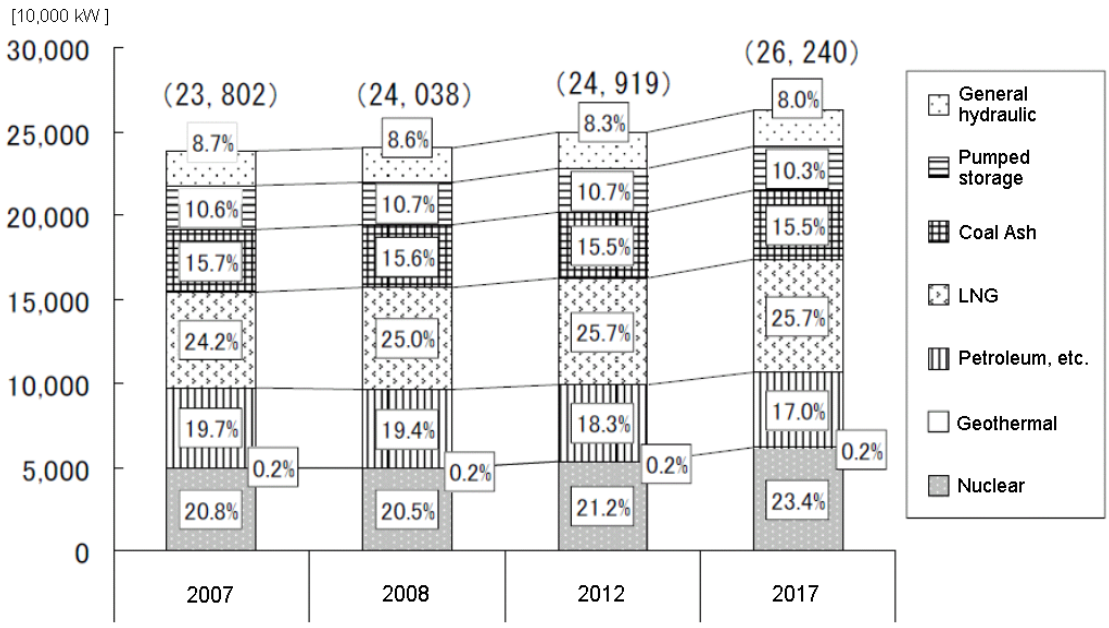

Fig.2: Current status and future composition prospects of power generation equipment in Japan

3.2 Coal ash emission and its effective use in Japan

As shown in Fig. 3, the annual emission of coal ash in 2007 in Japan is about 12 million tons, 73% of which is from the power industry with the remaining 27% from general industries other than the power industry. As shown in Fig. 4, of the total emission of 12 million tons, about 11.6 million ton were put to effective use, with only 400,000 tons sent to landfills without being reused or recycled. This means that 97% of the total emission of coal ash is effectively reused, with only 3% sent to landfills.

Fig. 4 clearly indicates that the landfill volume has been remarkably reduced compared with that of 10 years ago.

Fig. 5 shows how coal ash is reused. The breakdown by reuse area is as follows: 66% by the cement area; 14% by the civil engineering area; 4% by the building area; 1% by the agricultural, forestry, and fisheries area, and 15% by other users. This breakdown highlights one major characteristic of the effective use of coal ash in Japan, which is the great dependence on the cement field. Coal ash in the cement field is used as a raw material of cement, not as an admixture of cement, which is majoring direct contrast with foreign countries [2)].

In addition, note that about 90% of the coal ash produced in Japan is fly ash captured with electric duct collectors.

3.3 Desulfurized gypsum emission and its effective use in Japan

The desulfurized gypsum emission in 2006 in Japan is over 2 million ton for both the electric industry and other industries. Emission from the electric industry occupies about 90% of the total emission.

In terms of recycling desulfurized gypsum, 85% of that produced by the electric industry is reused for gypsum board material, with the remainder reused for cement material.

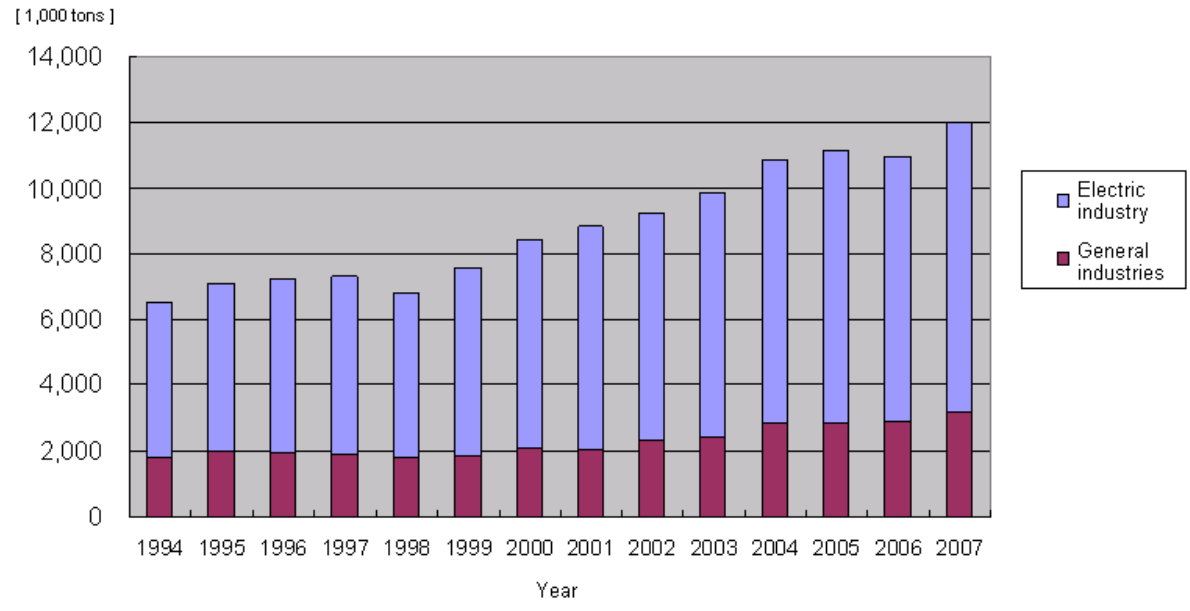

Fig. 3 Changes in coal ash emission by industry

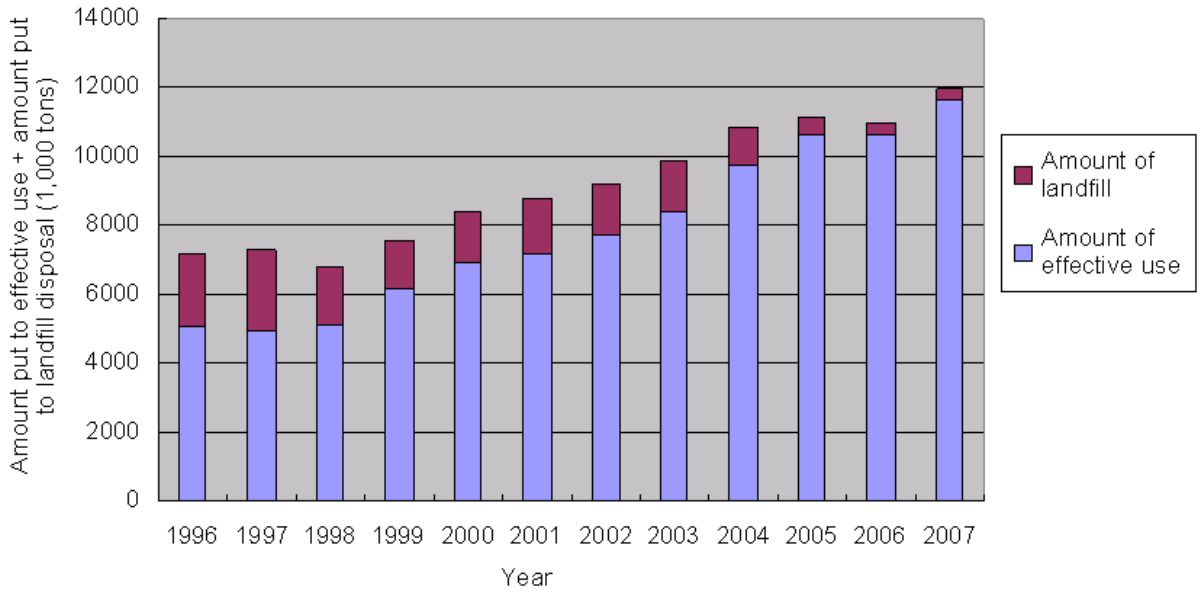

Fig. 4: Changes in coal ash put to reuse and landfill

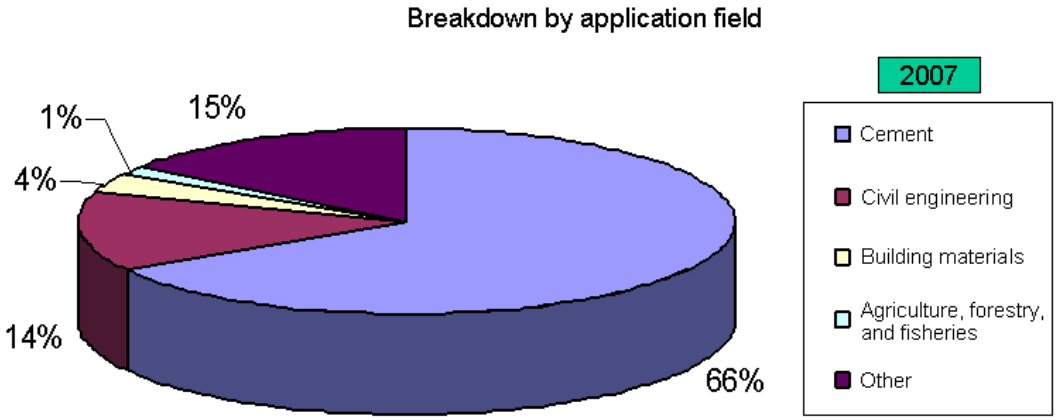

Fig. 5: Reuse of coal ash

4. THE JAPANESE STANDARDS FOR FLY ASH USED FOR CONCRETE

4.1 Changes in fly ash standards in Japan

The standards for fly ash for concrete use in Japan are specified in JIS A 6201, which was amended several times since its establishment, as summarized in Table 1 [3)], and outlined below.

In 1958, the JIS standards (JIS A 6201) concerning the quality of fly ash as an admixture for concrete was first enacted.

The JIS standards were modified in 1974, when thermal power plants changed their major fuel source from coal to heavy oil. In consideration of the balance between supply and demand of fly ash, the standard figures were mitigated; in other words, the standard figures on fineness were deregulated to a certain degree without any detriment to fly ash. At the same time, standard figures on unit water volume ratio

and compressive strength ratio were reviewed, and as for fineness, the regulation concerning residue on sieves was abolished. Therefore, only the regulation using Blaine value remains valid.

Amendment of the JIS standards in 1991 included a changeover to the International System of Units (SI), and reviews of expressions on testing methods, representation of calculation formulas and reagent symbols, while standard figures remain unchanged.

In 1996, the JIS standards were again revised with a view to preparing a user friendly environment on the quality of fly ash, wherein consistent standard testing methods between other JIS standards and standards of foreign countries were incorporated. Major revisions in 1996 included the introduction of the flow value ratio instead of unit water volume ratio, introduction of the activity index in place of the compressive strength ratio, and setting of the mesh sieving method in the fineness standard.

The JIS A 6201 experienced a major revision in 1999, the purpose of which was to extend the scope of effective applications of fly ash, including the establishment of four grades of quality in place of the original single grade, review of the ignition loss testing method and temperature, and introduction of alternatives by directly measuring un-burnt carbon in the ignition loss. The conventional JIS type fly ash corresponds to the current JIS type II fly ash.

Table 1: History of amendments to JIS A 6201 for concrete-use fly ash

Item		JIS standard (1958)	JIS standard (1974)	JIS standard (1996)	JIS standard (1999)			
					Type I	Type II	Type III	Type IV
Ignition loss (%)		5 or less	5 or less	5.0 or less	3.0 or less	5.0 or less	8.0 or less	5.0 or less
Fineness	Residue on 45 μm sieve (mesh sieving method: %)	25 or less	–	40 or less	10 or less	40 or less	40 or less	70 or less
	Specific surface area cm^2/g) (Blaine method)	2700 or more	2400 or more	2400 or more	5000 or more	2500 or more	2500 or more	1500 or more
Unit water volume ratio (%)		100 or less	102 or less					
Flow value ratio (%)				92 or more	105 or more	95 or more	85 or more	75 or more
Compressive strength ratio (%)	Material age 28 days	63 or more	60 or more					
	Material age 91 days	80 or more	70 or more					
Activity index (%)	Material age 28 days			80 or more	90 or more	80 or more	80 or more	60 or more
	Material age 91 days			90 or more	100 or more	90 or more	90 or more	70 or more
Density(g/cm^3) (specific gravity)		1.95 or more	1.95 or more	1.95 or more	1.95 or more			
Silicon dioxide: SiO_2 (%)		45 or more	45 or more	45.0 or more	45.0 or more			
Hygroscopic moisture (%)		1 or less	1 or less	1.0 or less	1.0 or less			
Homogeneity in quality: Not to exceed values of submitted samples	Blaine method cm^2/g)	± 450	± 450	± 450	± 450			
	Mesh sieving method (%)			5%	5%			
	Unit water volume ratio (%)	5%	5%					

4.2 Comparison between Japanese fly ash standards and their U.S. counterpart

The major differences between the Japanese standards for fly ash (JIS A 6201) and their U.S. counterparts (ASTM C618: the use of fly ash as a pozzolan or mineral admixture in concrete) are shown below:

(1) Base coal
In the U.S., coal ash is divided into three categories depending on the type of base coal: natural pozzolan, anthracite or bituminous coal, and lignite or subbituminous coal; these types are regulated by their respective specifications. In Japan, however, there is no such categorization based on the type of base coal, because the base coal has been mainly bituminous coal in recent years. Recently, new developments are being seen as part of the move toward diversification of the type of base coal used for fly ash, such as introduction of subbituminous coal or biomass-mixed combustion.

(2) Chemical properties
U.S. chemical limiting values for fly ash are (SiO_2+Al_2O_3+Fe_2O_3) and sulfur trioxide (SO_3). However, there are no such specifications in Japan, except for the limiting value of SiO_2. The value of loss on ignition in the U.S. is larger than that in Japan, meaning the Japanese control is stricter.

(3) Physical properties
There are no specifications on density or specific surface area in the U.S., whereas detailed specifications are imposed on specific surface area in Japan. Safety is controlled by autoclave expansion and contraction in the US, while no such regulations apply in Japan.

(4) Homogeneity
The U.S. regulations specify the density and the homogeneity of the residues from a 45μm sieve. The Japanese regulations specify the specific surface area and the range of changes in residues from 45 μ m sieve.

My paper published in 2005 WOCA indicated that the properties of the fly ash categorized as JIS Type II in Japan are very stable relative to JIS [4)].

Today, new movements such as use of subbituminous coal for base coal or biomass-mixed combustion mean that the situation is changing from the previous situation in which bituminous coal was the main base coal. It is considered necessary

to revise the Japanese fly ash standard by taking into account the relevant standards in the U.S., the EU, and Asian countries.

5. THE PRESENT STATUS OF RESEARCH ON FLY ASH BY RELATED ACADEMIC ASSOCIATIONS IN JAPAN

This chapter reports the activities of development and preparation of the guidelines to have appropriate application of fly ash as concrete admixture in Japanese academic associations, namely the Japan Society of Civil Engineers and the Architectural Institute of Japan, in conjunction with JIS revisions.

5.1 Activities of the Japan Society of Civil Engineers (JSCE)

The JSCE Concrete Committee set up the Fly Ash Survey and Research Subcommittee in April 1995 under the contract with the Japan Fly Ash Association and conducted survey and research for the scheduled period of about four years to prepare a guideline for use of concrete containing fly ash.

During the first phase from 1995 to 1996, the Fly Ash Survey and Research Subcommittee set up three working groups, or Quality Evaluation WG, High Performance WG, and Effective Use WG, and each of those working groups vigorously conducted research activities including revision of the specifications of JIS A 6201 (Fly Ash for Concrete) by QE WG, research for realization of use of fly ash in high-performance concrete by HP WG, and review on feasibility of use of fly ash not complying with the former JIS specifications by EU WG. In the second phase starting on 1997, the working groups were restructured into Quality Standard WG, Performance Evaluation WG and Guideline Preparation WG in order to achieve completion of the use guideline.

The Concrete Committee issued the *Engineering Guidelines for Concrete Using Fly Ash (draft)* [5)] in April 1999 as Concrete Library No. 94.

The JSCE Concrete Committee then set up the Fly Ash Effective Utilization Subcommittee in August 2006 under the contract with JCOAL in August 2006 and started research and survey on concrete-mixed fly ash for the schedule period of three years to clarify the advantages of its use from the viewpoints of (1) formation of recycle-based society, (2) strength characteristics and (3) mix proportion design and review and propose appropriate practical usage of the concrete-mixed with fly ash. At

the same time, the same Subcommittee was awarded a research contract by ten utility companies to clarify the advantages of effective use from the viewpoint of (4) prevention of reaction with alkali aggregate and (5) durability, and review and propose appropriate practical usage. Currently, the Subcommittee is in activity and plans to publish a book on the outcome of the research as a new addition to the association's concrete library.

5.2 Activities of the Architectural Institute of Japan (AIJ)

This paragraph mainly deals with the activities of the AIJ regarding fly ash and information on the guidelines thereof. Just like JSCE as explained above, AIJ also issued the *Recommendations for Practice of Concrete with Fly Ash (draft)* (1999) following the revision of the relevant JIS regulations. This guideline provides for appropriate usage of fly ash concrete in building works.

Then, AIJ set up the Fly Ash Concrete Research Subcommittee for research on application of fly ash to concrete for building works under the contract with electric power companies for the schedule period of three years from 2002 to 2004. During these three years, the Subcommittee conducted a wide range of research, put together the research results in the form of a contract research report and issued “the Guideline for the Recommendations for Practice of Concrete with Fly Ash (draft)” in March 2005.

In order to revise the Recommendations for Practice (draft) issued in 1999 based on the above Guidelines, AIJ set up the Fly Ash Concrete Guideline Revision Subcommittee within the association in April 2005 and studied the newest research results to advance the revision. In October 2007, AIJ published a major revision to the *Recommendations for Practice of Concrete with Fly Ash* [6)].

6. OUTLINE OF THE JCOAL'S EFFECTIVE CCP USE TECHNOLOGY

6.1 Description of effective CCP projects in JCOAL

JCOAL promotes R&D on various techniques on use of coal and conducts a number of projects on smooth promotion of use of coal through international cooperation projects and publicity activities. One of the essential projects is effective use of coal ash.

JCOAL has been engaged in projects to encourage and support development, commercialization and diffusion of technologies for production and use of coal for effective use of CCP and in substantive research on those techniques since 1980. The results of those research activities have been put together in the form of a large number of reports. The technology for effective use of CCP so far studied by JCOAL serving as the central player is divided into categories as shown in Table 2.

Table 2 Research on the technologies for effective CCP use conducted by JCOAL

Category	Description of effective CCP use technology
1	Technique for Recovery of coal ash and reuse of recovered coal ash in general industries
2	Utilization technique of unused resources in coal ash
3	Technique related to hardened composites of coal ash
4	Technology for use of incineration ash from the fluidized bed boiler
5	Test on technology for use of black ash
6	Feasibility study on mass use of coal ash
7	Development of anti-rust paint containing coal ash
8	Production technology of activated fly ash
9	Research on effective use technology of coal ash (Part 1)
10	Research on effective use technology of coal ash (Part 2)
11	Production technology of artificial light-weight aggregate using coal ash
12	Production technology of aggregated with high-pressure autoclave-curing
13	Technology for use of pulverized coal boiler coal ash as hardened materials for civil engineering application
14	Technology on evaluation of environmental characteristics of coal ash
15	Research on promotion of coal ash use

6.2 Outline of each project

Here are the outlines of some important projects out of those listed in Table 2.

(1) Techniques for recovery of coal ash and reuse of recovered coal ash in general industries

This research aims to establish the effective use of coal ash and encourage greater use of coal in general industries. In general industries, it is difficult for any single business alone to introduce and operate effective use technology for coal ash. The research therefore centers on the development of a system that accepts coal ash in return for supply of coal and realizes the effective use of recovered ash by the area.

The research was conducted from 1985 to 1995.

(2) Utilization technique of unused resources in coal ash
The effective use of a large amount of emitted coal ash being studied includes use as land development projects such as land fill, use as a material for cement, pottery and building materials, and recovery of valuable elements. This research focuses on the recovery of valuable elements in coal ash and specifically aims to recover aluminum, titanium, iron, silica and other valuable elements contained in coal ash through chemical treatment. The research was conducted from 1986 to 1999.

(3) Technique related to hardened composites of coal ash
This research intends to develop a hardened FGC (fly ash, gypsum and cement) material containing a large volume of coal ash and put it to marine applications field and others as one of the technique to effective use of coal ash. The research was conducted from 1986 to 1997.

(4) Technology for use of incineration ash from the fluidized bed boiler
Aiming to establish a technique for use of incineration ash from the fluidized bed boiler, this research focuses on establishment of technology for use of coal ash by developing the hardened material technique that includes humidification of incineration ash from the fluidized bed boiler and low-pressure steam treatment. The research was conducted from 1991 to 1997.

(5) Production technology of activated fly ash
This research aims to put into practical use of production of activated fly ash. To be specific, coal and calcium components are mixed for combustion to produce the advanced type of coal ash (activated fly ash) that is stabilized in terms of quality and is excellent in initial strength development as a cement mixture compared with conventional coal ash. The research focused on testing of such production technique and attempted production of activated fly ash as admixture for ordinary portland cement, which is expected as effective use method of a large amount of coal ash. The research was conducted from 1994 to 1997.

(6) Production technology of artificial light-weight aggregate using coal ash
The aim of this research is development of the production technology for recycling of pulverized coal boiler ash and fluidized bed boiler ash as a raw material of artificial light-weight aggregate. The research was conducted from 1996 to 2001.

(7) Technology for use of pulverized coal boiler coal ash as hardened materials for civil engineering application
The process studied in this research is to knead coal ash mixed with a small amount of coal ash and gypsum and water, steam the kneaded mixture and produce hardened materials. For the hardened materials whose post-hardening strength is about 10 N/mm^2, the research aims to apply them as roadbed material or fill material. For those whose strength is about 20 N/mm^2, they would be applied to ground improvement agent. The research intends to develop a technique to make effective use of a large amount of coal ash by those applications. The research was conducted from 1999 to 2003.

(8) Technology on evaluation of environmental characteristics of coal ash
In this research, the existing data on the environmental characteristics of coal ash, including elution of microelements in coal ash, were studied to develop systematization of the data based on statistic analysis. The research was conducted from 2000 to 2002.

7. FUTURE PROSPECTS OF THE CCP COMMITTEE

The current ongoing task of the CCP Committee is to survey what technologies for the effective use of CCP have been developed and used domestically and abroad, what research has been made by academic associations, and compile the data in a database. The CCP Committee plans to convert the data in the database into a format distributable to users both in Japan and overseas. In addition to the development of a database for effective use technology, the Committee also intends to transfer the technology for effective CCP use, accumulated at JCOAL, to Asian countries and provide related cooperation to those countries including support of human resources and R&D associated with such technical transfer. The ultimate goal is greater contribution to CDM by standardization of CCP in the entire Asian region and promotion of effective use of CCP.

Summarizing those efforts, the activities and goals of the CCP Committee are integrated into the following eight steps:

(1) Gathering and compiling information on technologies for effective use of CCP and the related academic information
(2) Converting the information into a digitized format for distribution domestically and abroad (establishment of JCOAL database)

(3) Exchanging information on technology for effective use of CCP and holding relevant workshops
(4) Technical transfers related to effective use of CCP
(5) Supporting technical human resources associated to transfer of technology of effective use of CCP
(6) Cooperating in the field of research and technical development related to technical transfer for effective use of CCP
(7) Standardizing the technology for effective use of CCP in the entire Pan-Pacific region
(8) Developing CDM related to the technology for effective use of CCP in the entire Pan-Pacific region

At present, steps (1), (2), and part of (3) are under way. Other steps are planned to be conducted sequentially.

External ongoing activities for Fiscal Year 2009 include efforts to formulate a platform for mutual cooperation on CCP use technology with China, the largest emitter of coal ash in Asia.

Finally, the Committee is firmly determined that the promotion of the Committee activities will help establish a Pan-Asian information network on effective CCP use, promote effective CCP use in the Asian region, and eventually offer solutions to environmental problems in Asia, such as increases in CO2 emission or acid rainfall.

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