Report of Study Tour to Japan (2-16 November 1996)

Bernard BRÛLÉ
ENTREPRISE JEAN LEFEBVRE

Background

This trip took place because of an invitation from the Japan Society of Civil Engineers (JSCE) sent to the National Council of Engineers and Scientists of France (CNISF) in which Mr. J.C. Parriaud is chairman of the Civil Engineering Commission. On the occasion of its 75th anniversary, the JSCE decided to provide financing to bring civil engineers from other countries to Japan in order to promote greater mutual understanding. The following engineers were invited.

Australia	Timothy W. Macoun (1992)
Sweden	Svante Roupe (1992)
United States	John Thompson (1993)
Canada	Michel Bruneau (1994)
England	Graham Dalton (1995)

In 1996, Bernard Brule (ENTREPRISE JEAN LEFEBVRE) received a JSCE grant for a study visit of two weeks from 2-16 November 1996.

Report of the Visit

The programme arranged by JSCE had obviously been meticulously and efficiently organised and was essentially carried out as planned. In addition, a meeting with NICHIREKI, Co., LTD. was held on 15 November 1996.

First and foremost I should mention the efforts and puncuality of Naoyuki Kumagai who accompanied me from the moment of my arrival at NARITA airport. His efficiency and kindness were among the crucial factors responsible for my fond memories of my first visit to Japan.

The business part of the trip began with my meeting the following staff of the JSCE.

Mr. Isami, General Secretary
Dr. Eng. Kenji Aoki
Mr.Hiroshi Kono, Executive Director of the JSCE
Prof. Dr. Minoru Matsuo, President of the JSCE

The JSCE was founded on 24 November 1914. It now has 35,000 members and seeks to be the nucleus for all civil engineering activities in Japan. It contributes to efforts to improve the quality of life and the environment in collaboration with academic organizations. It establishes contacts with research centres and learned societies abroad in order to encourage technical exchanges (my visit is a good example).

At the first meeting, which was very cordial and informal, the JSCE's objectives and the arrangements for the visit were discussed, including payment of the grant offered by the JSCE to cover the costs of the visit.

The first organisation visited (afternoon of 5 November 1996) was the "Port and Harbour Research Institute" of the Ministry of Transport, established in1946 and employing about 200 scientists.

Before visiting the facility, a short video presentation stressed the importance of establishing a balance between nature and technological development and protecting both the environment and industrial facilities. In Japan, many of these are built on reclaimed land for which soil mechanics studies are very important (with centrifuge simulation). The video also focused on the lessons learned from the Kobe earthquake of January 1995: educating the population, revising construction specifications.

The Port and Harbour Research Institute has very impressive facilities:

- wave generator (28 metres long, capable of generating 4 types of waves up to 40 cm high).
- centrifuge (2760kg to 113g)
- structural test slab (17x17x4 m) equipped with a 747 landing gear simulator (analyses of structure behaviour are carried out with a Falling Weight Deflectometer.
- soil mechanics laboratory equipped with original materials for triaxial tests on soft soils with a very high degree of precision (there is no gauge on the test piece, the quantity of water in the cell is measured very precisely).
- a costal ecosystem research laboratory (sand, mud deposits, sea water with a wave simulator to study the influence of dynamic factors) intended to protect or re-establish ecosystems in the event of construction of new industrial facilities.This facility is unique in that it uses three large basins for "realistic" studies.

6 November 1996: Visit to KAJIMA TECHNICAL RESEARCH INSTITUTE (KaTRI) of KAJIMA CORPORATION (My hosts were Dr. Eng. Hirotake Kurihara and Tadtsugu Tamaki).

KAJIMA CORPORATION was founded in 1840 and has over 150 years of experience in all areas of civil engineering. It employs about 14,000 people and has capital holdings on the order of 600 million US dollars.

KaTRI was established in 1949, initially as a professional laboratory. It has grown to become the largest private research centre in the world in the field of civil engineering. It employs 431 people including 292 engineers (52 Ph.D.'s) and 48 assistant engineers. It has impressive laboratory facilities such as:

- a 5x5 m earthquake simulation table with a load capacity of 30 tonnes, capable of producing vertical and horizontal accelerations of 2 g. It has six degrees of freedom and can produce dislocations combined with frequencies of up to 60 Hz. It also has computer systems to monitor the tremors and analyse the reactions. Simulation of the effect of Kobe earthquake on typical Japanese home furnishings is rather impressive!
- a wind tunnel which can create winds of up to 130km/h and study their effects on large structures (skyscrapers, bridges, etc.)
- a structure test slab (50x40 m) with vertical reaction wall 16 m long, 3m thick and 12m high used, among other things, for studying the resistance to fatigue of anti-earthquake vibration damping systems for buildings.
- a centrifuge (Acutronic) with a capacity of 1000kg to 100g or 500kg to 200g to study geotechincal models.
- actual size tests for anti-earthquake vibration damping systems.
- an auditorium for studying the acoustics of auditoriums (theatres, concert halls, stadiums) and for choosing material and configurations.

Here again one cannot help being extremely impressed by the resources devoted to earthquake protection, protecting the environment, and maintaining or improving the quality of life. The wish to live and to develop technology in harmony with nature (often harsh in Japan) is expressed everywhere.

After lunch (with KIKUO KOSEKI and TADAO MONZAWA, Assistant Director of KAJIMA ROAD CORPORATION LTD.) I visited Kajima Road Corporation with Dr. Eng. Hirotake Kurihara, Tadao Monzawa and Shigeo Higashi.

KAJIMA ROAD CORPORATION LTD. is a road construction company employing 1800 people, ranked third in Japan in terms of turnover (the largest Japanese road construction firm employs 3000 people) In addition to road construction and maintenance (65% of its activity), KAJIMA ROAD is also involved in civil engineering (25% of activity) and building construction (10%).

KAJIMA ROAD's areas of specialty include construction of bituminous concrete speed rings and equipment for laying (specialised, computer-controlled paver) and compacting (Arc Steel Rollers) (they built the ARIZONA TEST CENTER in Arizona), hydraulic reservoirs, dikes, and recycling operations (Super Remixer). In Japan, 1 to 5 million m^2 of pavement is recycled annually. KAJIMA ROAD has 3 Super Remixers for hot recycling of 3 cm of wearing course with addition of 40% new materials (machine speed 1 to 2m/min). Some forty machines of this type are in operation in Japan (it was surprising to learn that one of KAJIMA ROAD's three machines was rented to SOTER in Montreal!).

After a very interesting general discussion we proceeded to the visit of the laboratories which are equipped with:

- penetration equipment, automatic RBT
- a wheel rutting machine (neither German nor English)
- an INSTRON press
- a fatigue test bench, 4-point bending for hot mixture
- a brand new giratory compactor TROXLER (result of SHRP)
- a single jet foam bench (due to the KAJIMA ROAD - SOTER relationship)
- a machine for wearing of surfacing at low temperature
- a machine which simulates wear generated by the spikes of golf shoes!

According to the road constructions firms, the new Japanese government is providing less financing for road construction and maintenance than was initially planned (in contradiction with what appeared in the publication "MACHI").

With regard to civil engineering works (particularly in concrete), it appears that the requirement that they be watertight is recent. Before, it was the concrete which was subject to the freezing-defrosting cycles but now it is bituminous concrete which has stripping problems.

Japan's consumption of road bitumen is on the order of 4 million tonnes and the production of bituminous concrete on the order of 80 million tonnes.

7 November 1996: Visit to SHIMIZU CORPORATION

I was greeted by Yasumitsu Watanabe of SHIMIZU CORPORATION (15,000 employees) for a visit of the Daiba Tunnel, 2x2 lanes, about 200m long but in a very difficult location. This tunnel was built using a FREYSSINET process with prefabricated concrete caissons which were then drawn into place using cables once the terrain had been excavated (compact shale removed manually at a rate of 40 cm/day !).

The impression left by the visit was one of impeccable organisation and an extremely clean and safe work site. This impression was reinforced at all the other work sites visited during my stay.

On the afternoon of 7 November 1996 Yasumitsu Watanabe accompanied me for a visit to the JAPAN ROAD CONTRACTORS' ASSOCIATION LABORATORY where we were greeted by the Director and Head of the Laboratory (who unfortunately did not speak English, so all comments were through Yasumitsu Watanabe).

This laboratory (now 50 years old) is financed by 380 road construction firms and another dozen civil engineering firms. It has been at its current location since 1967. It carries out trials based on existing norms for:

- soils
- aggregates (for bituminous and hydraulic concretes)
- cements
- hydraulic concretes
- concrete reinforcements
- joints
- bitumen, hot mixtures, emulsions, fillers, etc.

It employs 22 people (including 17 engineers) and also carries out research projects under contracts from:

- the Ministry of Transport
- the JAPAN HIGHWAY AGENCY
- the Prefectures

These research projects account for about 30% of the activity of the laboratory and generally relate to ageing of polymer modified bitumens and the durability of pervious coated macadams. 50% of the laboratory's activity involves testing bitumens and bituminous concretes and the remainder, cements and hydraulic concrete. I discovered that because of concerns about the competitiveness of local products (considered expensive), imported products are being considered (e.g. French emulsion for tack coats).

The total production of bitumen in Japan is said to be 6 million tonnes per year and there are 1782 mixing plants with an average annual capacity of 80 to 100 tonnes/hour for annual production on the order of 80 million tonnes (of which 20 Mt from recycling).

The annual production of polymer modified binders (very precise statistics exist) is 240,000 tonnes of which 180,000 are "prefabricated" in special units and 60,000 tonnes are "plant mixed" (the opposite of the initial situation where the quantity of "plant mixed" was far greater than the "prefabricated"). The polymers used included SBR, SBS, SIS, EVA, EEA and there are several categories of specifications.

The main development has been in the area of pervious coated macadams whose market is expanding rapidly because of the desire to reduce noise pollution but with serious concerns regarding their maintenance (there is talk of a maintenance machine which sounds strangely like the RUGOR, developed by a Japanese industrialist).

The market for emulsions is said to be on the order of 600,000 tonnes/year, used mostly for tack coats (at a rate of 500g/m^2). There is very little surface dressing and virtually no slurry seals or microsurfacing. During the laboratory visit I observed the following equipment:

Bitumen Laboratory

- automatic penetration
- automatic RBT
- viscosity at 60° C and 130° C
- ductilometer
- automatic equipment for measuring toughness-tenacity (BENSON). This test is part of the specifications for polymer modified bitumens.

Hot mixture laboratory

- binder content by ignition (NCAT equipment)
- automatic rutting machine with 3 stations (tests at 60° C, 2500 cycles)
- MARSHALL
- automatic binder extractor: two units with 3 stations (1 million francs per unit), replacing the former SOXHLET method which was considered to pollute (this investment is a very good example of the strong will to improve work conditions and protect the environment).

In addition, there was the necessary equipment for classifying aggregates, soils, and hydraulic concretes, such as LOS ANGELES (used in CANTABRE), compression and traction presses, equipment to measure alkali reactions, CBR, ripening chambers, etc.

8 November 1996: Trip to KOBE (on the Shinkansen, the Japanese equivalent of the TGV) to see the AKASHI KAIKYO BRIDGE.

When it opens in the Spring of 1998, this steel suspension bridge will be the longest in the world (total length: 3910m). Its technical features are very impressive:

- steel piers of almost 300m length (46,200 tonnes)
- clearance height: 65m
- span between the piers: 1990m

The bridge is designed to tolerate winds of 46m/s. It has 2x3 lanes for traffic at an average speed of 100km/h. It is also designed to withstand an earthquake of 8.5 on the RICHTER scale with the epicenter 150km from the structure on the ocean shelf and any earthquake with a probability of 150 years occurring within a radius of 300 km of the structure.

The guided tour lead by Hiroaki Hoashi and Taku Hanai was every bit as impressive as the structure itself. The metallic slab (12mm thickness) is absolutely perfect with regard to geometry and appearance. There is not one square centimetre of rust and the alignment is millimetric before welding.

All of the metal parts are either protected with 50 micrometers of anti-corrosive rich in zinc primer or prepainted and packaged in such a way that no parts are damaged or contaminated. The work site is impeccably clean and safety regulations appear to be very strictly enforced.

The metallic slab is to be covered with 75mm of a complex composed of 40 mm of split mastic asphalt with bitumen modified with polychloroprenes and 35mm of wearing course (i.e. split mastic asphalt which is supposed to make it waterproof).

After the Kobe earthquake of January 1995, a thorough inspection of the section that had already been built confirmed the effectiveness of the vibration damping system in the structure's piers.

It was also observed that the two banks had moved further apart, that the cables were under a slightly greater stress than planned for and that the structure would have to be lengthened by 80cm! (This was done by adding 2x40 cm on either side of the middle section).

11 November 1996: Visit to KOBE UNIVERSITY.

I was greeted by Professor Dr. Eng. Shiro Takada accompanied by Freddy R.D Cardenas (Peruvian doctoral candidate) and Nemat Hassani (Iranian doctoral candidate).

The morning was devoted to a presentation on the sadly famous KOBE earthquake (more correctly referred t as the GREAT HANSHIN EARTHQUAKE). This event (probability of only once ever 2000 years!) shocked Japan, especially the KOBE region including the University.

...Takada (Chair ... Exchange Fund Committee 1996-97), Dr. Brûlé, Mr.Cardenas

It is thought to be fortunate that this tremor of 7.2 on the RICHTER scale occurred at 5:16AM (17 January 1995) so that the worst earthquake in history resulted in only(!) 6300 deaths and 43,000 injuries. The tremor lasted only 11 seconds and most of the energy was dissipated within less than three seconds. 100,000 houses were destroyed, the same number were damaged and 7,000 burned, resulting in 320,000 refugees for whom 50,000 temporary dwellings were built. The direct cost is estimated at 100 billion US dollars including 10 billion for the port of KOBE alone. The overall cost is thought to be ten times greater.

This exceptional event generated a huge volume of work for analysis to discover the causes of the destruction of structures and superstructures and to propose revisions for construction specifications. All existing structures were reinforced and new structures were built in such a way that they could resist earthquakes with a probability of once every 100 years (life span considered for building design).

The afternoon was spent visiting the sites that were most severely damaged:

- an uninhabited building which had not been rebuilt (one of the few remaining)
- civil engineering structures (completely rebuilt)
- subway/underground station
- an area that was completely burned (nothing remains)
- port and areas of "liquefaction" (specific damage due to loss of bearing capacity of soils which were "liquefied" by water escaping from broken pipes which led to the subsidence of many buildings).

They psychological impact of this disaster was enormous. Aid structures were set up but it is estimated that 5% of the population decided to leave the area permanently due to the extremely difficult living conditions following the catastrophe.

12 November 1996: Visit to the PUBLIC WORK RESEARCH INSTITUTE (PWRI)

I was greeted by Nobuyuki Tsuneoka who is in charge of international relations. A general meeting was organised bringing together the heads of the Department of Material and Construction and The Department of Roads (Haruyoshi Okazaki, Kiyoshi Katawaki, Hiroyuki Sakamoto, Itaru Nishizaki, Hiroyuki Nitta., Iwao Sasaki, Makoto Kimura). PWRI is 75 years old. It was founded in 1921 and was originally called the ROAD MATERIALS TESTING DEPARTMENT. It is composed of various Departments and Study Centres and employs 467 people with an annual budget of about 13 billion yen (about 650 million French francs). The "Chemistry" and "Road" Division are mostly involved with polymer modified bitumens for pervious macadams (5 million m^2 applied so far at a pace of about 1 million m^2 per year) which are SBS bitumens containing 7 to 10% polymer, their durability, wheel rutting problems, development of emulsion microsurfacing, use of fibres in recycling techniques, and new research for pedestrian pavements.

Equipment observed on the premises included :

- penetration, RBT
- 3 rheometers (RHEOMETRICS), two of which are used for bituminous binders
- Bending Beam Rheometer
- Direct tensile test with laser extensometer (abandoned due to unsatisfactory functioning)
- Pressure Aging Vessel (build on site)
- Multi-function press developed by SHRP (constant thickness shearing)

The outside facilities are also substantial and include a fatigue track with stress from radio-controlled trucks, an automatic finisher, a Falling Weight Deflectometer, etc.

It seems that PWRI has close contacts with LCPC (a visit by G. Pilot was planned for December 1996) which involve meetings every three years (the last one was in France in 1995, the next will be in Japan in 1998) and joint research projects (e.g., cold mixtures) involving companies (on the Japanese side).

13 November 1996: Visit to ORIENTAL CONSULTANTS CO., LTD.

I was greeted by Akihiko Hirotani, Executive Director for International Operations. Shigetsugu Seino, President of ORIENTAL CONSULTANTS, explained the history of the consulting profession in Japan, starting from its beginnings in 1945 after the war (construction of housing during the year of occupation). During the war, many Japanese engineers worked in occupied territories and then returned to Japan and started working as consultants. After the war there was an enormous need for reconstruction, leading to the establishment of engineering firms such as ORIENTAL CONSULTANTS, established in 1957 and employing 610 people. In Japan there are about 1000 engineering firms which share a total of some 13 billion US dollars worth of contracts. Most of these companies work within Japan (less than 5% internationally). It is thought that over the next 10 years there will be considerable development of infrastructure and that most of the demand will involve improving standards of living (in Asia, China, etc.). After lunch I was escorted by Sayori Ikeda who took us to see some of ORIENTAL CONSULTANTS’ projects at the Port of Tokyo such as the Rainbow Bridge, along with a Thai engineer (Boonying Yaltavorn).

When we were back at ORIENTAL CONSULTANTS, there were three presentations by company engineers concerning the Japanese road network and structural design methods, the effect of pervious macadams on decreasing noise pollution and the rehabilitation of infrastructures in KOBE following the earthquake.

14 November 1996: Visit to OBAYASHI CORPORATION and the TRANS TOKYO BAY BRIDGE

I was escorted by Hideki Kawamura for the tour of the TRANS TOKYO BAY BRIDGE. This remarkable structure crosses the Bay of Tokyo over a distance of 15km (10km of tunnel, 5km of bridge, total budget: 14 billion US dollars). This saves a trip of 80km (with a toll of US $50!).

The tunnel section is now being completed. It was dub by several fully automatic tunnel-boring machines with a diameter of 14m (a world record) with two parallel tubes (2x2 lanes plus the service and emergency passages).

The tour guide was Keizon Miki Assistant Project Director for OBAYASHI. They are now dismantling the tunnel-boring machines and finishing the cryostabilisation of the soils to allow for joining and completing the structure (injection of refrigerated calcium chloride solution).

This was yet another impressive structure. It holds the world record for diameter and is calculated for 100 years in a zone of seismic activity. It is built with concrete caissons placed by the tunnel-boring machine and then waterproofing with a thick interior layer of high-density polyethylene, then a reinforcement and then a second layer of concrete within the tunnel (which increases the weight and resists buoyancy on the structure).

As always, the work site was spotless and the safety regulations seemed to be rigorously enforced.

Late in the afternoon there was an informal reception at the JSCE. This was a cordial meeting which gave me an opportunity to thank the Association and the many people who had helped to organise my visit and who had made it a success.

15 November 1996: Visit to NICHIREKI CO., LTD.

On the last day, the JSCE representatives organised an interesting meeting with NICHIREKI CO., LTD. (Minoru Makita, Vice President, and Kohei Kobayashi, Technical Director) including a tour of work sites (completed) with pervious macadams and meetings at the company’s headquarters with various technical managers.

Since the work is carried out at night (within the Tokyo urban area), we could only tour completed works. We inspected several pervious macadams which have been recently layed. These are mostly excellent-looking sites of pervious bituminous concrete 0/13 mm with 20% voids in 5cm layers applied to reduce the noise pollution (hydroplaning is not considered a serious problem in Tokyo because of the average speed of traffic). The afternoon meetings were held at the NICHIREKI headquarters.

NICHIREKI is a rapidly growing company of 350 people which produces modified binders and emulsions. The company has twenty manufacturing plants (modified binders and emulsions) and produces 60,000 to 80,000 tonnes of polymer modified bitumens per year and 130,000 tonnes of emulsion. It has a research centre with 30 employees and it is the largest company of its type in Japan (its Vice-President, Minoru Makita, worked at the PUBLIC WORK RESEARCH INSTITUTE for 26 years. He has already been in France, particularly at the LCPC centres in Paris and Nantes and says he is very interested in setting up Franco-Japanese exchanges).

Some information about the development of the Japanese market was presented. Polymer modified bitumens account for 240,000 tonnes or about 6% of the total market for road bitumen of 4 million tonnes.

These are three main categories of modified binders for which official specifications exist:

- Type I for wearing courses with textured and durable surfaces
- Type II for durable, anti-rutting hot mixtures
- The “very viscous” for pervious bituminous concrete

These specifications are based on penetration (minimal), ring ball temperature (minimal), ductility, BENSON tests (toughness – tenacity) and viscosity at 60 °C (minimum value for the “high viscous” binder for pervious bituminous concrete).

There is competition from road construction companies such as:

- TOA ROAD CORPORATION
- OBAYASHI ROAD CO.

And also from specialised companies such as BRIDGESTONE (tire manufacturer) but very little from the refining industry (SHELL is the only refiner involved and its sales are very low).

The pervious macadams appeared in 1993 and their use is expanding rapidly. NICHIREKI is also specialised in the production of special modified binders used for surfacing of civil engineering structures and very high traffic roads subjected to the specifications proposed by the Association of Modified Bitumen Producers.

With regard to special surfacing for civil engineering structures, concrete bridges have only been built with waterproofing in the past ten years. This is in the form of a 1 to 2 mm membrane of a “high adhesive” binder (developed by NICHIREKI) whose formula is confidential (no patent, but the know-how is kept secret). 4 cm of dense macadam with polymer bitumens and 4 cm of pervious macadam are placed on this membrane.

Metal slabs (TRANS-TOKYO BAY BRIDGE, AKASHI KAIKYO BRIDGE near Kobe) are covered with a tack coat (dosage not specified) of “rubber-bitumen” with special properties, and then 35 to 45 mm of a “gussasphalt” to provide watertightness and, lastly, 35mm of a dense macadam, the two macadam layers incorporating a special polymer bitumen (including polychloroprene, among other things) whose composition is confidential.

NICIREKI is also developing its activity in road network inspection. The company owns four testing vehicles for high-yield analysis of cracking rutting and evenness, and has signed a contact to examine 10,000km of roads belonging to the national road network for the most part.

CONCLUSION:

It is clear that a study tour of this sort is extremely enriching and that the fact that it is organised and supports by an important group such as the JAPAN SOCIETY OF CIVIL ENGINEERS opens all possible doors to allow for a maximum number of contacts and visits in a short time and in a very efficient manner (without becoming totally saturated).

If we consider that the JSCE’s desire is to promote Japanese civil engineering among foreign engineers, it was certainly successful. All the people I met made an effort to explain what they knew without asking for anything in return.

The most striking feature of Japan is its particular geographic situation in a zone of high tectonic activity. All of its industries are affected by this reality and its consequences for safety norms, education of the population, and living conditions. Another important factor is population density.

When visiting work sites, one is always impressed by the order, cleanliness, esthetics, efficiency and safety, which all bear witness to very good organisation. Safety is considered fundamental and the law harshly with companies who are negligent, sometimes forbidding them from responding to invitations to tender.

According to the engineers I met, the next ten years should be intense with regard to the development of existing units towards improved esthetics and an improved quality of life.

With regard to the road construction sector, it appears that the market organization differs from that of France (many small companies in Japan) but that there is rapid technical development of polymer modified bitumens (market penetration rate of 6%), pervious macadams (typical example of technological development aimed at improving the quality of life) and special surfacings for civil engineering structures. The potential is strong and the rapid growth of companies such as NICHIREKI is a perfect illustration.