NATIONAL BUREAU OF STANDARDS REPORT

10 477

U.S./FRENCH COOPERATIVE PROGRAM ON BUILDING TECHNOLOGY

Second U. S. Team Visit

November 1970

U.S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

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NBS PROJECT 4213114

August 1971

NBS REPORT 10 477

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Second U. S. Team Visit
November 1970

By
D. R. Flynn
W. Werner
D. Rorrer
T. H. Morlan
W. R. Herron

U.S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

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1. INTRODUCTION

1.1 Background

Since this is a report of the second U. S. team visit to France, the reader is referred to the report describing the first U. S. team visit for background information. (The report describing that November 1965 visit is NBS Report 10237, May 1970.)

In January 1970, at the conclusion of the French team's first visit to the United States a plan was developed for the next U. S. team visit to France. The topics to be investigated were:

WIND ON STRUCTURES AND WIND EFFECTS

COMPUTING THE HEATING AND COOLING LOADS

DETERMINATION OF CONVECTION COEFFICIENTS

NOISE TRANSMISSION THROUGH STRUCTURES

SONIC BOOM

URBAN NOISE

AGING OF MATERIALS

SOILS AND FOUNDATIONS

PLUMBING

STRUCTURAL MODELING

PROCESS FOR EVALUATING NEW BUILDING SYSTEMS, COMPONENTS AND MATERIALS

BUILDING ECONOMICS

1.2 Team Members

The NBS/HUD team was made up of the following staff members:

BRD	Position	Professional Discipline
Mr. William R. Herron*	Coordinator International Affairs	General Engineer
Mr. Daniel R. Flynn	Acting Chief Applied Acoustics and Illumination Section	Physicist
Mr. Terry H. Morlan	Economist Building Systems Section	Economist
Mr. Daniel E. Rorrer	Mechanical Engineer Plumbing Systems Building Transport Systems	Engineer

HUD		
Mr. William Werner	Project Manager Testing and Evaluation HUD Operation BREAKTHROUGH	Engineer
Mr. Paul Brace	U. S. Embassy (HUD)	Architect

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* Head, NBS Team on Building Technology

Topics were assigned as follows:

TOPICS	PROFESSIONAL
Wind on Structures and Wind Effects	Herron
Computing Heating and Cooling Loads	Herron
Determination of Convection Coefficients	Herron
Noise Transmission Through Structures	Flynn
Sonic Boom	Flynn
Urban Noise	Flynn
Aging of Materials	Herron
Soils and Foundations	Herron
Plumbing	Rorrer
Structural Modeling	Herron
Process for Evaluating New Building Systems, Components and Materials	Werner
Building Economics	Morlan

1.3 ITINERARY

Sunday, November 8, 1970

Arrival of U. S. Team

The U. S. Team arrived in Paris on Sunday, November 8, 1971. Dr. Blachere, Director, CSTB, and Mr. Noel met the team at the airport and drove them to Hotel Alexander. The remainder of the day was free.

Monday, November 9, 1970 — Activity Group

Morning: Tour of CSTB research facilities at Champs sur Marne: Fire Research Furnace, Plumbing Tower, Environmental Research Lab, Solar Effects on Windows, Weathering of Materials.

CSTB hosts lunch at Champs sur Marne

Afternoon: U. S./French Joint Agenda Meeting

Tuesday, November 10, 1970

Day tour of industrialized construction in Paris Basin, Defense Complex (offices, dwelling, highroads, etc.) Super Argenteuil (new town with dwellings, shopping center, schools) Ermont, Sarcelles and Dame Blanche.

Wednesday, November 11, 1970

French National Holiday -- Nothing Scheduled

Thursday, November 12, 1970

National Day of Mourning -- Burial of General De Gaulle-- Appointments with French Government personnel are cancelled.

Morning: Mr. Flynn met with Dawance at Paris CSTB on acoustics.

Afternoon: Mr. Blachere met with Messrs. Werner and Herron. Mr. Flynn met with Giraud at UTI St. Remy Facilities, and left for Marseille at 10 p.m.

Friday, November 13, 1970

Morning: Mr. Herron visited Messrs. Croiset and Borel at Champs sur Marne to discuss computing heating and cooling loads and determination of convection coefficient.

Mr. Rorrer met with Mr. Huet at St. Remy.

Mr. Flynn traveled to Marseille (arrives 7:45 a.m.), visited Centre Recherches Physiques with M. Foti of the Applied Acoustics Group, departed Nice at 8:15 p.m.

Mr. Werner met with Messrs. Farhi and Chabrel of CSTB at Paris Offices to discuss Agrement.

Mr. Morlan met with Mr. Noel at CSTB, Paris Offices, to discuss building economics.

Afternoon: Mr. Herron discussed future exchanges with M. Blachere at CSTB, Paris Offices.

Saturday and Sunday, November 14 and 15, 1970

Nothing Scheduled

Sunday, November 15, 1970

Mr. Flynn left for Grenoble from Marseille

Mr. Rorrer left for Nancy.

Monday, November 16, 1970

Morning: Mr. Herron met Mr. Dawance (UTI) at St. Remy to discuss soils and foundations and structural modeling.

Mr. Rorrer visited PAB Foundaries and Research Center in Pont-a-Mousson and Liverdun; and met with Messrs. Mambourg, Pejot etc.

Mr. Flynn met with M. Josse, Chief of the Acoustics and Vibration Group at CSTB Grenoble Facilities.

Mr. Werner met with Messrs. Mathez and Lugez at CSTB, Paris Offices.

Mr. Morlan met with Messrs. Hunt and Le Duc at CSTB, Paris Offices.

Afternoon: Mr. Herron met with Yuan Tcheng to discuss soils and foundation at CSTB, Paris Offices.

Tuesday, November 17, 1970

Morning: Mr. Herron met with Mr. Bietry at CSTB, Paris Offices, to discuss wind effects.

Mr. Rorrer met with Messrs. Schaffnit, Garnian, Copin at Reims and Soissons Facilities.

Mr. Flynn met with M. Gilbert at CSTB Champs Facilities to discuss acoustics.

Mr. Werner met with Messrs. Bertheir and Veber at Champs to discuss Agrement.

Afternoon: Mr. Herron met with Mr. Croiset at CSTB Champs Facilities to discuss thermal loads.

Mr. Morlan met with Messrs. Haffner and Aubert to discuss building economics.

Wednesday, November 18, 1970 Group Activity

(all U. S. Taam except Mr. Rorrer)

U. S. team (minus Mr. Rorrer) plus Mr. Paul Brace (HUD advisor to U. S. Embassy in Paris) visited Vaudreuil "new town" site near Rouen. Also visited a plant producing precast panel systems (Desconne-Concorda).

Mr. Rorrer visited CNC laboratories at Champs sur Marne with Mr. Parrier to discuss plumbing.

Thursday, November 19, 1970 Group Activity

Entire team with exception of Mr. Rorrer visited UTI facilities at St. Remy la Chevreuse. Met M. Aubert, General Manager of UTI.

UTI/CEBPT formal luncheon.

Mr. Rorrer visited Multifluid (sanitary filling) installation at Les Mureaux with Mr. La. Masnes and Mr. Filles.

Friday, November 20, 1970 Final Meeting

U. S. team discussed future exchange and conclusion drawn from their visit with French team.

Final Banquet Dinner held on floating restaurant, Ile de France, hosted by CSTB and UTI.

Saturday, November 21, 1970

U. S. Team departs for U. S. A.

2. TEAM MEMBERS' REPORTS

2.1 General

A joint meeting was attended by all NBS team members on the first week-day of the visit. The team was received at the CSTB headquarters conference room by Dr. Gerard Blachere. A number of other representatives from CSTB and the construction industry in France were also present. During the meeting Dr. Blachere discussed the French construction industry and CSTB (its programs and missions).

The CSTB headquarters, which administers all CSTB activities, is located in downtown Paris. The main CSTB laboratories are presently located in the eastern suburbs of Paris at Champs sur Marne. Two other annexes are located at Grenoble and Nantes.

The annex at Nantes will handle wind studies on buildings, lighting, social sciences, and rain penetration. The annex at Grenoble will accommodate laboratory functions on the aging of materials, physics and building acoustics, and acoustics in relationship to sonic booms.

The trip around the laboratories was very fast and the reports on the other topics provide information on the various types of laboratory facilities. The larger facilities that show more interest to NBS programs are fire research, plumbing, and acoustics. Information on CSTB is contained in the NBS Report describing the first U. S. team visit to France. An organization chart is also included in that document. Also contained in NBS Report 10 237 is a general description of French scientific and technical research.

2.2 Organization of Reports

The itinerary for each team member was different, and themes were topic-related. The organization of the remainder of this report is shown below:

SECTION 2.3 - D. R. Flynn discusses: Urban Noise,
Building Acoustics,
Sonic Boom,
General Noise and Vibration Research
Subjective Response

SECTION 2.4 - W. Werner discusses: Process for Evaluating New Building Systems, Components and Materials: The Agrement System and HUD Certification

SECTION 2.5 - D. Rorrer discusses: Plumbing Research Activities, Agreements Reached as a Result of the Visit

SECTION 2.6 - T. H. Morlan discusses: Building Economics

SECTION 2.7 - W. R. Herron discusses: Wind on Structures,
Computing Heating and Cooling Loads and Determination of Convection Coefficients,
Aging of Materials,
Soils and Foundations
Structural Modelling
Document Exchange.

2.3 D. R. Flynn

Urban Noise

Building Acoustics

Sonic Boom

General Noise and Vibration Research

Subjective Response

REPORT ON

U. S./FRENCH COOPERATIVE PROGRAM ON BUILDING TECHNOLOGY

By

D. R. Flynn

Applied Acoustics and Illumination Section

Building Research Division

URBAN NOISE

The majority of the French work on urban noise generation and propagation was concerned with traffic noise. The work at CSTB had been under the direction of Mr. Josse prior to the recent relocation of his group from Champs-sur-Marne to Grenoble. Although the following information was received from Mr. Josse, it should be understood that this work will be continued under Mr. Gilbert at CSTB/Champs-sur-Marne.

The work on urban noise at CSTB started in 1963 under the direction of Mr. Lamure who carried out a study on the statistical distribution of noise near speedways. In later work, CSTB studied the effect of barriers on sound propagation near speedways. Most recently this barrier work resulted in a publication describing a modelling study, in which, using small bells mounted on rails, they did a 1/20 scale study of the effects of different types of barriers on sound propagation from speedways. They now have a project to make real screens on a highway south of Paris and study the effect of these screens on the acoustical environment nearby. (There is a feeling that the screens will improve driver attention).

The CSTB group has now completed a fairly large study on street noise in Paris. Measurements were made two meters outside windows, using a statistical counter with an automatic camera to take a statistical distribution of the A-weighted sound levels every hour. The physical measurements were made at 120 different stations, with 48 hours of data being taken at each station. Traffic counts and weather conditions were also recorded for each station. A social survey of some 500 people is being carried out in conjunction with this study. The results of the research project will be published soon.

Josse's people have also underway a study, somewhat analogous to that mentioned above, on train noise. The measurements have been completed and the data are now being analyzed. Near the Paris-Lyons Line there was a straight stretch of track with three kinds of rail -- short rails, long rails, and what they refer to as "alternate medium rails." If I recall correctly, this means the rails were of medium length, but the joints on the right-hand rail were staggered with respect to the joints on the left-hand rail. They made measurements out to 300 meters away from the tracks, and at heights up to 30 meters. Most of the work was dBA, but some octave band analysis was carried out. They have characterized the noise signature of the trains in terms of a simplified set of parameters which enables them to compute a mean energy level. They used a camera to measure the speed and length of the variety of trains studied. They are putting speed, length, distance, and height all into the computer, to find correlations with the physical measures of sound pressure levels. In the future, they hope to make a social survey to attempt to find correlations with the physical measurements, but at the present time do not have the necessary funds to undertake such a survey.

At the Centre de Recherches Physiques, Mr. Foti described, very briefly, two projects that are related to urban noise. In one, they carried out a model study of the acoustical and optical treatment of tunnels -- apparently tunnels for automobile traffic rather than for trains. As a result of their studies, they used slit resonators with foam in the slits to absorb sound and, in some parts of the tunnel, Helmholz resonators in order to attain even further attenuation. In order to minimize noise in the community near either end of the tunnel, and also to make the transition from the tunnel to the open highway less disturbing to the driver, they used a great deal of acoustical material near the ends of the tunnels, but less in their middle. In a separate study which was not described, they are doing model work in an anechoic chamber on the propagation of sound through an urban environment. From what was said it appeared that they were using model buildings and studying the propagation of ultrasonic waves.

BUILDING ACOUSTICS

Airborne Noise Transmission

CSTB, UTI, and CRP all had facilities for carrying out airborne sound transmission through partitions. However, very little active work appeared to be ongoing in this area. The particular facilities involved are discussed in Appendix B of this report.

The only recent work described at CSTB/Champs-sur-Marne was the work on the transmission loss of doors and windows subjected to free-field sound from the outside. This is similar to the work at UTI -- which is described in more detail below. A few general comments on the CSTB work: They found that the sound transmission loss was essentially independent of the angle of incidence. They found that they obtained good agreement with measurements made in a diffuse sound field. They found that the effects of leakage around doors and windows were very important at all frequencies. In conjunction with this, they also carried out measurements with balconies, with and without absorptive material applied to the balconies.

At UTI, at St.-Remy-les-Chevreuse, measurements have been carried out recently on transmission loss of curtain walls, with and without windows, under free-field conditions. Outside the building is a paved area with marks painted on it. A tower with a number of loudspeakers at different heights and suitable for different frequency ranges is moved to the appropriate locations to generate the necessary sound levels as a function of angle of directionality. The receiving room uses a single microphone located on an apparatus which revolves one revolution every 80 seconds and sweeps through a circle of perhaps one meter diameter on a plane roughly 45° from normal. Because of the small size of the room and the lack of diffusers, there is some question regarding the extent to which a uniform diffuse sound field is obtained.

Although the CRP has good facilities for making airborne sound transmission loss, there was no evidence of current work in this area.

Structure-borne Noise Transmission

Mr. Josse indicated that he hopes to have an international center on structure-borne noise located at Grenoble. They have not yet written their program nor have they any facilities for carrying out this work at the present time. It was indicated that their work would include, not only shunting paths for sound transmission through the structure, but also the effects of plumbing and other building components, and the effects of ground vibration.

At both UTI and CRP, there was some work done on simplified scale models of buildings to study how vibration is transmitted throughout the building structure.

Impact Noise

Although there was some mention of the importance of impact noise, I did not see any active work in this area. Mr. Josse, at CSTB, has published a recent paper describing an apparatus for simulating footfalls.

Plumbing Noise

Work on plumbing noise was going on both at CSTB, at Champs-sur-Marne and at UTI, St.-Remy-les-Chevreuse. At UTI, they have a small complex simulating a typical layout of apartments. They mount particular fixtures including lavoratories, bathtubs, bidets, and toilets, and then make measurements of the sound level in adjacent rooms, mounting fixtures and, plumbing in different ways. In a separate set-up, at UTI, they study the noise produced by taps or faucets. The method is similar to German DIN 52.68 and the French PRS 31.014. They use a passive hydraulic noise generator to calibrate the apparatus. The ISO is working on this test method, but the generator will be slightly different. A very similar set-up was in operation at CSTB/Champs-sur-Marne.

Heating, Ventilation and Air Conditioning Noise

There was very little evidence of work in this area, possibly because of the relative lack of air conditioning and forced air heating systems in France. At UTI, some measurements have been carried out of the sound power output from air conditioning equipment. At CRP, some measurements have been underway on the transmission of sound through ducts.

SONIC BOOM

The only work discussed on the effect of sonic booms on buildings was that under Mr. Josse at CSTB Grenoble. Since French buildings are very different from those in the United States, it was felt that the research carried out in the U. S. would not necessarily be applicable to French construction. In particular, French exterior walls are much heavier than those in the United States and some of the ceiling constructions are much more brittle. A program is underway to calculate the vibration which they expect to be induced in a one-story, three-room house built in the south of France and then to verify this using sonic booms from over-flights by military fighters sometime this March. They have also made models of rooms with windows to study the extent to which the over-pressure is amplified. They propose further to construct a piston apparatus or small sonic boom simulator to test specific components and how they perform after several thousand simulated booms. They wish to send Mr. de Tricaud to the United States for up to six months to study U. S. work on the effects of sonic booms on structures.

GENERAL NOISE AND VIBRATION RESEARCH

A number of the topics discussed during this visit do not conveniently fall under any of the above categories. At UTI, Mr. Giraud was concerned with protection of buildings from vibration due to transportation systems, both traffic and rapid transit. In conjunction with this he has developed an apparatus for measuring the dynamic stiffness and loss factor of vibration isolators at very high static loads. He finds significant differences between measurements of dynamic properties at these high static loads and those at essentially no static load.

At CRP Mr. Bergassoli has been carrying out work, mainly model studies, on the fraction or scattering of sound. They also have done some work on propagation of sounds from fog horns, where they are comparing the results with those obtained using the mathematical analogy to antenna theory.

The people at CRP also were doing some work on absorptive materials. They had an apparatus set up to measure flow resistance that was patterned after Beranek's design. They also had, in Corsain's Sections, a number of impedance tubes. In addition to a 20 cm diameter steel wall impedance tube, they had two 0.5 $meter^2$ by 6 meter long impedance tubes and a single 1.2 $meter^2$ by 6 meter long impedance tube. This large one was used to study the normal absorptance of some of the wedges used in one of their anechoic chambers.

In one laboratory, there was a small elliptical reverberation chamber with a major axis of perhaps 1.5 meters and a minor axis of perhaps 0.6 meters that they had used to check three different mathematical methods of predicting boundary value problems for waves.

An additional research program was underway on the effect of brake noise, where a small tire was mounted on an axle driven on a belt from outside the room, and a platform could be raised against this wheel with a certain force, simulating the wheel/pavement interaction, and the resultant noise from braking studied.

SUBJECTIVE RESPONSE

There appeared to be very little active work ongoing in the area of subjective response to noise. As mentioned above, Mr. Josse's people have carried out a social survey in conjunction with their study of traffic noise in Paris, and hope to carry out a sociological study in conjunction with their work on train noise. There was essentially no mention whatsoever of any basic psychophysical work. A-weighted sound level was used as a predictor of human response but no research appeared to be underway to validate correlations with actual response.

APPENDIX A

Places and Persons Visited

1. Centre Scientifique et Technique du Batiment (CSTB)/ Champs-sur-Marne

In addition to the visit of the entire team on November 19, Mr. Gilbert was visited on November 17 in order to see the acoustics facilities of CSTB and to discuss their research efforts.

2. Centre Scientifique et Technique du Batiment (CSTB)/ Grenoble

On November 16 a visit was made to Mr. Robert Josse, who is in charge of the Acoustics and Vibration Group at CSTB Grenoble, to discuss possible U. S./French cooperation in the areas of (a) urban noise, (b) vibration transmission in structures, and (c) the effects of sonic booms on structures. Other persons on Mr. Josse's staff who participated in the discussions included: Miss Jeanne-Maire Ardillon (vibrations), Mr. Robert Plagnol (acoustics), Mr. Jean-Maire Rapin (urban noise), Mr. Paul de Tricaud (sonic boom), and Mr. Alain Chaumette (sonic boom).

3. Union Technique Interprofessionalle des Federations Nationales du Batiment et des Travaux Publics (UTI)/St.-Remy-les-Chevreuse

On November 12, a visit was made to Mr. G. Duwance at the Paris laboratories of UTI where a brief discussion of acoustical field measurements was held with Mr. B. Marseille. A visit was then made to Mr. J. Giraud at the UTI laboratories at St.-Remy-les-Chevreuse to discuss their work in sound and vibration, including: (a) study and measurement of plumbing noise, (b) free field sound transmission through curtain walls, and (c) vibration isolation of buildings.

4. Centre de Recherches Physiques, Centre National de la Recherche Scientifique/Marseille

On November 13, a visit was made to Mr. Foti, who is in charge of an applied acoustics group (building and urban noise) at the Centre de Recherches Physiques. The tour included discussion of work under the direction of Mr. Bergassoli (correlations between theory and experiment), Mr. Corsain (vibration isolation, transportation noise, model studies, and absorption measurements), and Mr. Bladier (propagation of sound in ducts). Several other persons, working on various acoustics problems were visited in rapid succession.

APPENDIX B

Research Facilities

1. Anechoic Chambers

The only anechoic chambers seen were those at CRP. One anechoic chamber is approximately 125 $meters^3$ (5 x 5 x 5 meters) inside the wedges. The wedges are 0.5 meters thick. This room has about a 150 Hz low frequency cutoff. It was a 50 cm space between its inner and outer walls and provides greater than 80 dB isolation from its surroundings. However, it was not stated at what frequencies this 80 dB isolation was obtained.

A second, larger anechoic chamber, 368 $meters^3$ inside the wedges, was also in use at CRP. The wedges are made from approximately 2" thick fiberglass board in a manner similar to that used at a few places in the United States. The chamber is "good" down to 60 Hz. Several points regarding the construction of this anechoic were of interest. They intentionally did not put in the cable floor; rather they put legs up through some of the floor wedges and then used removable platforms so that they only had a floor where they needed it. This was because of concern with the floor acting as a diffraction grating at certain frequencies.

2. Reverberation Chambers

Reverberation chambers were seen at UTI, CSTB/Champs-sur-Marne, and at CRP.

The chamber at UTI has a volume of approximately 200 meters^3 and uses spherical diffusers, perhaps one meter in diameter, to obtain a diffuse sound field. The doors are rather massive, being made of concrete.

At Champs-sur-Marne there is a large reverberation room with no mixing vanes and provided with a roof opening for ducts. There is also a small reverberation room not currently being used. In addition, one room of the transmission chambers can be used for sound power measurement or absorption measurements if needed.

At CRP, in addition to the rooms constituting one side of the transmission chambers, there is a fairly large reverberation room of 455 meters^3 volume (10.3 x 6.8 x 6.5 meters). The room is rectilinear and has a large number of flat and curved plate diffusers suspended within it.

3. Transmission Chambers

In general, the transmission chambers in France are too small to comply with the requirements of ASTM E90, and furthermore, many of them are not adequately isolated from one another so as to permit meaningful testing of high transmission loss walls.

At CSTB/Champs-sur-Marne, the transmission chambers for wall tests have a 10 meter^2 opening and a rather serious shunting path problem, in that there is no break in the concrete connecting the two rooms. This was pointed out as a defect in their installation. The rooms are somewhat unique in that a specimen can be lowered from above, somewhat like a slice of bread into a toaster, rather than having to be built in place. Mr. Gilbert pointed out that a 20 cm concrete wall was the highest transmission loss that they could handle in this room. They have two facilities for measuring on floor/ceiling assemblies. These are located side by side and constructed so that a completed floor/ceiling assembly can be lowered from above; then, the roof can be replaced on the upper chamber. This enables them to measure a number of floor/ceiling assemblies in a single day. In addition, the group at CSTB/Champs-sur-Marne have a small transmission chamber especially for carrying out measurements of doors.

At UTI/St.-Remy-les-Chevreuse, Mr. Giraud has a pair of small transmission chambers (approximately 50 meters^3 in each room) used specifically for measurements on doors. A certain amount of absorptive material is placed in the receiving room so that it will not be necessary to make the corrections to a 0.5 second reverberation time required in the French standards. The source and receiving room are structurally coupled rather than isolated, such as would typically be done in the United States. In the case of doors, since the transmission loss is typically so low, this is probably not of great significance.

Mr. Giraud's point in justifying the structural coupling was that this is similar to actual field conditions. There are one or two similar sets of small transmission rooms used for diffuse field measurements of transmission loss on curtain walls and on windows.

At CRP the receiving room in the transmission chambers has five non-parallel sides, but the floor and ceiling are parallel. Mr. Foti said that this was patterned after some Japanese work. There are two openings into the receiving room, one small opening approximately 1.5 meters side x 2 meters high connecting to a small source room and used for work on doors and windows. The main opening is 3.85 meters wide x 2.50 meters high and connects to a not-very-large source room, certainly not over 4 meters on any side. The wall in the source room opposite the test panel has a large double hinge swinging concrete door that looked to me to be, perhaps, 20 cm thick, so that the panels can be taken in. Because of the difficulties with installation of panels, Mr. Foti indicated that if he were doing this again, he might want to have what he called a mobile receiving room, so that the source room would be fixed and could have a wall built into it, and then, at a later time, the receiving room could be wheeled up to it. Apparently, he was meaning "mobile" in that he could move the room a meter or two away to let the workmen install the wall, and then it would be moved up -- rather than to have one receiving room that can be coupled to a number of different source rooms. Mr. Foti feels that there is a real need for better specifications on edge conditions as to how specimens are mounted for transmission loss tests.

4. Plumbing Noise Facilities

As mentioned before, UTI/St.-Remy-les-Chevreuse has a small complex simulating apartments in which they have studied noise and have undertaken different types of mountings to see what can be done to limit transmission. There is nothing particular that needs to be said about the details of this facility. The laboratory arrangement for measuring the noise of taps consists of three rooms in a row. The first room is the room in which the taps and apparatus are located. The pipes feed through a wall into a small central room where the pipes are rigidly coupled to the opposite wall. The sound level is actually measured in the third room. The arrangement at CSTB/Champs-sur-Marne is very similar to that at UTI.

2.4 W. Werner

Process for Evaluating New Building Systems, Components and Materials:

The Agrement System and HUD Certification

REPORT ON

U. S./FRENCH COOPERATIVE PROGRAM ON BUILDING TECHNOLOGY

By

W. Werner

Project Manager for Testing and Evaluation

Department of Housing and Urban Development

Operation BREAKTHROUGH

THE AGREMENT SYSTEM AND HUD CERTIFICATION

The first U. S. Team visit to France in November 1969, as reported in NBS Report 10 237; contained an extensive discussion of the operation procedures of the Agrement System as well as detailed information concerning the organizational structure of the Centre Scientifique et Technique de Batiment (CSTB). It was not considered necessary to reiterate the information which is contained in the aforementioned document, rather, the Agrement System and the relationship of CSTB thereto, will be examined in light of the proposed HUD Certification being developed under Operation BREAKTHROUGH and the interrelationships of the Department of Housing and Urban Development (HUD), the National Bureau of Standards (NBS) and the National Academies of Science and Engineering Advisory Committee (ACHUD).

In examining the reasons for the establishment of a system of technical certification in the building industry, the social, economic and political atmosphere prevalent at the time is of utmost importance. These factors determine the structure as well as the depth to which a certification system must go in order to be successfully responsive to the needs of the country.

At the end of the Second World War, France was a ravaged country in need of massive re-building which, if to be timely and successful, would have to employ not only traditional methods of construction but also new industrialized techniques. Complicating this was the fact that the French building industry functions under a ten year contractor's liability law which tended to make the major contractor's liability insurance underwriters cautious as to their degree of financial risk for other than proven traditional materials and methods of construction. Coupled with this obvious need for new construction and the legitimate concerns of the insurance underwriters was the fact that the French Government was the source of a great deal of the funding required for the rebuilding program and, as such, also had legitimate duties, responsibilities and the ability to direct action merely by the withholding of funds from recalcitrant programs. With this very effective lever and the determination to employ it as necessary, it was obvious that the French Government could take the lead in establishing a system responsive to the needs of rebuilding, the concerns of the insurance underwriters and yet would have a high degree of acceptance and success. With almost all the housing being constructed at that time "social housing", which would be akin to "public housing" in the United States, financed by the French Government; the market potential was tremendous and would of itself contribute to the success of any form of rational technical certification or evaluation procedure. It was within this climate that the Agrement System was founded in 1945.

The system that evolved created technically competent Boards of review and evaluate construction materials and methods from the viewpoint of the French legal requirements contained in the ten year contractor's liability statutes. These Boards which were composed of practicing architects, engineers, manufacturers, fabricators, contractors and insurance specialist were staffed on the basis of the expertise of the individual members in the particular technical matter under consideration. Through the years, some Twenty Agrement Boards have been created, the commonality being that provided by CSTB which functions as Board Secretary; preparing the technical documentation and review, presenting the matter to the assembled Board and preparing, executing and distributing the Agrement Certification. As a result of the technical and secretarial efforts of CSTB, it is possible for several Agrement proposals to be judged within one afternoon session which is generally convened on a monthly basis. These Board meetings are open to the public and any interested party may speak for, or against, the proposal under consideration. Only the proponent himself is excluded from the proceedings.

Most important, the findings which result from this process are not constructed in any way as an approval or guarantee of the product or system by the Agrement Board, the CSTB or the French Government. It was pointed out that CSTB in no way accepts any civil responsibility in regard to the law--this responsibility still rests with the contractor--but does accept a "moral" responsibility functioning in its professional capacity. What does eminate then is an "agreement", hence the name Agrement, between the design professionals, industry, insurance interests and the Government that a particular product or system is durable in relation to the liability statutes and conforms to the safety rules of the French Building Code. The Certificate itself defines the product, system or process, identifies the proposer and recommends limitations on usage. Although private industry is still responsible under the law, the main advantage of this process is that the insurance underwriters receive the benefit of top level technical product assessment and consequently reduce their degree of risk in underwriting non-traditional, or limited history, techniques. This procedure enabled re-building to proceed at a vigorous pace inasmuch as: it did not restrain the design freedom of the professionals since the Agrement Certificate merely recommended limits of product usage within which the architect was completely free, it established a technical assessment relating to durability and safety which minimized insurance risks while at the same time affording the Government the protection for its massive financial interest while being responsive to the desire for accelerating the building process.

Of benefit to the speed with which Agrement Certificates could be granted is the fact that the building industry in France is composed of a relatively small number of large building contractors which function from design inception through to building occupancy. As a result, Certificates over a period of time are increasingly granted to the same firms, although for different products or processes, and a relationship of mutual respect and understanding is consequently established between CSTB and these firms. Therefore, products or processes submitted for Agrement Certification are generally technically competent and may even have been used by the contractor, (albeit at a higher insurance rate), on previous work, in order to display their qualities to CSTB and the Agrement Board. In this same vein, construction insurance liability policies are written by a small number of large insurance companies who likewise have developed a relationship of mutual trust and understanding with CSTB, such that CSTB technical findings and recommendations are generally accepted. Consequently, since Government, industry and the insurance companies are all striving for the same goals, their interests are complimentary and the French Agrement System has, heretofore, functioned in a very efficient manner.

However, as times have changed, over the past twenty-five years, the pace of rebuilding has slowed, a backlog of technically competent products has been established and the economic climate of France has improved so that a move is currently underway which would substantially affect the Agrement System as presently structured in France. It is as though the Agrement System had outlived its usefulness by establishing the credibility of the building contractors with the insurance industry such that the concern of the French building industry is no longer with acceptance of its products but rather with the intervention and role in the building industry of the French Government under the Agrement System. As a result, the General Contractors Association in France, similar to our Association of General Contractors (AGC), has succeeded in instituting organizational and philosophical changes in the Agrement System, as currently structured, which will become effective early in 1971. These changes essentially reduce the influence of CSTB in the Agrement process while at the same time broadening design and construction freedom by the nature of the revised Agrement Certification.

Under the proposed procedure, the Agrement Certificate will become a "technical advice" having less of the "certificate" connotation prevalent under the present procedure. New products or processes will be evaluated for conformance with the safety provisions of the French Building Code, and the performance of the products in the areas of fire, acoustics and thermics will be evaluated. Any product or process deemed "safe" will be passed, regardless of its performance in these other areas. It will be the responsibility of the architect or contractor that--knowing what the performance levels of the product are--he will use his judgment to determine whether the product meets the particular project performance criteria. All products will, of course, within the limits of their performance characteristics be suitable under the ten year liability statute, however, the assessment of limitations of usage will rest with industry, as opposed to being delineated by CSTB. Based on this, there is a very strong possibility that the name of the procedure may be changed from "Agrement System" to "Technical Advice System" to further indicate the reduction of governmental direction and influence.

As presently structured, the Chairman of the Agrement Board is the Director, CSTB. In addition, all testing, if it is to be credible to the Board, must be performed by CSTB at their facilities. Under the forthcoming revision, the Chairman of the Board will no longer be the Director, CSTB; but will be appointed by the Ministry of Construction and Equipment. Furthermore, test data presented to the Board may be performed at other facilities approved by CSTB. This one action has done much to increase the stature of the test and research facilities of the Contractor's Association (UTI) which equal or exceed the capabilities of CSTB. The net effect of these procedural and organizational changes is to greatly reduce the impact of CSTB on the proceedings and to give greater latitude and freedom to the private sector in determining product usage. This is felt to be possible only because of the strong test and research facilities available to the French Contractor's Association through the capabilities and facilities of the UTI of which the National Bureau of Standards would be closest counterpart in this country. These proposed changes are quite understandable when one views and studies the private sector "Centre Experimental de Recherches et D'Etudes de Batiment et des Travaux Publics" (CEBTP) which in the "Union Technique Interprofessionnelle des Federations Nationales de Batiment et des Travaux Publics" (UTI) is the technical counterpart to the quasi-public CSTB. An organization with this technical and financial strength could not long be excluded from the Agrement proceedings.

As noted above, the social, economic and political climate in France gave rise to a certification system unique to that country and its statutory ten year contractors' liability. Moreover, the strong impact of the government, state or local, in France to protect the health and safety of the public was not as pronounced as it is in this country. When visiting construction sites in France, one is immediately aware of the absence of the "local building official" or "inspector," as we know them, since total and complete responsibility, financial and one would presume criminal, rests with the Contractor. The citizenry then seek, not the government for redress, but rather the insurance companies. If an "inspector" were to be found on a construction project, he would likely be from the "Bureau de Controle" of the insurance industry, seeking conformance in order to reduce underwriting risk.

Since the basic premise of unilateral contractor's liability for extended periods of time is non-existent in the

United States, while the influence of state and local governments in the protection of public health and safety is so pronounced, it is not felt that the Agrement System, or more uniquely the results of the Agrement Board deliberations may be adapted directly to the needs of HUD and Operation BREAKTHROUGH. The needs, relationships and peculiarities existant in France do not exist in the United States such that, with the exception of organizational relationships which have developed within the Operation BREAKTHROUGH program closely paralleling those in France, the HUD Certification must address itself to an entirely different set of circumstances to which the French Agrement System would not be totally responsive. These will be discussed first on the basis of organizational relationships and then on the basis of type and format of building system certification.

Although not specifically modeled on the French Agrement System, organizational relationships have developed within Operation BREAKTHROUGH which closely parallel those of the Agrement System. HUD by means of an Interagency Agreement with the National Bureau of Standards has secured the technical assistance of an organization which will function much the same as the CSTB. NBS is currently evaluating, in depth, the housing systems being developed for volume production under the Operation BREAKTHROUGH program--performing physical testing as required on housing systems and preparing a formal report and recommendation for presentation to the National

Academies of Science and Engineering for validation. Whereas the Agrement Service is an on-going organizational entity within CSTB, NBS drew from its existing in-house capabilities to bring together a multi-disciplinary BREAKTHROUGH Evaluation Team responsive to the immediate needs of HUD.

In addition, a unique similarity exists between the Agrement Board and the Advisory Committee to HUD of the National Academies of Science and Engineering (ACHUD). The Technical Panel of ACHUD is composed of members selected, much the same as the Agrement Board, for their expertise in engineering and construction. Due to the fact that Agrement Certificates may be granted for building components--i.e., windows, partitions, cladding, etc.--Agrement Boards tend to be very product or process specific. On the other hand, since HUD is evaluating a complete housing system, the ACHUD Technical Panel is multi-disciplinary, containing many sub-panels with expertise in a particular engineering discipline. ACHUD on a much broader scale, than the Agrement Boards, will deliberate upon the analyses, tests and recommendations developed by NBS, validating and recommending to HUD that it certify the housing system.

This latter flow of responsibility marks the most pronounced deviation between the Agrement process and that of HUD. As was pointed out earlier, the Agrement Board grants the Certificate which is issued and maintained by CSTB, whereas, under the HUD process the Certificate is granted by

HUD, based upon the favorable recommendation of ACHUD which acted upon data developed by NBS. The reasons for this relationship will become clear when the implications of the HUD Certification vis a vis the Agrement Certification are discussed.

While the exact format of the HUD Certification Report has not been finalized, preliminary discussions between HUD and NBS indicate that a degree of similarity will exist between the HUD and Agrement format. Presently, Agrement reports are composed of four parts:

1. A description of the item being certified which usually takes the form of the manufacturer's or proposer's written description.
2. An Appendix containing the results of tests and analyses carried out by CSTB.
3. The Report of the Agrement Commission resulting from the deliberations of the Board, which is signed by the General Reported who is on the Agrement Service Staff of CSTB.
4. The final decision of the Board either granting or rejecting the Agrement Certificate which is signed by the Director, CSTB.

The format of Agrement under the proposed revisions as herein before discussed would undoubtedly follow the same rational approach with the exception that tests and analyses would no longer be exclusively by CSTB and the final Agrement Certificate would be executed by the Chairman of the Agrement Commission appointed by the Ministry of Construction and Equipment, instead of the Director, CSTB. As can be seen the technical content and format of the Agrement Report is quite logical and, certainly, similarities would exist to that being developed by NBS and HUD. However, what is of utmost importance is not the similarity between presentation and format but rather the depth and implications of the data and recommendations contained therein.

It was pointed out earlier that, even though termed a "Certificate," what was developed by the Agrement System was actually a "technical advice" with no civil responsibilities attached thereto. This fact will become all the more obvious if and when the name is in fact changed from "Agrement" to "Technical Advice." In the United States, however, the primary concern is not one of insurance liability but rather one of governmental acceptance within the framework of a building code structure enforced to insure the public health and safety relying heavily on historical success as a major performance criteria. To deal with this situation, while at the same time encouraging innovative materials and techniques in order to fill the current housing shortage, the proposed HUD Certification must stand for more than the Agrement Certificate or the present FHA Engineering Bulletin which are acceptances predicated on financial considerations. For this reason Operation BREAKTHROUGH has chosen to "certify" a total housing system as safe, sanitary and durable thereby meeting the intent of local building codes in these areas. This intent, however, is met, not with prescriptive requirements, but with compliance to approved performance levels within which the designer is given complete freedom as to choice of materials or processes. This procedure enables the public health and safety to be assured while at the same time does not constrain industry to the use of particular materials or techniques to meet these performance criteria. Granting this certificate to a housing system would then permit HUD to "certify" to a local building official that the system, although not in strict literal conformance with the local code, was in fact equivalent to or better than construction carried out under the technical regulations contained in the local code.

This responsibility and endorsement is a quantum jump over the technical assessment carried out under the French Agrement System. Indeed, the French were amazed at HUD's venturing into this area but came to realize that the unique situation in the United States requires a certification of this magnitude. It was for this reason that the comment was made earlier that the Agrement Certificate as granted in France would not be responsive to the needs of the United States in fostering industrialized housing techniques, since a technical advice or assessment predicated only upon financial considerations would not be sufficient justification to permit a local building official to waive his building code requirements which are predicated on protection of the public health and safety rather than economic considerations.

There is much that can be learned from the French regarding the mechanics of testing and system evaluation, regardless of the extent of responsibility accepted by the certification agency. Although the present direction in France is away from strong national government influence in the building industry, the HUD certification process will be closely watched and studied by the French, not only for the mechanics of our evaluation, but also for how responsive we are to our particular situation.

2.5 D. Rorrer

Plumbing Research Activities

Agreements Reached as a Result

Of the Visit

REPORT ON

U. S./FRENCH COOPERATIVE PROGRAM ON BUILDING TECHNOLOGY

By

D. Rorrer

Building Transport Systems Section

Building Research Division

PLUMBING RESEARCH ACTIVITIES

French CSTB

PLASTICS:

The CSTB vertical plumbing research facility has a plastic pipe research laboratory located in the basement. This is where research is being conducted in the areas of sag, expansion, and utility, when the pipes are used with water at elevated temperatures. In addition, tests are being conducted to determine the minimum strength allowable and the minimum diameters which may be used. As yet, the French government has not approved plastic pipes for use.

TAPS:

Research is being conducted on the so-called newer types of taps (i.e. single handled assemblies). In addition, chemical effects on various tap materials are being studied.

INSTRUMENTATION:

The CSTB is also studying various instrumentation techniques to be used in plumbing research. Particularly important is the necessity for finding a better method for measuring trap-seal depth. Methods are also being studied whereby the large amounts of data obtained by plumbing

experiments can be more easily reduced.

French Contractors (UTI)

INSTALLATION TECHNIQUES:

Since the prime concern of the French contractors society (UTI) is in aiding their members in the more economical completion of their projects, their prime research is being conducted in the installation techniques area. Of concern here are such things as single-stack plumbing installations and reduced vent sizes.

INSTRUMENTATION:

The UTI is endeavoring to perfect a new system for measuring trap-seal depth. This system, when finalized, will be completely linear and operate in all media.

PLASTICS:

Since plastics, when used in plumbing systems, are considerably cheaper than conventional materials, there is a great amount of emphasis and pressure being placed on the ultimate goal of having them approved for unconditional use in this type system.

Agreements Reached as a Result of Visit

FUTURE COORDINATION:

It was agreed by CSTB that they would send to NBS a precise description of the instrumentation devices used in both CSTB and UTI plumbing towers. It was also agreed that the NBS would send similar descriptions to the CSTB plumbing people of any new devices which we might begin using.

FUTURE VISITS:

The plumbing project will remain in the program for technical cooperation and will be a matter to be taken up in the future as detailed programs arise. It was agreed that a U. S. team will visit France in October of 1971; however, there was no mention or consideration given to a plumbing representative.

It was agreed that close cooperation between the two countries in the plumbing area will be maintained. In the event of a major breakthrough by either country the counterpart representative of the other country will be informed.

Discussions and Conclusions

In my opinion, the trip was worthwhile, not only from the standpoint of the personal knowledge gained, but also because of the good will and future work relationships which were established between representatives of both France and the United States. Future visits by either country should prove profitable. In addition, it is felt that coordination, particularly in the plumbing area, will be extremely good.

APPENDIX A

Places and Persons Visited

Research Facilities

CSTB Champs-sur-Marne

I spent two entire days at this facility. The first day was basically concerned with a quick but very comprehensive tour which was conducted by Monsieur Hieroltz of CSTB (Centre Scientifique et Technique du Batiment). All members of the U. S. team were together on this day. The following test operations were included.

PLUMBING:

The primary CSTB plumbing research is conducted in a high-rise 8-floor vertical test laboratory. Each floor is approximately 8 meters by 8 meters and contains instrumentated water supply lines, drainage systems, and mixtures of the more common bathroom and kitchen fixtures (sinks, laboratories, water closets, bathtubs, and bidets). The ground floor contains offices, a technician's workroom, and a central instrumentation data acquistion and test sequence control room. In this control room exists the capability of either manually or (through a manually programmable sequencer) automatically controlling the actual plumbing tests which are taking place on the upper floors of the facility. In addition, the control room contains a visual display whereby colored lights indicate the status of each fixture (filling, full, emptying, or empty). Data is accumulated by standard methods and recorded on strip charts. In my opinion, the system lacks flexibility due to the fact that the programmable sequencer would take a considerable amount of time to change when deviations were made in test parameters.

Most of the drainage systems are composed of plastic pipe. The basement floor contains (in addition to the support pumps, tanks, etc. for the facility) a plastic pipe test laboratory. Tests in this basement lab appeared to be limited to those tests not requiring the use of chemistry.

At the present time the operation of the facility (as well as the operation of all plumbing test facilities at Champs) is the responsibility of Monsieur Perrier, who reports directly to Monsieur Chargrasse (Chief of the CSTB overall plumbing operation).

WATER FIXTURE TAPS:

This facility consists of three large rooms (office area, workshop, and test room) dedicated to the testing of different manufacturers' water faucets and taps. Tests on life expectancy, reliability, wear, and utility are conducted automatically by means of a servo-motor-clutch arrangement, whereby each tap is opened and shut under water pressure a specified number of times per unit time. Manual inspection of all taps under test are conducted periodically.

At the present time the operation of this facility is under Monsieur Schaffnit who reports directly to Monsieur Perrier.

MATERIAL AGING:

The second day which was spent at this facility was the most productive of the entire trip. This entire day was spent with Monsieur Perrier (Chief of the CSTB Champs plumbing operation) in a discussion of test programs, techniques, common problems, and solutions. A large part of this day was spent going over test methods for plastic pipes (PVC, PVCC, and Polyethelene), as well as instrumentation techniques for plumbing systems in general. Also in attendance this day were Monsieurs le Masne and Mambourg, engineers who work under Monsieur Perrier.

<u>UTI St.-Remy-les-Chevreuse</u>

One day was spent at the research facility of the UTI (Union Technique Interprofessionelle - a society or union of French contractors) located at St.-Remy-les-Chevreuse, France. This day was spent in the company of Monsieur le Masne of CSTB (Secretary of UTI Plumbing Operations), with

Monsieur Heut acting as guide and interpreter.

This facility has a large plumbing tower which is seventeen stories above ground, two stories below ground, and uses the roof as an additional test floor giving it a total of 20 floors. In addition, the tower has an attached room on the ground floor that contains a large general purpose laboratory which is used for prototyping instrumentation set-ups. The plumbing tower uses a water softener (and a water purifier which adds some chlorine), both of which are located in the basement. It has a constant head tank of approximately 3 cubic meters. One notable aspect of this tall tower was the presence of many flies above the sixth floor. I was told that this was a common problem in most buildings of this type.

The instrumentation techniques used in this tower were common ones using strip chart recorders for final recording of the data. One interesting piece of information, however, is the method by which the trap depths are measured. Two platinum wires are suspended approximately one centimeter apart. These wires have a 50 cycle, 6-1/2 volt source placed across them. The output is then rectified and, supposedly, a linear relationship with trap depth is obtained. This system is still in the experimental stages and I have been assured we will be furnished a paper on it when it is completely proven out.

At the present time, the plumbing test facility day-to-day operation is being conducted by Monsieur Pichon.

In addition to the plumbing test facility, I was also given a very quick rundown of the acoustics and soil bearing test capabilities within the same complex.

Pont-a-Mousson test facility:

About two hours were spent by Monsieur Mambourg and me at the Pont-a-Moussen Science Research Center. This is a center conducting research for (and belonging to) the Pont-a-Mousson Foundry Group. Here, Monsieur Rivory (Chief, Public Relations) gave us a tour consisting of a brief walk-through of the entire facility. The main emphasis seemed to be in the area of foundry techniques, metallurgy, and plastics. There was very little research being done in areas concerning plumbing. The facility itself was a very modern up-to-date laboratory. It was situated just outside Nancy, France, in a relatively new building.

Industrial Facilities

Pont-a-Mousson Foundry:

I was given a complete tour of the Pont-a-Mousson Cast Iron Plumbing Foundry located on the outskirts of Nancy, France. Monsieur Pierre Jullien of the Pont-a-Mousson group was the guide leader. The foundry was complete in all respects. The beginning point of the tour was where the raw iron ore (consisting of 50% French ore and 50% Brazilian ore) enters the building. The ending point of the tour was where the finished cast iron pipes come out ready for shipment. The technical part of the tour was conducted by Monsieur Bourgoin who was the technical engineer in charge of centrifugation. This as a modern foundry with very good quality control (the final failure rates on their cast iron pipes were in the neighborhood of 5%). Of course, all of the pipes were manufactured by completely automatic centrifugation equipment.

At this foundary I was also introduced to Monsieur Garveaux (Director). Monsieur Garveaux welcomed me to his facility and expressed a desire for continued close scientific coordination between France and the United States.

Liverdun Foundry:

The Liverdun Foundry is a part of the Pont-a-Mousson Group. Here I was given a complete tour by Monsieur Robert Henry (Director, del USINE DE LIVERDUN). This foundry is dedicated to the purpose of manufacturing cast iron fittings (by the mold method) for use in France and other countries. I saw many packages of fittings packaged and marked shipment to the U.S. This was not a modern facility, however, the workers were very dedicated and produced a good looking product.

Reims-Jacob Delafon Tap Foundry:

Monsieur Schaffnit of CSTB and I spent about one half day at the Rems Tap Foundry of the Jacob Delafon Company. This foundry is responsible for making faucet taps to be used on the Jacob Delafon line of plumbing fixtures. The tour through the foundry was conducted by Monsieur J. Delafonde who was the manufacturing engineer in charge of the operation. This was a very modern facility using automatic machinery to produce most of the parts making up the taps. Also incorporated in the taps were plastic handles which were being chrome plated.

After the tour I was conducted to the office of Monsieur Regis Garnier who was the Chief and Director of the facility. Monsieur Garnier spent a considerable amount of time discussing his trips to the United States and his interests (in particular) concerning Delta Faucets in Greensburg, Indiana, a material called Zamack, and the effects of chlorine on taps in the United States.

Soissons Jacob Delafon Bathtub Foundry:

I was given a tour of the bathtub foundry of the Jacob Delafon Company located in Soissons, France, by Monsieur

Copin who was the engineer in charge of the facility. This foundry was dedicated to making only cast bathtubs. It was not an extremely modern facility but it was efficient. In addition to the responsibility of actually casting the tubs, this foundry was also responsible for applying the finish to them. This finish was of an enamel base and consisted of three coats; each coat being baked in large ovens. The application of the finish was completely a hand operation.

Les Mureaux Multifluid Prefabricated Plumbing Factory:

About one half day was spent in Les Mureaux, France, at the Prefabricated Plumbing Factory of the SNCI Multifluid Company. This is a factory dedicated to the manufacture of prefabricated walls containing all plumbing necessary for kitchens, baths, water closets, and heating systems. This also was not a very modern factory but was efficient in that they were set up somewhat on an assembly line basis.

The tour was conducted by Monsieur LeGeard (Assistant Manager) who also spent a considerable amount of time discussing the technical aspects of his factory with me. He was very interested in the approval of the use of plastic pipes (PVC, PVCC, and Polyethelene) as his factory was very heavy in their use.

2.6 T. H. Morlan

Building Economics

REPORT ON

U. S./FRENCH COOPERATIVE PROGRAM ON BUILDING TECHNOLOGY

By

T. H. Morlan

Building Systems Section

Building Research Division

BUILDING ECONOMICS

Introduction

As stated in the Program Plan for U. S./French Cooperative Program in Building Technology, dated January 30, 1970, the purpose of an exchange in the area of building economics was to "...consider the desirability of sending a U. S. intern to CSTB for 2 months. The intern would spend his time adapting the CSTB method of economic appraisal of social housing to U. S. usage." The intent of the statement was primarily directed to the ARC method which is a cost analysis/cost estimating method only. The primary emphasis of this report is therefore on the ARC method, although it is recognized that economic appraisal by definition involves the simultaneous evaluation of cost and quality or performance.

In addition to the major findings to be reported here I participated in several of the group tours. Considerable insight was gained into the problems and corresponding research for French building from tours of the CSTB laboratories at Champs-sur-Marne (Monday 11/9) and the UTI laboratories at rue Brancion and St. Remy (Thursday 11/19). On Tuesday, November 10, we saw several housing systems under construction in the new towns of Super Argenteuil, Sarcelles, and Dome Blanche. Later (Wednesday 11/18) the picture of modern French building techniques was enhanced by a visit to the Cotraba prefabrication plant in Nantes. While these tours provided general information which was useful in evaluating the building economics of the CSTB, I will not repeat the reports of some other team members by going into detail.

CSTB Programs in Building Economics

The ARC Method

Some general description of the ARC method was included in the report of the first U. S. team visit to France. [See report on topic No. 1 and Appendix D.] In order to give a more specific report on the ARC method, the present paper will expand on its theoretical structure, and then discuss more briefly its various applications. The basic theory is arithmetic in nature and is primarily concerned with the estimation of quantities. That is, if the total price of a building, P_{T_1} is represented by equation (1) where p_i is the price of a unit element i and q_i is the quantity, the ARC method is primarily a means of calculating q_i's.

$$(1) \quad P_T = \sum_{i=1}^{n} (p_i q_i)$$

The acronym, ARC, is derived from the French equivalent of "Rational Cost Analysis" or, alternatively, "Rapid Cost Analysis." Its rationality is derived from the rigorous framework provided by the arithmetic theory. In addition, it is rational because the basic unit of the theory is a box, rather than some combination of trades and materials. For example, in housing, which is the present area of application, the basic unit is the dwelling "cell" (apartment) which is made up of boxes (rooms). The rationality in this approach is, of course, that the cost estimates and analyses are easily related to the primary use of the building being developed and could, of course, be computerized in the future.

One of the most interesting applications of ARC is in building cost analysis. Its ability to predict costs rapidly on the basis of relatively few parameters makes design analysis much easier and more systematic. A description of the application of the computerized method to "building cost optimization" is included as Appendix A of this report. A list of the building parameters is also included in that appendix. As the ARC format is used to estimate buildings, it makes possible the recording of cost data for improving its own accuracy.

With regard to speed, the rule of thumb quoted by CSTB is that the traditional estimate took about 3 days, the rapid method takes about 3 hours, and the computer takes about 3 minutes. This is not to be taken quite literally, of course, since much of the data input preparation requires time which is not included in the latter two estimates. Nevertheless, impressive time savings are encountered.

The various applications of the ARC method are characterized by a fairly large set of graphs and tables which are designed to replace the arithmetic calculation of various quantities. While these are very quick to use, they also hide many assumptions which must go into their construction. For some calculations, which are purely arithmetic, no problem is really created by this. However, in early-stage estimates where a price is supplied by method, this can cause serious errors unless the price is quite accurate. For public housing in France, which is about two thirds of all housing construction, this is not such a great problem because nearly all construction of that type is load bearing, cast-in-place or pre-cast concrete. This homogeneity of materials and methods facilitates using, for example, a common price per square meter of verticle surface of a certain type. In the United States, with such a diversity of materials and techniques it may be that prices, rather than quantities, are the most volatile elements.

In the latter stages of estimation, such as at time of bidding, the ARC method utilizes the price inputs of contractors. The accuracy of the quantities estimate pays off here since the prices are real. The ARC method primarily calculates areas, the contractors must still determine the types of materials involved in each area and the amount. The attractiveness of such a bidding system in the U. S. would be the ability to generate data which could be used to improve the estimating capacity of the industry at early stages in the building process. Any good-quality, uniform format would accomplish this aspect of the system. The problem remains one of gaining industry acceptance on a scale sufficient to generate a useful body of data. This country lacks the direct control over a large volume of housing construction, that the French have.

In summary, it appears that the ARC system as a whole fails to meet two of the most volatile elements for cost analysis and estimating in this country. It lacks the flexibility to be applied efficiently where a large variety of materials and techniques are used in building construction unless it is applied on a very broad scale; such application appears unlikely given present industry structure in the U. S. The other element which has been extremely volatile in this country is price. The ARC method is not a method of prices, therefore it would need to be complemented by a means of estimating prices more accurately. We are also weak in this difficult area. For these reasons I do not recommend sending an intern to CSTB at this time.

Making the ARC method known within the U. S. may result in the generation of industry interest. Some firms which have a large volume of repetitive type building may find a use for a method such as ARC. For this reason the above detail of the appendix are included in this report.

Other Problems in Economics

"Consistency" Method for the Evaluation of Quality for Price

The consistancy method has been in use since 1960 and is required for the approval of all social housing schemes. The method received considerable space in the report of the first U. S. team visit [See Appendix C]. In practice, the method serves as one means of enforcing social housing regulations. There are 2,207 items which must be compiled with. The method compares prices and quality of materials in a candidate building design with prices and quality in a reference dwelling built only slightly above the required standards. The format for the comparison has been streamlined so that 600-700 apartments per day can be evaluated by CSTB. The items covered by the method include only those items which can be touched or manipulated by the occupants of the housing, for example finishes and fittings. These account for only 55% of the total building price. The remainder is evaluated separately under the headings of thermal and acoustical performance. The approach is not a life-cycle approach.

Other Programs

I discussed only very briefly some of the work CSTB is doing in the economics section. A study for developing a uniform specification format is in the early stages of research. As nearly as I could tell, without a translator, this is not being directly related to the ARC format, nor is it in any sense a performance type of document. In addition to the basic methods which have been briefly described there are several special applications of the techniques which are being used at CSTB.

Visit to the Union Technique Interprofessionelle (UTI)

On the afternoon of Tuesday, November 17, I visited M. Aubert and M. Haffner of the UTI. The purpose of the visit was to determine what programs they have in the area of building economy. As it turned out, they have no programs comparable in use to those of CSTB. That is, they do not concern themselves with the study of micro-building costs. However, they are quite active in the broader areas of building economics, primarily in data gathering and publication. In this role they are more akin to our Construction Statistics Division of the Bureau of the Census or to the Business and Defense Services Administration of the Department of Commerce, except that they are not a government agency. They publish various price indexes and reports of construction activity.

APPENDIX A

The Optimisation of Building Costs: Economic Indicators Given by the ARC Method

Translated for the U. S./French
Exchange by Centre Scientifique
et Technique du Batiment

Among the many criteria which the designer and the builder are concerned to satisfy, that of economic performance has a special place.

This is because it is related to all the other considerations and the degree of satisfaction given to any of them are bound to have an effect on the final cost of the construction. The designer is anxious to determine what that effect will be at the earliest possible moment, since it is a fundamental factor of decision.

In current practice, and with the exception of rapid and very approximate methods such as those based on a cost per square metre, most designers make their cost estimates from bills of quantities. By its very nature, this method can be applied only at a very advanced stage in the design process, i.e. when a large number of decisions have already been taken by the designer. If the ceiling cost imposed by the promotor is found to be significantly exceeded, the whole design has to be completely overhauled - involving considerable time-wasting - or, and this is the usual custom, economic estimates are made solely on those features which do not entail altering the basic design (such as facings), which is clearly not a very rational solution.

The ARC method is an answer to the need for a virtually permanent control of the final cost at all stages in the design process. Owing to its synthetic approach to the problem, it can be operated with much fewer data than are required for conventional estimating methods, while at the same time leading to the same degree of accuracy in assessing the final cost. Furthermore, improvements to the method have recently been introduced with a view to enabling it to be applied even more rapidly. At present, there are three separate methods (basic, standard and rapid) which differ as to the amount of the data input required and as to their stage of application (sketch-plans, pilot drawings, contract drawings). A fourth method is currently being developed (ultra-rapid method) which is specifically adapted to the sketch-plan stage and which will also provide the designer with indicators pointing to any anomalies, such as any headings which appear to be over-expensive as compared with normal practice.

All these methods, which can be applied much more rapidly than conventional estimating methods, are no less accurate than the latter: the "basic" and "standard" versions of the ARC method give the same degree of accuracy as traditional bills of quantities. The shorter versions, applied at the sketch-plan or pilot-drawings stages, remain accurate to a margin of less than 3 per cent.

The manual application of these versions of the ARC method has been described in several issues of the CSTB Bulletin.

Manual applications of the method already mark a great advance over conventional estimating techniques, and it is clear that processing by computer can enhance its value still further.

American specialists investigating the ways in which computers can be made to contribute to the architectural design stage of construction work consider, moreover, that cost control is a priority consideration.

Status of Programme Research

The basic programme has now been revised and perfected, and is henceforth available for calculating the cost of a building.

Possible Applications of the Existing Programme

The programme can be applied in several ways according to the degree of precision required and to the input data available.

As concerns the general components of a building and those of the individual dwelling units, the user can choose between the following lines of approach:

- Introduction of a standard all-in cost (supplied with the method) per type of dwelling, with any adjustment factors as appropriate;
- Direct introduction of unit costs (supplied with the method) grouped into three categories of buildings: economy, subsidised, high-class;
- Introduction of a special scale of unit costs presented by the user.

Input Data

These are supplied by the user on a series of cards. They include:

- Data supplied by the user: these have been reduced and simplified to the best possible extent;
- Fixed data: these are supplied with the method and are pre-printed on the cards;
- Cost data: the three series of costs and the all-in cost are also pre-printed. A space is left to enable the user to fix some costs himself if this is desired;
- Computed data: these are mainly transcriptions or transfers of data and are made by the computer operator.

So as to establish a clear distinction between the data supplied by the user and the other data, the latter are pre-printed in shaded form.

The data take the form of a maximum of 70 punch cards in the case where the greatest degree of accuracy is required and when the building comprises 15 different types of dwelling units. The data supplied by the user himself concern only 60 cards, some of which, moreover, need only a small number of additional insertions, since the remainder are supplied together with the method. Subsequently, it is intended to make a different arrangement of the data so as to reduce the number of cards containing data supplied by the user.

In an average case, using the existing programme, the number of cards for punching is reduced from 70 to 40, of which about 30 are partly or wholly filled in by the user.

Programme Description

The programme is written in Basic Fortran IV and it is at present processed on a 1130-8K IBM computer. With this equipment, it was necessary to split the programme into two consecutive runs which are recorded on the disc.

The first part, which concerns the actual computing operations, takes up virtually the whole of the central memory (about 5,000 words); it hands over to the second part of the programme which prints the results.

This splitting of the main programme could have been avoided by employing a more powerful computer, but it was considered preferable to work from the outset in the same conditions as those which are likely to obtain in the building industry as a whole. The IBM 1130 type of computer is well-adapted, from the standpoints of capacity and cost, to the present size of the firms in the industry: some design offices and contractors already possess machines of this type.

Current Development Work

Current development work is directed to optimising the presentation of the input data.

As already stated, the aim is to reduce as far as possible the number of cards to be punched whilst at the same time obtaining the clearest form of presentation for the user. An explanatory leaflet will give the exact definition of each term employed and, wherever necessary, instructions for filling in the cards.

The programme itself will be adapted in the light of results. In addition, study of real building projects already handled by the manual method or due to be handled on the computer using the existing programme will enable checking of the data and of certain intermediate results. These checks will have a twofold purpose. In the first place, they will make it possible to identify any aberrations in the input data (such as a decimal point in the wrong place: the computer will report an error concerning the floor-area of a living room, for example, if this is stated to be 140 sq. metres). This will give greater reliability to the programme. Incidentally, it may be pointed out that, even in the absence of such checks, the risks of error, omission and duplication are much less with the ARC method than with conventional methods, since the input data are presented in the form of a check list which must be gone through each time. In addition, the checks will draw the user's attention to any anomalies arising by comparison with general practice (such as when an item is found to be significantly more expensive than the average cost recorded in previous cases handled by the manual method or by computer; this, of course, will merely be a comment - or indicator - which the user may ignore if he wishes).

Another aspect at present under study is that of the output data. The ARC method enables two types of cost estimate:

- By item of work and by rooms (or group of rooms). It is possible to make separate estimates for horizontal structures (floors, floor and ceiling coverings), vertical structures (facade walls, gable walls, crosswalls and partitions with all cladding and decoration), and fittings (household and sanitary appliances, doors, etc.). These estimates can be made either at the level of a single set of rooms or at that of a group of rooms;
- By square metre of rooms (or group of rooms). The cost per square metre obtained depends on the size and form of the premises and on the number of separate rooms; in the case of a group.

Certain of these quantities can be given by the existing programme and others can be added at the request of the user.

Finally, the "indicators" referred to above are, of course, given in printed form.

Planned extension of the existing programme

As designed at present, the existing programme fulfills the main purpose of estimating the cost of a building project. However, the ARC method has a wider potential than this, and it is considered appropriate to make the other possibilities available to users of the computer programme.

1 - Cost Analysis Capability

As previously described, the "indicators" mentioned in the method serve mainly to detect errors in the input data and, to a lesser extent, any major defects in the project design. However, this indicator principle can be generalized and applied to a systematic cost analysis.

This is because the method can give the incidence on the final cost of the basic parameters listed below:

- The -- bearing -- system chosen;
- The composition of the dwelling unit;
- The number of rooms;
- The area;
- The depth;
- The number of floors;
- The ceiling height;
- The size of private annexes;
- The size of entrances and passageways;
- The size of common annexes;

- The scale of common fittings and equipment;
- Unit work costs;
- Density of fittings and equipment per unit.

If this analysis is conducted to a sufficiently early point in the design stage, it is possible to adjust the project by reference to any anomalous features observed.

2 - Combined Cost Analysis and Cost Comparison

These applications are merely other forms of cost analysis.

Combined cost analysis consists in causing various parameters to vary within a total ceiling cost; for example, simultaneous variation of the quality (i.e. the unit cost) of different items such as cladding, to such a magnitude that the total cost remains unchanged at a predetermined level.

Comparison of the costs of the various projects can be conducted in three ways:

- On the basis of constant unit costs, when it takes the form of a comparison between drawings and architectural designs using equivalent materials;
- On the basis of real unit costs, when it is a comparison of all-in costs and is an application of special relevancy in connection with the current methods of financing -- social -- housing;
- On the basis of real unit costs by reference to certain fixed quantities, which can make the comparison more objective, such as by taking identical values for the area and the number of habitable

rooms, but counting the other factors (bearing system chosen, real number of dwellings, number of floors, number of annexes, etc.) at their real values.

3 - Division of a Building for Co-ownership

The cost data is displayed under separate headings:

- The dwelling unit proper;
- The private annexes;
- Entrances and passageways;
- Common works and equipment;
- Common annexes.

This breakdown clearly corresponds to the requirements of a promotor who has to divide a building between several co-owners.

Taking things to an extreme, it is even easy to exclude certain parts of the premises (shops, garages, etc.) due to be sold separately.

4 - Payment of Installments on Account of Work Terminated

It is not necessary to make a demonstration to illustrate the value of the ARC method in connection with making installment payments. In particular, the fact that the auxiliary premises can be charged separately makes it possible to invoice most of the premises located on the lower floors as soon as they are constructed, by the application of unit prices weighted according to their purpose and state of finition or the body of works concerned.

5 - Calculation of Thermal Losses

By differentiating between all the walls, the method also makes it possible to calculate all the areas involved in thermal transfers, thus facilitating calculation of the volumetric loss factor when the U values of each wall are known.

6 - Management Forecasting Applications for Building Contractors

By replacing the unit costs by bills of quantities, it is possible to obtain the total quantity of the materials involved in constructing a building.

This version of the method has already been used, in particular, to calculate the quantities of cement used for various structures.

It could also be used by building contractors to plan time-schedules of supply for materials and structures. It would be sufficient to apply the method by reference to the planned work schedule for the site at each stage of construction and, if appropriate, to introduce a coefficient allowing for wastages. Consideration of the unit costs of materials and fittings would make it possible to schedule the contractor's expenditure outlay, whereas consideration of the unit working time would enable scheduling of labor hirings.

In this version, the aims of the ARC method coincide with those of management information systems. Consequently, it will be necessary for the standardization of management documents to be extended to the documents involved in the method itself, and for this standardization to be approached with this fact in mind.

APPENDIX B

Building Economics

The basic theory is presented in outlined form below in order to make it, hopefully, more clear.

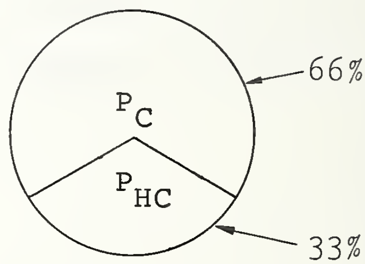
1. Total Cost $P_T = P_C + P_{HC}$

   P_T = total price or cost

   P_C = cell cost

   P_{HC} = other areas cost

   a. P_C = 66% of P_T



2. Calculation of cell cost

   a. Can be as a whole or per habitable square meter.

   b. $P_C = P_L + P_H + P_N$

      where P_L = price of verticle elements

      P_H = price of horizontal elements

      P_N = price of equipment or fittings

      (1) horizontal elements of a cell include the structural floor, its covering, and the ceiling covering.

      (2) Vertical elements are walls of four kinds subscripts are:

         F = facade walls (facade)

         R = structural cross walls (refend)

C = partitions (claison)

B = end walls (pignon)

(a) Cost of common walls are split in half relative to total perimeter calculation.

(3) Equipment includes items such as plumbing, electrical, sinks, commodes, and doors (doors could be in walls but more convenient to put separate because of prevalence of pre-constructed wall systems.

3. Calculation of verticle cell costs P_L. This method of calculation is considered to be one of the major breakthroughs of ARC. They have a means of calculating the perimeter without measuring. (Their big discovery)

a. Mathematics

$P_L = (D_L)\ (h)\ (r_L)$

where D_L = perimeter of inner faces of all walls corresponding to habitable surface

h = floor to ceiling height

r_L = average price of verticle sq. meter

(1) D_L calculated as $\Upsilon\sqrt{S_h}$

S_h = habitable square meter

(a) Υ = perimeter coefficient discussed below or in appendix

(2) h is known value

(3) $r_L = (t_F \cdot r_F) + (t_B \cdot r_B) + (t_C \cdot r_C) + (t_R \cdot r_R) + r_p$

where subscripts refer to types of walls defined above and r_p is the average price of the inside lining t_i is % of walls of type i.

(4) Calculation of

(a) $\Upsilon = \Upsilon^{I} + \Upsilon^{II} + \Upsilon^{III} + \Upsilon^{IV}$

The superscripts refer to four different categories of rooms. There are also corresponding values for surface area.

S^{I} = area of living room and bedrooms and other large rooms.

S^{II} = smaller rooms e.g. kitchen, bathroom, small office, etc.

S^{III} = entry foyers and hall-ways.

S^{IV} = closets, water closet, other cubby holes.

These categories generally take the following percentages of the habitable surface area.

S^{I} = 68%

S^{II} = 18%

S^{III} = 10%

S^{IV} = 4%

(b) The general formula for the calculation of a Υ value is

$$\Upsilon = A \sqrt{nt}$$

where Υ = perimeter coefficient

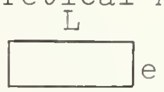
A = mean form coefficient

n = number of rooms of a type

t = % of surface area for type of room

(1) The rationale is that the 3 variables A, n, and t account for most of the variation in perimeter for a given S.

(2) A is calculated by formula in the theoretical ARC method.



$\alpha = L/e$ (the coefficient of elongation)

$$a = 2\left(\frac{\alpha + 1}{\sqrt{\alpha}}\right)$$

A = average a

4. Calculation of horizontal cell costs

a. This calculation is fairly straightforward the only formula is the calculation of the mean span. The price of horizontal elements depends on the mean span.

$$l'm = \sqrt{\frac{n_1 l_1^3 + n_2 l_2^3 + \ldots + n_n l_n^3}{\varepsilon\, nl}}$$

where $l'm$ = mean span

n_i = number of spans of length l_i

l_i = span of certain length.

b. r_H, the price per sq. ft. of horizontal works, is calculated by graph related to l'm and thickness. I don't know how it was derived.

2.7 W. R. Herron

Wind on Structures,

Computing Heating and Cooling Loads

and

Determination of Convection Coefficients,

Aging of Materials,

Soils and Foundations,

Structural Modelling,

Document Exchange

REPORT ON

U. S./FRENCH COOPERATIVE PROGRAM ON BUILDING TECHNOLOGY

By

W. R. Herron

Coordinator, International Affairs

Building Research Division

WIND ON STRUCTURES AND WIND EFFECTS

On the morning of Tuesday, November 17, 1970, I met in the CSTB Paris Offices with Mr. Biertry, Mr. Philippe, Mr. Duchene-Marullaz and Mr. Gandemer. The discussion consisted of two parts, one an explanation of Dr. Marshall's work in wind effects on buildings, being conducted at the Gaithersburg site, NBS; and, secondly the proposed visit of Mr. Gandemer to the United States in the spring of 1971 for a period of approximately two to three months. The three gentlemen were extremely interested in Dr. Marshall's work and requested a description of instrumentation, which I promised to have Dr. Marshall forward to Mr. Bietry after I returned to Washington.

The CSTB direction of effort appears to be initially to establish a better method for determining wind velocity gradeant with altitude. Two aspects seemed to concern them: the first related to the international standard 10 meter height for measuring meterological wind velocity data. They are concerned that this height is not sufficient for predicting wind effects on taller buildings. The second relates to CSTB responsibilities regarding wind velocity and design criteria in the French protectorate in the Hurricane Zone of the Carribean.

These gentlemen outlined their general interests in

visiting U. S. locations. Mr. Gandemere should spend some time with Dr. Marshall at Gaithersburg. Another point of interest would be a visit to Weather Bureau Hurricane Center in Miami. They mentioned interest in visiting the Wind Tunnel facilities of Dr. Davenport in Canada. They are also interested in discussion and indoctronation into the U. S. designing principle for wind effects on tall concrete and steel buildings.

COMPUTING THE HEATING AND COOLING LOADS OF BUILDINGS AND DETERMINATION OF CONVECTION COEFFICIENTS

These two themes are both under the direction of Dr. Kusuda at the Building Research Division who spent 6 weeks in the summer of 1970 working with the people of the CSTB in the facilities at Champs sur Marne. On Friday morning, November 13, 1970, I visited Mr. Croiset and Mr. Borel and their staff at the CSTB Champs-sur-Marne facilities. We discussed the work of Dr. Kusuda and his experiments with these gentlemen last summer. Their work was concerned with two themes: Computing Heating and Cooling Loads and Determination of Convection Coefficients.

Since there is little use of air conditioning in France, we discussed the natural ventilation of buildings. In order to see some of the ventilating controls developed by CSTB in actual use, I was taken to the home of Mr. Berthier. This, I was told, was a typical apartment installation. The apartment was on the third floor. The floor plan arrangement consisted of a central stairway and elevator serving apartments on either side, with each apartment having cross ventilation. Individual apartments appeared to have a U-shaped floor plan, the indentation in the U being the space occupied by the stairs and elevator facility. The utilities were at the extreme ends of the two apartments from the stairwell and were back to back with the adjoining accomodation of two apartments clustered around the next stairwell. The ventilating installations consisted of a slot through the wall into which a closure flap was fit. The flap is actuated by the wind pressure; as the wind velocity increases the flap is pressed tighter over the opening. The flap is designed to have a maximum closure above a specified wind pressure. The flap is made of springy material so that when there is little or no wind blowing it opened to a maximum ventilating openning.

Out second visit to Mr. Croset and his staff at Champs-sur-Marne was on Tuesday afternoon November 17. After showing me some additional items connected with their thermal research, Mr. Borel took me to a school constructed at Bry-Sur-Marne. The CSTB has been allowed to install some air conditioning equipment in this building. There are three classrooms being air conditioned to test the desirability of using air conditioning under varying circumstances. Right now, the three rooms are being cooled by a single air conditioning unit which gives 20 air changes with 60 percent maximum Relative Humidity. It is a two horsepower system. The three rooms are on the same side of the building; they have about equal square footage and each has a capacity to seat approximately 30 students. The difference between the three rooms is in ceiling height. Traditionally space is allowed at the ceiling of such rooms to accumulate warmer air near the ceiling level. One room has a ceiling height of 250 centimeters, the second room has a height of 270 centimeters, and the ceiling height of the third room is 290 centimeters.

After touring the school demonstration project, I returned to the research station and presented the HUD Breakthrough Slide Lecture to Mr. Croiset and his staff. The lecture, which consists of about 40 slides, has been prepared by the Building Research Division.

AGING OF MATERIALS

On the afternoon of Friday, November 13, we returned to CSTB offices in Paris for a discussion with Dr. Blachere on the future exchange program. The theme on Aging of Materials had been left open for discussion at this time in the preliminary plan developed in January 1970. It was agreed that a material expert would be part of the next French team to visit the United States, since the French are very interested in the U. S. development of instrumentation for materials research.

SOILS AND FOUNDATIONS

On Monday, November 16, I visited UTI facilities at St.-Remy-les-Chevreuse with Mr. Dawance. There I was shown facilities which are described in detail in the report of the first U. S. team visit--i.e., the large-scale pile and retaining wall testing facility. I explained to Mr. Dawance that at the present time NBS does not have a program in the soils mechanics and foundations area. However, we are thinking of establishing such a program, and some future exchange team would be utilized as the vehicle for acquainting our researchers in soil mechanics and foundations with the work already on going in France.

On the afternoon of November 16, I went to the Paris offices of the UTI on Brancion for an appointment with Mr. Le Rouchellec. Mr. Le Rouchellec was unavailable, so I spent the rest of the afternoon with Mr. Yuan Tcheng. I explained to Mr. Tcheng that our program in soils and foundations had not yet begun at NBS. We spent a profitable time discussing the foundation problems in the Paris area which are somewhat unique. The whole area of Paris is honeycombed with caves; this must be taken into consideration in developing foundations for construction. The caves are so extensive that frequently the foundation must be carried through the void of the cave and supported at its floor. These foundation considerations would be of much value in a newly established program at the Building Research Division. Future U. S./French exchanges of information on soils and foundations would be most helpful.

STRUCTURAL MODELLING

During the morning visit on Monday, November 16, Mr. Dawance showed me through the entire research facilities at St. Remy which include facilities for structural modeling. Dr. Leyendecker, a member of the first U. S. team, visited these same facilities. I was shown the facilities for photo-elastic analysis and their experimentation with halogen test methods. One experiment on going during my visit--which Dr. Leyendecker did not see--concerned a three-dimensional aluminum alloy through trust bridge which was being subjected to various live loadings. This model load had a roadway of approximately 2 feet and was between 5 and 6 feet in longitude. Mr. Dawance remembered Dr. Leyendecker's visit with the first

U. S. team, and I explained that he would be in the near future establishing the NBS program in structural modeling at which time a meaningful exchange could be developed.

DOCUMENT EXCHANGE

On the morning of Friday, November 20, I met with Dr. Blachere to discuss the exchange of documents. In discussing CSTB's "obligation" to provide 100 translated pages per month to the Building Research Division, Dr. Blachere explained that it had become a chore to provide such a large quantity. He suggested that the CSTB might attempt to provide that same amount on a quarterly basis. The submissions from CSTB to date have not been reprinted by the Building Research Division because of problems associated with editorial and publications policies of the Bureau, I explained that our Scientific and Professional Liaison Section has been working to establish more leinant publication policies for such material and that I would pursue this project with them on my return.

In a broader sense Dr. Blachere expanded the discussion to include his view of the total exchange program. He envisions three levels of exchange: On the first level one country sends a team member to the other country to open channels of communication with a counterpart expert. On the second level is a short-term exchange of a high-level expert--examples would be Dr. Kusuda's six-week stay in Paris and the proposed three-month stay of Mr. Gandemer in the United States and Canada to study wind constructors and wind effects. The third level of exchange involves internships of approximately one year.

After the discussion, I gave the slide presentation on Operation BREAKTHROUGH for Dr. Blachere; this is the same approximately 40-slide lecture which I gave for Mr. Croiset and his staff at Champs-sur-Marne. After the slide lecture, I made a gift of the slides and the test to Dr. Blachere for his use with his staff and others as he saw fit.

APPENDICES

APPENDIX A

Program Plan
for
U. S./French Cooperative Program
in
Building Technology

January 1970

Research Project	Responsibility for Developing Detail Proposals	Remarks
1. Wind on Structures and Wind Effects	CSTB	Include as an item for October 70 visit to France. Dr. Marshall attending.
2. Computing the Heating and Cooling Loads	NBS	Comparison of NBS and CSTB method of computation. Dr. Kusuda and Mr. Borel would correspond direct and Dr. Kusuda would spend approximately 4 weeks in France. After the meeting in France a detailed joint research project would be developed.
3. Determination of Convection Coefficients	NBS	Comparison of NBS and CSTB methods. Further discussion is required.
4. Noise Transmission Through Structures	CSTB	CSTB has planned to develop a new division and facilities in acoustics at Grenoble. BRD will send acoustician with team visit in October 1970. Detailed research program will be developed after CSTB developes proposal and October visit to France.

Research Project	Responsibility for Developing Detail Proposals	Remarks
5. Sonic Boom	CSTB	CSTB is developing the planning for a program in France on sonic boom on buildings. CSTB and NBS/BRD would probably send an intern for 6 months research work at the Landley, Virginia, and Long Island, New York, Department of Transportation and NASA would be involved. CSTB wants to move fast on this project and will be recruiting immediately.
6. Urban Noise	CSTB NBS	Both CSTB and NBS are interested in this problem and have some research underway (such as tire noise). This topic would be discussed further by U. S. representative during October visit to France.
7. Aging of Materials	CSTB NBS	This could start with an information exchange. Both will develop papers on this topic, giving programs and facilities being used. This will be discussed in the fall of 1970, at which time details of exchange of people could be decided.
8. Soils and Foundations	NBS	NBS will work up a proposal for CSTB and CEBTP. There is a possibility that NBS would send a guest worker for 1 year to CEBTP.
9. Plumbing	NBS	After the October 70 visit to France, NBS (if interested) will decide

Research Project	Responsibility for Developing Detail Proposals	Remarks
9. Plumbing (cont'd)		on program and U. S. guest worker. U. S. guest work would probably be a new young intern and would spend 6 months in France.
10. Structural Modeling	NBS	NBS is not certain on this topic. They will investigate further and inform CSTB. Research would be at CEBTP.
11. Process for Evaluating New Building Systems, Components, and Materials	NBS	CSTB has in operation an agrement (evaluation) system. NBS is currently developing evaluation criteria for experimental housing for HUD under project "BREAKTHROUGH," and will also develop criteria for testing and evaluation. As a short range project CSTB would review NBS material. At a later date there could develop a long-range exchange program.
12. Building Economics	NBS	This topic would be included in the October 70 visit to Paris. During the fall visit the U. S. member will consider the desirability of sending a U. S. intern to CSTB for 2 months. The intern would spend his time adapting the CSTB method of economic appraisal of social housing to U. S. usage.

APPENDIX B

Plans for Future U. S./French Cooperative Exchange

After the second visit of an American team in France in the frame of French-U. S. cooperation in the field of building, the following steps have been taken for the future.

EXPLORATORY VISITS

A French team will visit the United States in April or May. This team will be composed for one half by CSTB representatives and for the other half by representatives of other technical centers.

Topics considered:

--bricks construction,

--human sciences applied to building,

--mastics and tightness products for joints,

--new materials for roofing,

--heating,

--Breakthrough progress.

These topics will be determined by letter before Christmas.

NBS will propose a programme for each topic for 15th February.

A U. S. team will visit France in October 1971.

EXCHANGE OF DOCUMENTS

CSTB has sent 2 sets of documents.

NBS will inform CSTB soon of the precise means of distribution within the States. Very likely in the Building Science Series.

It appears that the project to translate and distribute each month 100 pages of French technical documents is too ambitious. It is more convenient to plan 100 pages quarterly.

NBS will cross in the table of contents of CSTB and UTI the documents which he wishes to have translated.

EXCHANGE OF RESEARCH PROGRAMS

The exchange of programs has been done on the CSTB side and will be done before Christmas on NBS side.

ACOUSTICS

1. Sonic Booms

Mr. Flynn will organize the stay of Mr. de Tricaud in the States as from 1st July 1971.

This stay as an intern will be devoted to real work in organizations working on the effect of sonic booms on structures.

NBS is invited to attend actual tests which will be carried out at Istres in March 1971 and which will last a fortnight.

Mr. Flynn will send the documentation available on the topic.

2. Traffic Noises

Messrs. Flynn and Josse will set up a permanent contact and will exchange the results of the research on the topic.

CSTB will see if the I.R.T. (INSTITUT DE RECHERCHES DES TRANSPORTS) is interested in the NBS studies on the noise caused by tires.

3. NBS and CSTB have acknowledged the interest to create an international department of research devoted to the study of noise through structures and they have agreed to inform each other of the progress of this French project.

MOISTURE AND HEAT TRANSFER

Relations in this field will be settled as per proposal of 27th July 1970 of Messrs. Kusuda and Croiset.

WIND

Mr. Gandemer of CSTB will go to America for 4 months from 19 April 1971 and will stay 2 months and a half in the States.

He will study the work carried out at NBS and elsewhere in the field of interaction of wind and buildings, he will visit the Weather Bureau and get information on hurricanes.

A proposal of future program will spring from this stay.

EVALUATION OF BUILDINGS

NBS/HUD will choose 4 or 5 of the successful projects in BREAKTHROUGH and will send to CSTB detailed projects.

CSTB will give its technical advice or remarks.

CSTB will send NBS the project of a house with electric heating which will be assessed by NBS following BREAKTHROUGH criteria.

TECHNICAL EVALUATION

The problem will be dealt with the French team going to the United States in the Spring 1971.

TOTAL COST

NBS and CSTB will exchange the results of their works and documentation related to this concept.

PLUMBING, SOILS, MODEL OF STRUCTURE

These topics remain in the program of technical cooperation and will be the matter for detailed programs in due time.

As for plumbing, CSTB will send to NBS a precise description of the devices used in CSTB's and UTI's towers.