NATIONAL BUREAU OF STANDARDS REPORT 10 112

SUMMARY OF ACCOMPLISHMENTS FY 1969

Building Research Division Institute for Applied Technology National Bureau of Standards



U.S. DEPARTMENT OF COMMERCE NATIONAL BUREAU OF STANDARDS

WAT DEALE - - - - -

NATIONAL BUREAU OF STANDARDS

The National Bureau of Standards ¹ was established by an act of Congress March 3, 1901. Today, in addition to serving as the Nation's central measurement laboratory, the Bureau is a principal focal point in the Federal Government for assuring maximum application of the physical and engineering sciences to the advancement of technology in industry and commerce. To this end the Bureau conducts research and provides central national services in four broad program areas. These are: (1) basic measurements and standards, (2) materials measurements and standards, (3) technological measurements and standards, and (4) transfer of technology.

The Bureau comprises the Institute for Basic Standards, the Institute for Materials Research, the Institute for Applied Technology, the Center for Radiation Research, the Center for Computer Sciences and Technology, and the Office for Information Programs.

THE INSTITUTE FOR BASIC STANDARDS provides the central basis within the United States of a complete and consistent system of physical measurement; coordinates that system with measurement systems of other nations; and furnishes essential services leading to accurate and uniform physical measurements throughout the Nation's scientific community, industry, and commerce. The Institute consists of an Office of Measurement Services and the following technical divisions:

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THE INSTITUTE FOR MATERIALS RESEARCH conducts materials research leading to improved methods of measurement standards, and data on the properties of well-characterized materials needed by industry, commerce, educational institutions, and Government; develops, produces, and distributes standard reference materials; relates the physical and chemical properties of materials to their behavior and their interaction with their environments; and provides advisory and research services to other Government agencies. The Institute consists of an Office of Standard Reference Materials and the following divisions:

Analytical Chemistry—Polymers—Metallurgy—Inorganic Materials—Physical Chemistry. THE INSTITUTE FOR APPLIED TECHNOLOGY provides technical services to promote the use of available technology and to facilitate technological innovation in industry and Government; cooperates with public and private organizations in the development of technological standards, and test methodologies; and provides advisory and research services for Federal, state, and local government agencies. The Institute consists of the following technical divisions and offices:

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THE CENTER FOR RADIATION RESEARCH engages in research, measurement, and application of radiation to the solution of Bureau mission problems and the problems of other agencies and institutions. The Center consists of the following divisions:

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THE CENTER FOR COMPUTER SCIENCES AND TECHNOLOGY conducts research and provides technical services designed to aid Government agencies in the selection, acquisition, and effective use of automatic data processing equipment; and serves as the principal focus for the development of Federal standards for automatic data processing equipment, techniques, and computer languages. The Center consists of the following offices and divisions:

Information Processing Standards--Computer Information -- Computer Services -- Systems Development--Information Processing Technology.

THE OFFICE FOR INFORMATION PROGRAMS promotes optimum dissemination and accessibility of scientific information generated within NBS and other agencies of the Federal government; promotes the development of the National Standard Reference Data System and a system of information analysis centers dealing with the broader aspects of the National Measurement System, and provides appropriate services to ensure that the NBS staff has optimum accessibility to the scientific information of the world. The Office consists of the following organizational units:

Office of Standard Reference Data—Clearinghouse for Federal Scientific and Technical Information ^a—Office of Technical Information and Publications—Library—Office of Public Information—Office of International Relations.

¹ Headquarters and Laboratories at Gaithersburg, Maryland, unless otherwise noted; mailing address Washington, D.C. 20234. ² Located at Boulder, Colorado 80302.

³ Located at 5285 Port Royal Road, Springfield, Virginia 22151.

NATIONAL BUREAU OF STANDARDS REPORT

NBS PROJECT 42100-4210900

October 1, 1969

NBS REPORT 10 112

SUMMARY OF ACCOMPLISHMENTS FY 1969

Building Research Division Institute for Applied Technology National Bureau of Standards

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Approved for public release by the director of the National Institute of Standards and Technology (NIST) on October 9, 2015 accounting documents intended ubjected to additional evaluation isting of this Report, either in Office of the Director, National the Government agency for which vies for its own use.



U.S. DEPARTMENT OF COMMERCE NATIONAL BUREAU OF STANDARDS

INTRODUCTION

In the past year a number of national committees and commissions have reported on the building industry and its response to the nation's needs, primarily in housing. In the reports they had expressed some concern in the lack of uniformity within the Federal construction programs.

In response to these reports the Bureau of the Budget has requested that the National Bureau of Standards/Building Research Division undertake additional activities to improve communications between Federal agencies in building technology.

The following project summaries provide a brief account of the work that was done in the Building Research Division of the National Bureau of Standards during FY 1969.

Each summary contains a funding figure, a summary of output, and the name of the project leader. Comments, suggestions and inquiries are welcomed (please contact the individual project leader). The summaries are arranged under the following Sections of the Building Research Division, each of which has the major responsibility for work in a particular area:

Structures Fire Research Materials Durability and Analysis Codes and Standards Building Systems Scientific and Professional Liaison Sensory Environment Environmental Engineering Psychophysics Building Transport Systems

The distribution of this information is just one effort of the Building Research Division to improve communications between Federal agencies and to increase the dissemination of building research results.

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BUILDING RESEARCH DIVISION INSTITUTE FOR APPLIED TECHNOLOGY NATIONAL BUREAU OF STANDARDS



PROJECT SUMMARIES FY 1969

Structures Section (421.01)

Project Number and Title: 4212111, Masonry and Reinforced Concrete

Project Leader: Edward O. Pfrang

RTS Funds Expended: 24.8K

Summary of Output:

Basic research on the behavior of masonry structural systems has been carried out under this project. Fundamental theoretical studies paralleling the work presently underway on projects 4215412, Racking Strength of Walls, and 4215416, Environmental and Work Effects on Masonry Structures sponsored by the Army, Navy, and Air Force have been undertaken. The sponsors for these projects were more concerned with obtaining data which would be useful for the solution of short-term problems rather than a long range understanding of the mechanisms controlling the behavior of masonry structural systems. By carrying out theoretical studies under this project, the effectiveness of the work performed with other agency support has been significantly amplified. An analytical procedure for predicting the response of masonry systems subjected to combined axial and flexural loading has been developed. It has been shown to give close correlation with the results of physical tests.

Considerable committee work was carried out by staff members on ACI committees on standard building code, columns, computers, shear composite construction, cracking, high-strength reinforcement, lightweight concrete, and insulating concrete. Other committee activities by staff members included work on ASTM Committee on Building Construction and other committees of ASCE, USASI, Highway Research Board, PCI, etc.

R. G. Mathey was appointed as Chairman of USASI Committee A-41 on the Design of Masonry. Mr. Mathey has completely reorganized and reoriented this Committee. The Committee is now taking an active role in attempting to develop rational procedures for the design of masonry structural systems.

Research results from this project are being incorporated into nationally accepted design criteria for building systems and are thus affecting design and construction economies.

Project Number and Title: 4212115, Criteria for Design of Composite Structural Systems

Project Leader: H. S. Lew

RTS Funds Expended: 69.8K

Summary of Output:

The scope of this project is to develop design criteria for concrete-steel composite beams with headed stud shear connectors. As an immediate objective, it was proposed that laboratory tests be carried out to examine the design values and design procedures in the current American Institute of Steel Construction building specification.

A total of six beams were fabricated and tested under repeated pulsating load in order to evaluate the fatigue strength. These beams were the exact duplicates of the six beams tested under static load which were comprised of a 4 x 48 in. concrete slab and a 12WF27 steel beam. The beams were tested in pairs with respect to the shear span. The three lengths of shear span were 3, 4 and 5 feet. One beam of each pair had uniformly spaced studs along the lengths of the beam, while its mate contained the same number of studs in the shear span.

A total of 48 push out specimens were tested under static load, in order to establish the shear strength of studs as affected by the size of stud and the strength of concrete. The sizes of studs used were 1/2, 5/8, 3/4 and 7/8 in. dia. and the strength of concrete 3,000 psi and 6,000 psi. These specimens were tested under three different loading conditions: (1) monotonically increasing load; (2) incrementally increased repeated load to failure with equal increments of load; (3) incrementally increased load to failure with the load increments based on equal increments of slip.

A total of 54 fatigue "push out" specimens, 27 with 1/2 in. dia. studs and 27 with 5/8 in. dia. studs, were fabricated and are being tested in order to evaluate the fatigue life of stud shear connectors. Two separate reports covering each test series will be prepared for NBS publications.

Based on the results of the static beam tests, a theory predicting the ultimate load of composite beams with incomplete interaction has been developed. A report including both the experimental and analytical parts is being prepared for publication as a Building Science Series report. The experimental part of the report was presented at the ASCE National Meeting held in Louisville, Kentucky.

Results and conclusions drawn from research work carried out in this project provide a rational basis of designing composite beams with effective and efficient uses of stud shear connectors. Based on these, a new design procedure will be recommended to AISC to adopt as part of its building specification. Adoption of the new design procedure will result in substantial savings in design time and materials, thus furthering building economy.

Project Number and Title: 4212116, Safe Loads on Structures

Project Leader: James O. Bryson

RTS Funds Expended: 24.6K

Summary of Output:

A manuscript describing the live load and fire load studies carried out thus far was published as Building Science Series 16 and entitled "Techniques for the Survey and Evaluation of Live Floor Loads and Fire Loads in Modern Office Buildings."

An invited talk on the subject of live loads in buildings was presented at the 1968 ASCE Annual Meeting and National Meeting on Structural Engineering held in Pittsburgh, Pennsylvania.

Committee work directly related to this project was carried out with the ASCE Task Committee on Structural Safety. The main objective of this committee is to develop a reliability - based code for structural design.

A grant to NBS of \$20,000 was made by the American Iron and Steel Institute to aid in the continuation of the study of occupancy loads in buildings. Planning on the continuation of the study, featuring surveys of several buildings to add to the bank of data already accumulated, will commence shortly after the first of the Fiscal Year 70. A meeting with representation of the steel industry to discuss the plans for the next phase of the work has been scheduled for the middle of August, 1969.

Design loads now specified in codes and standards have evolved over the years through the best judgements of regulatory agencies and standards organizations using information from very limited studies. Consequently, the concenses is that buildings are presently being designed using extremely conservative loads.

The present program is designed to develop a large bank of loads data relating to building occupancies and the geometry of areas, to predict with measured accuracy the actual loads that will be imposed on buildings. An immediate and very significant economic benefit will be derived from a reduction in safety factors even if the same or higher design loads, than those presently used, are shown to be needed.

Project Number and Title: 4212117, Criteria for Connections in Prefabricated Structural Systems

Project Leader: Edgar V. Leyendecker

RTS Funds Expended: 18.9K

Summary of Output:

Six continuous beam-to-column connections were tested, two of these were subjected to beam axial load as well as beam transverse load. These tests were carried out to measure the ultimate load capacity, failure mode, and load response characteristics of the beam-to-column connections. The objective was to compare the behavior of different types of beam-to-column connections and to develop a method of test for the evaluation of connection performance.

All of the beam-to-column connections were designed for an ultimate moment corresponding to a beam vertical load of 40,000 lbs. The design shear strengths of the beams were 30,000 to 40,000 lbs. depending on the amount and location of shear reinforcement. Concrete strengths were about 5000 psi.

Two different types of beam-to-column connections were tested. The first (Type 1) was a monolithic connection containing continuous tension and compression reinforcement which served as a control specimen. In the second type (Type 5) the beams contained tension and compression reinforcement; however, in order to make the connection continuous, bars were placed through an opening in the column and welded to the tension reinforcement in the beams. The compression reinforcement was not continuous. After weld-ing, the opening in the column was grouted.

The Type 1 connection carried slightly more load at yield of tension reinforcement than the comparable Type 5 connection for cases of no axial load or large axial loads in the beams. Ultimate capacity was similar. Preliminary data indicates that both connections perform satisfactorily and similarly. It was observed in one Type 5 test that a faulty weld reduced the load carrying capacity of the connection. The failure was sudden and extremely undesirable.

These tests and tests to be completed in Fiscal Year 1970 will provide comparable test data on different types of beam-to-column connections which may result in more economical design practice.

Project Number and Title: 4212118, High Level Sustained Loads

Project Leader: T. W. Reichard

RTS Funds Expended: 5.0K

Summary of Output:

The sustained loading equipment was repaired after a failure in a pressure regulator ruined an experiment and some of the equipment. All 24 of the loading frames and the hydraulic system controls were modified to reduce the possibility of such an accident occurring in the future.

Without a knowledge as to the sustained capacity of the higher strength materials which are now becoming available for construction, the construction industry is being forced to use artifically high factors of safety to insure the reliability of new buildings. This project is providing much needed information which will permit lower factors of safety and therefore more economical buildings.

Project Number and Title: 4212411, Precast Concrete Structures

Project Leader: James O. Bryson

OA Funds Expended: 1.1K

Summary of Output:

A manuscript has been prepared which describes the experimental and analytical studies of prestressed composite concrete Tee beams subjected to flexural loadings. The experimental work for this program was completed in FY68. The project was extended with funds to carry out additional analytical studies and to finalize the report on the work. The manuscript is in the review stage which should be completed shortly after the beginning of FY70.

This work was carried out at the request and under the sponsorship of the Department of the Navy to investigate a different concept of composite prestressed concrete design and construction technique which appeared to offer economic benefits of savings in materials.

Project Number and Title: 4213417, Scientific, Testing and Advisory Services -Post Office Department

Project Leader: E. O. Pfrang

RTS Funds Expended: 25.2K

Summary of Output:

The requested work items for this project were outlined in a number of work orders from the Post Office Department and covered several subjects.

Two reports (9998 and 10038) were prepared on computer programs for concrete beams and columns and for some miscellaneous structural components. These computer programs were derived from existing programs, but were modified to make them compatible with current building codes and the IBM 1130/Fortran IV language.

One letter-report was transmitted to the Post Office Department covering tests made on the "Wejit" drilled-in anchoring device.

Other work which concerned concrete inserts was reported under Project 4215417.

Another letter-report, sent to the Post Office Department, dealt with a suggested test program for a proprietary steel forming system. This test program included a description of testing procedures by which the manufacturer could have the performance of his system evaluated. The manufacturer is now negotiating with a university to have this test program performed.

The computer programs which were developed for the Post Office Department are being given wide circulation and will permit considerable increased efficiency in the process of designing building structures.

Project Number and Title: 4215112, Structural Models

Project Leader: Edgar V. Leyendecker

RTS Funds Expended: 10.5K

Summary of Output:

Seventy, one-quarter scale masonry prisms were tested in compression with varying load eccentricities. The objective was to develop masonry modeling techniques and evaluate the feasibility of modeling masonry walls.

Each prism was constructed of three, one-quarter scale models of 8 x 8 x 16 hollow concrete masonry blocks bonded together with model mortar. The model mortar (or micromortar) was designed using a conventional masonry mortar mix design with a sand graded in proportion to the scale of the model hollow block units.

The prism test results were evaluated by plotting load versus moment (compressive load times eccentricity). The test results agreed well with a theoretical short column ultimate load interaction diagram and were in reasonable agreement with test results on similar full size prisms.

A masonry wall testing program using models will reduce testing time and costs as well as reduce laboratory space requirements for testing and storage. Based on the tests described above it was tentatively concluded that masonry models were a practical research tool. Further verification on more complex walls under various loadings will be carried out during the Fiscal Year 1970 to establish the degree of reliability.

Project Number and Title: 4215113, Wind Loads on Structures

Project Leader: Richard D. Marshall

RTS Funds Expended: 44.8K

Summary of Output:

A pilot study of the effects of wind on buildings was initiated and Building 226 on the Gaithersburg Campus of the National Bureau of Standards was selected for the first phase of this research program. An array of six meteorological towers was erected directly north of Building 226, where the topography provides a relatively clear exposure to the prevailing winds. The towers and related instrumentation provide data for the determination of mean wind speed and direction as well as a description of the turbulent wind structure as the flow approaches the building. Seven pressure transducers have been installed in the windward and lee faces of the building to measure mean and fluctuating pressures. These observations are complemented by measurements of window deflections.

Arrangements were made with NASA for the loan of anemometers and recording equipment and ESSA has provided the program with considerable financial and technical support. A high-speed digital data acquisition system capable of unattended operation was designed to replace the temporary system which is currently being used. This new system will be available sometime during the last half of FY 1970.

Work was initiated on a computer program for processing wind load data. This program will provide for a statistical analysis of wind and pressure records from which aerodynamic admittance functions can be estimated. Work is also continuing on the evaluation of instrumentation and experimental techniques required for the acquisition of data from full-scale structures.

Benefits resulting from increased economy and safety should far exceed the cost of this program. U.S. Weather Bureau records indicate the average yearly damage to structures by wind in the continental U.S. is approximately \$600 million. The Public Building Service and the Veterans Administration have indicated an immediate need for information on wind loading of cladding panels. Existing code provisions have proved to be unsatisfactory in this area. Directly related to this program was the organization of a technical meeting concerned with wind effects on buildings and structures. This meeting was sponsored by NBS and ESSA and was held at NBS on January 27-28. This meeting was attended by 75 people from the United States and Canada and 13 technical papers were presented. The purpose of the meeting was to bring together meteorologists, aero-dynamicists and structural engineers and to establish those areas where additional research is needed.

Project Number and Title: 4215412, Racking Strength of Walls

Project Leader: Dr. F. Yokel

OA Funds Expended: 45.8K

Summary of Output:

Work has continued on the analysis of test results obtained in FY68 on the racking strength of masonry walls. A total of 58 walls have been tested in order to develop an improved racking test method and rational design criteria for masonry walls.

Analysis of test data obtained to date has led to the following conclusions: 1) the traditional test method for racking strength of walls (ASTM E-72) does not provide sufficient information and 2) racking strength of walls increase where compressive vertical loads are applied. A report on the program will be completed in the first quarter of FY70.

At the present time masonry design standards do not recognize the beneficial effects of compressive loads on the racking strength of masonry walls. With the increasing use of shear walls in masonry bearing wall buildings, the data which is being developed will result in improved design procedures and more economical construction.

Project Number and Title: 4215415, Evaluation of New Housing System

Project Leader: Dr. E.O. Pfrang

OA Funds Expended: 20.0K

Summary of Output:

A full scale one story section of the Neal Mitchell System has been tested in FY68 and an interim report on the testing was issued. On the basis of the work the City of Detroit has been able to issue building permits for the system. A precedent of great importance was thereby established since it was possible to secure a building permit for an innovative system which did not satisfy existing codes.

The effort in FY69 was concentrated on consolidating this achievement. Performance specifications were reviewed and revised and a final report was submitted to HUD. Work was also completed on a manuscript which will be published in the Building Science Series.

By establishing a new precedent for the introduction of innovative building systems into the U.S. construction process, this project has the long range potential of saving between 10 and 20% of the total cost of construction of publically financed housing construction.

Project Number and Title: 4215416, Environmental and Workmanship Effects Masonry Structures

Project Leader: Dr. Felix Y. Yokel

OA Funds Expended: 31.6K

Summary of Output:

In order to obtain experimental data on the effect of freezing temperatures on the strength of masonry, a research program was conducted which involved the fabrication and testing of 784 small masonry specimens.

The specimens (brick prisms and block prisms) were exposed to 40°F and/or 15°F temperatures for periods ranging from 2 hours to 3 days and then they were stored at 73°F for 28 days prior to testing. Test results for these specimens were compared to test results obtained from control specimens which were built and stored in 73°F temperatures.

Based on test results obtained, the compressive and flexural strengths of the small specimens were not adversely affected by their exposure to freezing temperatures for periods of up to 3 days immediately following construction. Additional research involving other variables not investigated, such as wind, masonry units having different initial rates of absorption, etc., is recommended. A report of the program will be completed in September 1969.

Information and data obtained in this and future programs should eventually permit some changes in present cold weather construction practices. These changes will aid in reducing the seasonality in the construction industry and the amount of money which is spent for various cold weather protective measures. Various estimates indicate that winter construction presently adds 0.5 - 1.5% to the total contract cost of buildings.

Project Number and Title: 4215417, Pull-Out Strengths of Inserts - P.O. Dept.

Project Leader: T. W. Reichard

OA Funds Expended: 30.0K

Summary of Output:

Approximately 400 reinforced concrete slab specimens were prepared for about 530 pull-out tests on the inserts. The major variables studied were; 1) Insert type, 2) Concrete type, 3) Concrete strength, 4) Reinforcement spacing and cover, 5) Bending moment magnitude, 6) Cyclic loading, and 7) Sustained loading.

A progress report (NBS Report 9954) was transmitted to the Post Office Department in November. A draft of the final report was prepared and sent to the sponsor in May. The final report (to be issued in July as NBS Report 10055) was prepared. The major conclusion was that although the pull-out strengths of the inserts are much higher a design load of 3 kips per insert is reasonable when all factors are considered.

Because of lack of information concerning the pull-out capacity of inserts cast into structural floors, the Post Office Department has been forced to adopt an extremely conservative policy towards the design of postal buildings. In many cases the total design of postal buildings has been controlled by the load capacity permitted on embedded inserts. In addition the Post Office Department has generally not permitted the use of lightweight aggregate concrete. As a result of the improved knowledge available from this study the Post Office Department will now be in a position to take a far more realistic approach towards the design of post offices and will also be able to permit the use of lightweight aggregate concrete, thereby affecting very significant economies.

Project Number and Title: 4215418, Live Loads - Postal Facilities

Project Leader: James O. Bryson

OA Funds Expended: 98.3K

Summary of Output:

This project was initiated at the beginning of FY69. The major objective is to investigate actual occupancy loads imposed on postal mail handling facilities for the purpose of making engineering recommendations for the loads to be used in the design of new facilities.

In the first three months of the program the work was concerned with developing a sufficient background of information on mail handling operations, process machinery, and building facilities, to formulate the most suitable measurement techniques and evaluative methods for carry= ing out the study. Concurrently, load sensing devices and data acquisition instrumentation for field measurements were being designed and developed in the laboratory.

A pilot study was conducted in the Philadelphia, Penn. GPO facility to experiment with planned measurement techniques for loads principally associated with conveyors suspended from the ceiling, and for the response of the conveyors to the applied loads. In addition the study provided the opportunity to gather, firsthand, important field information for the development of floor load survey techniques and procedures. This work was carried out during the "Christmas rush" period where it was expected that the mail load would reach a high point for the year.

The information obtained from the preliminary studies suggest that the height of a postal facility, in terms of the number of building stories, is an important denominator for live load evaluation. Considering this, a schedule of survey work in 9 postal facilities located across the nation was prepared. The 9 facilities that were selected for load surveying will provide a sample of post office buildings ranging from 1 to 4 stories in height and are grouped according to the number of stories to accommodate the work of field surveying, data reducing and evaluation, and reporting.

Load surveys have been conducted in 2 of the 9 facilities selected for the sample. These were the Greensboro, N.C., and Chicago (AMF), Ill. facilities. The data from these surveys are being evaluated and a preliminary report to P.O.D. is being prepared. Preparations were made to survey another facility (Buffalo, N.Y.) in July, 1969.

The results of this study will provide the P.O.D. with a reliable measure of actual occupancy loads imposed on their facilities. Savings in construction cost can be realized with future designs based on real loads information rather than an assumed maximum load increased by a safety factor.

Project Number and Title: 4215421, Structural Evaluation of Relocatable, Sandwich-Panel Building & Components

Project Leader: T.W. Reichard

OA Funds Expended: 17.6K

Summary of Output:

Two parts of the lab work for this investigation were completed. The first part was a structural evaluation of the Mark III building. This building was erected and tested under simulated wind and snow loading. Informal reports to the Navy regarding the erection and test results have resulted in extensive redesign of the building.

The second part of the completed lab work involved a comparative evaluation of the structural performance for similar sandwich panels produced by three manufacturers. Again informal reports have led to quality control requirements for the panels in the redesigned buildings which are currently on order. Formal reports to the Navy are now being prepared.

Project Number and Title: 4215601 - Concrete Masonry Research

Project Leader: Dr. Felix Yokel

OA Funds Expended: 17.3K

Summary of Output:

The objective of this investigation was to determine the effect of wall slenderness and load eccentricity on the compressive strength of concrete masonry walls as a first step in the development of rational design methods which can be incorporated in masonry design practice standards.

A test program involving fifty-eight reinforced and unreinforced concrete masonry walls was completed. Over seventy small prisms were also tested.

Analysis of test results indicated it was possible to predict ultimate failure loads by rational methods. A paper on the test program was presented at the ACI Convention in May, 1969. A final report is presently under preparation and will be completed in September, 1969.

A comparison between the rational methods developed and presently used empirical design methods indicates a revision of present codes would be desirable. The use of proposed rational design methods will result in safer and more economical concrete masonry wall construction which is becoming increasingly used in high-rise buildings.

Project Number and Title: 4215626, Miscellaneous Testing

Project Leader: Thomas W. Reichard

OA Funds Expended: 16.0K

Summary of Output:

Routine and special tests were conducted on the strength and other properties of building components and materials for other government agencies, but mostly for the D. C. Government.

Reports on tests of approximately 78 samples were issued in FY69. Fees charged for these tests totaled approximately \$15,600.

Without the miscellaneous testing service provided under this project the District of Columbia Government and other Federal agencies in the Washington area would have to set up and operate their own testing laboratories which would be quite expensive.

PROJECT SUMMARIES FY 1969

Fire Research Section (421.02)

Project No. and Title: 4212229 - Field Fire Studies

Project Leader: Irwin A. Benjamin

RTS Funds Expended: \$69.5K

Summary of Output:

1. CIB Program

We participated in a cooperative test program on "Fire Growth to Flashover" sponsored by CIB. The work was completed and the summary of the results is yet to be prepared.

2. Pratt Field Tests

Footage for a movie on the field burn-out tests on two apartment dwelling units was edited, and a preliminary narrative prepared. The Office of Technical Information has requested that this be made into a NBS film.

3. Special Studies

Studies were made, and technical reports provided to the Coast Guard on revisions to their fire test specifications for fire testing of bulkheads and insulating materials. Also, work was done for the IMCO cooperative test program on noncombustibility.

4. Mobile Field Laboratory

The design of the mobile field laboratory was effected and instrumentation purchased up to the \$20,000 allocated. The lab is now under construction. Some of the instrumentation has been received and special instrumentation is being built and installed.

5. Potential Heat Test

Studies were continued on the potential heat method as a means of controlling materials in building construction. A manuscript entitled, "Interlaboratory Comparison of the Potential Heat Test Method" by Gross and Natrella was prepared and approved for publication in ASTM Special Technical Publication. This manuscript was also published as NBS Report No. 9865.

6. Smoke Chamber

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Studies were continued on the development of the smoke chamber for commercial test purposes. A detailed study of the initial commercial chamber was conducted and modifications to the chamber were tried out and incorporated. A "Proposed Tentative Method of Test for Measuring" was prepared and circulated for comment to some 40 interested parties.

7. Design was completed for a smoke test facility -- a two-story high building with two rooms per story. This test facility will incorporate standard air handling outlets and variable volume air controls. The facility to be built during the coming year will allow for studies on smoke and fire spread through dampers, ducts, and doors.

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Project No, and Title: 4212427 - Aircraft Finish Materials

Project Leader: Daniel Gross

RTS Funds Expended: \$40K

Summary of Output:

A report of smoke and toxic gas measurements from 144 burning aircraft interior materials was made available. Technical assistance was provided to FAA in preparing for and conducting hearings on proposed new regulations. Also advice was given to commerical firms and industrial laboratories planning to build smoke test chambers according to the NBS design.

Work continued on the model enclosure tests in a 20 x 20 x 40 inch box using a radiant exposure and fuel consisting of polyurethane cubes. The purpose of these tests is to determine the critical conditions for flashover. A progress report summarizing the model enclosure tests conducted in FY 68 was prepared and forwarded to FAA. A large chamber, 2' x 2' x 16', was fabricated and additional tests were performed to further study the ignition and flashover behavior.

BSS 18, "Smoke and Gases Produced by Burning Aircraft Interior Materials", by Gross, Loftus, Lee and Gray.

NBS Report No. 9331, "Fire Growth and Flashover in Model Enclosures Simulating Airplane Cabins" by D. Gross.

Project No. and Title: 4215122 - Fire Endurance

Project Leader: Lionel A. Issen

RTS Funds Expended: \$64K

Summary of Output:

1. Structural Analysis Program

The STRESS program was obtained and made operational for the Univac machine. This program is to be used in conjunction with two other programs now under development.

2. Thermal Analysis Program

The TRUMP program was obtained from Livermore and made partly operational for the 1108. Two sections of this program are being reworked so that the isothermal plots can be obtained and calculations made for the thermal properties from the input data.

3. Conversion Program

Preliminary studies were made on designing a program to convert heat flow data from the TRUMP program into strain components for input into the STRESS program.

4. Floor Furnace

The floor furnace was cleaned up and repairs made. Concrete planks were bought to form a roof for the furnace. The planks are now being dried. Future experimental work in the furnace will involve studies on the effect of varying the time-temperature curve on the thermal properties and performance of protection materials.

5. Small-Scale Tests

Six small slabs from a previous program were available for tests in the 2' x 2' furnace. Three tests were run in the past year: the balance to be run in the coming year. These tests will be used to determine parameters of the furnace and provide checkout data for the TRUMP program.

6. Flame Spectral Radiance Measurements

Equipment was designed and assembled to measure the spectral distribution in the infrared region of radiant energy sources employed in fire test methods. Also a number of diffusion flames were studied. Energy distributions were obtained for acetylene, ethylene, methane, ethynol and candle flames. A gas-fired radiant panel and the smoke chamber heat source were also studied. Thermal radiation from the radiant panel was graybody in nature while the flame radiation was concentrated intwo bands corresponding to CO_2 and H₂O emission. This work will be written up during the current year.

Project No. and Title: 4215420 - Shipboard Fire Research

Project Leader: Daniel Gross

OA Funds Expended: \$70K

Summary of Output:

Work was initiated on this project during November. A visit was made to an aircraft carrier to review the use of materials on board ship. All of the specifications covering materials for shipboard use were collected and reviewed.

A variety of deck covering materials was assembled, prepared and tested at Naval Applied Science Laboratory in Brooklyn. Radiant panel, smoke and candle tests were conducted on thermal insulation materials proposed as alternative insulations for submarine hull insulations. Various standards and special tests were conducted on materials purchased under the MIL specifications.

Information on test methods for performing rate of heat release calorimetry was assembled. Preliminary design of a test method was considered.

Project No. and Title: 4215422 - Tests of Structural Sandwich Panels

Project Leader: Irwin A. Benjamin

OA Funds Expended: \$12.8K

Summary of Output:

This is a joint project coordinated by the Fire Research Section.

Structural tests were conducted on small samples of building panels to evaluate their physical properties under sheer, compression, and flexural loading. Also the effects of weathering on these panels was studied.

A full-scale building was erected and air infiltration tests were conducted. Also racking and vertical loading tests were conducted on the same building.

Evaluation of the thermal and physical properties of the extrusions used in the building are now being conducted. A report on the test is under preparation.

The project is to be continuing in Phase II in FY 70.

Project No. and Title: 4215627 - Miscellaneous Materials

Project Leader: Irwin A. Benjamin

OA Funds Expended: \$20K

Summary of Output:

Reimbursable tests were conducted during the year primarily for the Coast Guard.

Tests on marinite bulkheads were run. The report is awaiting completion of drawings. Meetings were held with the Coast Guard to work out testing details for a new series of bulkhead tests to be run in accordance with IMCO regulations.

Considerable number of tests were conducted to determine the noncombustibility criterion and potential heat of various types of structural insulation.

NBS Reprot No. 9988, "Noncombustibility of Mineral Wool and Glass Fiber Insulation Materials" by J. J. Loftus was prepared.

Project No. and Title: 4216223 - Analysis of Fire Gases

Project Leader: E. Carroll Creitz

RTS Funds Expended: \$65K

Summary of Output:

1. Smoke - Chemical

Gas chromotagraphic techniques for the analysis of some organic components of smoke produced in fire have been successfully worked out. Actual analysis will begin in the following year.

2. <u>Smoke - Physical</u>

Technique for using scanning electron microscopy for smoke particle characterization was investigated and found to be useful.

3. Inhibition Work

A system was designed and assembled for studies of the gas phase production and reaction of hydrogen and oxygen atoms with CF_3Br , using an RF generator and analyzing the products in the infrared spectrophotometer. Very little reaction was observed between Hydrogen and CF_3Br .

- 4. Gas chromotagraphic work on inhibition was reactivated and a suitable column was built for determining H₂ profiles in small diffusion flames.
- 5. The following papers were prepared:
 - a. "Flame Inhibition with Electron Attachment as the First Step" by R. M. Mills, Combustion and Flame, Vol. 12, No. 2, 1968.
 - b. "Construction Details and Measurements of Response of a Gas Density Balance" by Creitz, Journal of Chromotagraphic Science, Vol. 7, March 1969. (Also repeated in Journal of Research NBS, Vol. 72C, No. 3 under "Gas Density Balance Design Considerations".
 - c. "A System for Continuously Monitoring Hydrogen Chloride Concentration in Gaseous Mixtures Using a Chloride Ion Selective Electrode" by T. G. Lee, Analytical Chemistry, Vol. 51, February 1969.

Project No. and Title: 4219652 - Smoke Measurement Methods (UL)

Project Leader: G. T. Castino

OA Funds Expended: \$1.9K

Summary of Output:

The research associate program for UL was conducted very successfully. Mr. Castino worked on the development of the smoke box chamber bringing it up to a point where it would be suitable for commercial production. He investigated several variations in testing procedures and suggested modifications to the test apparatus.

NBS Report No. 9914, "Selected Bibliography on Smoke Measurement, Characterization, and Related Subjects" by G. T. Castino was prepared. PROJECT SUMMARIES FY 1969

Materials Durability and Analysis Section (421.04)

Project Number and Title: 4212247, Simulated External Environmental Changes of Roof Assemblies

Project Leader: Thomas H. Boone

Funds Spent FY 69: \$35,556

Summary of Output:

A publication, NBS Technical Note 473, "Laboratory-Field Comparison of Built-Up Roofing Membranes", by Thomas H. Boone, Leopold F. Skoda and William C. Cullen was issued December 1968. In this publication the values of breaking load, elongation and thermal expansion of nine different types of bituminous built-up membranes prepared by roofing contractors under field conditions and by technicians in the laboratory, were measured at sub-freezing temperature. The data reported indicated that the fieldprepared specimens agreed favorably with the laboratory-prepared specimens, although the samples from the field frequently reflected higher values for thermal-shock resistance than did their laboratory-prepared counterparts. The higher values were attributed to the smaller amounts of bitumen used between the plies of the field specimens. The results appeared to support the validity of the application of the "strength-thickness rule" to bituminous built-up membranes.

A two-day symposium on Roofing Technology, in cooperation with the National Roofing Contractors' Association, was held at NBS. Three of the ten technical papers were presented by BRD staff:

"Conclusions based on Research	and Experience"
	by Thomas H. Boone
"A Basic Material-Asphalt"	by Max Tryon
"Summary of the Symposium"	by William C. Cullen

The program, designed to provide an opportunity for a constructive exchange of ideas and information on roofing technology as presented by the researcher, consumer, specifier and contractor, was attended by 239 persons.

This project is designed to help alleviate, through research and information exchange, the high maintenance, repair and replacement cost of roofing. For example, one Government Agency, the General Services Administration, had an outlay of \$13,463,197.00 on roof repair from March 1968 to March 1969, involving 30% of the buildings under their jurisdiction. Eighty per cent of these roofs were less than 20 years old. The basic understanding of the causes of the above premature failures, such as thermal movement, moisture migration and roof slippage under this project has led to a replacement criterion with freedom from unnecessary over-design and from the sorrows of under-design.

Project Number and Title: 4212270, Atmospheric Corrosion of Metallic Composites

Project Leader: Joseph W. Pitts

Funds Spent FY 69: \$32,118

Summary of Output:

Further tests were devised and carried out in the environmental test chamber designed to simulate and accelerate natural outdoor weathering of metals. The effects of very high concentrations of sulfur dioxide (up to 400 ppm SO_2) and of the time of exposure to these high concentrations on the corrosion of aluminum-coated steels were determined. Also, studies were conducted of the effect of time of wetness on the corrosion of uncoated mild steel.

The laboratory evaluations of the aluminum-coated steels were completed and NBS Report No. 9937 was issued under the title of "Final Report on Evaluation of the Weathering Characteristics of the Type 2 Aluminized Steels". This report also included initial information and activity on the placement of these materials on outdoor exposure at the six NBS Exposure Sites. The results of the laboratory evaluations indicated that the steel coated with commercially-pure aluminum should out-perform the steel coated with the aluminum-silicon alloy; however, the general conclusion reached was that the major difference in the laboratory results can probably be attributed to differences in coating application techniques rather than to the difference in coating composition.

Two additional laboratory tests of these materials were initiated: one is a determination of the corrosive effect of ozone in the atmosphere and of sulfur dioxide plus ozone, both in 100% relative humidity. It has been found that ozone alone has no deleterious effect on these materials. The second test is a cyclic water vapor condensation exposure test; preliminary results confirm the apparent superiority of the aluminum coating over the aluminum-silicon coating.

Several of the major steel companies followed the progress of the aluminized steel evaluation with considerable interest. One company, which heretofore was producing only the Type 1, has recently gone into production of the aluminum-coated Type 2 and is believed to have been influenced in its decision by the NBS evaluation.

Project Number and Title: 4212272, Test Methods for Coating Systems

Project Leader: Paul G. Campbell

Funds Spent FY 69: \$48,503

Summary of Output:

Cooperative studies with ASTM Committee D-1 relating to test method development were continued. These investigations included accelerated weathering, soil removal, hail damage, and brushability tests. Cooperation with ASTM programs enables us to maintain and improve BRD competence in test method development.

The method of styrene-acrylate resin analysis previously developed, has been incorporated into the Federal Specification TT-P-1181a. An infrared method for the analysis of vinyl toluene-butadiene resin has been developed, and the method is currently being tested on proprietary materials containing this resin. The proposed specification for a deep tone latex-base paint also includes a modified storage stability test. The importance of the continuing need for the development of analytical methods is evidenced by the fact that this work is also supported by the tri-service paint project.

The paper "The Determination of Styrene-Butadiene and Styrene-Acrylate Resins in Solvent Type Paint" based upon test methods developed, has been given conditional acceptance in J. Paint Technology.

Project Number and Title: 4212273, Field and Laboratory Investigation of Floor Assemblies

Project Leader: Winthrop C. Wolfe

Funds Spent FY 69: \$23,617

Summary of Output:

The BRD staff continued to exchange information with manufacturers, industry groups and standards making bodies such as ASTM, USASI, Canadian Government Specifications Board, and British Standards Institute. The staff also participate in ASTM Committees C-3; D-13; and F-6 on resilient flooring, of which Mr. Boone is chairman. Mr. Wolfe is active in Task Group F-6.33, Abrasion Resistance, Mr. Wolfe and Mr. Skoda presented talks at the ASTM Annual Meeting, Atlantic City, June 22-27, 1969 during the Symposium on Simulated Service and Performance Tests for Floor Coverings. In the talks an account was given of work on resistance of floor coverings to wheeled vehicles and resilience as related to foot comfort, factors for which the staff developed performance tests. Mr. Cullen also reported on this work at the First Conference on Performance of Buildings, "Man and His Shelter" at the National Bureau of Standards, Sept. 23-25, 1968.

Observations of wear test machines in industrial laboratories showed that this field is active and new methods are under development. Research during FY 1969 at BRD indicates promise of developing correlation between laboratory wear tests and service. This may be possible by making slight modifications in existing equipment. Floor coverings tested were those well known to have poor, fair, good, or excellent wearing characteristics. Experiments with new types of wearing wheels and with wheels which have been used for other applications indicate that it may be possible to test all types of floor coverings on the same machine. Carpets, so-called "resilient floor coverings", and monolithic surfacings have all been tested on the Taber abraser and the NBS Traffic Paint Tester. The NBS Carpet Wear Tester, inactive for a number of years, was rehabilitated for the testing program. The machine had been used successfully to test wool carpets but test experts had not found it applicable to synthetics. However, the BRD has received reports from industrial testing laboratories that this machine can be used to evaluate carpets made of man-made fibers.

Screening tests for flammability and flame spread were performed on carpet samples to ensure safety in test installations. One of the test methods used was the standard pill test as in Federal Specification DDD-C-95 and NBS Report 8622, January 15, 1965. The other method was available at BRD as it had been used to evaluate asphalt roofing. The asphalt roofing method was a modification of that described in Underwriters Laboratories VL790, September 1958. Mr. Greenfeld of the Fabric Flammability Section is continuing work on the pill test and Underwriters Laboratories has developed a further modification of the VL test method for carpets.

Project Number and Title: 4212279, Definition and Measurement of Elements of Outdoor Environment

Project Leader: Warren D. Hayes, Jr.

Junds Spent FY 69: \$35,176

Summary of Output:

Several weaknesses in the calibration technique for irradiance measuring devices have been eliminated. The <u>scattered light reduction</u> so essential for sensors with nearly hemispherical viewing was accomplished by an enclosure for the sensor which restricts its view to very nearly the calibrating source. Furthermore, the sensor being calibrated is checked at a light level some fraction below the calibration level using the inverse square relationship of distance to intensity to insure linearity at the calibration level. The appropriate current meter was borrowed to provide the necessary accuracy of current setting for the standard source.

Certain applications of the battery portable U-V light-time integrator required increased sensitivity and therefore it was redesigned to provide for two ranges of measurement--(0 - 2) and (0 - 20) milliwatts per square centimeter. A small panel meter was also included in the redesign to provide for readout of the irradiance level. Errors caused by sensitivity to temperature changes continue to be a problem, but these were cut in half by a circuit modification.

Arrangements were made with Dr. Kusuda (421.11) to receive data from his weather station near our N.B.S. exposure site. An ultra violet light sensor was incorporated into his weather station.

Arrangements with Mr. Richard of the USAF Environmental Technical Applications Center were begun for the receipt of standard weather information for the military bases on which we have exposure sites. He has expressed interest in tabulating information on certain elements of outdoor environments not presently measured at weather stations. Hopefully, he will be influential in having sensors for these elements, perhaps developed and supplied by us, added to the weather stations from which he gets his data.

Project Number and Title: 4212413, Building Joint Sealants

Project Leader: Arthur Hockman

Funda Spent FY 69: \$19,440

Summary of Output:

The accomplishments of the Building Join Sealants research program are summarized as follows:

(1) Quarterly reports covering the progress of the joint sealant study were submitted to the Tri-Service Committee on Engineering Investigations. Interim special reports were made to the committee by telephone and letter.

(2) Revised, upgraded versions of Interim General Specifications TT-S-00230b and TT-S-00227d covering single and multi-component elastomeric sealants have been issued by the GSA. All performance requirements and standard test procedures described in the specifications were based on laboratory studies made at NBS as well as on field observations and consultations with producers, architects and other interested groups. The revised specifications are unique in having performance requirements which include both extension and compression at -15°F and 158°F respectively in an automatic cycling procedure. As a result of the new requirements, sealant and polymer producers are being motivated to improve the performance characteristics of their old commercial formulations.

(3) A series of studies in the mechanism of joint sealant degradation by UV radiation has been started with the ultimate goal of developing a standard test procedure for this effect. Studies completed on 50 samples using a carbon arc weatherometer, with and without water spray but with continuous UV radiation, resulted in severe and unrealistic effects after 1400 hours exposure when compared with natural exposure of 55 similar samples over a 4 year period. Preparation has been made to include a 6 hour dark period (no light and water) in each 24 hour cycle for further study along this line.

(4) A final draft of a manuscript titled "Guide to Joint Sealants for Concrete Structures" was completed by the ACI Technical Committee 504 (A. Hockman, member). The target date for this comprehensive publication in the ACI Journal is late 1969 (5) With the cooperation of the National Paint, Varnish and Lacquer Association, NBS has completed laboratory studies for the drafting of a new Federal Specification covering 1 part solvent release elastomeric compound. These sealants, which include butyl rubber formulations, require no primer and can perform well in a joint with limited movement, especially in metal panel structures.

(6) Meetings, conferences and symposiums are attended and roundrobin studies participated in with ASTM, NPVLA, Adhesives and Sealants Council, Joint Sealants Coordination Conference, Society of the Plastics Industries and others.

Two ASTM standards on sealants, based on NBS laboratory studies, have been issued: C603-69 (Extrusion Rate and Application Life);
C639-69 (Rheological Properties).

(8) The Department of Defense utilizes the technical data submitted to them in the quarterly reports by including such information in Military Technical Manuals.

(9) A most important aspect of the Bureau's work on sealants is the guidance it offers the architect in selecting a proper sealant for a specific job through unbiased channels, i.e. Federal Purchase Specifications or ASTM Standard Test Methods or Specifications.

Project Number and Title: 4212441, Characteristics of Protective Coating Systems

Project Leader: Paul G. Campbell

Funds Spent FY 69: \$15,630

Summary of Output:

Continued emphasis was placed on the tri-service manual "Paints and Protective Coatings" which is now in print. The manual is in military distribution and is also available through GPO. Publicity announcements were prepared, and letters of appreciation were sent to the contributors. The manual will provide the military with a uniform and comprehensive guide for original and maintenance painting. It is expected that this text may also serve as a standard reference for painting in industry.

The following Federal specifications were published with revisions to include several analytical methods prepared jointly under this project and under project 4212272:

TT-P-97d Paint, Styrene-butadiene Solvent Type, White (For Exterior Masonry) TT-P-1181a Paint, Styrene-acrylate Solvent Type, Tints and Deep Tones (For Exterior Masonry)

A proposed specification for a latex-base, interior, flat, deep-tone paint has been submitted to GSA.

Field tests of exposure panels, coated with a silicone-alkyd enamel were continued at the six NBS exposure sites. Also exposure panels painted with stainless steel paints, and silico chromate paints are being field tested. This is part of a program to test newer paint formulations to meet the changing needs of the military.

Field tests of six exterior house paints on converted barracks and Capehart houses were continued at Ft. Meade. Inspections were made and observations recorded on a quarterly basis. At the end of 48 months all paints were performing adequately.

Consultative and advisory services were provided as requested by the sponsors.

Project Number and Title: 4212447, Performance of Roofing

Project Leader: Thomas H. Boone

Funds Spent FY 69: \$15,318

Summary of Output:

For the purpose of evaluating the performance of 3-and-4-ply asbestos felt built-up roofs a field survey of 26 roofs ranging in age from 6 to 42 years was made in 9 cities in 3 different climatic regions of the country. In addition, laboratory investigations were made on the cut-outs taken from the roofs inspected. Physical tests such as breaking load, elongation, and linear thermal expansion of specimens prepared from the roof cut-outs were performed. The cut-outs were also examined for composition, condition of bitumen between plies, thickness of bitumen between plies, and weight. NBS Report 9992, issued 7 February 1969, "Report on the Performance of Asbestos Fiber-Base Built-Up Roofs", was submitted to the sponsors and covered the procedures of the research, data obtained, and the following significant conclusions: (1) Satisfactory field performance was obtained from this type of roof.

(2) The advantage of top coatings was questionable.

(3) There was no evidence to indicate difference in performance based on regional climatic conditions.

(4) The examination of the built-up roof cut-out membranes indicated that the between-ply moppings of bitumen were generally less than specified by currently promulgated roofing specifications.

Consultative and advisory services were provided to the sponsors on serious roofing problems which occurred on various Military Installations. For example, on-site investigations were made at: White Sands Missile Range, New Mexico; Holloman Air Force Base, New Mexico; Fort Bliss, Texas; Military Ocean Terminal, Bayonne, N. J.; Military Traffic Management and Terminal Service, Brooklyn, N. Y.; Hanscom Field, Bedford, Massachusetts; Fort Wainwright, Alaska; Missile Early Warning Site, Clear, Alaska. Reports on the findings and recommended treatment, repair or replacement were submitted to the sponsors for each case.

This specific program on the performance of built-up roofing as investigated in the laboratory and in the field has led to the process of a standard, yet competitive roof design, by seven construction agencies of the Federal Government in the form of a Prototype Guide Specification. The benefits will be fewer construction failures, clearer presentation, fewer types of construction and, most important, improved interchange of information between construction agencies.

Project Number and Title: 4212448, Performance of Flooring

Project Leader: Winthrop C. Wolfe

Funds Spent FY 69: \$10,096

Summary of Output:

The study released to the DOD as NBS Report 9806 was published in November 1968 issue of FLOORING magazine. Over 200 reprints were sent in response to request: from architects, government agencies, manufacturers, flooring contractors, research laboratories, standards institutions, universities, consumers' magazine and trade journals in the United States and 17 foreign countries.

A simple test was devised to measure penetration of fats and oils into concrete floors, as in military kitchens and meat packing plants. In this test, the test panel or floor is cored or chipped to a depth of 1/4 to 1/2 inch; the core immersed or the chipped out hole treated with aqueous dye solution; then the core or hole flushed with water. The dye adheres to and colors the uncontaminat concrete but the oily or greasy portion remains gray. This test was applied to test cement mortar panels previously contaminated with fats and oils to determin how much penetration is likely in practice. The test was also applied to concrete floors in mess hall kitchens in local Army posts. Oil can penetrate test panels up to 3/8 inch and concrete floors were found to be contaminated at depths varying from 1/32 to about 1/4 inch. This test would be useful in determining how much scarifying would be necessary to obtain a clean surface for topping.

Laboratory work at BRD shows that contaminated floors may be topped successfull by using a barrier film. The most promising barrier is a composite sheet with polyethylene, aluminum foil, and kraft paper, laminated together. The BRD research staff placed this sheet material on contaminated concrete slabs, using asphalt cutback adhesive. The adhesive was a commercial product used to cement asphalt and vinyl asbestos tile. The polyethylene side of the composite sheet was rolled over the tacky asphalt cut-back adhesive. Epoxy and polyester trowel-on monolithic surfacings were applied to the kraft paper side of the composite sheet after it was placed on the concrete slab. The system appears promising and bond tests are being performed to determine adhesion.

No. 4212448

The effect of heat or temperature gradient has been cited as a possible cause of failure of monolithic surfacings in military kitchens. Using a portable pyrometer and thermocouple, temperature measurements were performed under ranges, bake ovens, grille, and hot water heaters at Fort Belvoir, Virginia and Fort George G. Meade, Maryland. The highest temperature observed was 145°F under one of the hot water heaters. This indicates what temperatures are likely to be encountered in service. The Shell Chemical Company told the BRD staff that theirTechnical Center uses a laboratory test, whereby a test panel is heated with a heat lamp in 60 seconds to a surface temperature of 140°F; then the panel is immersed in water at room temperature. Research on effect of heat on monolithic surfacings and a test for the same is under way at BRD.

A number of monolithic surfacings have been applied to cement mortar panels prepared in the BRD laboratories. These specimens are being used for various tests, including wear or abrasion tests. In our wear tests we have used the Taber abraser with special wheels. These wheels have been used by Mr. Hockman in his work on abrasion resistance of natural stone. The wheels are relatively inexpensive, so that a wheel can be used for one specimen only, then discarded. Also the wheels are comparatively "self-cleaning", so that "loading" or clogging is minimized.

One of the monolithic surfacings which has been studied in the laboratory is an acrylic decorative type of coating. This is also being evaluated under service conditions in a corridor of a barracks at Fort George G. Meade, Maryland. This type of laboratory-service test is an example of how BRD is trying to relate laboratory tests to actual service.

Project Number and Title: 4212654, Test Development and Adherence Studies of Porcelain Enamel (Porcelain Enamel Institute Research Associates)

Project Leader: Milton D. Burdick

Man Years: 3

Summary of Output:

A test method was developed to determine the cleanability of porcelain enamel and organic surfaces. The test procedure involves applying a given amount of a water soluble soil to the surface being tested, removing most of the soil by a "film-thinning" process, and measuring the soil retained on the specimen surface by a sensitive fluorescent tracer method. This test method was found to be sensitive to changes in relative humidity so cleaning tissues and specimens must be "conditioned" in a constant humidity chamber before testing.

A scratch-abrasion test was developed. This test consists of abrading the specimen with silicon carbide paper and measuring the change in cleanability before and after abrasion. This method was found to produce abrasion qualitatively similar to that found in service.

The work on the development of a test for continuity of porcelain enamel coatings has been completed. The test method and a paper describing its development have been submitted for publication.

The three year inspection of enamels exposed in the 1964 Exposure Test of Porcelain Enamels on Aluminum has been completed. An accelerated test has been developed which appears to predict the weatherability of the enamels exposed at the most severe site better than the boiling acid solubility test which is currently used.

The research project to determine the mechanism of adherence of porcelain enamel to aluminum experienced significant advances in identifying by electron microscopy and microprobe analysis the microconstituents occurring at the enamel-metal interface. A paper describing some of this work has been accepted for publication by the American Ceramic Society.

The following NBS reports were issued by the P.E.I. Research Associates during FY 69: NBS Reports No. 9944, 9965, 9980, 10012, 10031, 10050 and 10075.

Project Number and Title: 4213418, Roofing Failure - Cedar Rapids, Iowa

Project Leader: William C. Cullen

Funds Spent FY 69: \$2,423

Summary of Output:

Investigation of roofing failure on Post Office Building at Cedar Rapids, Iowa was made on March 12, 13, 1969. Laboratory investigation of roof sample was also conducted. Findings and recommendations based on field and laboratory tests were submitted to Post Office Department on April 3, 1969.

An on-site investigation of a roofing system was conducted at the new Post Office Facility, Oakland, California on June 17-19, 1969. Laboratory tests were made on samples of roofing obtained during inspections. A report giving findings and recommendations was submitted to the Post Office Department on July 3, 1969.

Project Number and Title: 4215104, Consultative and Advisory Services

Project Leader: William C. Cullen

Funds Spent FY 69: \$25,492

Summary of Output:

The main effort in this project was directed toward providing consultative and advisory services to those in both the private and public sectors who require technical assistance in the areas of paints, plastics, sealants, metals, etc. used in buildings and in the performance of foundation, flooring, siding and roofing. The technical services were provided via telephone communications, letters, visits to NBS laboratories and in some cases by on-site inspections and actual laboratory work. Specifically members of the professional staff gave others the benefit of their expertise by answering about 350 letter requests, over 1000 telephone requests and by entertaining over 200 visitors during FY 1969. The services were subscribed to by representatives of many levels of the economy from the housewife concerned with paint or flooring problems in her home to a Congressional Committee concerned with the quality of cement used in Indonesia.

Federal, state and local governments were recipients of technical services provided under the project as reflected by requests for assistance in the preparation and review of specifications, standards and codes. Further assistance was provided in the solution of specific problems relating to the performance of materials in buildings.

The private sector was served to a large degree by the participation of the professional staff in professional and technical societies and in manufacturing and trade associations. These activities afford the opportunity to exchange information.

Section personnel participated in the activities of 16 trade, professional and technical societies during FY 1969.

Project Number and Title: 4215629, Miscellaneous Testing

Project Leader: Paul G. Campbell

Funds Spent FY 69: \$25,297

Summary of Output:

Acceptance tests were performed on a total of 139 samples of paint and related materials to determine compliance with Federal, Military, Technical Society, and other specifications. During the same period, tests were reported on 9 samples of sealants and caulking compounds. Also, vapor permeability and thermal conductivity tests were performed on 12 samples of foamed insulated materials.

Government agencies for which the tests were conducted included the District of Columbia Department of Highways and Traffic, Mississippi Department of Highways, Maritime Administration, General Services Administration, NAVFAC, and the Corps of Engineers.

Test reports were prepared on all the samples submitted. The reports served the function of informing the agencies of the quality of the materials examined and also provided consultative and advisory services supported by laboratory data. It also provided our staff with the opportunity to maintain and improve competence in chemical and physical test methods, and to assess the adequacy of these methods.

Project Number and Title: 4216201, Evaluative Techniques for Plastics, Bitumens and Sealants

Project Leader: V. E. Gray

Funds Spent FY 69: \$49,371

Summary of Output:

Evaluative techniques to predict the relative performance of plastics and bitumens are being developed.

1. Plastics

The use of sulfur dioxide to accelerate degradative changes in vinyl materials was described in NBS 9922 (issued 9-18-69). This research was presented to the Steering Committee of the Manufacturing Chemists' Association Weatherability Project. This technique appears useful to formulators of vinyls and other plastics which may be sensitive to moisture

The development of valid laboratory tests for the durability of plastics is being examined. The degradation of plastics exposed in laboratory weathering devices is accelerated by moisture. Tests are being run at high moisture levels for prolonged periodsto produce, hopefully, the surface effects normally observed in outdoor exposure.

2. Bitumens

Two techniques being used for characterization of asphalts and pitches:

a) A study of the temperature-viscosity relationship for a wide range of asphalts and roofing pitches has been completed and the results reported in a talk before the 1st National Roofing Manufacturers¹ Conference held at the National Bureau of Standards. The idea of the use of bulk viscosity data such as reported here in addition to penetration index and softening point as a desirable parameter in specifying roofing asphalts was generally well accepted.

The same technique for viscosity measurement was applied in a preliminary study of the effect of pot temperature and heating time on the properties of roofing asphalts. This study was reported to the Research Committee of the Asphalt Roofing Manufacturers! Association.

b) A new technique is being used to study the photodegradation ratio of bitumens. This involves the use of gas chromatography to measure oxygen consumption and the concomitant carbon dioxide generation during light exposure. This method offers promise for evaluating the oxidative stability of many organic plastics, bitumens and sealants.

Project Number and Title: 4216202, Correlation of Simulated and Actual Exposure of Building Materials

Project Leader: Joseph W. Pitts

Funds Spent FY 69: \$15,854

Summary of Output:

A control system was developed for visually showing and maintaining an accurate check on the locations and types of materials exposed on each rack at each site at all times. The basis of the system is a series of status charts on which color-coded magnets show the exact position on each rack of every specimen or group of specimens on exposure. Cards attached to the charts give complete descriptions and identifications of the materials. The system was designed to maintain continuity of longtime testing, independent of personnel changes.

Installation of the exposure racks at Fort Greely, Alaska was completed and materials were later placed on exposure when a member of the section visited the site. Visits were made, also, to two of the other remote sites: Fort Lewis, Washington, and Roosevelt Roads Naval Station, Puerto Rico.

An article describing the six test sites was published in the June issue of the NBS Technical News Bulletin; a poster featuring the test sites was prepared and displayed in the lobby of the Building Research Building; and letters of appreciation were sent to the commanding officers of the military installations where test sites are located. The publicity regarding the test sites generated considerable interest among outside groups, including two foreign organizations.

The exposure site at Gaithersburg was used by the Electroplating Section to study the weathering of plated electrical contacts and has resulted in a research paper on the subject.

<u>Project Number and Title</u>: 4216415, The Effects of Atmospheric Contaminents on the Durability of Building Materials

Project Leader: V. E. Gray

Funds Spent FY 69: \$27,311

Summary of Output:

Studies have been mainly concerned with measurement of the effects of ozone (at 0.5 ppm level) on the photo degradation of paints and plastics.

Weathering devices were modified to permit the introduction of gaseous air contaminants directly into the machine without polluting the room or building air supply. Experiments showed that levels of ozone and sulfur dioxide could be maintained within plus or minus 10% of their nominal values of 0.5 and 2.0 ppm, respectively.

When materials were exposed to continuous light in these devices at 0.5 ppm ozone level (85% R.H. and 90°F), only vinyl and acrylic-latex paints were found to be slightly sensitive to ozone. If an intermittent light cycle with 100% R.H. during the dark cycle was used, ozone appeared to affect all paints and some plastics.

In a cooperative program with the Public Health Service, a first step was taken to establish relative levels of air contamination at the six NBS exposure sites. Air pollution "effects packages" have been placed at the Gaithersburg and Ft. Holabird sites. These have been designated as stations 272 and 273 in the air surveillance network of National Air Pollution Control Administration.

Project Number and Title: 4216416, Performance of Exterior Siding

Project Leader: L F. Skoda

Funds Spent FY 69: \$23,155

Summary of Output:

A need for research of high maintenance cost items, i.e. exterior siding, was established by the Naval Facilities Engineering Command. A questionnaire was devised in order to determine what materials posed the greatest maintenance problems for naval housing maintenance personnel. Questionnaires were sent to seventy-four Naval Bases in thirteen Naval Divisions. Seventy-two questionnaires were returned and a tabulation of the results indicated the following distribution of materials used in family housing units: masonry 50%; wood products 29%; cement asbestos 17%; aluminum and steel 4%. The problem areas seem to be the wood products and the cement asbestos. Personal preference of materials indicated by respondents to the questionnaire were: masonry 40%; aluminum 21%; no preference 21%; cement asbestos 12%; other materials 6%.

The following industry groups have been contacted to get information on manufacturers of siding materials.

American Plywood Association Aluminum Association Aluminum Siding Association Society of Plastics Institute

From information received from these associations and other sources, manufacturers have been contacted for information, specifications and sources of supply of their products. The manufacturers contacted are too numerous to list at this time (approximately 25-30) but include those that produce base materials of steel, aluminum, wood and vinyl plastics.

The outdoor weathering phase of the study has been initiated and exposure samples have been prepared and installed at four of our six weathering sites. The exposure samples consist of painted exterior plywood, approximately 2x3 feet in size with the siding materials under test applied to both sides. The samples face north and south at an angle of 90° with the horizontal. At present materials from 5 different manufacturers are being exposed at the following sites: Ft. Greely, Alaska,; Ft. Lewis, Washington; Ft. Holabird, Maryland; and at NBS, Gaithersburg. The artificial weathering phase of the study has been initiated on companion samples of those materials that have been exposed at the outdoor weathering sites. The artificial weathering test consists of a minimum of 1000 hours exposure in a carbon arc weatherometer. Gloss and color measurements were taken prior to the beginning of the test. These measurements will be made periodically throughout the exposure test to determine changes that may take place.

Additional lab tests are being devised and will be performed on the siding materials available to further evaluate them from a maintenance standpoint. The aim of this research project is to establish a ratio of initial cost in dollars, to maintenance free service in years, for materials or systems of materials that are presently available. This kind of information should be of great economic value to the sponsors of the project.

Project Number and Title: 4216421, Laboratory Evaluation of Sandwich Wall Panels

Project Leader: V. E. Gray

Funds Spent FY 69: \$ 932.00

Summary of Output:

This project was a part of the evaluation of the NAVFEC relocatable building. A comparative evaluation of similar sandwich panels from three different manufacturers was made by subjecting specimens to the aging tests as described in ASTM procedure C-481. This involved temperature and humidity cycling of -40° F to $+160^{\circ}$ F with wet to dry conditions.

A survey was made of possible plastic materials to replace the aluminum extrusions used for connecting hardware and weatherproofing. Three candidate materials meet the heat deflection temperature requirements and were suggested for consideration and testing of physical properties.

Project Number and Title: 4216640, Weatherability of Plastics (MCA)

Project Leader: Dr. Joseph E. Clark

<u>Man Years:</u> 3

Summary of Output:

The Research Associates have accomplished intermediate goals set for the research program:

- a) <u>weather factors</u> important in outdoor deterioration of plastics have been pinpointed, and some of their interactions studied;
- b) a <u>new device</u> has been constructed and modified for rapidly testing the effects on plastics of air pollutants and other weather factors, and its correlation to outdoors established;
- c) tentative <u>recommendations</u> have been made for the most effective types of accelerated weathering tests;
- d) <u>prediction and correlation</u> of weatherability in various climates has been put on a quantitative basis via mathematic models.

Details of these developments have been circulated to the sponsoring companies on the MCA Plastics Committee in the form of NBS Reports:

#9961 - "Evaluation of the Brucksch Controlled-Atmosphere Weathering Device"

#9912 - "Outdoor Performance of Plastics I. Introduction & Color-Change"

#10014- "Outdoor Performance of Plastics II. Tensile & Flexural Properties"

Improvement and continued modification of the following 3 ASTM Recommended Practices concerning laboratory-weathering tests resulted directly from the studies: ASTM #-239, E-188, and E-240.

An outdoor exposure program has been in progress for three years for six classes of plastics at Washington, Miami and Phoenix. Appearance, physical and "earlydetection" properties of the weathered plastics are measured periodically at the NBS and member company laboratories. These computerized data provide the broadest background ever assembled as a base of comparison for accelerated tests. A series of reports is being issued on these data and their analysis. PROJECT SUMMARIES FY 1969

Codes and Standards Section (421.05)

Project 4211152 - National Conference of States on Building Codes and Standards

Project Leader: Gene A. Rowland \$70,313

The interest of the states and their participation has reflected continued growth in this program area. The highlight of the year's activity was the Annual Meeting in April with 36 states, Puerto Rico and the District of Columbia in attendance. Delegates representing the states present, reflected over 80 percent of the national population. It also consisted of 7 states which had not been represented at previous meetings of the Conference. A final Constitution and Bylaws was unanamiously approved. The Executive Committee had been assigned by the previous Conference to review and suggest such questions as necessary in order that a final document could be presented in the April meeting. The Executive Committee, along with the Secretary here at the Bureau, spent considerable time in rewriting the document, circulating it to all the states prior to the Annual Meeting. The Conference at its Annual Meeting established registration fees which created a treasury of ample amount to carry on an increased program participation by the Executive Committee and the respective Committee Chairmen. As of the completion of this fiscal year, the newly elected officers had met once and the Standing Committee on Standards and Evaluations had been reorganized and had met. The latter had developed several resolutions which are to be presented to the next Executive Committee meeting. A participation of the Building Research Division was in the assistance of the organization of the Annual Conference and the several meetings held before and after, as well as the dissemination of information including that sent to the membership as requested by the officers.

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Project 4211154 - Agrément Project Leader: B. E. Foster \$30,741

A paper on "European Systems for Evaluation and Approval of Innovations in Buildings" was presented at the Conference "Man and His Shelter-Performance of Buildings" held at NBS September 22-25, 1968. The written version of the talk has been cleared by the editorial process for publication and will be a part of the proceedings of the Conference.

A paper on the same general subject was given before the 2nd Annual Conference of the National Conference of States on Building Codes and Standards, held April 27-30, 1969, in Hollywood, Florida.

A written report entitled "European Systems and Their Potential Application in the United States" was prepared in contrast with previous talks and publications on this subject. This report discusses the potential application of the Agrément concept to the needs of the building industry in the United States.
Project 4211155 - Precoordination of Building Component Systems

Project Leader: Russell W. Smith \$18,769

During FY 1969 this project completed the technical analysis necessary to formulate a basic program of standardization on which to base the industrialization of the bui[ding industry.

The first phase of dimensional standardization has been completed and recommendations submitted to industry and accepted as USA Standards. These include A62.5 and A62.7, Basis for Horizontal, and Basis for Vertical, Dimensioning, respectively.

The first phase of functional standardization has also been completed with the acceptance of A62.6, Classification of Properties and Performances, as a USA Standard. This Standard is fundamental to a uniform approach to implementation of the performance concept including agrement.

The anticipated economic impact of these three standards on the U.S. building industry is conservatively estimated to be in the range of 2 to 5 percent of construction cost, or between 1-1/2 to 4 billion dollars per year.

Project 4211156 - Technical Assistance to States Project Leader: Gene A. Rowland \$3,046

This activity is a new activity of the Building Research Division. Through this activity the cost of the Building Research Division response to technical requests from the states will be handled. To date, this Section has developed a technical assistance request and an in-house report control. The Section had also developed a questionnaire to be sent to the entire staff of the Building Research Division to establish both the technical and practical experience of the staff in order to better reflect the overall ability of the Division in response to requests. The funds of this program will start with dispensing relief in substitute responding to the requests by respective technical sections. Since the number of requests and the procedures for handling the requests were very insignificant in Fiscal 69, the funds used from this program were very small.

Project 4211157 - Uniform Code Language Project Leader: Gene A. Rowland \$3,360

The activities in the Uniform Code Language were in two areas of cooperation. One in the cooperation of the Model Code Standardization Council, an organization encompassing three of the Model Code groups, aimed at bringing about more uniformity in the definitions used in the respective codes. Such information will be used by the Building Research Division in advancing the use of uniform, computerized code language for the future needs of the National Conference of States. The activities of the Standing Committee on Computer Technology of the National Conference of States will be funded from this activity. Such information will be published by this Section, as developed, as a series of uniform code language documents for use by the National Conference of States on Building Codes and Standards and other interested groups. To date, no publications have been issued with regards to this activity.

Project 4212151 - Standard and Model Codes Project Leader: Gene A. Rowland \$72,948

The output of this project can be classified into two general catagories; one, codes and two, standards. Each of these areas can be classified into administrative support of codes or standards writing organizations, technical input to standards or code writing organizations, assistance to other federal agencies or countries in preparing codes and standards, and a consulting and advisory activity directly related to codes and standards requests.

In the standards area, the Section has participated as members of the Executive Committee of the Safety Standards Board and the Executive Committe of the Construction Standards Board of the United States of America Standards Institute. The Section personnel have also participated in individual standards activities with committees and sub-committees of ASTM and USASI standards. Of particular interest in this area was the National Electrical Safety Code. Standards documents produced by the respective standards committees are of a sizable nature, and are available through the Section's standards program. Code activity in this particular project area has been fairly minimum except for participation in what is commonly known as the Model Codes Standardization Council. This activity includes participation by Section personnel in the annual meetings of the several model codes groups.

Project 4212250 - Metric

Project Leader: Russell W. Smith \$18,750

This project was initiated in mid-FY 69 to implement PL90-472 relative to the construction industry. During this period, initial study was completed and a general plan for the conduct of the study developed.

Specific tasks were identified, an operational plan evolved and a schedule for completion prepared. In addition, liaison was established with industry, professional and labor groups of the construction industry in England and Canada, as well as the U.S.

Based on the experience of the United Kingdom in its conversion to Metric, the impact of Metric conversion on the U.S. Building Industry could result in an increased productivity measured in the billions of dollars per year. This project will attempt to develop the optimum response of the U.S. construction industry to Metric, relative to potential benefits. Project 4212451 - Cement and Concrete Reference Laboratory Project Leader: J. R. Dise Man Years: 9

During the fiscal year, 223 laboratories were inspected by the Cement and Concrete Reference Laboratory, and these were about equally divided between cement and concrete testing laboratories. The laboratories visited were located throughout 29 states of the United States, 5 provinces in Canada, Puerto Rico, and Grand Bahama. A total of 793 copies of reports covering these inspections were distributed to authorized recipients. In addition, 87 samples of the CCRL flow table material were requested from various laboratories, and two pairs of cement reference samples were distributed to about 145 laboratories. The data obtained from the reference samples enabled participants to assess their own laboratory operation, and it provided valuable information to several ASTM subcommittees which received copies of the data.

In August 1968, the CCRL completed its 16th Inspection Tour and started the 17th Tour. With the start of the 17th Tour, the inspection coverage was expanded to include facilities for the testing of aggregates, (other than in the central laboratories of State Highway Departments which are covered by the AMRL). Plans to further expand the inspection coverage to include facilities for the testing of structural steel are actively being developed.

The continued effort to increase the number of industrial sponsors of the CCRL has resulted in two additions -- The Chicago Fly Ash Company and the National Slag Association. This brings the total list of active sponsors from 15 to 17.

The manager of the CCRL served as the technical assistant (Technical Secretary) for ASTM Committee C-1 on Cement, as well as chairman of the Subcommittee on Coordination of Methods of Test.

The revised text of NBS Monograph No. 28, Causes of Variation in Chemical Analyses and Physical Tests of Portland Cement, has been published as Building Science Series 17.

A paper on "Precision of Air Permeability", Wagner Turbidimeter, and No. 325 Sieve Data from Interlaboratory Testing Program" by H. T. Arni, has been approved for publication. Projects 4212457 - 4212458 - 4212459 - AASHO Materials Reference Laboratory

Costs: <u>\$ 48,377</u>,

<u>\$ 22,432</u>, and

\$225,256 respectively

The laboratory staff carried out inspections at 49 laboratories operated by the State Highway Departments, the Bureau of Public Roads, and the U. S. Forest Service. There are now 60 laboratories in the program. Two pairs of asphalts, two pairs of soils, and two pairs of aggregate reference samples were distributed. Thirty-six months after the activation date the actions required to fulfull all of the original agreements concerning the scope of the AMRL activities were completed with the implementation of the Aggregates Reference Sample Program in 1968. The scope of the inspection work has been expanded to include the apparatus used for testing of bituminous mixtures for eight methods of test. Apparatus used in performing the tests for five additional soils methods were also added. These changes brought the number of methods receiving attention in aggregates, soils, and bituminous materials areas to forty-five. Printed forms for the reports on inspections of bituminous, aggregates, and soils laboratories have now been developed. Various staff changes resulted in the loss of a research engineer and an inspector. As a result of questions, observations, and recommendations by the AMRL staff to the sponsors, the AASHO Committee on Materials, a number of changes have been made in the AASHO methods of test for aggregates, soils and bituminous materials which can be directly related to the work of the AMRL. The AMRL staff has continued active association with ASTM Committee C-1, C-9, D-4, D-18, E-1 and E-11, thus providing lines of communication which have

resulted in promoting corresponding progress in parallel ASTM methods of test. A noteworthy contribution to the work of these committees included Mr. Howard Arni's continued service as Chairman of an Ad Hoc Committee responsible for writing a recommended practice for the preparation of precision statements for methods of test under the jurisdiction of Committees C-1, C-9, D-4, and D-18.

It was reported by the Manager of the Reference Laboratory that at the Annual Meeting of the AASHO Committee on Materials in August 1969 evidence of satisfaction of the work of the AMRL was indicated by continued financial support, numerous revisions to methods of test, and the favorable comment received from those in attendance.

Staff members participated in Committee meetings of the Highway Research Board, Middle Atlantic District of ASTM, Standing Committee on District Activities of ASTM and the American Concrete Institute.

The staff furnished a vice-chairman and secretary for the Middle Atlantic District of ASTM.

Project 4213450 - CTAB Panel on Housing Technology Project Leader: C. T. Mahaffey \$8,973

Prepared at the request of the Panel Secretary - David Pellish:

 A series of draft study papers relative to past and present construction labor problems, including drafts of suggested remedial actions and activators;

2. A series of draft reports on a review of opportunities for technological improvements in housing construction.

These reports are available from the CTAB Panel Secretary.

421.05 C. T. Mahaffey 421.13 R. S. Wyly PROJECT SUMMARIES FY 1969

Building Systems Section (421.06)

Project 4213106 - Consultative and Advisory Services

Project Leader: Robert W. Blake

Funds Expended: RTS \$12,780.00

Summary of Output

This project has as its objective the rendering of professional advice. Members of the Building Systems Section provided consultative services as follows:

Panelist - Design Methods Group Seminar

Lecturer - Office Design Group Seminar

Panelist - National Electrical Contractors Systems Seminar

Consultant - Prospective Systems Consortium

Advisor - Mobile Homes Manufacturers' Association

Alternate - Delegate - Internationa Building Congress (CIB)

Lecturer - University of Kentucky Systems Seminar

Consultant - Florida Schoolhouse Systems Project

Consultant - Academic Building Systems Project, University of California

Speaker - American Refrigeration Institute - Washington Chapter

Consultant - State of Massachusetts Housing Agency

Consultant - Cleveland Urban Planners

Consultant - Building Research Institute

Consultant - BLMRC of BRAB, National Academy of Engineering

Speaker - American Institute of Cost Engineers, Washington Chapter

Consultant - District of Columbia for Systems Applicability for D. C. Schools

Project 4217103 - Office Prototypes and Standards Development (old title: User Needs Federal Office Buildings)

Project Leader: Robert W. Blake

Funds Expended: RTS \$3,000.00

This project seeks to relate physical architectural environment to productivity of the office worker at his work station, and also to operational office effectiveness. Lack of manpower to develop OA funds support prevented action in FY 1969. RTS funds were expended on common aspects of this project and the PBS Building Systems Project (new office space construction). Results are in the form of an analysis of raw data of a 1600 Federal office worker survey. The report will be provided to Public Buildings Service.

Cost Performance Interim Output from this Project:

Rank order of environmental aspects desired (illumination, air temperature, sound, privacy, etc.), environmental aspects most satisfactorily met (illumination), and environmental aspects least satisfactorily met (sound and air temperature) provide designers with clues as to state of affairs in newer existing Federal Office Buildings. Thus, allocation of resources for construction during the design stage has some rational basis for judgemental decisions. Building Research Division Project Summary, FY 1969 Project 4217109 - Criteria for (NIMH) Rehabilitation Facilities 4217419 Project Leader: Robert W. Blake Funds Expended: 4217109 - RTS \$ 6,000.00 4217419 - OA \$75,000.00 NIMH

Summary of Output

This project seeks to develop relationship between the NIMH treatment program and statements of performance requirements for buildings which provide the treatment environment. The project was initiated in FY 1969 and substantially completed. At year end, the draft final report is under review by the staff and the client agency. The final report will be in the form of a kit for medical, social and building design professionals to state in a rank ordered way their weighting of desirable characteristics, from their professional viewpoint, that the building should have. It is the intent that the mental health facilities so designed will be more responsive to the users than conventionally designed hospitals.

Cost-Performance

The goal is a more responsive facility in terms of mental health treatment. Testing and validating the premise is planned for the follow-on work for the client.

Project 4217111 - Urban Technology

Project Leader: Thomas Ware

Funds Expended: RTS \$33,000.00

Summary of Output

This project seeks to apply the performance specifications method to an actual housing construction project towards an objective that performance will equal or exceed conventional performance at costs no more than 90 per cent of conventional costs. The project was initiated in late FY 1969. At year end, the program plan had been completed and work initiated on the parameters of the main effort. Clients for the project are being solicited for other agency support. The City of Cleveland and the Tennessee Valley Authority are prime candidates. Both of these agencies have asked for a proposal.

Project 4217416 - PBS/NBS Building Systems Project Leader: Robert W. Blake Funds Expended: RTS - 0 OA - FY 69 - \$70,000.00 Previous years - \$260,000.00

Summary of Output

The PBS/NBS Building Systems Project is a full scale test of the systems approach to construction of Federal Office Buildings. By means of a performance type specification, the Public Buildings Service plans to procure, installed, one million square feet of a floor-ceiling sandwich and space divider system.

During Fiscal Year 1969 the complete performance specification and contract conditions were prepared and circulated to interested industrial organizations for commentary. Review with the sponsoring client was initiated and completed.

Evidence of industrial and professional interest in participating in this project has been received in the form of "letters of interest." At least two prospective bidding groups have indicated that they plan to submit bids. A magazine article devoted to describing the project sold in excess of 80,000 reprints.

In conjunction with the Commissioner PBS, a group of six buildings were identified in the PBS building program as recipients of the developed system. Due to the cut back in Federal construction in FY 1970, the actual building phase of the project is postponed.

At year end, preparations continued for issuance of the final documentation. Incorporation of industrial, professional, and Federal commentary is necessary to assure a specification and procedure acceptable to all parties.

Cost-Performance - Interim output from this project

From space standards developed, during the analysis phase, a method was developed to control the configuration of the typical floor of an office tower (of the office building) during the programming and design stages. Application of the method assures "typical" floor office space of the order of 80 per cent of total gross space compared to approximately 75 per cent at present, with a few cases as low as 60 per cent.

From analysis of existing building procedures and associated work for the PBS, postulated methods to decrease total time (for design and construction) by approximately one half.

Project 4217481 - Cost Analysis/Cost Synthesis Systems for Construction Control

Project Leader: Philip Chen

Funds Expended: RTS \$50,000.00 OA \$73,000.00

Summary of Output

This project seeks (1) to develop a common Federal costing language, and (2) develop a method of collecting unit pricing information not now available through application of advance European methods. The project was reorganized in mid and late FY 1969. Funds were committed to outside contractors to produce first phase work (not due until mid FY 1970).

Cost-Performance

Improved methods of collecting cost data and retrieval for use by Federal Program Builders.

PROJECT SUMMARIES FY 1969

Scientific and Professional Liaison Section (421.07)

Project Number and Title: 4212170, Industrial and Professional Studies

Project Leader: James L. Haecker

RTS Funds Expended: \$73.16K

Summary of Output:

The first conference in the "Man and His Shelter" series was held on September 23-25, 1968. The conference, entitled, "Performance of Buildings - Concept and Measurement", attracted over 200 registrants in a wide range of disciplines.

The proceedings of the conference, "Performance of Buildings - Concept and Measurement" is being edited and is near completion. Publication will be in the Building Science Series.

All conferences and seminars in the Division are now being coordinated under this project. These include scheduling, mailings and other such details.

A brochure describing the scope and activities of the Division is now being printed. This brochure will serve as a general introduction to the Division's activities and goals.

All inquiries, replies, publications and publicity releases are being filed and catalogued for efficient retrieval and analysis.

Several universities have been contacted in an effort to attract engineering and architecture students to spend a semester in the Division as part of their college training. They would be assigned to a mentor in one of the appropriate fields.



PROJECT SUMMARIES FY 1969

Sensory Environment Branch (421.10)



Project No. and Title: 4212231 - Thermophysical Properties

Project Leader: D. R. Flynn

RTS Funds Expended: \$55.53K

Summary of Output:

The objectives of this project are to develop measurement methods, apparatus, procedures, and reference standards for accurate and expedititous measurement of the thermal conductivity and heat transfer properties of solid materials and insulations; to explore the basic phenomena governing heat conduction with an aim toward prediction of thermal conductivity by correlations with other physical properties; and to provide a facility for making heat transfer measurements to satisfy requirements of NBS and other Government agencies.

In order to promote dissemination of information, a paper entitled "Thermal Conductivity of Ceramics" by D. R. Flynn was published in NBS Special Publication 303. Work has been begun on an extensive review of theoretical and experimental techniques for studying the thermal conductivity of metals, and is to be published as a chapter in a series of volumes entitled "Techniques in Metals Research," published by John Wiley and Sons.

Considerable work was done on the development of mathematical methods for the solution of the heat conduction equation with mixed boundary conditions. General techniques have been developed for both two and three dimensional problems in rectangular and cylindrical coordinate systems. Tests of the validity of these techniques, which are designed for computer-produced solutions, are being made both by application to specific geometrical configurations and by a study of their mathematical properties.

To further the goal of developing thermal conductivity standards, work has been in progress on the measurement of the thermal conductivity of platinum. Preparation and installation of a very pure Pt specimen in the NBS platinum apparatus has been nearly completed, and measurements on this specimen are about to begin. Measurements have been completed on a composite Pt specimen, consisting partly of material from an earlier NBS specimen and a specimen measured by the National Physical Laboratory, Teddington, England. Final analysis of these data is in progress, and when completed will aid in the establishment of pure platinum as a thermal conductivity reference standard. There has been an ongoing activity in the development of two pieces of apparatus whose design and construction were reported in the summary for FY 1968. Both apparatuses employ an electrical heating method. In one, the specimen is a small electrically-conductive rod, while in the other, the specimen is a thin metal foil. Preliminary data have been acquired for specimens in both apparatuses. Data analysis completed as of this time has led to minor design changes and to an estimate of correction factors needed to properly calibrate the apparatuses. Upon completion of calibration work, these apparatuses will provide the capability of fast and accurate measurements of the thermal conductivity of metals and alloys.

Work which was begun under an outside assistance contract has led to the development of an apparatus to enable accurate measurements of the thermal conductivity of glasses, ceramics, and other low-conductivity solids.

Supervision for the Dow research associateship (4212653) was provided under this project.

Project No. and Title: 4212653 - Heat Flux Measurements (Dow Research

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Associateship)
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Project Leader: H. E. Robinson

OA Funds Expended: \$6638

Summary of Output:

The objective of this project is to study and develop methods of measuring heat flux at interior surfaces of buildings. A primary objective is development of a method and instrumentation for in situ measurements applicable in occupied buildings.

Additional mathematical analysis was conducted to evaluate the errors due to heat-shunting effects in typical applications of heat flux meters.

An apparatus was fabricated to permit calibration of heat flux meters under conditions closely simulating actual use conditions. This apparatus consists essentially of a guarded metal plate, approximately four feet wide and eight feet high. By accurately measuring the electrical power input to a heater on this plate, the average heat flux through a specimen attached to the plate can be determined. Comparison of this measured heat flux with the indications of heat flow meters attached to the specimen permits study of the various errors associated with the heat flow meters.

The apparatus was connected to a data acquisition system so that the emf outputs of all thermocouples and heat flow meters could be automatically converted to digital form and punched onto cards for input to a computer. Computer programs were written to process the experimental data obtained.

A specimen consisting of one inch of fibrous glass board and one-half inch of plywood was installed in the apparatus and a number of tests were run with a variety of heat flow meters attached to the specimen.

The data obtained showed that covers should be placed over heat flow meters to damp out fluctuations due to convective effects. The data also provided information regarding the relative merits of different types of heat flow meters. Additional analysis of these data, plus

data on at least one more specimen, will be needed to confirm the accuracy of the apparatus and to demonstrate the magnitude of errors due to shunting heat flows.

<u>Project:</u> 4214138 -Visual Environment <u>Project Leader</u>: Henry E. Robinson <u>RTS Funds Expended</u>: \$16.6 K

Summary of Output:

The objective of this project was to determine the state of current technical knowledge on visual factors and present practices in the illumination of the indoor environment, the prospective trends of future developments, and the national needs for research or evaluative techniques in this area of applied science, as a basis for planning an appropriate activity in the Building Research Division in visual environment. The project anticipated the formation of a Sensory Environment Branch in the Division during FY 1969.

Two contracts were executed with William M.C.Lam and Assoc. to develop recommendations for a research program in visual environment in the Sensory Environment Branch of NBS. The program development was carried out in two phases, with a separate contract and report for each phase. The report of the first phase outlined the research needs of importance to the Federal government; evaluated current technical information in the various aspects of the luminous environment; and outlined areas of research needed for improving the visual environment in buildings, for developing performance criteria and evaluative procedures, and for reducing the economic cost of lighting. The report of the second phase contrasted the investigative approaches based on vision research and that based on perceptual psychology, and recommended that emphasis be placed on the latter in the NBS program. It also recommended organizational structure, personnel, facilities, methods for disseminating information and technical review. A good bibliography was provided as resource material, as well as an identification of the principal U.S. and foreign investigators in this field.

Both contracts were completed in FY 69.

Project No. and Title: 4214432 - Thermal Conductance of Soils

Project Leader: D. R. Flynn

OA Funds Expended: FY 69: \$1,677 (FY 68: \$36,249)

Summary of Output:

The objective of this project was to experimentally measure the effective thermal conductivity, as a function of temperature, of nine soils selected and furnished by Sandia Corporation. Test temperatures were to be from room temperature to just below the molten range for each soil with a maximum as near 1700 °C as possible whenever the melt range level permitted.

A second specimen of each of the remaining five soil samples was prepared and thermal conductivity measurements were completed. These measurements completed the experimental work connected with this project, most of which was done during FY 1968.

The final report was written and submitted to the sponsor. This has now been published as:

Flynn, D. R., and Watson, T. W., Measurements of the Thermal Conductivity of Soils to High Temperatures - Final Report, SC-CR-69-3059 (April, 1969).

A condensed version of this report was published as:

Flynn, D. R., and Watson, T. W., High temperature thermal conductivity of soils (Proc. Eighth Conf. Thermal Conductivity, Purdue University, West Lafayette, Ind., Oct. 7-10, 1968), Book, Thermal Conductivity, Ed. C. Y. Ho and R. E. Taylor, pp 913-939 (Plenum Press, New York, 1969).

The contractual obligations of this project are now completed, and the project has been terminated.

PROJECT SUMMARIES FY 1969

Environmental Engineering Section (421.11)



Project No. and Title: 4212132 - Psychrometry and Instrumentation

Project Leader: Joseph C. Davis

RTS Funds Expended: \$20.00K

Summary of Output:

The project operating under a broader objective, that of psychrometric measurements and experimental instrumentation, made significant contributions in both areas. Modifications to and operation of the automatic data acquisition were under the direction of this project.

Some experimental work and considerable analytical work on psychrometrics was accomplished. In collaboration with Mr. L.P. Harrison of the U.S. Weather Bureau efforts were continued to refine psychrometric formulation and to establish more accurately the empirical constant used in vapor pressure determinations. An analysis of the original Ferrel data was made to determine the consistency of reported wet-bulb observations. The information derived from this joint effort will be published in the revised ASHRAE, Psychrometrics Brochure.

Several papers were reviewed or approved during the past year.

The paper, "Radiation Errors in Temperature Measurements of Moving Air under Non-Isothermal Conditions, using Thermocouples, Thermistors and a Resistance Thermometer"; was approved for NBS publication in the Building Science Series. Another paper, "Performance of Louvered Devices as Air Mixers", has been approved at the Division level review. A paper, "The Dry-and Wet-Bulb Psychrometer," was also approved for publication.

General use of the data acquisition system was made by several projects and additional trunk lines were placed to the large environmental chamber. The data logging system has a capacity of receiving 300 two-wire channels of analog signals, converting to digital signal and printing out on punched cards ready for computer processing.

This project was completed during FY 1969.

Project No. and Title: 4212133 - Heat and Mass Transfer

Project Leaders: T. K. Faison and E. M. Barber

RTS Funds Expended: \$80K

Summary of Output:

Laboratory investigations were conducted to gain a better understanding of simultaneous transfer and movement of heat, vapor and air through building materials and construction and within indoor spaces of buildings.

The investigation of moisture transmission through plastic foam insulation has been completed. Polyurethane, polyvinyl chloride and polystyrene foam insulations were used to investigate moisture transfer phenomena under nonisothermal conditions. Modified wet-cup tests were continued during this reporting period to determine the rate at which moisture penetrates and is retained within these three insulating materials.

Development was continued of the method for measuring rates of moisture transmission and retention of specimens when exposed to controlled environmental conditions. By exposing one side of the specimen to an initially dry environment and monitoring the change in moisture content of that environment as a controlled rate of air at a fixed condition was allowed to penetrate the specimen, moisture retention and transmission could be predicted.

An extensive study has been made of the convection and modeling theory. This study has shown that, in order for good correlation to be obtained between the results observed in the model and those actually occurring in a room, the Grashof number, Prandtl number and aspect ratio existing in the room must be duplicated in the model. The effects of thermal radiation can be ignored in the model. A state-of-the-art type paper has been drafted on this investigation.

An experimental apparatus was designed and constructed for use in modeling of air motion in rooms. After considerable difficulty with such problems as leaks and rust, the apparatus was made operational. The apparatus uses high temperature water $(300 \, ^\circ F)$ as the working fluid. Pressure is maintained in the apparatus to keep the water in the liquid phase at the high temperature. A technique has been developed whereby photographs can be made of the convection patterns generated within the model. Photographs of the convective motion have been made at temperatures as high as 300 $^\circ F$. A computer program has been developed to display graphically on the calcomp plotter the results of an analytical convection program.

Project No. and Title: 4212134 - Air Cleaning

Project Leader: Charles M. Hunt

RTS Funds Expended: \$10K

Summary of Output:

The objectives of this project are to develop methods for evaluating air cleaner performance and for monitoring amount and kind of particulate in air. It is ultimately hoped to extend capabilities to the detection and monitoring of gaseous contaminants in buildings. Primary emphasis in FY 69 has been the development of testing devices of low and intermediate efficiency particularly under field conditions. Some specific accomplishments are listed as follows:

1. It has been experimentally verified that the rate of air flow through a filter may be represented by the empirical relationship,

 $v = k p^{a}$

where v is the face velocity, p is pressure drop across the filter, k is a parameter which is a function of the amount and kind of dirt on the filter, and a is a constant. This is a more versatile way of representing flow resistance characteristics of filters than the usual "loading" curve. With this relationship it is simple to reconstruct "loading" curves for different air velocities. It also provides a starting point for predicting the performance of a media as a roll filter from parameters obtained from tests as a panel filter.

2. Paper tape samplers have been evaluated for determining the efficiency of air filters. They are not as accurate as the conventional laboratory dust spot method, primarily due to variations in the optical density of the paper tape. Their greatest value seems to be in furnishing a time record of rises and falls in dust level.

3. High volume samplers equipped with high efficiency filters have been obtained. It is now possible in this laboratory to sample atmospheric dust in weighable amounts, and determine the nature of the collected dust.

4. A technique has been developed for recovering dirt from filters and separating the lint from the remaining particulates. This is a first step in determining the nature of the dust captured and passed by air filters.

Project No. and Title: 4212239 - Heating and Cooling Load Calculations

Project Leader: T. Kusuda

RTS Funds Expended: \$27.9K

Summary of Output:

The objective of this project is to develop computer calculation routines for an improved heating and cooling load determination incorporating recent advances in heat transfer theories.

Several subroutines have been developed since the inception of this program in FY 1968: such as those for thermal response factors, wall cavity thermal resistance, energy usage calender, air side heat transfer coefficients, and psychrometrics. These subroutines were subsequently incorporated into the ASHRAE (American Society for Heating, Refrigerating and Air Conditioning Engineers) Procedures for Determining Heating and Cooling Loads for Computerized Energy Calculations.

During FY 1969 preliminary routines were developed for the solar energy data analysis and for the deconvolution of the space or building thermal response factors based upon the predetermined thermal loads or energy estimates. The latter routines will be extremely helpful in reducing the computational efforts for the energy calculation.

NBS Report No. 9818, "Algorithms for Psychrometric Calculations", was produced and has been approved for publication in the NBS Building Science Series.

A technical paper entitled "Thermal Response Factors for Various Heat Conduction Systems" was published in 1969 ASHRAE Transactions.

Another paper entitled "Effectiveness Method for Predicting the Performance of Finned Tube Coils" was presented at the 1969 winter meeting of ASHRAE and will be published in a special Symposium Bulletin.

As a chairman of the subcommittee for Heating and Cooling Loads for the ASHRAE Task Group on Energy Requirements, the project leader gave several talks on the subject to local and national meetings of ASHRAE.
Project No. and Title: 4212435 - Standards for Refrigeration Components

Project Leader: C. W. Phillips

RTS Funds Expended: \$94.7K

Summary of Output:

The broad objective of this project is evaluation of commercial and specially-designed refrigeration (and heating) systems for the U. S. Army Natick Laboratories to determine suitability for military field use.

During FY 70, the principal item under laboratory study was the 9000 Btuh gasoline engine-driven refrigerating unit. Three styles of units were investigated and performance of at least six military standard engines was measured. A series of more than 200 dynamometer tests were required under a variety of environmental conditions to establish optimum redesign requirements of the basic unit, fan speeds, engine speeds and performance.

The thermal and air leakage performance of a 21 ft. military refrigerated trailer was measured. As a consequence of these tests, redesign of the trailer is underway utilizing improved insulation.

Three liquid nitrogen refrigeration systems were evaluated for cooling capacity, control, and adaptability for military application.

Monthly progress reports have been submitted regularly and final reports are in preparation.

Project No. and Title: 4212436 - Heat Transfer In Underground Protection Structures

Project Leader: T. Kusuda

O.A. Funds Expended: \$27.9K

Summary of Output:

This is a continuation of research project sponsored by the Office of Civil Defense, which was started in 1959 in conjunction with the evaluation of therm41 environment within occupied underground shelters. It has been found during earlier studies that the earth temperature fluctuations influenced by surface cover, outdoor climatic factors and solar radiation needed further and comprehensive exploration. Earth temperature probes of 30 ft. depth were subsequently installed at the NBS campus at Gaithersburg under the center of five different surface conditions; bare earth, short grass, long grass, paved, and paved and painted white. In addition to the hourly earth temperature data, simultaneous measurements of the hourly values for air temperature, humidity, wind and rain data, ground heat flux, soil moisture content and solar radiation have been collected by an automatic data acquisition system.

The data logging started in June of 1968 and has continued to the present with several interruptions. These interruptions were caused by the flooding of the underground instrument bunker in which the data logger is installed and by frequent thunderstorms. The data were collected on punched paper tape and analyzed through the use of the NBS computer. The analysis showed the effects of painting paved surfaces to decrease the soil temperature rise. It is expected that the data acquisition will be continued until the end of February 1970 to complete one year of data with least amount of interruption.

A report describing the automatic data acquisition system employed in this project is under preparation.

Committee work related to this project was carried out with the ASHRAE Task Group, which prepares a chapter on Survival Shelters for the ASHRAE Guide and Data Book.

Project No. and Title: 4213417 - Air Cleaner Consulting (Post Office Department)

Project Leader: Charles M. Hunt

0.A. Funds Expended: \$5.0K

Summary of Output:

The purpose of this project is to furnish consultation to the Post Office on a program which has been set up to evaluate the effect of air conditioning and air cleaning on machine and personnel performance. The air cleaning system includes a Cosatron, a device which is claimed to neutralize the charges on dust particles and thereby reduce deposition on equipment and surfaces. GARD-GATX (General American Research Division of General American Transportation Corp.) is the prime contractor on this project, and McCrone Associates is a subcontractor for particle monitoring. GARD-GATX has constructed a 58,000 ft³ enclosure with its air conditioning and air cleaning system at the Chicago Main Post Office, and measurements are about to get under way. A visit was made to Chicago in November during the planning stages of program and again in May after most of the equipment was installed. Consulting has mainly taken the form of personal contact and correspondence with GARD-GATX and Mr. James Anders of the Post Office Department and also reviewing reports submitted by GARD-GATX and McCrone Associates.

Project No. and Title: 4213620 - Miscellaneous Air Cleaner Tests (NBS Reimbursable)

Project Leader: Charles M. Hunt

Reimbursable Funds Expended: \$1K

Summary of Output:

The objective of this project is to obtain data by laboratory tests on the performance of air cleaners and filters used in air supply systems of buildings for use by government agencies in procurement and acceptance of filtration systems.

One filter was received for test during FY 1969.

Within the year the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) has put out a standard on air cleaners. This will have some impact on future filter testing at NBS and may also have had indirect effect on the amount of testing during the past year. A staff member of the Building Research Division participated in the drafting of the ASHRAE Standard. The ASHRAE test method provides for measuring the dust arrestance of an air cleaner by both the discoloration method developed at NBS and by the weight method. The techniques on air mixing developed at NBS were also incorporated into the apparatus described in the Standard.

Project No. and Title: 4214136 - Thermal Performance of Whole Buildings

Project Leader: B. A. Peavy

RTS Funds Expended: \$60K

Summary of Output:

The objectives of this project are to investigate analytically and experimentally the thermal performance and merit of a proposed inverted system of masonry building construction. In this inverted system the insulation will be placed on the outside of the structure and the masonry will form the inside surface; the reverse of normal construction practice. The project has two primary phases, (1) to develop mathematical solutions and (2) to provide experimental evidence to verify predicted performance.

The first phase of the study has been continued by developing mathematical solutions for determining the dynamic thermal performance of walls, roof, floor and windows; heat exchange between the air and furnishings and interior walls; internal heat generation; and air infiltration and ventilation. A report entitled, Heat Transfer Aspects of Inside-Out Construction, is being prepared and its purpose is to show the effects of a periodically varying thermal environment on instantaneous heat flows. The heat fluxes will be transmitted to or from a thermostated internal environment through a two body composite where insulating material is placed either on the inside or outside of a masonry material. A paper entitled, Dynamic Thermal Performance of Buildings, is being prepared and is intended to encompass the whole building system including windows and temperature variations in the internal environment.

The second phase of this study is to investigate experimentally the thermal performance of inside-out building systems. The design and plans were developed for a prototype structure to be constructed in the high bay environmental chamber. The initial construction and the purchase of materials, equipment and instrumentation began in FY 69. The test procedure and the sequence of tests have been resolved. Other disciplines of the Building Research Division will be included in the experimental program.

Project No. and Title: 4214137 - Criteria for Refrigerated Enclosures

Project Leader: C. W. Phillips

RTS Funds Expended: \$15K

Summary of Output:

This project was originally designed to further study the effect of door usage on air exchange of refrigerated truck bodies under a variety of load patterns, and under several ambient conditions. The Truck Body and Equipment Association (TBEA), the U.S. Department of Agriculture, and NBS were cosponsors. TBEA had available \$8000 and was to provide the test vehicles, and USDA and NBS were each to provide about \$15,000 each. USDA contract money was not available to implement the program early in FY 69 and before it could be arranged, the following change in objective was considered essential.

Following adoption by TBEA of the NBS-developed cooling load test method, that group began to recognize the need for a simplified in-plant test method. A paper on this subject,"Simplified Laboratory Procedures for Simulating the Effect of Air Leakage into Refrigerated Enclosures" by P. R. Achenbach, was prepared and presented to Commission VII, International Institute of Refrigeration at Vienna, Austria. This paper discusses the need for simplified methods of measurement and suggests two test procedures for laboratory development NBS, USDA and others have been considering the possibility of using liquid nitrogen as such a simplified method if means can be included to prevent the nitrogen from interfering with the air leakage into the vehicle during the cooling load test. A possible method under consideration for doing this is the reduction of the interior pressure by a small amount.

Work was done to compute the magnitude of the negative pressure which would be equivalent to the air leakage into the vehicle caused by a 60 mph front air impact speed, or a 30 mph side wind impact speed. For a range of vehicles from 20 to 40 feet in length, the pressure was computed to be in the general area of 0.040 inches W.G.

It was decided, with agreement of both USDA and TBEA, to reconstruct the project to determine feasibility of this method. Neither USDA or TBEA transferred any funds during FY 69; however NBS funds were used to develop and prepare most of the apparatus and instrumentation required to conduct these studies for a program to be implemented in FY 70. The existing NBS heat sink apparatus was relocated and rebuilt to accommodate the truck interior loads and sizes and the liquid nitrogen weighing mechanism, including an electronic load cell was acquired and checked. A series of meetings was held between USDA, TBEA, ATA, and others to develop the actual test phase of the project for FY 70.

Project No. and Title: 4214433 - Evaluation of Air Cleaners and Prefilter Media (Post Office Department)

Project Leader: Charles M. Hunt

O.A. Funds Expended: \$38.3K

Summary of Output:

The purpose of this project is to provide the Post Office with test data and evaluations of air cleaning devices and systems in order to aid in decisions regarding the selection of equipment and the design of future air handling systems. During FY 69 two systems were investigated, (1) the roll filter units at the Philadelphia Main Post Office and (2) the Dynavane Systems at the Omaha Post Office.

1. Comparison of Polyurethane Foam and Fiber Glass Roll Filter Media

A field and laboratory study was made of the comparative efficiency, dust holding capacity, and service performance of polyurethane foam and fiber glass roll filter media. The salient findings of this study were that polyurethane foam developed higher resistance to air flow than fiber glass when both were highly dirty, but that polyurethane foam outlasted fiber glass when both were operated as roll filters at the Philadelphia Post Office. The reason for this apparent contradiction has not been established, but it is suspected that there are some heretofore unidentified factors which control the movement of roll media. This work has been described in NBS Report 10025.

2. Evaluation of Farr Dynavane Air Cleaning Systems

Dynavanes are mechanical air cleaning devices which operate on the inertial principle to separate dust and lint from air without the use of filters. Tests have been made on two of these devices at the Omaha Post Office to determine their effectiveness in cleaning the air from areas where mail bags are handled. Preliminary measurements of one of the units with dust spot samplers indicated that it was not effective in removing fine dust from the air. A subsequent set of tests were carried out using high-volume samplers and weighing the collected dirt. The results from these latter tests show that the devices have some value in separating layer dust particles and lint, but the tests are still undergoing evaluation.

<u>Project No. and Title</u>: 4214438 - Heating and Cooling of Insulated Food Containers

Project Leader: C. W. Phillips

0.A. Funds Expended: \$48.0K

Summary of Output:

The purpose of this project was to evaluate the performance of speciallydesigned devices and insulated containers for storage and handling of hot and frozen food, and of various devices for cooling and/or heating the containers. At the sponsor's request, the project was terminated on June 30, 1969 and tasks in progress as of that date were combined and continued under Project 4212435.

Four prototype insulated food containers were studied under extreme ambient temperatures in laboratory tests to determine their ability to maintain both hot and cold food temperatures. Heat loss, cooling load, product holding time, resistance to low refrigerant temperatures and high ambient temperatures were investigated. Laboratory work was completed and preparation of a final report is in progress.

The existing NBS metering heat sink was rebuilt and relocated to perform cooling load tests of a 21 ft. military trailer (completed) and a series of 20 ft. containers (to be done).

Three absorption-type refrigerators under consideration for military field use were studied in the laboratory to determine performance characteristics under high ambient conditions. Effectiveness of refrigeration produced, fuel consumption, optimum fuel pressure, ambient temperature causing failure, and other characteristics were measured. The first two refrigerators have been completed except for maximum tilt angle tests now in progress, the third unit is currently undergoing the full series of tests.

Monthly progress reports have been submitted to the sponsor.

Project No. and Title: 4214439 - Development of Optically Read Data Forms for Heating and Cooling Load Calculation by Computer

Project Leader: Everett M. Barber

O.A. Funds Expended: \$8.5K

Summary of Output:

In an effort to speed preparation time needed to enter input data into computer programs, for determining energy consumption and heating and cooling loads, a contract was negotiated with the Post Office Department for NBS to generate a standard form from which the input data could be read directly.

Input data forms for the Post Office Department's Load and Energy Calculation Program and their System Simulation Program have been completed. The user enters data by hand printing values directly on the forms or by marking answers to multiple choice type questions. An optical scanner is used to read the data from the forms and put it into computer compatible terms.

The data forms have been submitted to the Post Office Department for review and comment.

A paper on cost and convenience aspects of optically read data forms for this type of application has been prepared and is at Section level review. A second paper, in outline form, is being prepared to describe the layout of the forms and will include examples of input information on the data forms.

<u>Project No. and Title</u>: 4214440 - Mathematical Study for Coincidental Weather Data

Project Leader: T. Kusuda

0.A. Funds Expended: \$32.9K

Summary of Output:

This project was initiated during September of 1968 at the request of the U. S. Post Office Department (Construction Research) to conduct a feasibility study on the mathematical representation of several coincident hourly weather parameters. The parameters considered are dry-bulb temperature, dew point temperature, wind data, solar radiation, cloud cover and barometric pressure from selected weather stations in the United States. All of these parameters are vital input data for the energy estimate calculations of Post Office buildings throughout the United States. With the cooperation of Mr. Z. O. Cumali of the Consultant Computation Bureau (a consultant to the project), weather tape of Fresno, California, containing hourly coincident values of above parameters for a period of 1953 through 1962 was decoded and analyzed. The analysis was made to study the power spectrum of all of the individual parameters and also to determine coherency and phase spectra of all pairs among the parameters mentioned above. These spectral studies were an essential step before a suitable form of mathematical representation was obtained.

The results of this study were submitted to the Post Office Department via NBS Report 10113 entitled, "Feasibility Study for the Mathematical Representation of Coincident Weather Data for the Heating and Cooling Load Calculations of Buildings".

Although the initial plan was to study the data from several selected stations in the United States, the NBS report contains an analysis based upon a single station, namely Fresno, California, because of the lack of time.

Since the analysis obtained from the data of Fresno, California indicated strong spectral coherency among most of the pairs studied, and distinctive cyclic natures of power spectra of all of the parameters, it is concluded that the mathematical representation is feasible. A suggestion to the U. S. Post Office Department has been made to perform similar analyses to data from other stations in the forthcoming year.

Project No. and Title: 4214441 - Air Distribution Studies Thru Use of Modeling Techniques

Project Leader: Everett M. Barber

O.A. Funds Expended: \$8.6K

Summary of Output:

This project is funded by the Office of Civil Defense to supplement the effort in Project 4212133 <u>Heat and Mass Transfer</u> on convection studies. Office of Civil Defense is interested in extending the convection study and modeling techniques to the area of shelter ventilation. An extensive study has been made **on** convection and modeling theory for application in this area. The study has shown that three parameters must exist for good correlation between model and prototype, these are: Grashof number, Prandtl number and aspect ratio. The effect of thermal radiation can be ignored in the model. A state-of-the-art type paper has been drafted on this investigation.

The design of a second generation water model apparatus has been started for the study of multi-room configurations.

Project No. and Title: 4214442 - Thermal Performance - Navy Relocatable Building

Project Leader: C. W. Phillips

0.A. Funds Expended: \$7.0K

Summary of Output:

The purpose of this project was to evaluate the air leakage and thermal performance of a prototype-relocatable building for the U. S. Navy in the Building Research Division's large environmental chamber. Contributing to a larger joint effort, the Environmental Engineering Section made measurements to determine the rate of air leakage at selected pressure differences and thermal performance of the total structure. Air leakage was determined under isothermal conditions both with and without racking forces applied to the building for simulation of wind loading. To determine the effect of racking upon air leakage, measurements of air leakage were made as forces were applied incrementally up to the design load of 25 psf. With no racking forces applied, the windows and doors were taped sequentially to determine the contribution of each to the overall rate of air leakage. Smoke tests were performed to locate the major leaks such as doors, windows and joints.

Measurements were made of the gross heat loss for the structure by exposing the building to a cold environment and metering the energy required to maintain a selected indoor temperature.

Special studies were conducted on the analysis of heat transfer and condensation caused by the aluminum extrusions, high heat flow paths.

A preliminary report on air leakage and thermal performance was submitted to the U. S. Navy.

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Project No. and Title: 4215103 - Consultative and Advisory Services

Project Leader: Frank J. Powell

RTS Funds Expended: \$35K

Summary of Output:

This project supports consultative and advisory activities for Government, industry, professional societies, technical committees and the public that fall within the Section's competence and which are not directly chargeable to other projects. Technical, non-proprietary information was furnished on the environmental performance of buildings, sub-systems of buildings, and associated technology by means of correspondence; consultation with visitors; participation in the contributions to meetings of technical committees, task forces, ad hoc groups; preparation of technical papers; and technical evaluation of papers submitted by others for publication.

After discussion and analysis, research proposals were prepared and transmitted to:

- 1. Post Office Department: concerning a) advisory services regarding contracts with GARD-GATX, b) energy conservation, c) air cleaning, d) weather data and e) optically read computer data forms.
- 2. National Capital Housing Authority: for air infiltration and fuel consumption measurements on two apartments.
- 3. U. S. Navy: for air leakage and thermal performance of a prototype relocatable building.
- 4. Tri-Service: a total of twelve proposals were prepared including one for underground heat distribution systems.
- 5. U.S.D.A.: concerning refrigeration requirements and rating methods for transportable frozen product enclosures.
- 6. O.C.D.: on air convection studies.
- 7. HUD: as a contribution to the BRD proposal.

A seminar on Durability of Insulating Glass, sponsored jointly by ASTM, BRI, CSI and NBS was held on November 14-15, 1968, at NBS.

Travel to Europe for exchange of technical ideas and review of foreign effort in environmental engineering work was completed in May 1969. International conferences sponsored by ISO, IIR and CIB were attended during these trips.

Several foreign visitors were received and the usual correspondence including congressional correspondence was transmitted.

Project No. and Title: 4215623 - Reimbursable Travel and Costs for Environmental Engineering Section

Project Leader: Frank J. Powell

RTS Funds Expended: \$2.0K

Summary of Output:

In an effort to provide consultative and advisory services in response to government and provide industry needs, the project was used for reimbursable travel to ASHRAE technical meetings by various members of the Environmental Engineering Section.

In response to a request by the National Capital Housing Authority, air infiltration and fuel consumption were measured in two apartments in the Washington, D.C. area. A report, NBS No. 10030, Air Infiltration of Two Apartments in a Public Housing Area of Washington, D.C., was issued to the National Capital Housing Authority. The report included a description of the apartments, the test procedure, conditions of exposure, results and a summary discussion. The measurements were conducted on the two apartments during mid-winter (Feb. 1969) to determine if excessive natural air leakage was responsible for the very high rates of fuel consumption. The measured values indicated that the air infiltration rates were not excessively high.

Project No. and Title: 4215628 - Reimbursable Thermal Conductivity Measurements

Project Leader: Thomas W. Watson

Reimbursable Funds Expended: \$8.2K

Summary of Output:

The objectives of this project are to provide industry and government with thermal conductivity reference materials for standards, and to supply data on new materials and devices over a wide range of conductivities and temperatures on a fee basis using existing NBS methods.

Twenty-one thermal conductivity reference samples were calibrated and returned to governmental, commercial and industrial laboratories including a college, Virginia Polytechnic Institute, and The National Aeronautics and Space Administration, Langley Research Center. The measurements were made in the NBS Guarded Hot-Plate conforming with the requirements of Standard Method of Test ASTM C177 at temperatures ranging from 0 to 130°F. Thermal conductivity measurements were also made at 75°F on three cellulose insulations for the Bureau of Deceptive Practices, Federal Trade Commission, and on five foam insulations at 40°F in connection with "Libby Dam Project" for the Corps of Engineers, Seattle, Washington.

Thermal conductivity and electrical resistivity measurements were made on a metal sample of Udimet 700 alloy over the temperature range 100 to 830°C for The National Aeronautics and Space Administration, Lewis Research Center. The results are given in the following NBS Report:

NBS 10044, "Thermal Conductivity and Electrical Resistivity of a Specimen of Udimet 700 Alloy."

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PROJECT SUMMARIES FY 1969

Psychophysics Section (421.12)

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Project4212266:Architectural AcousticsProjectLeader:FundsExpended:\$40K

The objective of this project is to implement a program of research and study of the acoustical environments associated with buildings. The program involves development of methods of measurement and evaluative procedures to identify and characterize sources of noise both of exterior and interior origin. Additionally, the acoustical properties of building materials, structures and systems are explored with regard to standardization of methods employed to determine such properties. An important part of the program involves the study of subjective responses to the acoustical environments of buildings. A more immediate objective is to recruit additional personnel who are qualified in these areas of research.

During FY 1969, the major acquisition of a well-equipped mobile acoustical laboratory was realized. This unit provides instrumental measurement capability for field application of the quality usually found only in fixed laboratories. Acceptance testing and calibration is in progress as well as correction of some deficiencies.

The program related to the acoustical performance of hospital floor coverings, funded in FY 1968 under project 4212537, was continued. A report titled, "Acoustical Performance of Some Floor Coverings for Hospitals", was published. Before-and-after data have been collected in a field measurement site at a local hospital wherein carpeting was installed in an entire nursing unit. These data presently are being reduced and may reveal the net effect produced by carpeting upon the acoustical environment of a hospital nursing unit.

Prospective field research sites at which the mobile unit will be employed were explored. Cooperation of Mr. Don Clifford, Executive Director of the Montgomery County Housing Authority, has been obtained as well as that of the builder-developers of two sites near NBS Gaithersburg.

Other activities under this project include participation in several ASTM Committees and other standards organizations. Consultations have been provided for other U.S. Government Agencies, e.g., HUD, FAA, NIH, POD, PHS, DOT, DOI Bu. of Mines.

Project 4214434: Development of Noise Control Standards Project Leader : George E. Winzer Funds Expended : \$15K

The objectives of this project are to develop design, construction, evaluation and performance standards for control of noise in buildings for the Tri-Service Committee. The initial objective was to survey the state-of-the-art in the published literature so that extant information might be utilized without duplication of research efforts.

During FY 1969, a search of the literature was conducted. Methods of measurement and evaluative procedures were collected and summarized. A survey of noise control requirements and recommendations contained in building codes of progressive foreign countries was made and the information was summarized. An initial draft of a report of the literature search was prepared. PROJECT SUMMARIES FY 1969

Building Transport Systems Section (421.13)

Project: 4212135 - Performance Characteristics of Plumbing Systems Project Leader: Robert S. Wyly RTS Funds Expended: \$56.0K

Summary of Output:

Participated actively in the technical work of the USASI A40 Committee on the National Plumbing Code. Results of this effort have been incorporated in the code draft, expected to be approved shortly as USA Standard.

Reviewed and commented on a proposed revision of the California State Plumbing Code. Delivered recommendations at a public hearing in Sacramento, California, derived from an analysis of NBS input to the USASI A40 project.

Reviewed proposed standards on plumbing materials as required, and worked with committees of BRAB and ASME-ASHRAE concerned with problems of predicting peak loads on plumbing systems.

Completed drafts of three papers:

- A short paper summarizing findings in a laboratory investigation of the performance of reduced-size vents (possible savings of \$25-\$50 per dwelling).
- 2. A longer, more thorough treatment of 1.
- 3. A paper describing the findings in a survey of the state of the art in single-stack and vacuum drainage in western Europe (possible savings in construction cost, 25-40% of the sanitary DWV system. In the case of vacuum drainage, domestic water consumption may be reduced by 30-40%).

In cooperation with the National Association of Home Builders, constructed a working model to demonstrate reduced-size venting, and put on several programs utilizing the apparatus. Made presentations to local and national meetings of the American Society of Plumbing Engineers concerning new trends and opportunities in plumbing system design and performance.

Several alternative sites were surveyed for possible relocation of the plumbing research laboratory, formerly in the Hydraulics Building at the Van Ness site. The site that apparently will be utilized, and for which preliminary plans have been prepared, is in Bldg. 226 at Gaithersburg. In connection with the new laboratory, substantial progress can be reported in the specification and initiation of purchase activity for a modern automatic data acquisition system and associated "starter set" of transducers. In developing support for new plumbing research facilities, a survey of attitudes of other organizations, both public and private, was carried out, with positive results.

Project 4212135

Summary of Output, continued:

Completed the experimental work on a study of grease accumulation in piping having different thermal properties, and completed the move of laboratory apparatus and equipment from the Van Ness site to Gaithersburg.

Explored opportunities for cooperative research programs with private organizations, and for other-Government-agency support programs. Several such opportunities were identified. To capitalize on these opportunities requires continuing emphasis on the acquisition of suitable research facilities and the acquisition and training of personnel.



