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U.S. - JAPAN COORDINATED PROGRAM

FOR

MASONRY BUILDING RESEARCH

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SUMMARY REPORT:
U.S. COORDINATED PROGRAM
FOR
MASONRY BUILDING RESEARCH

submitted by

TECHNICAL COORDINATING COMMITTEE
FOR MASONRY RRESEARCH

SEPTEMBER 1985 to AUGUST 1986

Conducted under the auspices of:
The UJNR Panel on Wind & Seismic Effects

Funded by The National Science Foundation

This report presents the results of a research project which was part of the U.S. Coordinated Program for Masonry Building Research. The program constitutes the United States part of the United States - Japan Coordinated Masonry Research Program conducted under the auspices of the Panel on Wind and Seismic Effects of the U.S.-Japan Natural Resources Development Program (UJNR).

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EXECUTIVE SUMMARY

The U.S. Coordinated Program for Masonry Building Research is a comprehensive program of research into the structural aspects of reinforced masonry. It addresses the needs of the United States for improved technology applicable to the design and construction of reinforced masonry buildings. Improved masonry structural technology is expected to enable masonry buildings to become a more viable alternative to steel and concrete buildings, hence stimulate competition and foster reduced building costs. It is expected to stimulate engineering education in structural masonry because of the availability of a more cohesive and well-founded limit state design methodology. It is expected to contribute to the competitive position of the country in two ways; 1) by providing structurally adequate building at less cost thus reducing overhead costs for other industries, and 2) by providing the U.S. construction industry with a superior product to market elsewhere.

Because materials are often locally available, extensive or sophisticated construction equipment is not mandatory, and forming is not required, masonry construction is possible in most parts of the world and constitutes a significant portion of world building inventories. However, masonry design and construction technology has not kept pace with that developed for buildings of other materials, e.g., steel and concrete. This is especially of concern for construction in seismically active locations.

Existing design codes and design methods are a mixture of empirical rules and linear-elastic working stress methods neither of which is satisfactory for designing reinforced masonry buildings with the proper level of ductility and strength for seismic and other conditions.

While reinforced masonry buildings have generally performed satisfactorily in previous earthquakes, the present state of reinforced masonry building design and analysis methods is not adequate to predict seismic response and safety. Much additional information and work is required to support the development of a limit state design methodology and analytical procedures which are necessary to bring masonry structural technology up to a level compatible with steel and concrete structural technology.

With NSF support, the Technical Coordinating Committee for Masonry Reserach (TCCMAR) was formed in February 1984 for the purpose of defining and performing both analytical and experimental research and development necessary to improve masonry structural technology. The research tasks are listed below:

Preliminary Material Studies
Material Models- Concrete Masonry
Material Models- Brick Masonry

Force-Displacement Models
Strain Element Models
Dynamic Response Models of Shear Walls

Dynamic Properties of Masonry Systems

In-Plane Walls, Story Height
Sequential Displacement- In-Plane Walls (3 story)
Out-of-Plane Walls (Static-Concrete Masonry)
Out-of-Plane Walls (Dynamic- Concrete Masonry)
Out-of-Plane Walls (Static and Dynamic - Clay Masonry)

Wall-to-Wall Intersections
Floor-to-Wall Intersections

Concrete Plank Floor Diaphragms- In-Plane Behavior
Survey of Existing Diaphragm Data

Grouting Procedures- Hollow Unit Masonry
Reinforcement Bond and Splices

Small Scale Model Buildings

Limit State Design Methodology
Numerical Reliability Indices

Design of Research Building
Test Facility Preparation (for full-scale test)
Full Scale Test Plan
Full Scale Test

Design Recommendations and Criteria Development

Coordination

TCCMAR was and is aware that the research tasks initially defined address critical issues and further that the need for task modification and the addition of other research tasks may be required in the future.

A systems approach is being taken to execute the research, i.e., the individual research tasks are time-phased and coordinated to avoid duplication of effort and to provide information when it is needed for continuing activities. The project has a strong interface with the masonry industry (producers, builders and developers, code bodies). Its direction and procedures are reviewed by a panel of outside experts.

Work began on the initially scheduled research tasks in Sept-Oct. of 1985 except for a special-purpose task "Preliminary Material Studies" which was completed on September 1985. The complete program is scheduled for completion by Jan. 1992.

At the time of this report, with the exception of the Preliminary Material Studies task, the initial set of research tasks are approximately 20% complete.

Work in the near future includes holding the second U.S.-Japan technical meeting, continuing with the experimental tasks under way and reviewing early data and continued investigation of and refinement of analysis procedures.

The masonry industry has agreed to supply, at no cost, the masonry units needed for experimental specimens. Discussions have begun with the industry and will continue regarding fabrication, at no cost, of the larger experimental specimens which will be needed.

There have been and will continue to be a limited number of exchanges of U.S. and Japanese researchers as well as the annual joint meeting of the research items from both countries.

1.0 INTRODUCTION

The U.S. Coordinated Program for Masonry Building Research is a comprehensive program of research into the structural aspects of reinforced masonry. It addresses the needs of the United States for improved technology applicable to the design and construction of reinforced masonry bulidings. Improved masonry structural technology is expected to enable masonry buildings to become a more viable alternative to steel and concrete buildings, hence stimulate competition and foster reduced building costs. It is expected to stimulate engineering education because of the availability of a more cohesive and well founded limit state design methodology. It is expected to contribute to the competitive position of the country in two ways; 1) by providing structurally adequate building at less cost thus reducing overhead costs for other industries, and 2) by providing the U.S. construction industry with a superior product to market elsewhere.

The U.S. Coordinated Program of Masonry Building Research is the U.S. part of the third in a series of joint U.S.-Japan research programs conducted under the auspices of the United States-Japan Natural Resources (UJNR) panel on Wind and Seismic Effects. The objectives of the panel are:

1) To encourage, develop, and implement the exchange of wind and seismic technology (including data, information, measurement and test facilities and equipment, and researchers) between appropriate United States and Japanese organizations.

2) To develop strong technical links between scientific and engineering researchers of the government, industrial and academic organizations from the two countries and encourage exchanges of guest researchers.

3) To conduct joint research in areas of strong winds, earthquakes and related phenomena. Publish findings from joint research efforts and distribute proceedings of annual joint meetings.

4) To conduct cooperative programs to improve engineering design and construction practices and other wind and earthquake hazard mitigation practices.

The U.S.-Japan Coordinated Program for Masonry Building Research was designed to meet these objectives with respect to the design and construction of reinforced masonry buildings for seismic conditions.

This report presents a brief review of the current status of masonry structures design in the United States, an overview of the research program being conducted in the United States, status of the U.S. research as of the date of the report, a review of domestic and joint U.S.-Japan meetings, foreign researcher visits, researcher exchanges and program reports.

2.0 BACKGROUND

2.1 Current Status of Masonry Structures Design in the U.S. - Masonry buildings are essentially box structures in which the walls resist vertical and lateral loads, subdivide space and serve as the architectural surface. They are often economically competitive for low-rise buildings and for mid-rise buildings with repeated floor plans. Because materials are often locally available, extensive or sophisticated construction equipment is not mandatory, and forming is not required, masonry construction is possible in most parts of the world and constitutes a significant portion of world building inventories.

Masonry design and construction technology has not kept pace with that developed for buildings of other materials, e.g., steel and concrete. This is especially of concern for construction in seismically active locations.

Existing design codes (1) and design methods (2) are a mixture of empirical rules and linear-elastic working stress methods neither of which is satisfactory for designing reinforced masonry buildings with the proper level of ductility and strength for seismic conditions. A masonry building code in the development process by a joint committee of the ASCE and ACI will also be a mixture of empirical rules and linear-elastic working stress methods. It should be noted that the UBC (1) does contain a limited set of limit state provisions.

While reinforced masonry buildings have generally performed satisfactorily in previous earthquakes, the present state of reinforced masonry building design and analysis methods is not adequate to predict seismic response and safety. In the U.S. and elsewhere a significant amount of research has been done in the past decade or so (3, 4, 5, 6) with much of it supported by the National Science Foundation. While the research has produced much potentially useful information, much additional information and work is required to support the development of a limit state design methodology and analytical procedures which is necessary to bring masonry structural technology up to a level compatible with steel and concrete structural technology and to provide for improved public safety. This need has been recognized by the UJNR Panel on Wind and Seismic Effects (7).

2.2 Technical Coordinating Committee for Masonry Research (TCCMAR)- With NSF support, TCCMAR was formed in February 1984. TCCMAR was and is comprised of researchers from academic and industrial organizations who have strong backgrounds in research into the properties and characteristics of reinforced masonry materials, structural components and systems, analytical techniques, building codes, and seismic considerations. TCCMAR was not intended to be a closed group; researchers may be added as needs develop. Current TCCMAR researchers are listed in Table 1.

The initial TCCMAR purposes were 1) to specifically define the research topics, both experimental and analytical, necessary to

TABLE 1

TCCMAR RESEARCHERS

Samy Adham Agbabian Associates 250 N Nash El Segundo, CA 90245 213-640-0576 H-213-854-7772	Richard Atkinson Atkinson-Noland & Assoc., Inc. 2619 Spruce St. Boulder, CO 80302 303-444-3620 H- 303-494-3765	Russell Brown Civil Engineering Dept. Clemson University Clemson, SC 29631 803-656-3000 ex 3314 H-803-654-6395
Robert Ewing Ewing & Associates Inc. 28907 Doverridge Dr. Rancho Palos Verdes, CA 90274 213-541-3795 H-213-377-1905	Ahmad Hamid Department of Civil Eng. Drexel University Philadelphia, PA 19104 215-895-2342 H-215-896-8429	Harry Harris Department of Civil Eng Drexel University Philadelphia, PA 19104 215-895-2364
Gary Hart Englekirk & Hart 2116 Arlington Ave. Los Angeles, CA 90018-1397 213-825-1377 H-213-829-4220	Gilbert Hegemier Dept. of Eng. Sciences B-010 Univ. of California San Diego La Jolla, CA 92093 619-534-4280 619-453-0060x406	Albin W. Johnson S. B. Barnes & Assoc. 2236 Beverly Blvd. Los Angeles, CA 90057 213-382-2385
John Kariotis Kariotis & Associates 711 Mission St. #D South Pasadena, CA 91030 213-682-2871	Ronald Mayes Computech Engineering Service 2855 Telegraph Ave #410 Berkeley, CA 94705 415-843-3576 H-415-376-2627	James L. Noland Atkinson-Noland & Assoc 2619 Spruce St. Boulder, CO 80302 303-444-3620 H-499-5966
Max Porter Dept. of Civil Engineering 416A Town Eng Bldg,ISU Ames, IA 50011 515-294-7456 H-515-292-3321	Freider Seible Dept. of Eng. Sciences B-010 Univ. of California San Diego La Jolla, CA 92093 619-534-4640 H-619-944-9004	Leonard Tulin University of Colorado Dept. CEAE Box 428 Boulder, CO 80309 303-492-7994 H-303-494-7724
P.B. Shing University of Colorado Department of CEAE Box 428 Boulder, CO 80309 303-492-8026 Home 494-8816	Bjorn Sveinsson Computech Engineering Service 2855 Telegraph Ave. #410 Berkeley, CA 94705 415-843-2576	Kyle Woodward Dept. of Eng Sciences Univ. of California La Jolla CA, 92093 619-452-4640 H-619-944-9004

develop a consistent masonry structural technology for the U.S. and 2) to establish communication with its Japanese counterpart to enable Japanese and U.S. programs to be coordinated for the benefit of both.

TCCMAR-U.S. met in February 1984 and succeeded in identifying the research to be done and established the scope of an integrated program of many specific topics for the U.S. effort. It was recognized by the committee that such a program could not provide all the answers which ultimately should be provided, but would develop a basic body of knowledge and framework for future development.

Four members of TCCMAR-U.S. plus the U.S. chairmen of the UJNR Committee on Large-Scale Testing and Repair and Retrofit of Existing Structures met with the Japanese team in March 1984 to discuss masonry research and to conduct preliminary discussions on U.S.-Japan masonry research coordination. The results of the meeting are summarized in the resolutions (8). Essentially both sides reaffirmed the need for a masonry structural research and that benefits could be obtained through coordinated programs. Subsequently, at the meeting of the UJNR Committee on Large-Scale Testing held in May 1984 it was resolved that a coordinated masonry research program be carried out under the auspices of the UJNR Panel on Wind and Seismic Efforts (9).

Based upon an evaluation of abstract proposals, specific researchers were asked to prepare formal proposals addressing the research tasks identified. The proposals were submitted as a set to NSF in August 1984.

3.0 U.S. RESEARCH PLAN

3.1 Research Approach - Although a great amount of masonry research information exists in the U.S. (3, 4, 5, 6) and elsewhere, much of it is difficult to compare because of differences in test procedures, instrumentation used, data recorded, analyses performed, presentations of results and so on. The research was usually initiated by individuals with varying interests and generally not coordinated in a formal manner with other research. Hence, research has tended to produce an uneven distribution of information with some areas having received more emphasis than others. Effective utilization of research results has been inhibited and comprehensive design method and code development rendered difficult because of this situation.

The U.S. plan, therefore, consists of a phased step-by-step program of separate, but coordinated research tasks. Emphasis is being placed upon intra-task information exchange, the effectiveness of which is enhanced by use of common materials and test procedures to the extent possible. It is expected that this approach will improve the consistency of data collected and assure that all the data required for component and system modeling, and design method development is obtained. Transfer of data among the researchers thus allows results of separate tasks to be utilized in others, i.e., the U.S. plan is a "building block" procedure.

The research tasks which have been defined include experimental efforts to evaluate masonry materials behavior, small-scale masonry behavior, component behavior, and finally, full-scale masonry, i.e., building behavior. Mathematical modeling tasks defined address, in progressive levels of sophistication, material behavior, small-scale masonry behavior, component behavior and full-scale masonry system behavior. Existing information and procedures, both analytical and experimental are being reviewed and utilized to the extent possible consistent with program objectives. The final tasks, development of design recommendations and building criteria, include development of masonry system analytical approaches suitable for use by practicing engineers and architects. The research program defined, although extensive, will not provide all the information on all details regarding masonry building design and analysis. It is expected and intended, however, that program results will support substantial design code change as well as provide a consistent limit-state design methodology and basic cohesive design information.

The U.S. program is being conducted on a project basis to provide the task and schedule coordination required for efficient and orderly conduct of the program. The organizational structure of the project is shown in Figure 1. The research tasks are described in the following section. Research tasks will be done by the TCCMAR members. Basic TCCMAR policies, and objectives, have been and will continue to be developed by an Executive Panel. The Consultants Panel, consisting of eminent individuals listed in Table 2, provide an objective overview of the program to assure program objectives are met.

Industry Observers, listed in Table 3 provide the main interface between the project and the ultimate user group of the program results. The Observers were selected so that the main components of the user group, i.e., building codes bodies, masonry unit producers, trade organizations, and design professionals, would be represented.

Funding for the U.S. program is being provided by the National Science Foundation and coordination with the UJNR panel is done through TCCMAR-UJNR Liaison personnel.

TABLE 2
CONSULTANTS PANEL

Vitelmo Bertero	Professor of Civil Engineering, University of California - Berkeley.
John Meehan	Research Director and Principal Structural Engineer, Structural Safety Section. Office of the State Architect, State of California.
James Amrhein	Executive Director, Masonry Institute of America, Los Angeles, California.
Robert Hanson	Professor of Civil Engineering, University of Michigan, Ann Arbor.

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FIGURE 1 - TCCMAR ORGANIZATION (U.S.)

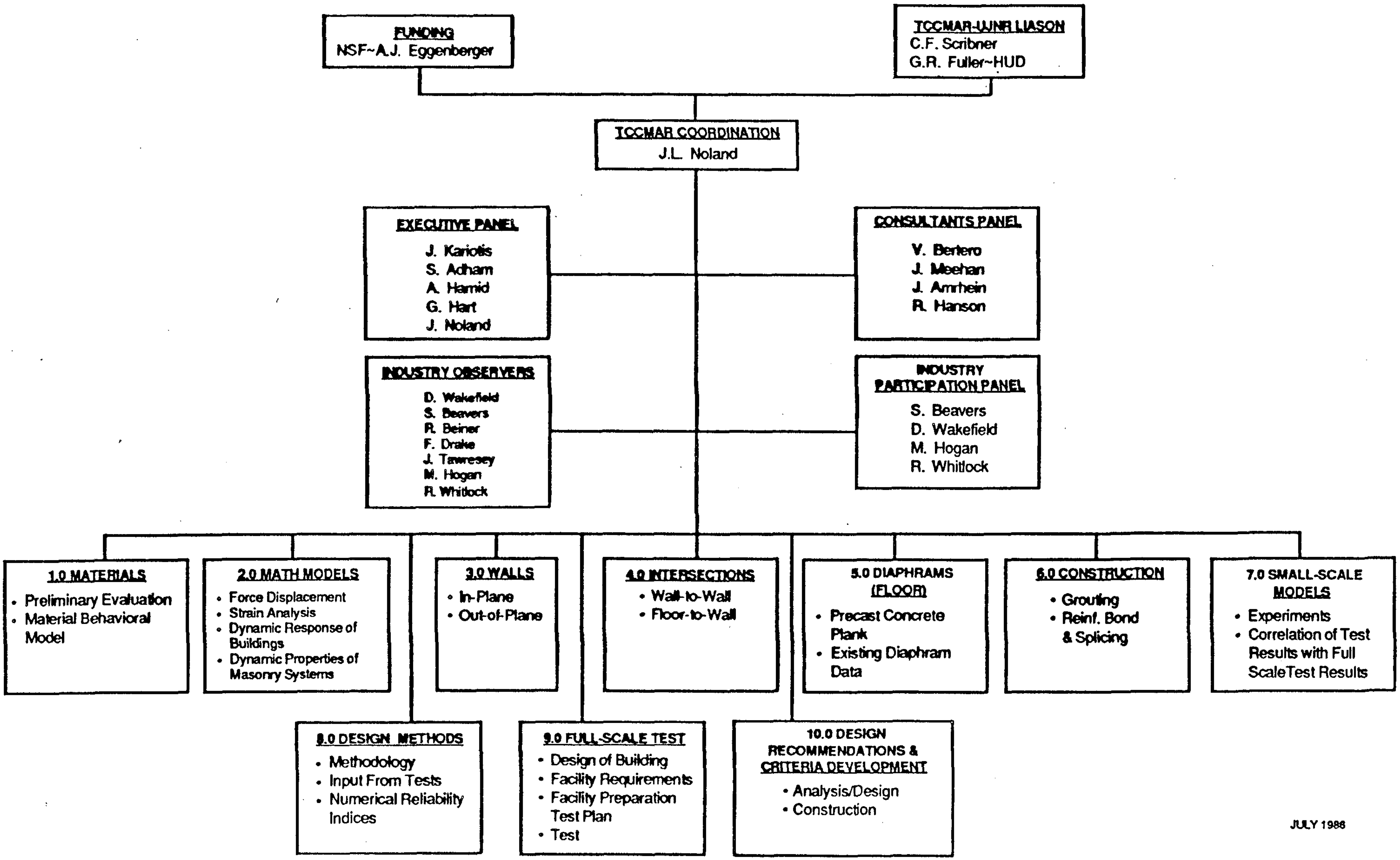

TABLE 3
INDUSTRY OBSERVERS

Donald Wakefield	Vice President - Marketing, Interstate Brick Co., West Jordan, Utah.
Stuart Beavers	Executive Director, Concrete Masonry Association of California and Nevada, Sacramento, CA
Robert Beiner	Director of Engineering, International Masonry Institute, Washington, D.C.
Frank M. Drake	Assistant Technical Director, International Conference of Building Officials, Whittier, CA
John Tawresey	Vice President of Finance and Consulting Engineer, KPFF, Seattle, WA
Mark Hogan	Engineer, National Concrete Masonry Association, McLean, VA
Gerald Dalrymple	Engineer, Brick Institute of America, Reston, VA

3.2 Research Tasks - Research tasks which were identified by TCCMAR fall into ten categories each of which may contain one or more research tasks. The task and basic purposes for each task are listed below:

Category	Task	Title-Purpose
1.0	1.1	Preliminary Material Studies - To establish the range of continuity of masonry behavior to provide a basis for selection of the type or types of masonry to be used. To establish standardized materials test procedures for all the experimental tasks.
1.0	1.2	Material Models - To evaluate K1, K2, and K3 for the flexural stress-block. To determine uniaxial & biaxial material properties for analytical models (Tasks 2.1 and 2.2) including post-peak behavior. To evaluate non-isotropic behavior.

Category	Task	Title-Purpose
2.0	2.1	Force-Displacement Models for Masonry Component - To develop force-displacement mathematical models which accurately characterize reinforced masonry components under cyclic loading to permit pretest predictions of experimental results. To develop models suitable for parameter studies and models suitable for design engineering.
2.0	2.2	Strain Analysis Model for Masonry Components - To develop a strain model for reinforced masonry components in conjunction with Task 2.1 to enable regions of large strain to be identified thus assisting in experimental instrumentation planning. To develop a simplified model to be used to provide data for strength design rules and in-plane shear design procedures.
2.0	2.3	Dynamic Response of Masonry Buildings - To develop a generalized dynamic response model to predict interstory displacements using specified time histories. To correlate force-displacement models and to investigate force-displacement characteristics of structural components in the near-elastic and inelastic displacement range. To provide data for building test planning.
2.0	2.4	Dynamic Properties of Masonry Systems - To develop a consistent, unified, rationale for seismic design of masonry buildings considering elastic and inelastic response of masonry buildings and of the soil/structure interaction and related to seismic hazard zones.
3.0	3.1(a)	Response of Reinforced Masonry Story-Height Walls to Fully Reversed In-Plane Lateral Loads - To establish the behavior of story-height walls subjected to small and large amplitude axial force, and bending moments considering aspect ratios, reinforcement ratios and patterns, and the effect of openings.

Category	Task	Title-Purpose
3.0	3.1(b)	<u>Development of a Sequential Displacement Analytical and Experimental Methodology for the Response of Multi-Story Walls to In-Plane Loads</u>- to develop a reliable methodology for investigating, through integrated analytical of multistory reinforced hollow unit masonry walls. The methodology will be the basis of studying the response of a full-scale masonry research building.
3.0	3.2(a)	<u>Response of Reinforced Masonry Walls to Out-of-Plane Static Loads</u> - To verify the behavior of flexural models developed using material models, to evaluate the influence of unit properties, bond type and reinforcement ratios upon wall behavior. To provide stiffness data for correlation with dynamic wall test results (Task 3-2(b)).
3.0	3.2(b)	<u>Response of Reinforced Masonry Walls to Out-of-Plane Dynamic Excitation</u> - To determine effects of slenderness, reinforcement amounts and ratios, vertical load and grouting on dynamic response, to verify mathematical response models, to develop design coefficients for equivalent static load methods.
4.0	4.1, 4.2	<u>Wall-to-Wall Intersections and Floor-to-Wall Intersections of Masonry Buildings</u> - To determine the effectiveness of intersection details to connect masonry wall components, to construct a nonphenomenological analytical model of intersection behavior.
5.0	5.1	<u>Concrete Plank Diaphram Characteristics</u> - To investigate experimentally concrete plank diaphram floor diaphrams to determine modes of failure and stiffness characteristics including yielding capacity in terms of distortion as needed for masonry building models.
5.0	5.2	<u>Assembly of Existing Diaphram Data</u> - To assemble extensive existing experimental data on various types of floor diaphrams, to reduce to a form required for static and dynamic analysis models.
6.0	6.1	<u>Grouting Procedures for Hollow Unit Masonry</u> - To identify methods of grouting hollow unit masonry such that the cavity is solidly filled and reinforcement is completely bonded.

Category	Task	Title-Purpose
6.0	6.2	Reinforcement Bond and Splices in Grouted Hollow Unit Masonry - To develop data and behavioral models on the bond strength and slip characteristics of deformed bars in grouted hollow unit masonry, to develop data and behavioral models on the bond strength and slip characteristics of deformed bar lap splices in grouted hollow unit masonry as needed for building modeling.
7.0	7.1	Small Scale Models - To experimentally evaluate the use of small-scale modeling for reinforced hollow-unit masonry walls by correlating test results with test results of full-scale walls of the same configuration. To determine if tests of small-scale specimens can reveal basic characteristics and failure modes of full-scale masonry specimens.
8.0	8.1	Limit State Design Methodology for Reinforced Masonry - To select an appropriate limit state design methodology for masonry. To select and document a procedure to compute numerical values for strength reduction factors. To review program experimental research tasks to assure that statistical benefits are maximized and proper lid-
8.0	8.2	Numerical Reliability Indices - To develop numerical values of statistically-based strength reduction (i.e., 0) factors using program experimentally developed data, other applicable data, and judgement.
9.0	9.1	Design of Reinforced Masonry Research Building - To develop the preliminary designs of the potential research buildings which reflect a significant portion of modern U.S. masonry construction. To estimate inter-story displacements using methods developed in Category 2 tasks and the associated load magnitudes and distributions. To select a single configuration in consultation with TCCMAR which will be used as a basis for defining equipment and other laboratory facilities in Task 9.2.
9.0	9.2	Facility Preparation - Define, acquire, install and check-out equipment required for experiments on a full-scale masonry research building.

Category	Task	Title-Purpose
9.0	9.3	Full Scale Masonry Research Building Test Plan- To develop a detailed and comprehensive plan for conducting static load-reversal tests on a full-scale reinforced masonry research building.
9.0	9.4	Full Scale Test - To conduct experiments on a full-scale reinforced masonry research building in accordance with the test plan and acquiring data indicated. To observe building response and adjust test procedures and data measurements as required to establish building behavior.
10.0	10.1	Design Recommendations and Criteria Development - To develop and document recommendations for the design of reinforced masonry building subject to seismic excitation in a manner conducive to design office utilization. To develop and document corresponding recommendations for masonry structural code provisions.
11.0	11.1	Coordination - To fully coordinate the U.S. research tasks to enhance data transfer among researchers and timely completion of tasks. To schedule and organize TCCMAR and Executive Panel meetings. To establish additional program policies as the need arises. To stimulate release of progress reports and dissemination of results. To coordinate with industry for the purposes of informing industry and arranging industry support. To interface with NSF and UJNR on overall funding and policy matters.

Because of a reduction in funds available Tasks 4.1, 6.1, and 7.1 have been removed from the program for the present. Tasks 1.1, 1.2, 2.1, 2.2, 2.3, 3.1(a), 3.1(b), 3.2(a), 3.2(b), 4.2, 5.1, 5.2, 6.2, 8.1, 9.1, and 11.1 have been or soon will be funded. NSF Project Summaries (Form 4) of these Tasks are in Appendix 1.

3.3 Systems Approach and Task Coordination - A systems approach is being taken to guide an control the program, i.e, The U.S. Coordinated Program for Masonry Building Research is a cohesive entitity rather than a collection of separate projects. The individual research tasks which comprise the U.S. program are defined in a manner that they "fit together". Hence, the research tasks are interdependent, i.e., results from a given task may be required for the execution of others and vice-versa. Analytical tasks generally require interaction with experimental tasks on a fairly continuous basis so that analytical model development may incorporate data as they are obtained. The needs of the analytical tasks in turn serve to define, in part, the manner in which experimental tasks are

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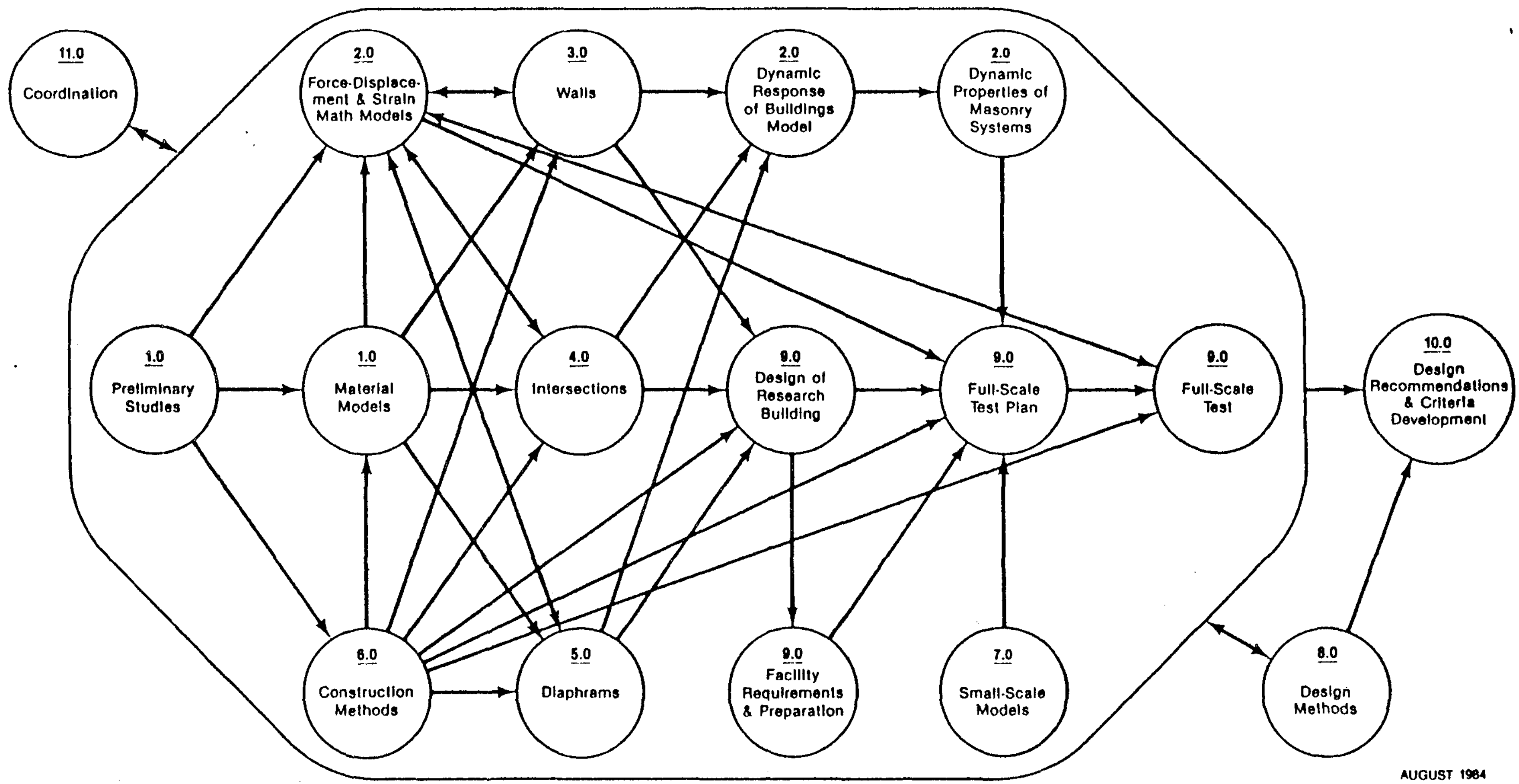
FIGURE 2 — TASK INGREDIENTS-DEPENDENCE CHART (U.S. PROGRAM)



designed and conducted and the data to be obtained.

The intra-task interaction is depicted generally in Figure 2. The circles represent task categories except where individual tasks within a category have different interaction relationships. The Coordination category and Design Methods category interact with all categories and tasks within the large boundary as well as with the Design Recommendations and Criteria Development category.

3.4 Schedule - The schedule for tasks comprising the U.S. program is shown by Figure 3. The total time required to complete the program is estimated to be approximately six years. The tasks are time-phased so that results will be available in the proper sequence.

4.0 BUDGET

Funding of the first phases has been awarded from fiscal year 1985, 1986, and 1987 NSF funds as shown in Table 4. The funds will generally support the project through calendar 1987 and slightly into 1988 for a few tasks.

Funding needs for the project in 1988 and beyond have not yet been firmly established. Preparation of proposals for work in that period will be done in 1987 for tasks which continue into that period and for tasks which begin in that period.

5.0 INDUSTRY PARTICIPATION

5.1 Masonry Units - Masonry units required for construction of experimental specimens will be furnished and delivered to the appropriate researchers at no cost to the program. Letters confirming the contribution are in Appendix 1.

The value of the units, including shipping, is:

20300 hollow concrete units at \$2.25 each =	\$45,675
9300 hollow clay units at \$2.00 each =	\$18,600
Total	\$64,275

5.2 Precast Concrete Planks- Prestressed, precast hollow core concrete planks will be donated for the purpose of fabricating the floor diaphragm specimens required for Task 5.1. It is estimated that the value of this contribution is approximately \$7500.

5.3 Miscellaneous Materials- Portland cement, reinforced bars, lime and a mortar mixer have been and will be donated for the purposes of Tasks 3.1(a) and 6.2. The value of this contribution is approximately \$2000.

5.4 Fabrication of Large Specimens- The Industry Participation Panel will attempt to arrange for industry to contribute to or donate labor to fabricate large masonry specimens needed for Tasks 3.1(b), 3.2(b1), 3.2(b2) and 9.4.

FIGURE 3 — TASK SCHEDULE (U.S. PROGRAM)

U.S.-JAPAN COORDINATED PROGRAM FOR MASONRY BUILDING RESEARCH

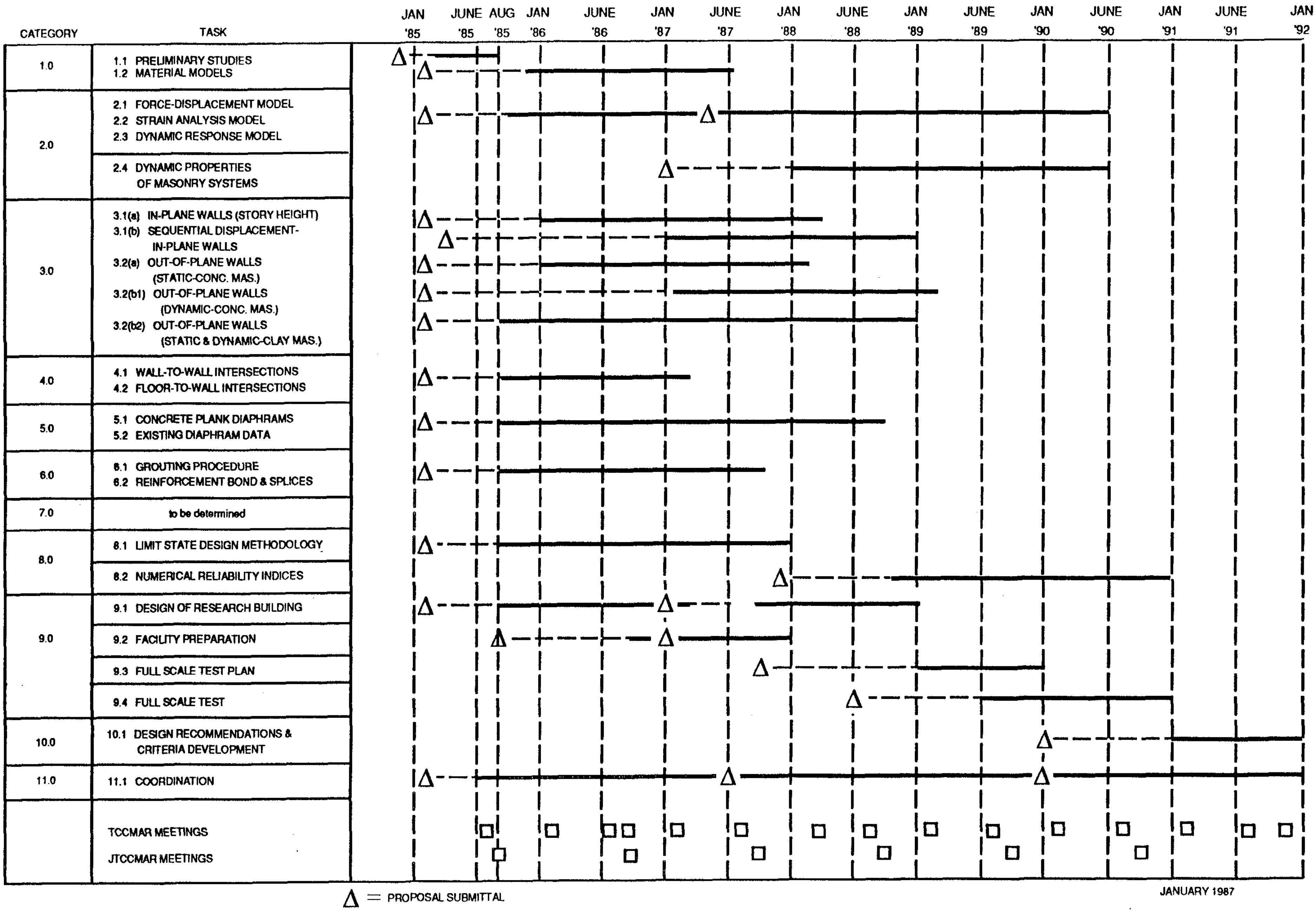


TABLE 4
FUNDS AWARDED FOR PHASES 1, 2, & 3

Task	P.I.	Phase 1 FY `85	Phase 2 FY `86	Phase 3 FY `87	Total
1.1	Atkinson	57346	-	-	57346
1.2(a)	Hamid/Harris	39839	31873	-	71712
1.2(b)	Brown	42560	41315	-	83875
2.1	Hart	48910	45830	84767	178889
2.2	Ewing	58009	42410	78470	179889
2.3	Kariotis	53590	41740	77201	172531
3.1(a)	Noland/Shing	77041	70433	-	147474
3.1(b)	Hegemier/Seible	-	199356	199988	399344
3.2(a)	Hamid/Harris	-	41500	48052	89552
3.2(b1)	Adham	-	-	105920	105920
3.2(b2)	Mayes	8992	40038	155713	204743
4.2	Hegemier	62400	-	-	62400
5.1/5.2	Porter	15000	52490	52490	119980
6.2	Tulin	46773	36975	-	83748
8.1	Hart	36088	21798	22782	80668
9.1	Johnson Kariotis	21920	-	-	21920
9.2	Hegemier	-	796055	409645	1205700
11.1	Noland	42275	44540	37540	124355
TOTAL		$610,743	$1,506,353	$1,272,568	$3,389,664

6.0 CURRENT STATUS OF RESEARCH TASKS

The current status of each research task is summarized in Table 5. More complete discussions are presented by the individual task status reports in Appendix 3.

7.0 TCCMAR (U.S.) MEETINGS

Meetings of the entire U.S. team including consultants and industry observers have been held for the purpose of direct communication of planning, review of results and discussion of problems and coordination of efforts. Because of distances and costs involved, the meetings have been and will be scheduled at approximately 6 month intervals. TCCMAR meetings which have been held are listed in Table 6.

8.0 JOINT U.S.-JAPAN TCCMAR (JTCCMAR) MEETINGS

Joint meetings have been held with the Japanese research team (TCCMAR/Japan) to develop lines of communication, discuss research plans, and review results. The meetings reflect the spirit of UJNR objectives and have been mutually beneficial. Papers and reports presented are in proceedings of the meetings.

To date two meetings have been held as listed in Table 7. Plans and arrangements have been made for the third on the date and at the place given in the Table. Resolutions made as a result of the meetings are in Appendix 4.

9.0 FOREIGN (NON-JAPANESE) RESEARCHER VISITS

9.1 Dr. John Scrivener of the University of Melbourne, Australia spent a six month sabbatical at the University of Colorado and at Atkinson-Noland and Associates. He was supported by the University of Colorado, the University of Melbourne and the National Science Foundation. Dr. Scrivener met frequently with the Principal Investigators of Tasks 3.1(a) and 6.2 to offer comments on the research at the University of Colorado and upon the overall U.S. research program. He prepared reports pertinent to Tasks 3.1(a) and 6.2 which have been published and distributed (12, 13).

9.2 Dr. M.J. N. Priestley of the University of Canterbury in New Zealand spent approximately two weeks in the U.S. for the purpose of consulting on the research plans for Tasks 3.1(a), 3.2(b), and 6.1. His time was spent equally between Boulder and San Diego. Meetings with Dr. Priestley were attended by Tulin, Shing, Atkinson, Hegemier, Seible, Woodward, Ewing and Noland. The results of the meetings are reflected in the research plans for Tasks 3.1 (a), 3.1(b), and 6.2.

Table 5
Summary Research Task Status- July 1986

Task	Title	Percent Complete	Work Remaining
1.1	Preliminary Studies	100	none
1.2(a)	Material Models- Concrete Masonry	50	Data analysis Report
1.2(b)	Material Models- Clay Masonry	20	Pilot tests Prism construction In-plane and out-of-plane tests Data analysis Report
2.1	Force-Displacement Model	15	Develop a method for modeling of reinforced masonry with degrading stiffness under cyclic loading.
2.2	Strain Analysis Model	15	Install two-dimensional nonlinear rebar element and a yield criterion to VISCOT. Modify pre and post processors. Compare predictions with experimental results. Develop a new program to predict response modes and limit states for shear walls in a bi-axial stress state.
2.3	Dynamic Response Model	15	Evaluation of simplifying inelastic material properties that include shear deformation in finite element program. Coordinate with experimental tasks to obtain modeling data.

Table 5 (Con't)
Summary Research Task Status - July 1986

Task	Title	Percent Complete	Work Remaining
3.1(a)	Story Height In-Plane Walls	10	Tests for approximately 17 specimens Analyze data for tests as tests are done to evaluate test matrix.
3.1(b)	Sequential Displacement - In-plane walls	-0-	The entire task
3.2(a)	Out-of-Plane Walls (Static-	20	Building of wall specimens and test fixture system. Test walls. Analyze data. Report.
3.2(b1)	Out-of-Plane Walls (Dynamic - Concrete Masonry)	-0-	The entire project.
3.2(b2)	Out-of-Plane Walls (Static and Dynamic- Clay Masonry)	15	Fabrication and Testing of wall specimens including development of time histories to be used. Analyze data. Report.
4.1/4.2	Wall-to-Wall and Floor-to-Wall Intersections	60	Finish review of data and prepare report.
5.1	Concrete Plank Floor Diaphragms	15	Test set-up and pilot tests. Check results and procedures and perform tests. Analyze data. Report.
5.2	Review of Existing Diaphragm Data	20	Complete review of existing data. Report.

Table 5 (Con't)
Summary Research Task Status - July 1986

Task	Title	Percent Complete	Work Remaining
6.2	Reinforcement Bond and Splices	30	Complete testing of specimens. Analyze results. Report.
8.1	Limit State Design Methodology	15	Continue with concept development including literature review.
9.1	Design of Research Building (preliminary)	60	Analysis of research building to establish general strength level of the building for test facility planning. Preliminary investigation of test loading schemes. Report.
9.2	Facility Preparation (equipment)	10	Definition and acquisition of test equipment required for Task 3.1(b) and 9.4.
9.3	Full Scale Test Plan	-0-	Entire task.
9.4	Full Scale Test	-0-	Entire task
10.1	Design Recommendations and Criteria Development	-0-	Entire task
11.1	Coordination	-	On-going coordination duties

TABLE 6

TCCMAR MEETINGS HELD

Date	Location	Main Topics
February 1984	Pasadena	Research need of reinforced masonry. Specific tasks identified.
July 1985	Boulder, CO	Research program reviewed. Budgets reduced by an average of 45%.
October 1985	Boulder, CO	Revised program reviewed and presented to consultants and visitors. Electronic mail for TCCMAR communications suggested.
February 1986	Los Angeles, CA	Review of research tasks. Changes suggested. Modeling concepts & philosophy discussed.
July 1986	Boulder, CO	Review of research tasks with comments and suggestions on each. Decision made to postpone if not delete Task 7.1 on small-scale models.

TABLE 7

JOINT U.S. - JAPAN MEETINGS

Date	Location	Title of Proceedings
March 1984	Tsukuba, Japan	First Workshop of U.S.-Japan Cooperative Research on Masonry Structures
August 1985	Tokyo, Japan	The First Joint Technical Coordinating Committee on Masonry Research: U.S.-Japan Cooperative Research Program
Planned: September 1986	Keystone, CO	The Second Meeting of the Joint Technical Coordinating Committee On Masonry Research: U.S.-Japan Cooperative Research Programs.

10.0 U.S.-JAPAN RESEARCHER EXCHANGE

10.1 Dr. Masaomi Teshigawara (BRI-Tsukuba, Japan) spent the fall of 1985 in the U.S. primarily at the University of Colorado. He involved himself in both Tasks 3.1(a) and 6.2 and was helpful in relating the Japanese experiences on the subjects of these Tasks.

Arrangements were made for Dr. Teshigawara to visit several U.S. organizations concerned with masonry, i.e., NCMA, BIA, NBS, PCA as well as the University of California in San Diego and Berkeley.

10.2 Dr. Osamu Senbu will visit the U.S. in August-September 1986. Arrangements have been made for him to stay in Boulder and to subsequently attend the joint meeting on September in Keystone, CO.

10.3 Dr. Frieder Seible will be the candidate for a Japanese Government Research Award. Discussions are underway with TCCMAR/-Japan to identify the necessary procedures. Dr. Seible spent an extra week in Japan immediately prior to the joint U.S.-Japan meeting in August 1985 to review the large-scale test facilities. This was done to discover any information which could affect the design of the large-scale test laboratory which has been built at UCSD.

10.4 Hart, Kariotis, Ewing and Noland visited BRI briefly (two days) in May 1986 as a stop-over on the way to a NSF-sponsored U.S.-China masonry structures meeting in Harbin, China. It was an opportunity to review Japanese test results and to continue with arrangements for the next joint U.S.-Japan meeting to be held in September 1986.

11.0 REPORTS

Several reports have been published by TCCMAR/U.S.. They are listed below:

Atkinson & Kingsley, Comparison of the Behavior of Clay and Concrete Masonry in Compression, September 1985.

Seible, F., Report on Large Structures Testing Facilities in Japan, September 1985.

Scrivener, J., Summary of Findings of Cyclic Tests on Masonry Piers, June 1986.

Scrivener, J., Bond of Reinforcement in Grouted Hollow-Unit Masonry: A State-of-the Art, June 1986.

Woodward, K., Report On a Site Visit to Building Research Institute, Ministry of Construction, Tsukuba, Japan, July 1986.

12.0 PRESENTATIONS

Presentations have been made at several industry and professional meetings to describe the nature and content of the U.S. Coordinated Program for Masonry Building Research. It is considered important that such groups, who are among the eventual users of program results, be aware of the work and have an opportunity to comment. Among the presentations made are:

12.1 Noland: Concrete Masonry Association of California and Nevada, September 1984
Western States Clay Products Association- Oct. 1984
Masonry Research Foundation- July 1985
ASCE Structures Congress- September 1985
ASCE Conference on Dynamic Response of Structures- March 1986
Concrete Masonry Association of California and Nevada- September 1986 (planned)

12.2 Porter: 18th UJNR Meeting, May 1986

12.3 Hamid: Fourth Canadian Masonry Symposium, June 1986

13.0 REFERENCES

1. Uniform Building Code, International Conference of Building Officials, Whittier, CA 1985.

2. Schneider, R., and Dickey, W., "Reinforced Masonry Design", Prentice Hall, 1980.

3. Proceedings of the North American Masonry Conference, Noland and Amrhein, ed., Boulder, Colorado, August 1978.

4. Proceedings - Conference on Masonry Research in Progress, Noland and Amrhein, ed., Boulder, Colorado, May 1980.

5. Proceedings of the 2nd North American Masonry Conference, Colville and Vannoy, ed., College Park, MD, August 1982.

6. Proceedings of the Third North American Masonry Conference, Matthys and Borchelt, ed., Arlington, TX, June 1985.

7. Resolutions of the Fifteenth Joint Meeting, U.S.-Japan panel on Wind and Seismic Effects - UJNR, May 17-20, 1983.

8. Resolutions of the First Workshop on the U.S.-Japan Masonry Program- UJNR, March 17, 1984.

9. Report of the Task Committee on Large Scale Testing Program - UJNR, May 17, 1984.

10. Earthquake Engineering Facilities and Instrumentation, Ad Hoc Committee on Earthquake Engineering Facilities and Instrumentation, Commission on Engineering and Technical Systems, National Research Council, National Academy Press, Washington, D.C., 1984.

11. Seible, F., Report on Large Structures Testing Facilities in Japan, TCCMAR Report 9.2-1, UCSD, September 1985.

12. Scrivener, J. C., Bond of Reinforcement in Grouted Hollow-Unit Masonry: A State of the Art, TCCMAR Report 6.2-1, Atkinson-Noland & Assoc., July 1986.

13. Scrivener, J.C., Summary of Findings of Cyclic Shear Tests on Masonry Piers, TCCMAR Report 3.1(a)-1, Atkinson-Noland & Assoc., June, 1986.

APPENDIX 1

PROJECT SUMMARIES

FOR RESEARCH TASKS

Category 1.0
Task 1.1

NOTICE OF RESEARCH PROJECT

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Atkinson-Noland & Associates, Inc.

... (INCLUDE DEPARTMENT)

2619 Spruce Street
Boulder, Colorado 80302

... INVESTIGATOR(S)

Richard H. Atkinson, Ph.D.

... OF PROJECT

AN INVESTIGATION INTO THE "CONTINUITY" OF HOLLOW CONCRETE AND CLAY UNIT MASONRY BEHAVIOR OVER THE COMPLETE STRESS-STRAIN RANGE

...NICAL ABSTRACT (LIMIT TO 22 PICA OR 18 ELITE TYPEWRITTEN LINES)

A study is proposed to investigate to what extent the two distinct types of masonry used in the U.S. for seismic resistant construction, namely, grouted hollow concrete block masonry and grouted hollow clay unit masonry, have similar engineering behavioral characteristics. If a "continuity" of behavior can be shown to exist, results from large scale tests including expensive tests of full scale masonry structures will be broadly applicable to many specific masonry types and configurations. This study will first review available data and then plan and conduct a limited test series to evaluate the extent to which commonly used types of U.S. masonry have similar engineering behavioral aspects. The results of axial concentric and eccentric tests and shear tests on grouted concrete and clay brick masonry specimens will provide the necessary basis for the evaluation of continuity. This study will also utilize and evaluate possible standardized specimen construction techniques and test techniques for use by other researchers. The results of this program will be dessiminated on a timely basis for use by other researchers for planning and conducting their programs.

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Category 1.0
Task 1.2(a)

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Department of Civil Engineering

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Philadelphia, PA 19104

PRINCIPAL INVESTIGATOR(S)

Dr. Ahmad A. Hamid
Dr. Harry G. Harris

TITLE OF PROJECT

MATERIAL MODELS FOR HOLLOW CONCRETE MASONRY UNITS

TECHNICAL ABSTRACT (LIMIT TO 22 PICA OR 18 ELITE TYPEWRITTEN LINES)

To be able to develop a rational design methodology for reinforced masonry structures the material properties should be well defined. It is the objective of this research project to determine experimentally key parameters required to develop strength and deformation analysis models for block masonry walls under in-plane and out-of-plane loading. The compressive stress distributions under different strain gradients will be determined. A total of 90 specimens will be tested under concentric and eccentric compression loading operated on strain control using a servo-controlled closed loop hydraulic system. Different strength and geometric parameters such as block size, block strength, and prism configuration are considered. The test results will be used to establish a rational ultimate strength design procedure for reinforced block masonry.

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Task 1.2(b)

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Clemson University
College of Engineering

... (INCLUDE DEPARTMENT)

Civil Engineering
110 Lowry Hall
Clemson, South Carolina 29631

... INVESTIGATOR(S)

Russell H. Brown

... OF PROJECT

PROPERTIES OF GROUTED HOLLOW BRICK MASONRY

... ABSTRACT (LIMIT TO 22 PICA OR 18 ELITE TYPEWRITTEN LINES)

The objective of this research is to determine the properties of the compressive stress block under strain gradient of grouted hollow brick masonry for both in-plane and out-of-plane bending. This information will be determined experimentally using prisms 18 in. wide and 24 in. high, with thicknesses varying from 4, 6, and 8 inches. Determination of flexural compressive stress block properties will be accomplished using a compression testing machine combined with closed-loop actuators to produce a neutral axis in the desired location. The compressive stress block will be determined for both in-plane and out-of-plane loading by positioning the actuator relative to the prism in the appropriate manner. Displacement control closed-loop feedback technology will be used to control the location of the neutral axis. Monotonic tests will be conducted on the compression stress block experiments. Deformation characteristics will be obtained by mounting deflection transducers on all test specimens. It is expected that a total of 150 test specimens in addtion to standard ASTM E447 compression prisms will be tested.

The results may be included in mathematical models for the prediction of in-plane and out-of-plane loading for reinforced grouted hollow brick masonry walls.

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Category 2.0
Task 2.1

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NAME OF INSTITUTION (INCLUDE BRANCH/CAMPUS AND SCHOOL OR DIVISION)

Englekirk & Hart

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Los Angeles, CA 90018

PRINCIPAL INVESTIGATOR(S)

Gary Hart

TITLE OF PROJECT

ANALYSIS MODELS FOR MASONRY COMPONENTS AND STRUCTURES

TECHNICAL ABSTRACT (LIMIT TO 22 PICA OR 18 ELITE TYPEWRITTEN LINES)

The force deformation characteristics of structural components using structural engineering models are developed and compared with test data obtained from other TCCMAR Researchers. The models are developed and then coded up for application during latest phases of the TCCMAR program on an IBM PC computer. A sensitivity analysis of the structural engineering parameters is performed. Normal design values are used to compare analytical models with the TCCMAR experimental data.

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Category 2.0
Task 2.2

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Ewing & Associates

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PRINCIPAL INVESTIGATOR(S)

Robert D. Ewing

TITLE OF PROJECT

STRAIN ANALYSIS MODELS FOR MASONRY COMPONENTS

TECHNICAL ABSTRACT (LIMIT TO 22 PICA OR 18 ELITE TYPEWRITTEN LINES)

The research of Task 2.2 is a part of the general TCCMAR Category 2 task of developing mathematical models for the analysis and design of reinforced masonry buildings subjected to seismic-induced relative displacements. The research of Task 2.2 will result in the development of strain analysis models for reinforced masonry components. These studies will lead to the estalishment of behavior rules for use in Tasks 2.1 and 2.3, where force-deformation models for reinforced masonry components will be developed and applied to static and dynamic models. The research of Task 2.2 will be conducted in conjunction and close cooperation with the research in Tasks 2.1 and 2.3.

The strain models will be static with nonlinear, hysteretic characteristics, and will include both finite element and lumped parameter formulations. They will incorporate all relevant response modes or limit states, such as flexure/rocking, diagonal compression/shear, and sliding. The development of the models will be keyed to strain prediction at specified nonlinear deformation levels, rather than tracking charges in strain during cyclic excursions. The models will be correlated with the component testing being conducted by others, and will be used to rank the importance of the various model parameters. Simplified models will also be developed to extend the experimental data base. Strength design rules for reinforced masonry will be developed from the simplified strain prediction model.

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Category 2.0
Task 2.3

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R.D. Ewing, J.C. Kariotis, R.E. Englekirk, G.C.Hart

TITLE OF PROJECT

DYNAMIC RESPONSE OF MASONRY BUILDINGS

TECHNICAL ABSTRACT (LIMIT TO 22 PICA OR 18 ELITE TYPEWRITTEN LINES)

Task 2.3 is part of the general task of the mathematical modeling of reinforced masonry buildings that are subjected to seismic induced relative displacements. The dynamic response model utilizes the force-displacement models that are developed in Task 2.1 to predict the relative displacement of floor levels of a building when it is shaken by seismic ground motions.

The development of the mathematical model must consider the force-displacement characteristics of the structural elements in both the elastic and inelastic range. To estimate the relative inelastic displacement of stories or other parts or portions of the building, time-history dynamic studies will be utilized. The mathematical model will be a structural analysis model that considers only two dimensional response to horizontal ground motions. The model will be used for parametric studies that will include soils interaction effects. The soils interaction effects will consider both the rocking of a building on the soils and the decoupling of the building mass from the horizontal ground motion by shear displacements in the soils.

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Category 3.0
Task 3.1(a)

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...INVESTIGATOR(S)

J. L. Noland and P. B. Shing

...OF PROJECT

RESPONSE OF REINFORCED MASONRY STORY-HEIGHT WALLS TO FULLY REVERSED IN-PLACE LOADS

...ABSTRACT (LIMIT TO 22 PICA OR 18 ELITE TYPEWRITTEN LINES)

The purpose of this research project is to investigate the inelastic seismic performance of reinforced masonry wall panels. Wall panels are the major seismic load resisting elements of reinforced masonry structures. The test specimens will represent a story-height panel of a multi-story structure, and will be subjected to simultaneous in-plane lateral loads, axial loads, and overturning moments, which could be encountered under real seismic conditions. The major parameters that will be investigated include: (a) the amount of vertical reinforcement; (b) the amount and distribution of horizontal reinforcement; (c) the magnitude of the applied axial stress; (d) the effective aspect ratio of wall panels; (e) the masonry type; and (f) the quasi-static displacement history imposed. The effects of these parameters on the capacity limit state, stiffness and strength degradation, base slip, ductility, and energy-dissipation capability of wall panels will be examined. A total of twenty-six wall specimens will be tested.

Scope of the project will include (a) determination of load histories and patterns applied to wall panels; (b) design, fabrication, and verification of test apparatus; (c) design, fabrication, and testing of wall specimens; and (d) data reduction and interpretation. The project will be an integral part of the U.S.-Japan Coordinated Program for Masonry Building Research.

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Category 3.0
Task 3.1(b)

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NAME OF INSTITUTION (INCLUDE BRANCH/CAMPUS AND SCHOOL OR DIVISION)

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The University of California, San Diego
Division of Engineering, Revelle College

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La Jolla, California 92093

PRINCIPAL INVESTIGATOR(S)

Gilbert A. Hegemier- Applied Mechanics
Frieder Seible- Structural Engineering

TITLE OF PROJECT

SEQUENTIAL DISPLACEMENT METHOD FOR MULTI STORY IN-PLANE REINFORCED HOLLOW UNIT MASONRY WALLS UNDER SIMULATED SEISMIC EXCITATIONS

TECHNICAL ABSTRACT (LIMIT TO 22 PICA OR 18 ELITE TYPEWRITTEN LINES)

The research proposed is part of the "U.S. Coordinated Program for Masonry Building Research". The ultimate objective of this U.S. program is the development of a consistent, basic framework of knowledge leading to design and construction methodology recommendations for safer and possibly more economical masonry buildings in seismic environments. To achieve this objective it has been proposed to conduct integrated experimental and analytical studies on simple components, main subassemblages, and finally a complete multistory masonry building (Masonry Research Building). These studies will be conducted using small, medium and full scale specimens.

The main objective of the studies proposed in this particular research proposal is the development of a reliable methodology for investigating, through integrated analytical and experimental studies, the in-plane behavior of multistory reinforced hollow unit masonry wall elements, when a building is subjected to earthquake ground motions. Emphasis will be given to the development of the experimental (test) methodology. The methodology to be developed should be such that it could be used as a basis for the experimental methodology for studying the earthquake behavior of the full scale Masonry Research Building. Results from the two and three story in-plane wall tests will be used to verify the analytical models developed as part of the U.S. Coordinated Program for Masonry Building Research.

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Category 3.0
Task 3.2(a)

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Drexel University
Department of Civil Engineering

...LUDE DEPARTMENT)

32nd and Chestnut Streets
Philadelphia, PA 19104

... INVESTIGATOR(S)

Dr. Ahmad A. Hamid and Dr. Harry G. Harris

TITLE OF PROJECT

NONLINEAR RESPONSE OF REINFORCED MASONRY WALLS UNDER OUT-OF-PLANE CYCLIC LOADING

...ABSTRACT (LIMIT TO 22 PICA OR 18 ELITE TYPEWRITTEN LINES)

Masonry structures are particularly susceptible to earthquake damage. For adequate performance under seismic loading, reinforced masonry walls should be ductile and capable of dissipating energy through inelastic response. Analytical procedures relating to seismic failure analysis necessitate the establishment of the hysteretic response and failure envelope of masonry walls. In this research program, an experimental study will be conducted to provide test data about strength, cyclic response and post-yield behavior of reinforced block masonry walls under out-of-plane cyclic quasi-static loading. A total of 14 full scale walls (4' x 8') will be tested vertically which covers parameters such as percentage of vertical steel, bond type, block size and type of cyclic load. The effects of different parameters on the flexural strength, ductility, hysteretic curves, post-yield envelopes and failure modes will be investigated. Of significant importance is the investigation of the stability of the hysteretic curves and the stiffness degradation that may take place under cyclic loading.

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Category 3.0
Task 3.2(bl)

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PRINCIPAL INVESTIGATOR(S)

Mihran S. Agbabian, Samy A. Adham, and Sami F. Masri

TITLE OF PROJECT

RESPONSE OF REINFORCED MASONRY WALLS TO OUT-OF-PLANE DYNAMIC EXCITATION

TECHNICAL ABSTRACT (LIMIT TO 22 PICA OR 18 ELITE TYPEWRITTEN LINES)

This project, which corresponds to Task 3.2(bl) of the TCCMAR program, will be used to determine the out-of-plane dynamic seismic response of slender msonry walls. The experimental program proposed here will be conducted by USC at Agbabian Associates in El Segundo, CA, and will test concrete block walls of thicknesses 4.5 and 6 in. A complementary program for 6 inch and 8 inch clay block masonry walls will be conducted by Computeck at Berkeley (Task 3.2(b2) of TCCMAR). The test set-up and instrumentation procedures will be adapted from other Agbabian Associates dynamic testing programs for wall panels. Data will be derived for the dynamic displacement of thin masonry walls excited by realistic earthquake motions at bottom and top of the wall panels. Six wall specimens 20 feet high will be fabricated for height/thickness ratios from 43 to 53.3. Same masonry strength and two reinforcing steel ratios will be used. A ledger weight corresponding to the roof weight will be used as an overburden mass. Predicted results from the analytical model developed in Task 2 of the TCCMAR program will be correlated with the test results, whereby the model can be upgraded and validated.

1. Proposal Folder
2. Program Suspense
3. Division of Grants & Contracts
4. Science Information Exchange
5. Principal Investigator
6. Off. of Govt. & Pub. Progs.

NSF FORM 4 (8-80)

Category 3.0
Task 3.2(b2)

NOTICE OF RESEARCH PROJECT

SCIENCE INFORMATION EXCHANGE

SMITHSONIAN INSTITUTION
NATIONAL SCIENCE FOUNDATION

PROJECT SUMMARY

SIE PROJECT NO.
NSF AWARD NO.
ECE-8642817

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…S/DIVISION	PROGRAM OR SECTION	PROPOSAL NO.	F.Y.

…OF INSTITUTION (INCLUDE BRANCH/CAMPUS AND SCHOOL OR DIVISION)

Computech Engineering Services, Inc.

…LUDE DEPARTMENT)

2855 Telegraph Avenue, Suite 410
Berkeley, California 94705

…IPAL INVESTIGATOR(S)

Dr. Ronald Mayes

…OF PROJECT

THE TRANSVERSE RESPONSE OF MASONRY WALLS SUBJECTED TO STRONG MOTION EARTHQUAKES

…NICAL ABSTRACT (LIMIT TO 22 PICA OR 18 ELITE TYPEWRITTEN LINES)

The increased use of reinforced masonry and concrete walls for commercial and industri-…l buildings in higher seismic zones is due principally to their economy, fire safety, archi-…ectural appearance, and ease of construction. Along with this increased usage, there has … a trend toward making these walls more slender in the interest of … proper design for these walls for strength and safety has been an important task for …he structural engineer, and a number of concepts have been developed for these walls to …sist seismic and wind forces. Current code design requirements are primarily empirical …h a limit (25) on the height-to-thickness ratio. Unfortunately, the experimental re-…arch that has been performed to date on the out-of-plane response of these walls has been …mited primarily to monotonic, static loadings.

The objective of the research program is to perform a series of full scale out-of-plane … tests using realistic seismic input. Ten hollow clay brick masonry walls of varying …ight to-thickness and reinforcement ratios will be used. The objective is to develop …fficient data to refine an existing nonlinear dynamic analytical model. Associated ele-…nt tests will also be performed to obtain parameters difficult to measure accurately dur-… the dynamic tests. The refined analytical model will then be used to perform a series … parameter studies to investigate the validity and limits of applicability of proposed …ltimate strength design procedures for the out-of-plane response of masonry walls subjected … realistic seismic loads. Recommendations to modify current and proposed design method-…logies will be developed from the results of the parameter study. The masonry industry is …viding a significant financial contribution($80,000)to the test program in that they have …eed to pay for the materials and construction of the ten test specimens.

1. Proposal Folder
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FORM 4 (3-30)

Category 4.0
Tasks 4.1, 4.2

NOTICE OF RESEARCH PROJECT

SCIENCE INFORMATION EXCHANGE

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PROJECT SUMMARY

SIE PROJECT NO.

NSF AWARD NO. ECE-8517027

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DIRECTORATE/DIVISION	PROGRAM OR SECTION	PROPOSAL NO.	F.Y.

NAME OF INSTITUTION (INCLUDE BRANCH/CAMPUS AND SCHOOL OR DIVISION)

University of California, San Diego
Division of Engineering
Revelle College

ADDRESS (INCLUDE DEPARTMENT)

Department of Applied Mechanics and Engineering Sciences, B-010
La Jolla, California 92093

PRINCIPAL INVESTIGATOR(S)
G. A. Hegemier, Professor of Applied Mechanics, Earthquake Engineering

TITLE OF PROJECT

BEHAVIOR OF FLOOR-TO-WALL AND WALL-TO-WALL INTERSECTIONS

TECHNICAL ABSTRACT (LIMIT TO 22 PICA OR 18 ELITE TYPEWRITTEN LINES)

This proposal is an integral part of the U.S.-Japan Coordinated Program for Masonry Building Research. It addresses Category 4.0, Task 4.1 entitled, wall-to-wall intersections" and Task 4.2 entitled "floor-to-wall intersections". The research objective is to provide a comprehensive summary on basic experimental data on the monotonic and hysteretic behavior of planar intersection response, and to propose a viable analytical/numerical model of intersection behavior.

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NSF FORM 4 (8-80)

Category 5.0
Task 5.1, 5.2

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PROJECT SUMMARY

SIE PROJECT NO.	
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NAME OF INSTITUTION (INCLUDE BRANCH/CAMPUS AND SCHOOL OR DIVISION)

Iowa State University

ADDRESS (INCLUDE DEPARTMENT)

Civil Engineering Department
Ames, Iowa 50011

PRINCIPAL INVESTIGATOR(S)

Max L. Porter, Professor Civil Engineering and Engineering Resources Institute/Specializing in Structural Engineering Teaching and Research

TITLE OF PROJECT

CONCRETE PLANK DIAPHRAGM CHARACTERISTICS

TECHNICAL ABSTRACT (LIMIT TO 22 PICA OR 18 ELITE TYPEWRITTEN LINES)

The proposed research is an experiemntal and analytical investigation of the response of concrete plank diaphragms. The overall objective of the investigation is to determine the behavioral and strength characteristics of concrete plank diaphragms as related to lateral loads on buildings from earthquakes, wind, etc.

The research is divided into two major tasks. The first task consists of an anticipated 12 to 15 full-scale experimental tests of concrete plank diaphgragm slabs. The second major task encompasses the assembly of existing diaphragm data and the coordination of the resulting recommendations with the results of the experimental tests. The results of these two tasks are to be used to aid the effort of the Technical Coordinating Committee for Masonry Research and to aid in the design of full-scale buildings subjected to lateral loads.

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Form 4 (5-83)

Category 6.0
Task 6.2

NOTICE OF RESEARCH PROJECT

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PROJECT SUMMARY

SIE PROJECT NO.	
NSF AWARD NO.	ECE-8740850

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NAME OF INSTITUTION (INCLUDE BRANCH/CAMPUS AND SCHOOL OR DIVISION)

The University of Colorado at Boulder

ADDRESS (INCLUDE DEPARTMENT)

Civil, Environmental and Architectural Engineering
Campus Box 428, University of Colorado
Boulder, Colorado 80309

PRINCIPAL INVESTIGATOR(S)

Leonard G. Tulin

TITLE OF PROJECT

CONSTRUCTION PRACTICES INVOLVING BOND AND SPLICES IN REINFORCED MASONRY

TECHNICAL ABSTRACT (LIMIT TO 22 PICA OR 18 ELITE TYPEWRITTEN LINES)

The purpose of the proposed project is two-fold. The first objective will be the evaluation of the effect of shrinkage and bridging defects on the bond between grout and cavity wall in the grout-masonry unit composite. This will be examined by constructing and testing specimens with and without commercial plasticizer expanding agents to compare their performance and to quantify the effect of the defects.

The second objective will be the determination of the effect of shrinkage and bridging the bond between grout and reinforced steel in reinforced masonry specimens. From the results of this study recommendations will be made regarding permissible bond stresses and required embedment lengths for anchorage and splice laps.

An attempt will be made to identify the generic components of commercial additives in order to make the use of plasticizer-expanding agents more attractive.

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NSF FORM 4 (8-80)

Category 8.0
Task 8.1

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PROJECT SUMMARY

SIE PROJECT NO.
NSF AWARD NO.

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... OF INSTITUTION (INCLUDE BRANCH/CAMPUS AND SCHOOL OR DIVISION)

The Regents of the University of California
School of Engineering and Applied Science
Civil Engineering Department

... LUDE DEPARTMENT)

Civil Engineering Department
6731 Boelter Hall, University of California, Los Angeles
405 Hilgard Avenue
Los Angeles, California 90024

...IPAL INVESTIGATOR(S)

Dr. G. C. Hart, Professor of Engineering

... OF PROJECT

LIMIT STATE DESIGN METHODOLOGY BY REINFORCED MASONRY

...ICAL ABSTRACT (LIMIT TO 22 PICA OR 18 ELITE TYPEWRITTEN LINES)

Task 8.1 will develop a limit state design methodology for reinforced masonry. This methodology will contain two fundamental parts. First, it will clearly define all principles which form the assumptions upon which the methodology is based. Second, it will describe the procedures that are to be used for the implementation of the principles.

The research in this task will also provide input to the experimental tests and mathematical model studies.

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FORM 4 (8-80)

Category 9.0
Task 9.1

NOTICE OF RESEARCH PROJECT

SCIENCE INFORMATION EXCHANGE

SMITHSONIAN INSTITUTION

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PROJECT SUMMARY

SIE PROJECT NO.

NSF AWARD NO. ECE-8517031

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NAME OF INSTITUTION (INCLUDE BRANCH/CAMPUS AND SCHOOL OR DIVISION)

Barnes-Kariotis, A Joint Venture

ADDRESS (INCLUDE DEPARTMENT)

711 Mission Street, Suite D
South Pasadena, California 91030

PRINCIPAL INVESTIGATOR(S)

A. W. Johnson, J. C. Kariotis

TITLE OF PROJECT

DESIGN OF REINFORCED MASONRY RESEARCH BUILDING- PHASE I

TECHNICAL ABSTRACT (LIMIT TO 22 PICA OR 18 ELITE TYPEWRITTEN LINES)

Category 9 tasks of the TCCMAR research program include a preliminary and final design of a full scale test structure, planning and construction of a test facility, preparation of a test plan, construction of the test structure, and conducting a full scale test of a multistory reinforced masonry building.

Task 9.1, Design of Reinforced Masonry Research Building, is divided into two parts. The Phase I task includes development of preliminary designs for candidate research buildings, estimation of story shear capacity of each candidate building, estimation of interstory force-displacements characteristics in both the elastic and inelastic range, and reporting of the data to TCCMAR members.

Task 9.1 is coordinated with Tasks 2.1, 2.2 and 2.3 of Category 2 research. Task 9.1 provides data for Task 9.2, Specific Test Facility Requirements, Task 9.3, Facility Preparation, Task 9.1, Full Scale Test Plan and Task 9.1- Phase 2 Design of Reinforced Masonry Research Building.

1. Proposal Folder
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5. Principal Investigator
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NSF FORM 4 (8-80)

Category 9.0
Task 9.2

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PROJECT SUMMARY

SIE PROJECT NO.
NSF AWARD NO. ECE-8520685

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... OF INSTITUTION (INCLUDE BRANCH/CAMPUS AND SCHOOL OR DIVISION)

University of California, San Diego
Revelle Campus
Division of Engineering

... (INCLUDE DEPARTMENT)

Department of Applied Mechanics and Engineering Sciences, B-010
La Jolla, California 92093

... INVESTIGATOR(S)

Gilbert A. Hegemier, Professor of Applied Mechanics
Frieder Sieble, Assistant Professor of Structural Engineering

... OF PROJECT

EQUIPMENT REQUEST FOR THE UCSD STRUCTURAL SYSTEMS LABORATORY

... ABSTRACT (LIMIT TO 22 PICA OR 18 ELITE TYPEWRITTEN LINES)

This document is an equipment proposal for special outfitting of the new UCSD Structural Systems Laboratory, funded in part by the National Science Foundation. This new laboratory will function as a regional facility. It is unique in that it is designed for full-scale testing of buildings up to five stories with the aid of a massive 50-ft high reaction strong wall. The UCSD Structural Systems Laboratory will service the United States side of the U.S.-Japan Coordinated Program for Masonry Building Research.

1. Proposal Folder
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Category 11.0
Task 11.1

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PROJECT SUMMARY

SIE PROJECT NO.

NSF AWARD NO. ECE-8421234

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		ECE-8643768	

NAME OF INSTITUTION (INCLUDE BRANCH/CAMPUS AND SCHOOL OR DIVISION)

Atkinson-Noland & Associates, Inc.

ADDRESS (INCLUDE DEPARTMENT)

2619 Spruce Street
Boulder, Colorado 80302

PRINCIPAL INVESTIGATOR(S)

James L. Noland

TITLE OF PROJECT

COORDINATION OF U.S.-JAPAN COORDINATED PROGRAM FOR MASONRY BUILDING RESEARCH

TECHNICAL ABSTRACT (LIMIT TO 22 PICA OR 18 ELITE TYPEWRITTEN LINES)

The U.S. side of the U.S.-Japan Coordinated Program for Masonry Building Research consists of twenty-three separate research tasks which must be coordinated to attain program goals. Among the coordination activities which must be performed are: organize and conduct meetings with the program researchers, monitor research progress, expedite data exchange among researchers, interface with the masonry industry to arrange for materials and promote researcher-user group communication, interface with the UJNR panel and with the Japanese research program.

1. Proposal Folder
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NSF FORM 4 (8-80)

APPENDIX 2

INDUSTRY PARTICIPATION LETTERS

CMACN

CONCRETE MASONRY ASSOCIATION OF CALIFORNIA AND NEVADA

83 Scripps Drive Suite 303 • Sacramento, CA • 95825
(916) 920-4414

July 6, 1984

TO: James L. Noland
Atkinson-Noland & Associates
2619 Spruce Street
Boulder, CO 80302

FROM: Stuart R. Beavers

RE: UJNR Technical Coordinating Committee for masonry research - U.S. Research Plan

We believe the coordinated plan dated March 1984 for research of masonry is extremely worthwhile. The Concrete Masonry Association of California and Nevada will commit to arrange for the delivery of concrete masonry units to all researchers. The concrete masonry units will be from a single manufacturer with a good reputation for consistency of product and quality control of manufacture.

We will work toward a joint industry financial commitment to the project to underwrite construction costs in addition to cost of materials.

Interstate Brick Company

August 30, 1984

Dr. James Noland, P.E.
Atkinson-Noland & Assocs.
2619 Spruce
Boulder, CO. 80302

Re. U.S. - Japan Coordinated Programs for Masonry Building Research

Dear Dr. Noland:

The Western States Clay Products Association (WSCPA) is a Promotional and Technical Trade Association representing the clay brick manufacturers in the Western United States. WSCPA is dedicated to the advancement of better, safer, higher quality and economical clay masonry. To accomplish this, they are interested in obtaining better knowledge of their products physical properties and the product's interaction with other products in the wall, beam or column assembly, especially under seismic conditions. The members of WSCPA have been made aware of the new research group, the Technical Coordinating Committee for Masonry Research (TCCMAR), and are enthused and applaud its principles, goals and ideals.

At a recent WSCPA meeting of their Board of Directors, approved the creation of a fund to finance the supply of the burned clay hollow and solid units to be used in the construction of the "experimental specimens" needed for the program. They also indicated a desire to be kept aware of the progress of the program and expressed interest in further involvement in later phases of the program as it matures and progresses.

Respectfully yours,

Don Wakefield, P.E.
Vice President
INTERSTATE BRICK COMPANY

DW/cw

780 South 5200 West • West Jordan, Utah 84084 • (801) 561-1

APPENDIX 3

RESEARCH TASK STATUS REPORTS

Date : July 14, 1986

Category: 1.0

Task: 1.1

Task Title: "Preliminary Studies"

I. Project Status

A. This task has been completed. The final technical Report, "A Comparison of the Behavior of Clay and Concrete Masonry in Compression" was published September 1985 and has been distributed to TCCMAR members. Papers based on this work have been presented at the Third ASCE Engineering Specialty Conference on Dynamic Response of Structures, UCLA, April 1986 and at the Fourth Canadian Masonry Symposium, June 1986.

B. Work Remaining

Due to budget limitations it was not possible to conduct tests in which the loading axis was offset from the center axis of the specimen. It was hoped that these tests would provide an indication of possible stress gradient behavior in grouted clay and concrete masonry proposed for the TCCMAR project.

II. Budget Status

National Science Foundation Grant No. ECE-8412279, $56,286.00. Funds fully expended.

III. Summary of Completed Project

The primary objective of this project was to investigate the extent to which clay and concrete hollow unit grouted masonry have similar behavioral characteristics. If a continuity of behavior exists then the expense of conducting separate, duplicate studies for each material could be avoided. A secondary objective was to obtain a body of high quality stress-strain data over the complete stress-strain range to support the adoption of the limit state design method in the US for masonry.

Ten series of tests were conducted to determine the influence of unit size, grouting, mortar strength, grout strength, bond pattern, load direction, and platen restraint on the relative behavior of clay and concrete masonry. It was concluded that, while clay and concrete prisms sometimes exhibited different failure mechanisms and responded differently to some parameter changes, the shapes of the compressive stress strain curves were consistently similar, and the two masonry types could therefore be considered as one material for purposes of design.

U.S. COORDINATED PROGRAM
FOR
MASONRY BUILDING RESEARCH

TCCMAR/U.S.
Task 1.2 Status Report

by

Dr. Ahmad A. Hamid
and
Dr. Harry G. Harris

Department of Civil Engineering
Drexel University
Philadelphia. PA

July 1986

TCCMAR/U.S.
Task Status Report

Date: July 21, 1986

Category: 1.0

Task No: 1.2

Task Title: Material Models

I. PROJECT STATUS

I.A. Work to Date:

1. Tests to determine the physical and engineering properties of the different types of concrete blocks have been completed. Four different sizes are considered; 4", 6", 8" and 12" with 6" being the main size. Three different block strengths are considered for 6" blocks. Tests to determine the physical properties of the block units include dimensions, density, absorption, saturation coefficient and initial rate of absorption. Tests to determine mechanical properties include compressive strength, flexural strength and splitting tensile strength. Summaries of the test results are presented in Tables 1 through 6 for different units.

2. The test specimens and test matrix have been finalized. It was decided to conduct the testing in two phases;

   Phase I in which 27 prisms of different shapes(see Table 7) will be tested under concentric compression to establish the stress-strain curves and to determine the basic material properties such as modulus of elasticity, Poisson's ratio and maximum ultimate strain. This phase will complement Task 1.1 and extend the information using the new blocks.

   Phase II in which 54 prisms will be tested under eccentric compression in the in-plane and out-of-plane, see Table 8. The results of this phase will provide information about the key parameters required to develop an ultimate strength design methodology for masonry walls.

3. Design and fabrication of the test set-up, See Fig. 1.

4. Development of the software for the feedback of the two actuators in the MTS closed-loop system.

5. Building the prisms and corresponding mortar and grout control specimens for Phase I. The construction materials and procedures, which have been determined by TCCMAR, are listed in Table 9

I.B. Work Remaining

1. Installation of the test set-up

2. Checking the feedback system and data acquisition system

3. Testing of Prisms - Phase I

4. Building of Prisms for Phase II

5. Testing of Prisms - Phase II

6. Analysis of test data

I.C. Technical Problem Areas

1. Definition of the shape of the prisms to be used. Grouted prisms made of 8" and 12" full blocks require axial compression capacity over 320 Kips which is the limit on the MTS Actuator. It has been decided in this case to use prisms made of half units. For 4" and 6" blocks prisms made of half and full units wil be tested (Table 7) which will provide data to compare the behavior of the two types of prisms.

2. Software development of the feedback system. An out side engineering firm is hired to develop the complete data acquisition system to drive the MTS actuators. This system has been designed to be utilized for other TCCMAR projects that will be conducted at Drexel University.

II. BUDGET STATUS

II.A. Budget total amount	$71,712
First year budget	39,839

Project period: Sept. 1, 1985 to Feb. 28, 1987

II.B. Total expenditures as of May 31, 1986 is $ 30,909

Table 1 - Material Properties for 4 in. Concrete Blocks

Properties	Unit 1	Unit 2	Unit 3	Average
Length (in)	15.555	15.563	15.570	15.562
Width (in)	3.617	3.625	3.617	3.620
Height (in)	7.555	7.539	7.594	7.562
Face-Shell Thickness (WT) min, in.				1.028
Web Thickness (WT) min, in.				1.114
Equivalent web Thickness(in)				3.08
Net/Gross area ratio				0.73
Absorption lb/ft^3	12.24	12.157	12.36	12.25
Absorption, %	11.94	11.845	12.14	11.98
Moisture Content, %	5.62	11.46	9.8	8.96
Saturation Coefficient	0.723	0.723	0.798	0.748
Initial Rate of absorption, gm/min/30 in^2	35.5	30.2	35.0	39.5
Compressive strength, psi				
- Gross Area	1860	1930	1920	1900
- Net Area	2550	2660	2600	2600

Table 2 - Material Properties for 6 in. NB Blocks

Properties	Unit 1	Unit 2	Unit 3	Average
Length (L), in.	15.625	15.594	15.594	15.60
Width (W), in.	5.625	5.625	5.625	5.625
Height (H), in.	7.578	7.594	7.578	7.58
Face-Shell Thickness (FST) min, in				1.052
Web Thickness (WT) min, in				1.043
Equivalent Web Thickness, in				2.67
Net/Gross area ratio				0.53
Absorption, lb/ft^3	11.1	11.0	10.9	11.0
Absorption, %	11.0	10.8	10.7	10.8
Moisture Content, %	4.66	3.74	3.08	3.83
Saturation Coefficient	0.731	0.720	0.713	0.721
Initial Rate of Absorption (IRA), $gm/min/30\ in^2$	44.57	44.92	42.3	43.93
Compressive Strength, psi				
- Gross Area	1570	1470	1600	1550
- Net Area	2950	2770	3020	2920
Splitting Tensile Strength, psi	310	300	220	280

Table 3 - Material Properties for 6 in. WB Blocks

Properties	Unit 1	Unit 2	Unit 3	Average
Length (in)	15.594	15.594	15.609	15.60
Width (in)	5.641	5.625	5.609	5.625
Height (in)	7.547	7.531	7.547	7.542
Face-Shell Thickness (FST) min, in				1.019
Web Thickness (WT) min, in				1.030
Equivalent Web Thickness (in)				2.60
Net/Gross area ratio				0.51
Absorption lb/ft^3	13.12	13.01	12.95	13.03
Absorption, %	13.0	13.0	12.84	12.95
Moisture Content, %	3.37	2.77	2.1	2.75
Saturation Coefficient	0.764	0.762	0.763	0.763
Initial Rate of Absorption $gm/min/30\ in^2$	86.6	80.3	82.3	80.0
Compressive strength, psi				
- Gross area	770	700	730	730
- Net area	1510	1380	1440	1440

54

Table 4 - Material Properties for 6 in. SB Blocks

Properties	Unit 1	Unit 2	Unit 3	Average
Length (L), in.	15.578	15.609	15.578	15.59
Width (W), in.	5.656	5.609	5.625	5.63
Height (H), in.	7.563	7.578	7.594	7.578
Face-Shell Thickness (FST) min, in.				1.011
Web Thickness (WT) min, in.				1.026
Equivalent Web Thickness, in.				2.62
Net/Gross area ratio				0.51
Absorption, lb/ft^3	10.45	10.62	10.51	10.53
Absorption, %	9.6	9.95	9.76	9.77
Moisture Content, %	1.94	1.89	2.03	1.95
Saturation Coefficient	0.761	0.785	0.758	0.768
Initial Rate of Absorption, $gm/min/30\ in^2$	11.06	19.91	13.64	14.9
Compressive Strength, psi				
- Gross Area	1830	1930	1620	1790
- Net Area	3590	3780	3170	3520

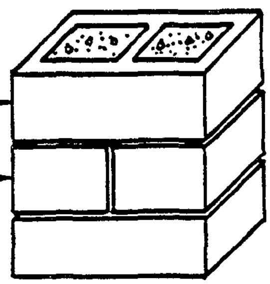
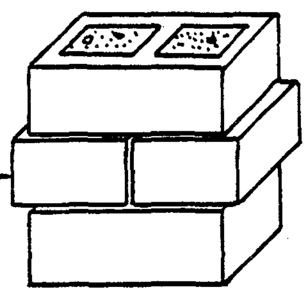
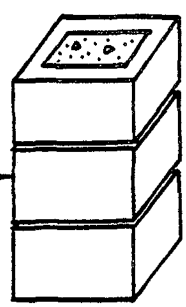
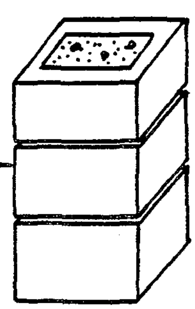
Table 5 - Material Properties for 8 in. Blocks

Properties	Unit 1	Unit 2	Unit 3	Average
Length (L), in.	15.539	15.563	15.554	15.55
Width (W), in.	7.625	7.633	7.617	7.625
Height (H), in.	7.617	7.609	7.594	7.61
Face-Shell Thickness (FST) min, in.				1.405
Web Thickness (WT) min, in.				1.093
Equivalent Web Thickness, in.				3.18
Net/Gross area ratio				0.53
Absorption, lb/ft^3	11.58	11.54	11.56	11.56
Absorption, %	11.04	11.04	11.12	11.18
Moisture Content, %	7.6	6.48	7.23	7.10
Saturation Coefficient	0.728	0.727	0.738	0.731
Initial Rate of Absorption, $gm/min/30\ in^2$	54.3	50.2	54.4	53.3
Compressive strength, psi				
- Gross Area	1510	1450	1470	1480
- Net Area	2870	2760	2810	2810

Table 6 - Material Properties for 12 in. Blocks

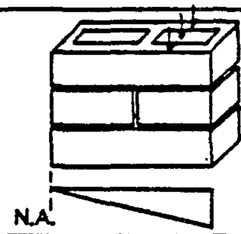
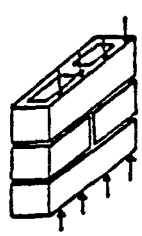
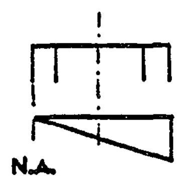
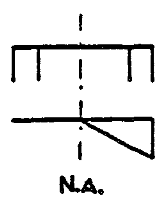
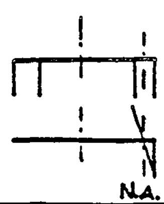
Properties	Unit 1	Unit 2	Unit 3	Average
Length (L), in	15.555	15.554	15.586	15.565
Width (W), in	11.594	11.594	11.609	11.599
Height (H), in	7.594	7.601	7.570	7.588
Face-Shell Thickness (FST) min, in				1.474
Web Thickness (WT) min, in				1.334
Equivalent Web Thickness				3.724
Net/Gross area ratio				0.50
Absorption, lb/ft^3	12.17	11.75	12.32	12.08
Absorption, %	11.70	11.43	12.11	11.74
Moisture Content %	6.70	7.41	2.76	5.62
Saturation Coefficient	0.72	0.776	0.836	0.777
Initial Rate of Absorption (IRA), $gm/min/30\ in^2$	20.	25.8	35.8	27.2
Compressive strength, psi				
- Gross Area	1310	1330	1330	1330
- Net Area	2630	2650	2630	2630

Table 7 - Concentric Tests - Phase I

Specimen	Block Size 4"	6"	8"	12"	Block Strength WB	NB	SB
full block; molded ½ block 	X					X	
		X			X	X	X
½ block cut from full block 		X				X	
molded ½ blocks 		X				X	
½ blocks cut from full blocks 		X				X	
			X			X	
				X		X	

Total number of specimens = 9 x 3 test repetitions = 27

Table 8 – Eccentric Tests – Phase II

Loading	Specimen		Block Size				Block Strength		
			4"	6"	8"	12"	WB	NB	SB
In-Plane			X					X	
				X			X	X	X
					X			X	
						X		X	
Out-of-Plane				X			X	X	X
				X			X	X	X
			X					X	
				X			X	X	X
					X			X	
						X		X	

Total number of specimens = 18 x 3 test repetitions = 54

Table 9 - Experimental Details

Materials

Blocks	Use of 4, 6, 8 and 12" close-ended concrete blocks with 6" being the main size. Three different block strengths are considered for 6" blocks; weak (WB), normal (NB) and strong (SB) blocks.
Mortars	Use of Type S mortar as per ASTM C 270. A minimum flow of 110% is maintained.
Grout	Use of 1:3:2 mix as per ASTM C 476. 3/8" pea gravel. Water is controlled to provide 8-10" slump. Grout Aid has been used as per manufacturer's instructions. It is added in a soluble form.

Construction Details

- Face shell bedding for bed and head joints
- Flush 3/8" mortar joints
- retempering of mortar is not allowed
- Grout is vibrated using 1" rod vibrator
- Air curing in the laboratory where both temperature and relative humidity is controlled. Temp 60-70 °F, 50% R.H.

Control Specimens

Mortar	2" x 4" nonabsorbent cylinders air cured as the test specimens
Grout	Three different types are used 1 - block molded prisms as per UBC 2 - 3" x 6" nonabsorbent cylinders 3 - 3" x 6" core drill from grout in the units

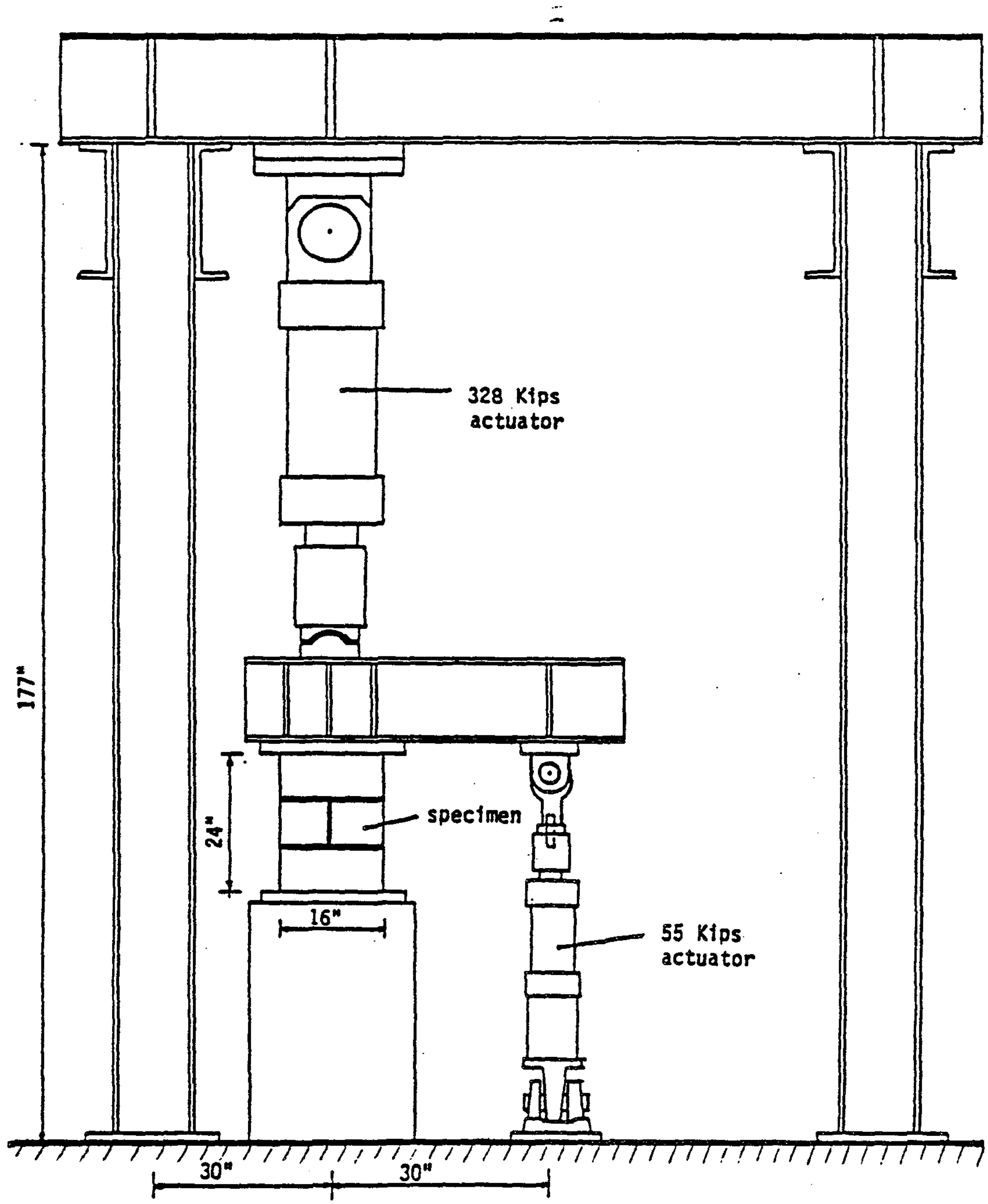


Fig. 1- Test Set-Up for Eccentric Copmression Loading-Phase II

TCCMAR/U.S.

Task Status Report

Date: July 8, 1986

Category: 1

Task No.: 1.2(b)

Task Title: Material Models-Clay Masonry

I. Project Status

A. Work To Date.

1. The 600,000 lb. capacity Forney testing machine has been modified with the fabrication and installation of a new enlarged upper loading platen and has been fitted with an internal pressure transducer to provide electrical output of load indication,

2. The Shore-Western closed loop servo hydraulic system has been relocated from the remote lab to the main Civil Engineering building. The pump has been installed with insulated housing and exhaust fan, and cooling water hooked up.

3. The data acquisition system which was planned for use with this project was found to be malfunctioning and not worth repairing. Hence, a new IBM PC computer based data acquisition system was ordered and is now functioning.

4. The Shore-Western loading actuators have been structurally connected to the Forney testing machine in order to permit loading eccentricity about either principal axis of the test specimen.

5. A climate controlled enclosure has been constructed in the laboratory to provide protection for the servo controllers and data acquisition equipment.

6. Approximately 20 test specimens have been fabricated. These specimens consist of 6 courses of grouted hollow brick laid in running bond and capped with gypsum.

7. A prism fabrication jig was constructed in accordance with plans recommended by James Noland. This jig has been used to construct the prisms built thus far, and works very well.

8. A technique has been developed for capping of completed prisms which permits the easy lifting and rotation of the heavy 200 lb. test specimens.

9. In consultation with the College of Engineering electronics technician, a servo-control feedback system has been devised which assures a fixed eccentricity of load about either axis. A technique for operating the equipment to accomplish loading of this type has been devised.

B. Work Remaining.

1. Conduct pilot tests of practice prisms to "shakedown" equipment and procedure.

2. Reduce and plot data from "shakedown" tests.

3. Construct prisms. It is expected that prism construction will take place in approximately five different stages.

4. Conduct in-plane tests

5. Conduct out-of-plane tests.

6. Evaluate data

7. Prepare draft report

8. Prepare final report.

C. Technical Problem Areas

1. Close loop feedback system - At the present time, the servo controlled system which controls the eccentric actuators is not functioning properly. We are now checking transducer calibrations, polarity problems, and general troubleshooting.

2. Hollow clay units - To date, the hollow clay units have not been delivered. We have received a partial shipment of units, but we now need all of the units. We have contacted Don Wakefield, and he has assured me that the units will be forthcoming.

3. Gypsum capping - We have encountered problems of capping the rather heavy, fully-grouted prisms. Generally we cap the bottom brick before we fabricate the prism. However, the top brick cannot be capped until the specimen is fully grouted, hence it weighs 200+ lbs. We have devised an apparatus which lifts and inverts the specimens and lowers them onto a capping plate.

4. Grout - In this area, it is difficult to obtain grout which has aggregate in compliance with ASTMC 476. We have found it necessary to special order this material at considerable expense.

II. Budget Status

A. Budget amount - $42,560 (2nd year funding has been applied for)

Start date - September 1, 1985

End date - November 30, 1986 (including 6 months unfunded flexibility period.)

B. Total Expenditures as of June 30, 1986 - $29,324

TCCMAR / U.S.

Task Status Report

Date: July 22,1986

Category: 2

Task No.: 2.2

Task Title: Strain Analysis Models for Masonry Components

Principal Investigator: Robert D. Ewing - Ewing & Associates

I. Project Status

The analytical work in this task (Task 2.2) is coordinated with the analytical work being conducted in the other two Category 2 tasks, namely;

- o Task 2.1 - Force-Displacement Models for Masonry Component Specimens by Englekirk & Hart (E & H).
- o Task 2.3 - Dynamic Response of Masonry Buildings by Kariotis & Associates (K & A).

All analytical modeling work will be developed in close collaboration with these researchers. The overall objective of these three coordinated tasks is to provide improved design and analysis procedures for reinforced masonry structures, as well as contribute to a better understanding of their performance.

<u>Work To Date</u>

During the first funded phase of the research, coordination with the other TCCMAR researchers was established and analytical methods and models were identified for the strain and force-deformation analysis of reinforced masonry components. Software packages have and are being adapted for these analyses, and this software has and will be distributed to the other TCCMAR researchers. All of the software will be designed for use on the new generation of scientific personal computers (i.e., COMPAQ Deskpro 286 and IBM-PC-AT compatible, as well as the COMPAQ Deskpro and IBM-PC-XT compatible computers, but to a lesser degree). With the approval of NSF, part of the approved computer budget was used to purchase a COMPAQ Deskpro 286 personal computer for these analyses. A two-dimensional, nonlinear, static finite element program for use in correlation with the prism and in-plane experiments has already been distributed to Atkinson-Noland & Associates, Kariotis & Associates, Englekirk & Hart, Ahmad Hamid, Russell Brown, and Frieder Seible. This program has been used in an analysis of the strong back for the full-scale building tests and to identify deformation modes and stress distributions for the in-plane wall experiments.

During the second funded phase of the research, the adaptation of a three-dimensional, nonlinear, lumped parameter dynamic analysis program for use in the dynamic response studies has been started. This program is based on force-deformation properties that are being developed from experimental and analytical correlations. In addition to an existing library of linear and nonlinear elements, a two-parameter, nonlinear element is being added. This element will have flexural and shear components with separate force-deformation properties. Coordination with the other TCCMAR researchers will continue on both analytical and experimental tasks, and analysis models will be developed and revised as the research continues.

Also, during the second funded phase, the development of the nonlinear static finite element program is being continued. This work includes the installation of a one-dimensional, nonlinear (Von Mises) rebar element in the program. The analytical work is nearly completed and the next step will involve the actual coding of the element and material model in VISCOT.

Work Remaining

The installation of the one-dimensional, nonlinear rebar element in VISCOT needs to be completed and checked out. This will require the installation of the new element in the program along with a Von Mises yield criterion for the material property. In addition, the pre- and post-processors need to be modified to allow the introduction of the new element for the input and output of data. We expect to complete the program modifications by September 1, 1986. The check out will be performed on the in-plane tests being conducted at the University of Colorado by Benson Shing. Following these calculations, the new program will be used to develop response modes and limit states for a series of masonry walls subjected to bi-axial in-plane loadings. We expect to have substantial check out on the program by November 30, 1986.

The analytical work on the three-dimensional, nonlinear lumped parameter dynamic analysis program needs to be completed and the coding developed and installed in the program. This will include the addition of new elements, such as the two-parameter, nonlinear element. Checkout of this program will be accomplished in several stages; first in two-dimensional problems with varying degrees of complexity, and then in three-dimensional problems. The check out will be made using problems with known solutions (closed-form or from other computer programs), when they can be found.

Technical Problem Areas

There are many technical challenges remaining, and we do not see any special technical problem areas at this time other than budget limitations.

II. Budget Status

The original grant from NSF was awarded to Agbabian Associates (AA) under the direction of Robert D. Ewing. The budget amounts awarded and start and end dates given in the grant letter are as follows:

Original NSF Grant No. ECE-8517021
"Analysis Models for Hollow Masonry Components"

Period	Amount	Status
9/ 1/85 to 8/31/86 (1)	$58,009	Completed at AA (2)
Fiscal Year 1986	42,430	Transferred to E & A (3)
Fiscal Year 1987	78,477	Transferred to E & A (3)
Total	$ 178,916	

The grant has been transferred to Ewing & Associates (E & A) under the direction of Robert D. Ewing (effective 3/1/86). Although not approved or funded by NSF at this time, the budget amounts and start and end dates requested are as follows:

New NSF Grant No. ECE-8696076

Period	Amount	Status
3/ 1/86 to 10/ 1/86 (4)	$42,410	In Progress
Fiscal Year 1987 (5)	78,470	(6)
Total	$ 120,880	

The total expenditures at E & A as of June 30,1986 are estimated to be about $22,000. An exact figure can be given after NSF approves the requested budget and requested indirect rates. The total expenditures as of June 30,1986 including those at AA and E & A are estimated to be about $80,000 ($58,009 + $22,000).

Notes:

(1) Includes a 6 month unfunded flexibility period.
(2) Final amount charged will not exceed this amount. However, the actual amount will be determined after an AA audit.

Notes:

(3) This is a continuing grant which has been approved on scientific/technical merit for approximately 3 years. Contingent on the availability of funds and the scientific progress of the project, NSF expects to continue support at the indicated levels.
The grant was transferred to E & A on march 1,1986.

(4) Does not include a 6 month unfunded flexibility period.

(5) Expected period of performance is 10/1/86 to 10/1/87.

(6) This is a continuing grant which has been approved on scientific/technical merit for approximately 2 years. Contingent on the availability of funds and the scientific progress of the project, NSF expects to continue support at the indicated level.

Kariotis & Associates Structural Engineers • 711 Mission Street, Suite D, South Pasadena, California 91030 (818) 799-8269, (213) 682

John Kariotis, President, S.E.
Nels Roselund, Vice President, S.E.
Michael Krakower, S.E.

TCCMAR/U.S.

Task Status Report

Date: July 23, 1986

Category: 2.0

Task No.: 2.3

Task Title: Analysis and Design Models for Masonry Components (Dynamic Response Model)

I. Project Status

A. Work to Date. Research to date has included conferences with the Principal Investigators for category 2 to outline and plan the development of analytical models to replicate experimental work, simplified models for extrapolation of experimental work, and preliminary structural design tools.

A finite element program developed by Bob Ewing for the PC-AT and Compaq-286 personal computers has been used for elastic two-dimensional analysis of elements of the shape and size proposed for testing at the Unviversity of Colorado. The elastic analyses indicate that available elastic finite element systems have a very limited application to reinforced masonry systems.

The planned analytical procedures have been discussed with researchers in Japan, the PRC, and Italy. These discussions indicate that other researchers recognize that a dynamic response model can be formulated from experimental work. The principle difference is that category 2 intends to develop a finite element model to replicate experimental work. This is needed to interpret the experimental work and to extend the experimental work to other element configurations and reinforcements.

B. Work Remaining. The available finite element program will be used for elastic elements to evaluate the probable error that is contained in the common simplifying assumptions that neglect shear deformation of initially plane surfaces.

Further analysis of experimental specimens requires that the current finite element be modified to include reinforcing bar elements.

C. Technical Problem Areas. Coordination of experimental work with the requirements of obtaining data that is necessary for the analytical program appears to be a continuing problem. Solution of the problem requires that the experimental and analytical researchers reach an agreement on loading sequences of masonry elements.

II. Budget Status

A. A total of $172,531 has been awarded ($53,590 for 1985-86; $41,740 for 1986-87; and $77,201 for 1987-88). The award for the second and third years is contingent on the availability of funds and the progress of the project. The first year award is effective October 1, 1985 to September 30, 1986, including a six month unfunded flexibility period.

B. Total expenditures as of June 30, 1986 were $31,722.17.

TCCMAR/U.S.

Task Status Report

Date: July 24, 1986

Category: 3.0

Task No.: 3.1(a)

Task Title: Response of Reinforced Masonry Story-Height Walls to Fully Reversed In-Plane Loads

I. Project Status

Test Setup. The experimental apparatus for the in-plane wall tests, illustrated in Fig. 1, has been fabricated and installed. One horizontal and two vertical actuators are being used to apply the shear force, axial force, and overturning moment on the wall specimens. The horizontal actuator has a load capacity of 165 kips and a maximum stroke of ±3 in. The two 55-kip vertical actuators are borrowed from the University of Wyoming, since the budget for the purchase of these actuators has been eliminated from the original proposal. The horizontal actuator is under displacement control, while the vertical ones are under load control, using MTS 458 controllers. An electrical interface device has been built to couple the overturning moment to the horizontal shear, in a way that would occur in real structures under earthquake load conditions. This device can provide a constant voltage offset to MTS controllers to ensure a constant and balanced axial force to be exerted by the two vertical actuators. In addition, the device has an electrical gain adjustment which can scale up or down the output voltage signal from the load cell amounted on the horizontal actuator. The scaled signals are then re-directed as input load commands to the vertical actuators, to impose the desired overturning moment on the specimens. The load frame and load beam, shown in Fig. 1, were fabricated by a contractor. The load frame is tied down to the strong floor by four high-tension rods, and the load beam is attached to the concrete beam at the top of the specimen by ten high-tension bolts. A steel frame, which is not shown in the figure, is installed to prevent the out-of-plane deflection of the specimen.

The bottom slab of a specimen, which is tied down to the strong floor, consists of three wedge-shaped reinforced concrete blocks, as shown in Fig. 2. The central block serves as the specimen's base beam, which has to be cast for every wall, while the two outer ones serve as tie-down blocks, which can be separated from the base beam and re-used for other tests. Shear keys are installed on the contact surfaces to prevent the sliding of the base beam. Three sets of such slabs have been fabricated, so that test specimens can be built three at a time.

Trial Tests. A series of trial tests has been recently performed to check the adequacy of the above apparatus and to project the failure mechanism of the proposed specimens. The trial specimen is a 6-ft.-by-6-ft. wall of concrete masonry, with #4 reinforcing bars in both vertical and horizontal directions. The flexural resistance of the wall has been analyzed using the computer program UNCOLA, which is developed by Mahin et. al at the University of California, Berkeley. The shear resistance has been estimated with the assumption that diagonal cracking is resisted by the horizontal reinforcement only. During the trial test with a zero axial load, flexural cracks occurred in bed joints at a 10-kip lateral force. A small diagonal crack was also developed at the center of the wall. This indicates that the mortar and concrete masonry have an extremely low tensile strength. Under a 40-kip axial load, the failure mechanism observed is a combination of flexural and shear cracking, as predicted by the preliminary analyses. The lateral stiffness measured during the tests is substantially lower than the calculated flexural stiffness. This indicates the significance of shear deformation in the wall panel. The loading apparatus is found to be in proper operation condition, except that the load frame tends to slide at a 30-kip lateral load. This deficiency will be corrected by increasing the tension in the four existing tie-down rods and adding two additional high-tension rods to increase the base friction.

Scheduled Test Plan. The proposed test matrix, shown in Table 1, consists of twenty wall specimens. The first thirteen specimens will be 6-ft-by-6-ft. walls, with different amounts of horizontal reinforcement and axial loads. As shown in Table 1, the amount of vertical reinforcement in the first nine specimens has been reduced to 0.38%. This is not only consistent with the current design practice, but also provides a good distribution and transition of failure mechanisms among the specimens. The flexural load resistance of the proposed specimens has been analyzed with UNCOLA, and compared to the approximate shear capacities of the panels. The main objectives of these test are to examine the effects of the amount and distribution of horizontal reinforcement, and of the axial load, on the failure mechanism of squat walls, and to investigate design parameters which can prevent brittle shear failure. According to the preliminary analytical data and the results of the trial tests, the proposed specimens can well satisfy these objectives.

The specimens will be carefully instrumented to provide useful information for the calibration of analytical models. The external and internal instrumentation plans for the proposed specimens are shown in Figs. 3 and 4, respectively. As shown in Fig. 3, 21 displacement transducers will be used to monitor the wall curvature as well as the shear deformation. Clips gages will be used to monitored cracks in the horizontal mortar joints near the base of the specimens. Twenty strain gages will be attached to the re-bars of each specimen, as shown in Fig. 4, to monitor the first yielding of the re-bars, and the efficiency of the vertical and horizontal reinforcement in resisting diagonal tension. For this purpose, the data acquisition system at the structural laboratory has been upgraded to acquire 47 channels of test data. The test data will be stored in 5-1/4 in., double sided, double density diskettes in a format compatible to Lotus 1-2-3, so that the data can be reduced and plotted with the spread sheet program.

Two graduate students are currently working on the project, and the proposed tests will be conducted from August 1986 to September 1987. Three wall panels will be tested in every two months, and the data obtained will be reduced immediately after each test.

II. Budget Status

First Year	\$77,041
Second Year	\$70,433
Total	\$147,474

First Year Budget:

Start: November 15, 1985 (Actual starting date is January 1, 1986)

End : April 30, 1987 (including a 6 month flexibility period)

Amount: \$77,041

Total Expenditures as of June 30, 1986: \$27,000

Expected Expenditures for July 1, 1986 to March 31, 1987: \$50,000

Second Year Budget:

Expected to start on April 1, 1987.

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Table 1 - TENTATIVE TEST MATRIX

	h/ℓ	Vertical Bars	Horizontal Bars	Masonry	P (kips)	M/Vℓ	Load* History
1	1	5# 5 (0.38%)	#5 @ 16"	CBL	0	1	A
2	1	5# 5	#4 @ 16"	CBL	0	1	A
3	1	5# 5	#3 @ 16"	CBL	0	1	A
4	1	5# 5	#5 @ 16"	CBL	40 (100 psi)	1	A
5	1	5# 5	#4 @ 16"	CBL	40	1	A
6	1	5# 5	#3 @ 16"	CBL	40	1	A
7	1	5# 5	#5 @ 16"	CBL	80 (200 psi)	1	A
8	1	5# 5	#4 @ 16"	CBL	80	1	A
9	1	5# 5	#3 @ 16"	CBL	80	1	A
10	1	5# 5	#3 @ 16"	CBL	80	1	B
11	1	5# 5	#3 @ 16"	CBL	80	1	C
12	1	2# 4, 7# 4 (0.44%)	#3 @ 8"	CBL	80	1	A
13	1	5# 3 (0.14%, Min.UBC)	#3 @ 16"	CBL	80	1	A
14	2	4# 5 (0.46%)	#3 @ 16"	CBL	27 (100 psi)	2	A
15	2	4# 5	#3 @ 16"	CBL	54 (200 psi)	2	A
16	2	4# 5	#3 @ 16"	CBL	54	4	A
17	2	4# 5	#3 @ 16"	CBL	27	2	B
18	2	4# 5	#3 @ 16"	CBL	27	2	C
19	2	4# 3 (0.16%, Min.UBC)	#3 @ 16"	CBL	27	2	A
20	2	4# 5	#3 @ 16"	CBR	54	2	A

*A: Normal Increments
B: Small Increments (Lower Bound)
C: Large Increments (Upper Bound)

REVISED: July 22, 1986

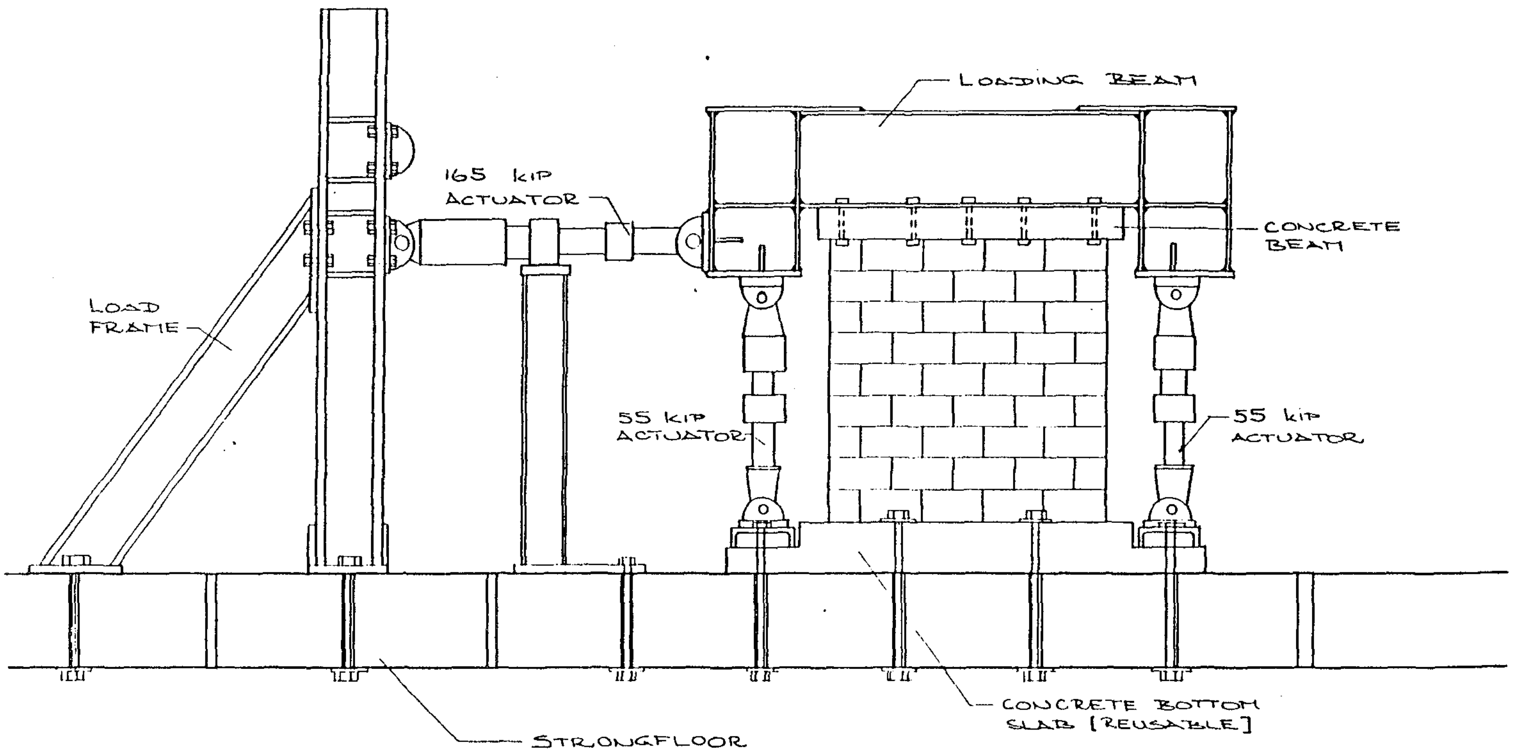


Fig. 1 - Test Setup

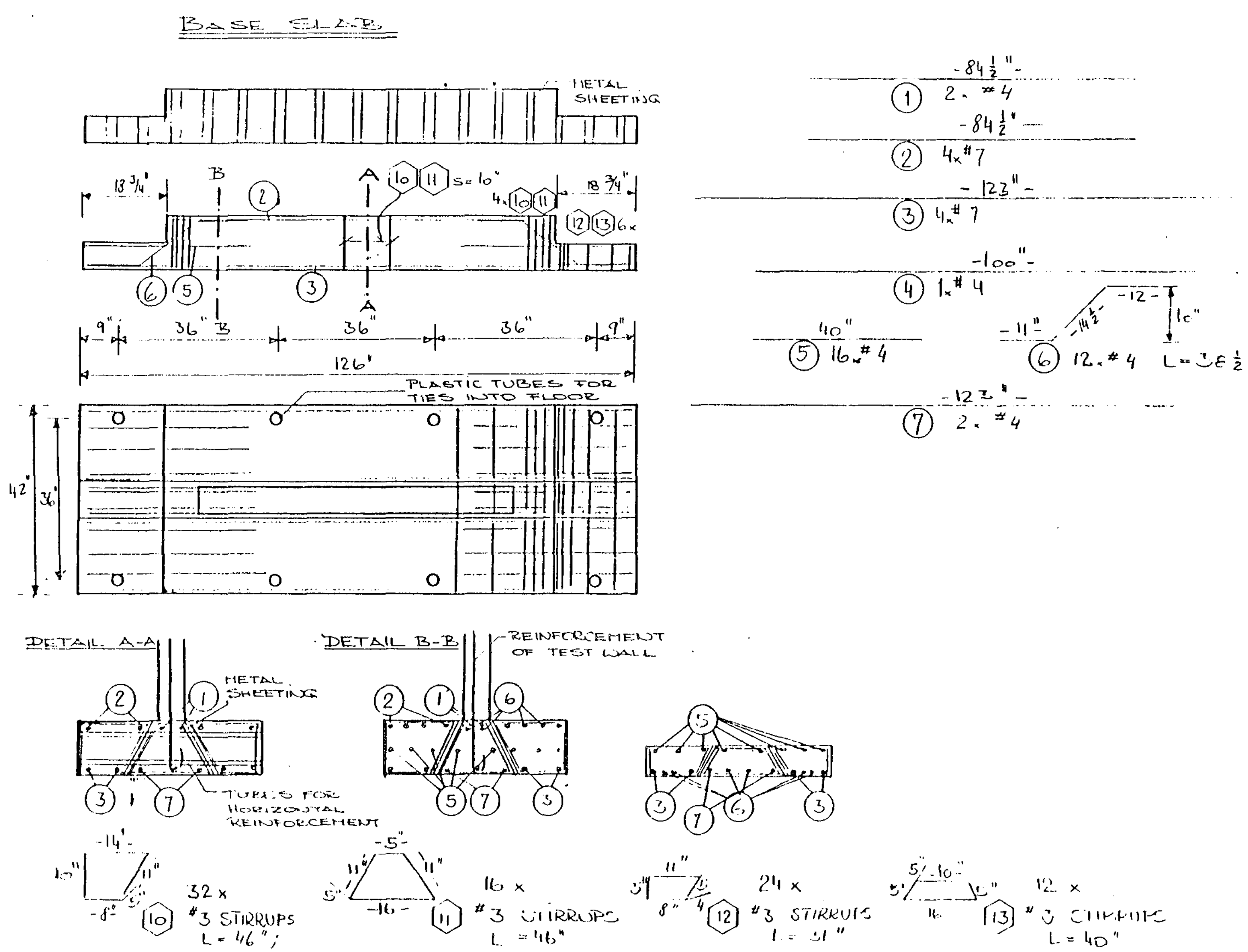


Fig. 2 - Design of the Base Slab

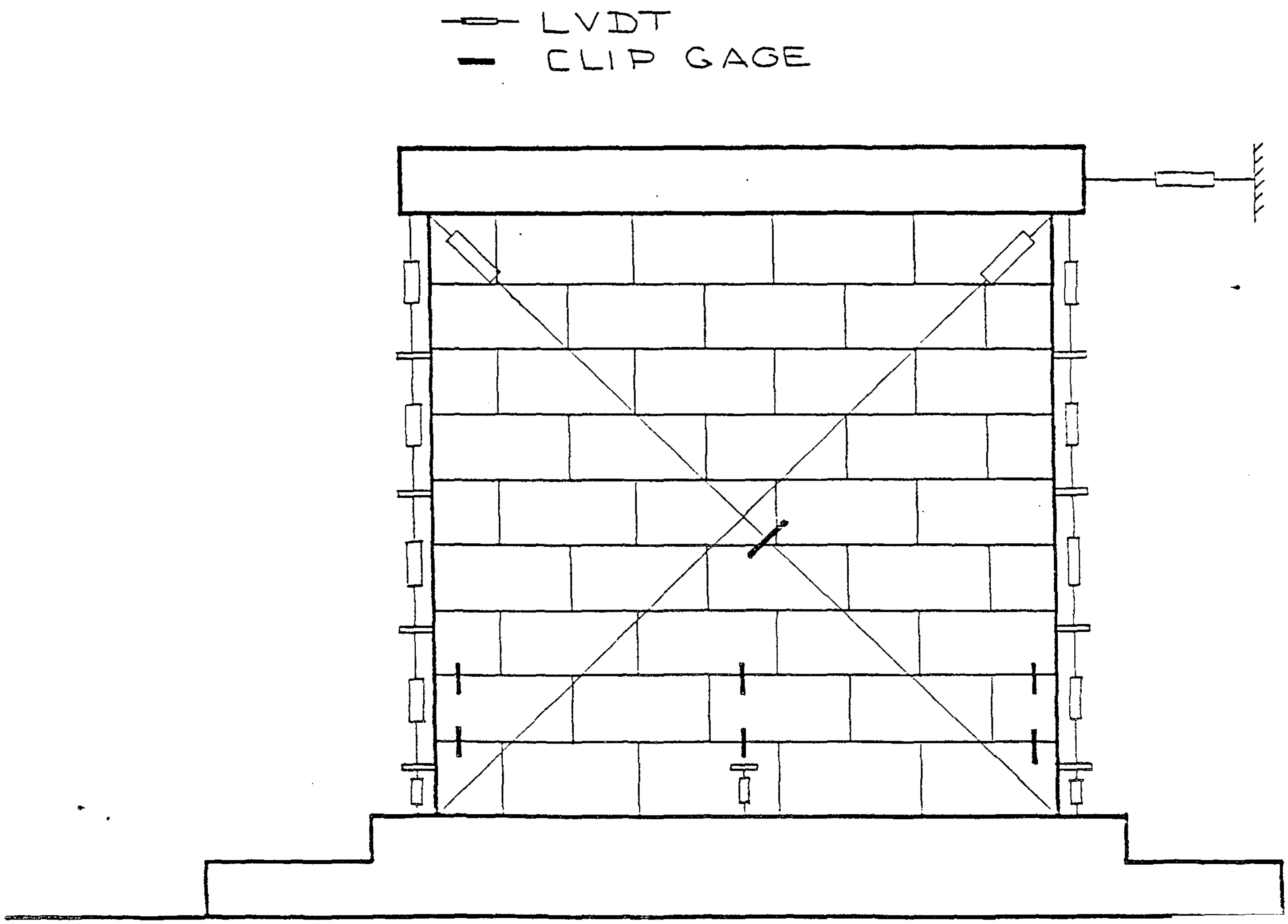


Fig. 3 - External Instrumentation

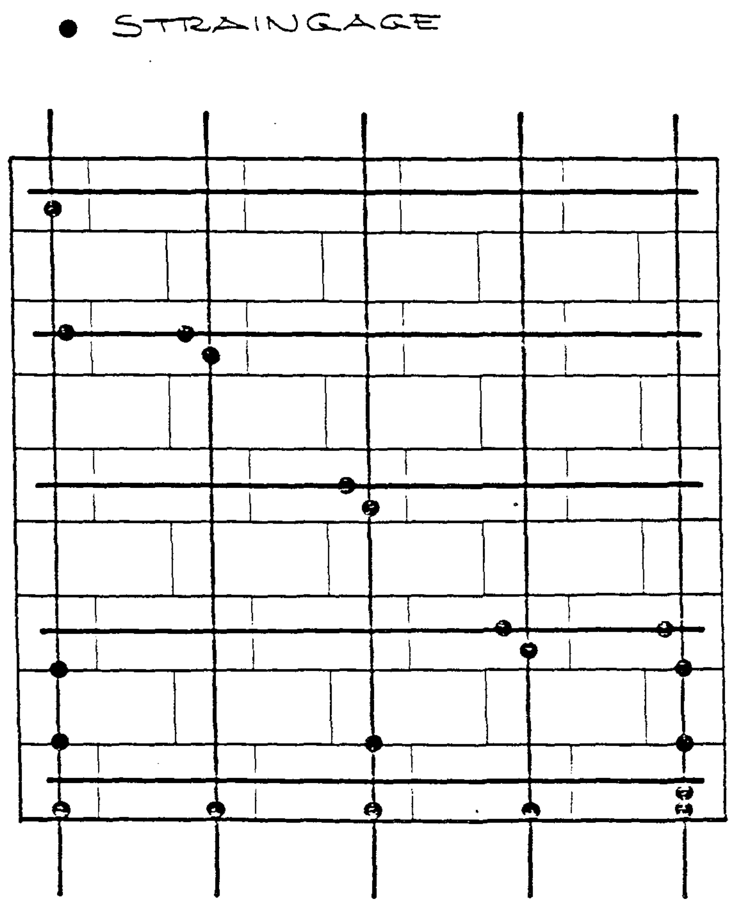


Fig. 4 - Internal Instrumentation

TCCMAR/U.S. -- TASK STATUS REPORT

Date: 7-8-86

Category: 3.0

Task No: 3.1(b)

Task Title: Sequential Displacements
3 Story In-plane Walls

I. Project Status

A. Work To Date: Since the grant has not yet been awarded, no work has been performed to date on the above research task.

B. Work Remaining: The entire research project from start to finish has still to be accomplished.

C. Technical Problem Areas: Prior to any testing of three story in-plane wall specimens, the UCSD Structural Systems Laboratory has to be outfitted with appropriate hydraulic and data acquisition equipment. Upon approval of the outstanding equipment grant, a lead time of about one year is envisioned prior to any full scale testing.

II. Budget Status

A. The total requested budget for Task 3.1(b) and the yearly breakdown is as follows:

Total Amount Requested	$399,343
1st year 1-1-86 to 12-31-86*	199,355
2nd year 1-1-87 to 12-31-87*	199,988

*dates on current proposal

New projected dates:

Start of Task 3.1(b) - Jan. 1, 1987
End of Task 3.1(b) - Dec. 31, 1988

B. Expenditures as of June 30, 1986: None

U.S. COORDINATED PROGRAM
FOR
MASONRY BUILDING RESEARCH

TCCMAR/U.S.
Task 3.2(a) Status Report

by

Dr. Ahmad A. Hamid
and
Dr. Harry G. Harris

Department of Civil Engineering
Drexel University
Philadelphia, PA

July 1986

TCCMAR/U. S.
Task Status Report

Date: July 21, 1986

Category: 3.0

Task No.: 3.2 (a)

Task Title: Response of Reinforced Masonry Walls to Out-of-Plane Static loads

I. PROJECT STATUS

I.A. Work to Date

1. Development of material characteristics of the units, grout and reinforcement that will be used to build the walls Figure 1 shows typical stress-strain curves for steel reinforcement.

2. Design of the test set-up and loading system. Two-point loading will be applied via spreader beams connected to the two faces of the wall, see Fig. 2. The cyclic displacements will be applied using MTS 55 kips actuator. Wall displacements will be measured atdifferent locations using wire potentiometers.

3. Development of the MTS loading system to apply fully reversed cyclic loading in a displacement-controlled environment.

4. Development of the data acquisition system for data collection, reduction and automatic plot of the hysteresis loops of different channels.

I.B. Work Remaining

1. Building of the walls

2. Fabrication of test set-up

3. Checking data acquisition system and feedback control

4. Testing of walls

5. Data analysis and reduction

I.C. Technical Problem Areas

The following are technical issues that need to be discussed in TCCMAR meeting in July 1985.

1. Type of units to be used; open-ended or close-ended.It is to be noted that closed-ended units have already been received from the manufacturer.

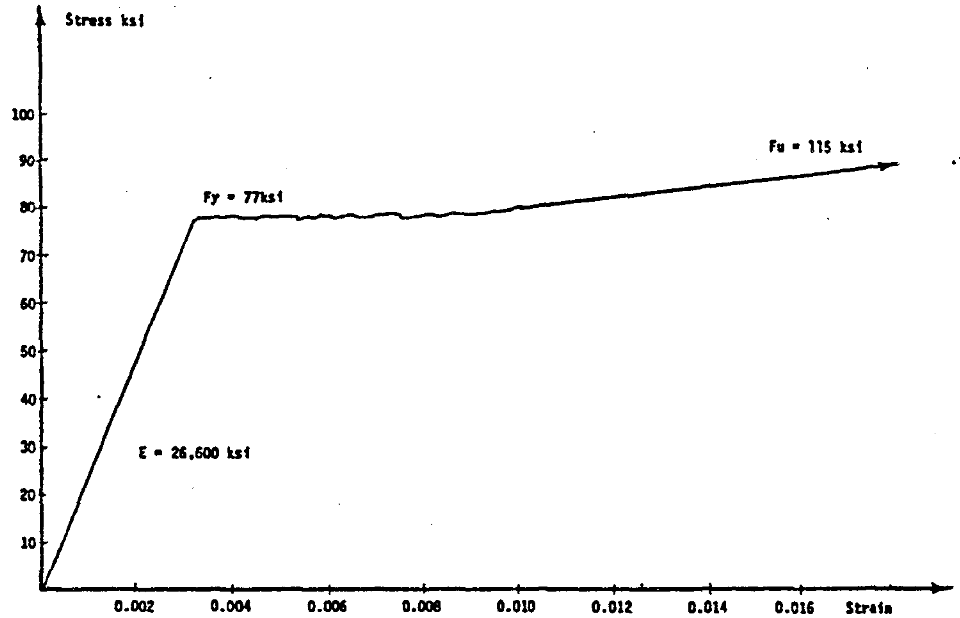
2. Support condition of the wall

3. Loading history

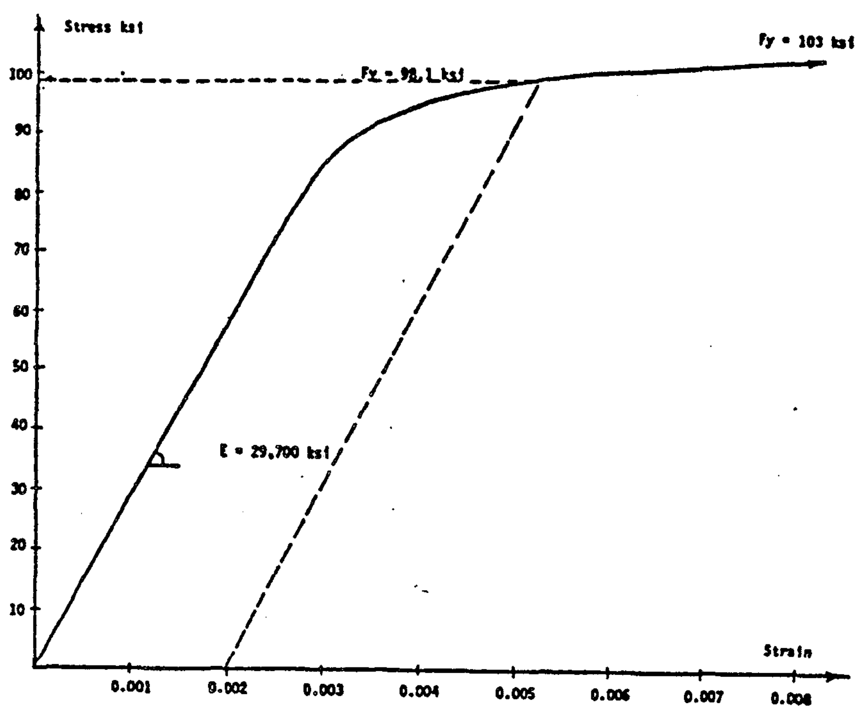
II. BUDGET STATUS

II.A. Budget total amount		$89,552
First year budget		41,500
Project period	Jan. 1, 1986 to June 30, 1987	

II.B. Total expenditures as of June 30, 1986 is $ 0.00. Note that the work to date in this project has been done as part of another NSF project in which horizontally spanned joint reinforced walls are tested in under out-of-plane cyclic loading.



a) No. 4 Reinforcing Bar



b) Dur-O-Wal Steel

Fig. 1- Stress-Strain Curves for Reinforcement

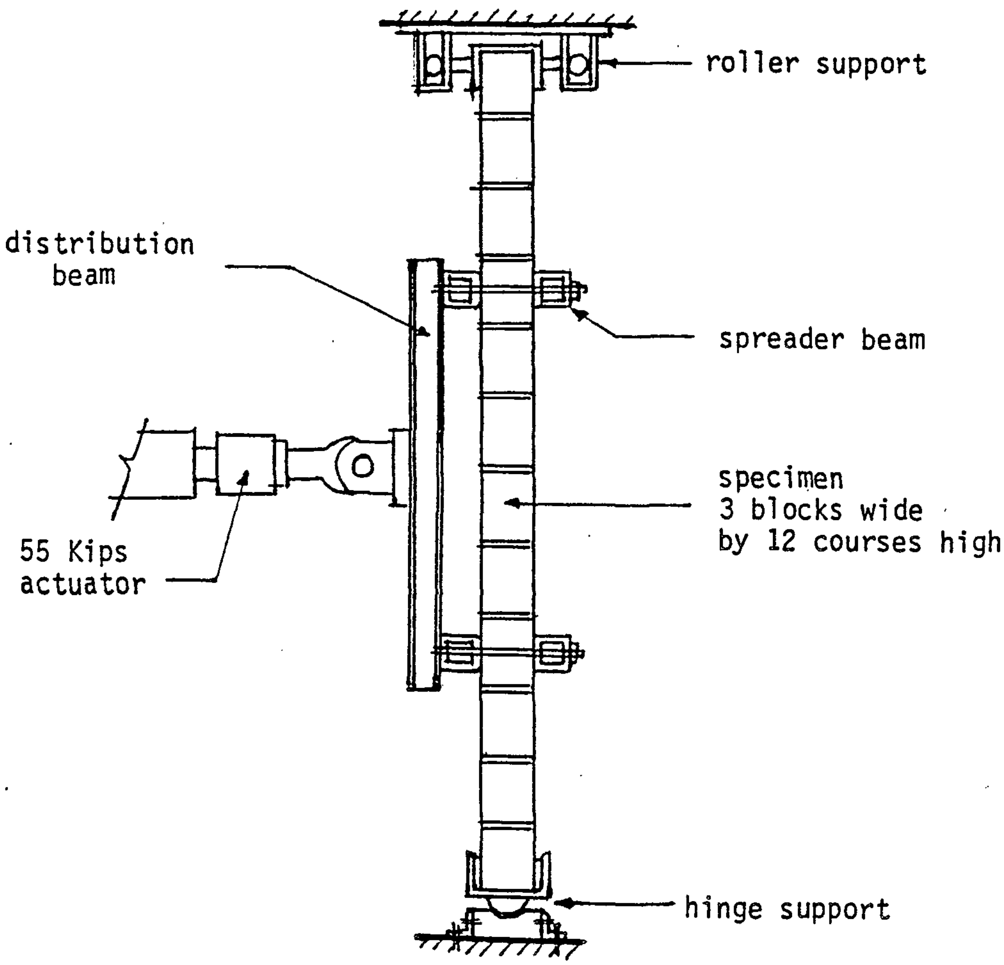


Fig. 2- Test Set-Up

TCCMAR/U.S.

TASK STATUS REPORT

Date: 31 July 1986

Category: 1

Task No: 3.2(b1)

Task Title: Response of Reinforced Masonry Walls to Out-of-Plane Dynamic Excitation

I. Project Status

Work is expected to start in January of 1987.

II. Budget Status

See attached form.

T C C M A R/U.S.

Task Status Report

Date : July 23, 1986

Category : 3.2(b2)

Task No.: 3

Task Title : The Transverse Response of Clay Masonry Walls Subjected to Strong Motion Earthquakes.

1 PROJECT STATUS

Timewise we are now half way through the second phase of the test program, yet workwise the test program is just starting. The following is a summary of the work done to date, i.e. during Phase 1 and Phase 2.

1.1 WORK PERFORMED IN PHASE 1 - 1985

The official start date of Phase 1 was October 1, 1985. During this first month, specifically October 17, 18, and 19, a general coordinating meeting between all TCCMAR participant was held at Boulder, Colorado. In attendance from CES and representing Task 3, Category 3.2(b2) were Dr. Ronald L. Mayes, the principal investigator and Mr. Bjorn Ingi Sveinsson, the project director. At the meeting the program participants scheduled their coordinated effort and outlined their respective tasks.

During the remainder of October, 1985 and prior to November 15, 1985 the out-of-plane clay masonry wall test program was finalized, schedules drawn up and submitted to the TCCMAR Chairman Mr. James L. Noland.

During November and December 1985 preliminary correlation studies were performed using an existing out-of-plane nonlinear mathematical model. This model was developed during a previous proprietary test program and represented a hollow concrete block masonry wall. Although the results of the correlation study are preliminary they indicate that the out-of-plane response of masonry walls can be predicted reasonably accurately with such a model.

1.2 WORK DONE IN PHASE 2 - 1986

In February, 1986 a general status meeting was held in Los Angeles, California. In attendance from CES were Dr. R. L. Mayes and Mr. B. I. Sveinsson. At the meeting the program participants outlined the progress of their respective tasks and reflected on the work ahead.

1.3 Work Remaining

The current schedule for 1986, under Task 3, Category 3.2(b2), calls for the testing of the initial two walls of a total of eleven walls. These first two walls will be tested under quasi-static cyclic loading and will not have any superimposed dead load. The walls will be four (4) feet wide (3 units) and 20 ft. high (60 units). The clay units are 16" x 6" x 4" units. Vertical reinforcement of Wall #1 will consist of 2#3 (0.08%) rebars and for Wall #2 it will be 2#5 (0.22%) rebars. These reinforcement ratios represent the low and medium of the full range of vertical reinforcement planned for the eleven test walls.

Construction of Walls #1 and #2 is scheduled to begin October 1, 1986 and the first wall tested during the first two weeks of November, 1986. Wall #2 will then follow and be tested before the end of the year. Data from the tests will be available to the other TCCMAR researchers in February, 1987. Included in the tests and resulting data are the respective masonry subassemblages, prisms, grout and mortar.

In order for these tests to take place the recearch facility of the Earthquake Engineering Research Center of the U.C. Berkeley will have to be prepared and performance of all equipment verified. This work will begin in September of 1986.

In parallel with the construction and testing of the initial two walls, preparations will be made for the testing of the remaining nine walls. These preparations involve not only plans for the construction of the remaining walls but also development of the time histories for the walls that are to be tested dynamically (Walls No. 4, 5, 6, 7, 9, 10 and 11).

The attached test matrix shows the parameters of this test program.

2 BUDGET

The table below illustrates the current budget status for the project. It requires no explanations.

YEAR	PHASE	REQUESTED BUDGET	AWARDED BUDGET
1985	1	$ 8,992	$ 8,992
1986	2	$ 40,038	$ 40,038
1987	3	$155,713	$ 0
	TOTAL	$205,253	$ 49,030

Proposed Test Matrix - Static and Dynamic Tests.

Wall No.	Input Type	Vertical Reinforcement	Superimposed Dead Load	H/t	Dynamic Input	Height	Thickness	Width	Test Year
1	Static	0.08% (2#3)	No	40	-	20'	6"	4'-0"	1986
2	Static	0.22% (2#5)	No	40	-	20'	6"	4'-0"	1986
3	Static	TBD	No	40	-	20'	6"	4'-0"	1987
4	Dynamic	0.08% (2#3)	Yes TBD	40	Type 1	20'	6"	4'-0"	1987
5	Dynamic	0.08% (2#3)	No	40	Type 1	20'	6"	4'-0"	1987
6	Dynamic	TBD	No	40	Type 1	20'	6"	4'-0"	1987
7	Dynamic	0.08% (2#3)	No	40	Type 2	20'	6"	4'-0"	1987
8	Static	0.08% (2#3)	No	50	-	25'	6"	4'-0"	1987
9	Dynamic	0.08% (2#3)	Yes TBD	50	Type 1	25'	6"	4'-0"	1987
10	Dynamic	0.08% (2#3)	No	50	Type 1	25'	6"	4'-0"	1987
11	Dynamic	TBD	No	50	Type 1	25'	6"	4'-0"	1987

Add two Panels

TBD = To Be Determined

1) Potential Grouting

2) Splice

3) Dead Load

TCCMAR/U.S. - TASK STATUS REPORT

Date: 7-8-86

Category: 4.0

Task No: 4.1 and 4.2

Task Title: Wall to Wall and Floor to Wall Intersection

I. Project Status

A. Work To Date: FLOOR to WALL INTERSECTION MODEL HAS BEEN CONSTRUCTED. VALIDATIONS INVOLVING COMPARISONS OF THEORY AND EXPERIMENTS ARE IN PROGRESS.

B. Work Remaining: A REPORT SUMMARIZING ALL UCSD FLOOR to WALL EXPERIMENTS IS IN PROGRESS.

C. Technical Problem Areas: NONE

II. Budget Status

A. Total Budget Amount - $62,400 for 1 year

Start Date: 12-15-85

End Date: 12-14-86 plus possible 6 month extension

B. Expenditures as of June 30, 1986: $ 19,218.55

CATEGORY 5

TASK 5.1

CONCRETE PLANK DIAPHRAGM CHARACTERISTICS

TASK 5.2

ASSEMBLY OF EXISTING DIAPHRAGM DATA

July 24 & 25, 1986

PROJECT STATUS OF TASK 5.1

Objectives

The general objectives of Task 5.1 are to determine the basic failure modes, ascertain behavioral characteristics, and investigate analytical strength predictions for the full-scale testing of the concrete floor plank system.

Test Comparisons With Varying Parameters

In order to complete the above objectives, the following key parameters are to be investigated: aspect ratio, slab topping, orientation, tie connections, edge connections, and slab thickness. Anticipated tests reflecting these parameters are summarized on Page 3. On Pages 4-6, a listing of how these tests can be compared with one another is indicated. The overall test comparison scheme is graphically presented on Page 7. Sketches showing the plan views of the tests follow.

Connections

Of primary importance to the testing is the development of connections simulating those used in practice. In order to represent a realistic edge zone stiffness, two of the four edges are fastened to the frame. Three types of edge connections are employed: steel beam-slab with stud connection (Page 13), concrete beam-slab connections (Pages 14 & 15), and masonry wall connection (Page 16). Two types of seam connections were incorporated into the testing arrangements: grout alone and grout with a mechanical connector (weld tie - Page 16).

Preliminary Task 5.1 Project Schedule

A summary of the anticipated time schedule is given in the table below. This timetable utilizes a two-year completion period as stated on Page 6 of the NSF Project Proposal, resulting in a completion date of January 1988.

Schedule

Month No.	Month	Phase
1-6	Jan-June 86	Literature review and preliminary designs
7-8	July-Aug 86	Pilot tests #1-3
9-18	Sept 86-June 87	Performance of lab tests #4-20
19-24	July-Dec 87	Analyze results and prepare final report

92

Assuming 17 tests will be performed, approximately 2.4 weeks will be available for each test. Please note; however, that this schedule is preliminary and may change depending on the results of previous tests and the availability of funding.

Points for Discussion

Is the weld plate (weld tie connection) spacing an important enough parameter to justify testing the maximum 3 ft. spacing versus the minimum of 3 connections for the joint between the planks? This latter condition would involve testing these at a 5 ft. spacing. (See Tests 18 and 19.)

Should a Span-Deck plank width of 8 ft. be considered a parameter for the testing? (This would compare with the results of the Span-Deck 4 ft. width plank.)

PROJECT STATUS OF TASK 5.2

Objective

The purpose of the proposed research for Task 5.2 is to gather existing literature and data generated from the discussion and testing of horizontal diaphragms, independent of the type.

Work To Be Completed Soon

A literary review of the documents pertaining to the discussion of the diaphragms is underway at present. The focus of these reviews are: behavioral characteristics, stiffness, failure mode and ultimate strength, analysis and prediction of strength, and the relationship of the document to Task 5.1 and the overall building masonry research of TCCMAR. These documents will be indexed according to author and subject content.

PROJECT BUDGET SUMMARY

TOTAL EXPENDED AS OF JUNE 30, 1986 (plus indirect costs makes total expended approx. $15,000)	$ 12,941.07
TOTAL AMOUNT FUNDED TO DATE (FY86)	$ 15,000.00
BUDGET FUNDS ANTICIPATED FOR FY87	$ 52,490.00
BUDGET FUNDS ANTICIPATED FOR FY88	$ 52,490.00

TEST SUMMARY

TEST NO.	ASPECT RATIO 1:1	1:2	1:1.33	ORIENTATION N-S	E-W	SEAM CONNECTION GROUT ONLY	GROUT+ W.T. @ 5'	GROUT+ W.T. @ 3'	TOPPING WITH	WITHOUT	N-S CONC. BEAMS	WITH MAS. WALL	PLANK DEPTH (in)
1	X			X			X			X			8
2	X				X		X			X			8
3		X		X			X			X			8
4	X			X			X			X			6
5			X	X			X			X			6
6		X		X			X			X			6
7	X				X		X			X			6
8			X		X		X			X			6
9		X			X		X			X			6
10	X			X		X			X				6
11	X			X		X				X			6
12	X				X	X				X			6
13	X				X	X			X				6
14	X			X		(shaded)	(shaded)			X			6
15	X			X		(shaded)	(shaded)			X	X		6
16	X				X	(shaded)	(shaded)			X	X		6
17	X			X		(shaded)	(shaded)			X		X	6
18	X			X				X		X			6
19	X				X			X		X			6
20	X			X			X			X			12

(shaded) OPTIONAL

95

PURPOSE FOR TESTING - A COMPARISON STUDY

		TESTS (see attached pages)
a)	Aspect Ratio (1:1 vs. 1:1.33 vs. 1:2) N-S orientation 5 ft o.c. weld tie connection spacing 6" Span-Deck	#4, #5, & #6
b)	Aspect Ratio (1:1 vs. 1:1.33 vs. 1:2) E-W orientation 5 ft o.c. weld tie connection spacing 6" Span-Deck	#7, #8, & #9
c)	Aspect Ratio (1:1 vs. 1:2) N-S orientation 5 ft o.c. weld tie connection spacing 8" Span-Deck	#1 & #3
d)	Topped vs. Untopped Slabs 1:1 aspect ratio N-S orientation grouted connection only 6" Span-Deck	#10 & #11
e)	Topped vs. Untopped Slabs 1:1 aspect ratio E-W orientation grouted connection only 6" Span-Deck	#12 & #13
f)	Slab Orientation (N-S vs. E-W) 1:1 aspect ratio 5 ft o.c. weld tie connection spacing 6" Span-Deck	#4 & #7
g)	Slab Orientation (N-S vs. E-W) 1:2 aspect ratio 5 ft o.c. weld tie connection spacing 6" Span-Deck	#6 & #9
h)	Slab Orientation (N-S vs. E-W) 1:1.33 aspect ratio 5 ft o.c. weld tie connection spacing 6" Span-Deck	#5 & #8

		TESTS
i)	Slab Orientation (N-S vs. E-W) 1:1 aspect ratio grouted connection only 6" Span-Deck	#11 & #12
j)	Slab Orientation (N-S vs. E-W) 1:1 aspect ratio grouted connection only topped sections 6" Span-Deck	#10 & #13
k)	Slab Orientation (N-S vs. E-W) 1:1 aspect ratio 5 ft o.c. weld tie connection spacing 8" Span-Deck	#1 & #2
l)	Slab Orientation (N-S vs. E-W) 1:1 aspect ratio 3 ft o.c. weld tie connection spacing 6" Span-Deck	#18 & #19
m)	Weld Ties With Grout (3 ft vs 5 ft spacing) vs Grouted Connection Alone 1:1 aspect ratio N-S orientation 6" Span-Deck	#4, #11 & #18
n)	Weld Ties With Grout (3 ft vs 5 ft spacing) vs Grouted Connection Alone 1:1 aspect ratio E-W orientation 6" Span-Deck	#7, #12 & #19
o)	Variation in End Support Condition: 6 vs 2 Studs per Section for Steel Beam-Slab Connection vs Concrete Beam-Slab Connection 1:1 aspect ratio N-S orientation 5 ft o.c. weld tie connection spacing (optional usage) 6" Span-Deck	#4, #14 & 15 OR # 11, #14 & 15
p)	Variation in End Support Condition: 6 Studs/ Secton for Steel Beam-Slab Connection vs Concrete Beam-Slab Connection 1:1 aspect ratio E-W orientation 5 ft o.c. weld tie connection spacing (optional usage) 6" Span-Deck	#7 & #16 OR #12 & #16

		TESTS
q)	Slab Thickness (6" vs. 8" vs. 12") 1:1 aspect ratio N-S orientation 5 ft o.c. weld tie connection spacing untopped sections	#1, #6 & #20
r)	Slab Thickness (6" vs. 8") 1:1 aspect ratio E-W orientation 5 ft o.c. weld tie connection spacing untopped sections	#2 & #9
s)	Slab Thickness (6" vs. 8") 1:2 aspect ratio N-S orientation 5 ft o.c. weld tie connection spacing untopped	#3 & #9
t)	Wall-Slab Connection 1:1 aspect ratio N-S orientation 5 ft o.c. weld tie spacing (optional usage) 6" Span-Deck	#4 & #17 OR #11 & #17

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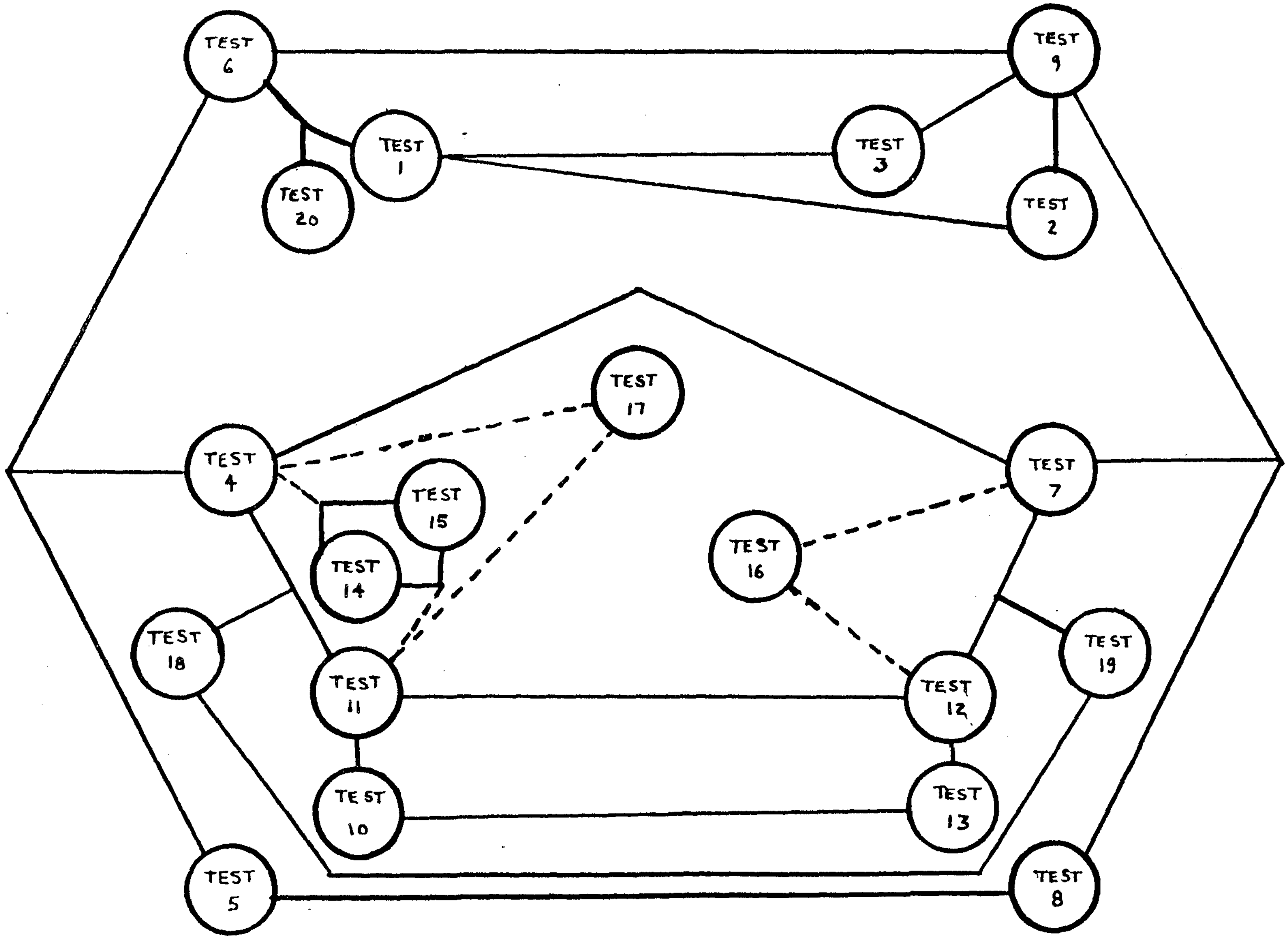
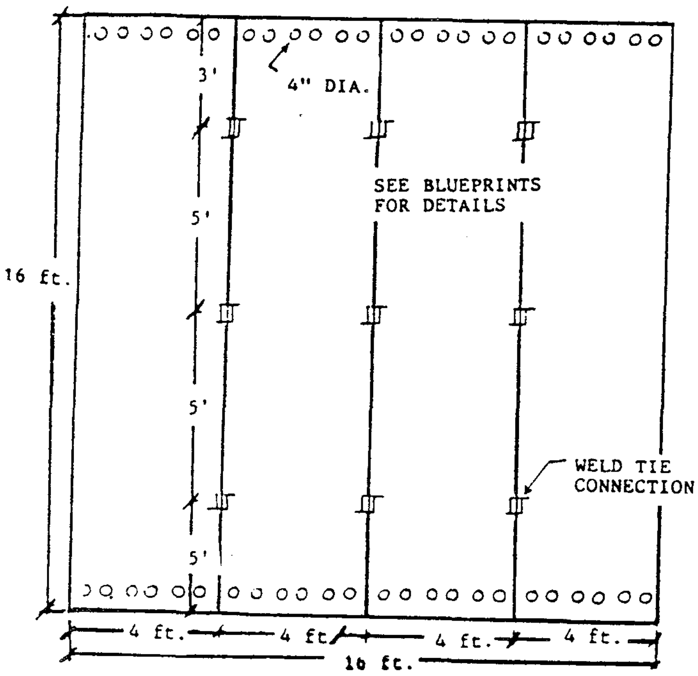


OVERALL TEST COMPARISON SCHEME

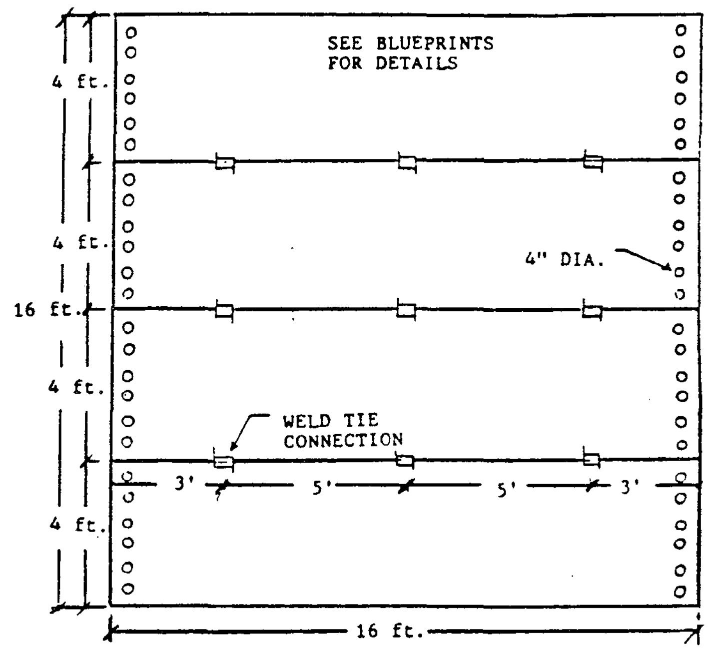
PILOT TEST #1

Aspect Ratio (1:1)
N-S Orientation
8" Span-deck



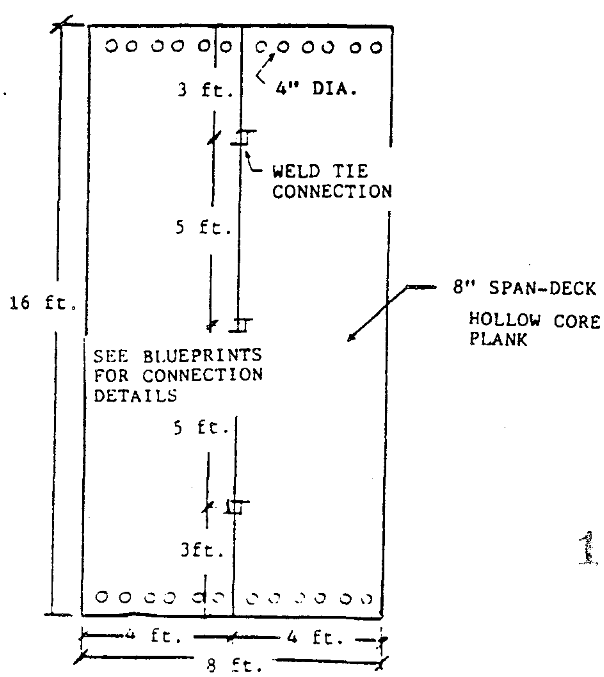
PILOT TEST #2

Aspect Ratio (1:1)
E-W Orientation
8" Span-deck



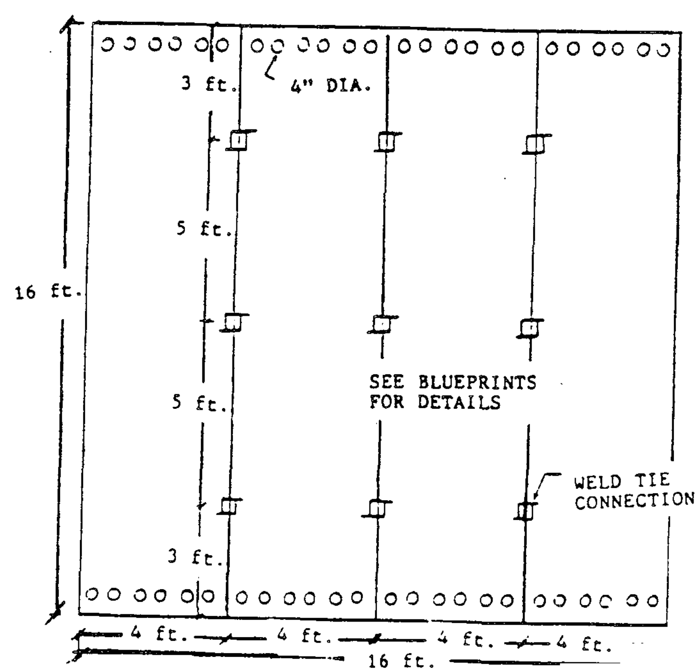
PILOT TEST #3

Aspect Ratio (1:2)
N-S Orientation
8" Span-deck



TEST #4

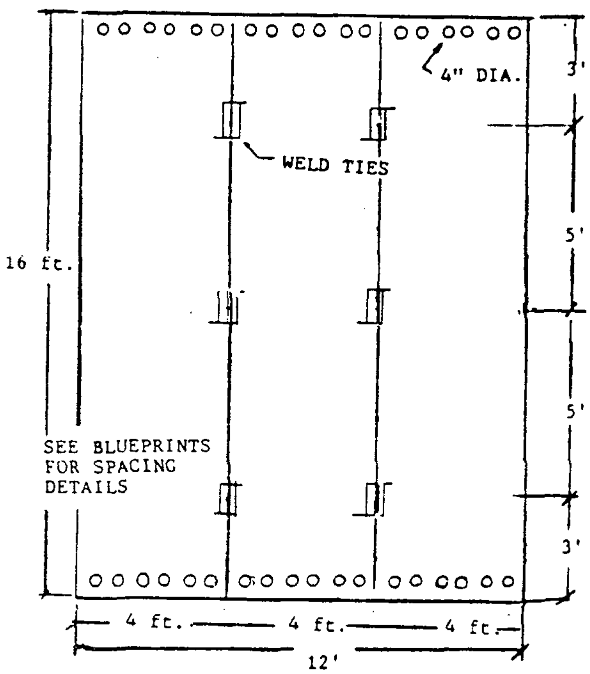
Slab Orientation
1:1 Aspect Ratio
6" Span-deck



100

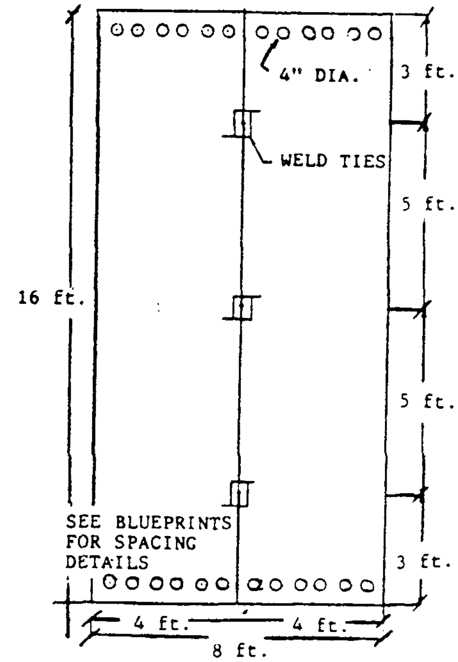
TEST #5

Aspect Ratio (1:1.33)
N-S Orientation
6" Span-deck



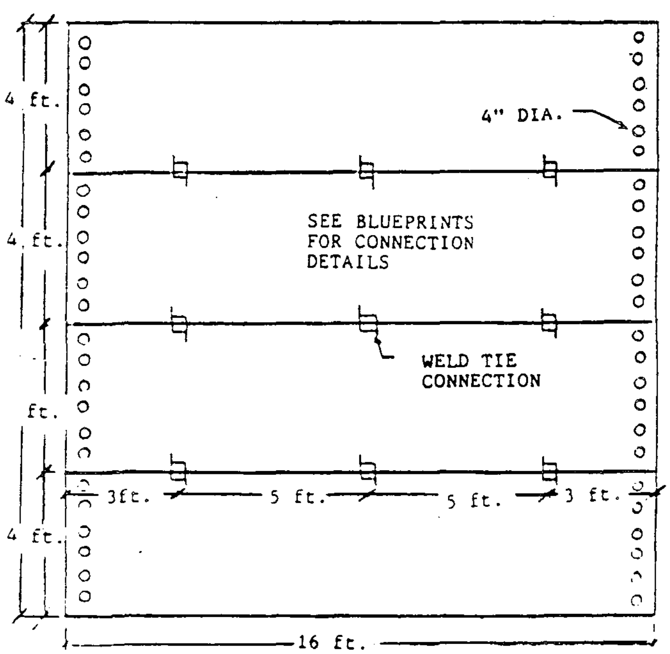
TEST #6

Aspect Ratio (1:2)
N-S Orientation
6" Span-deck



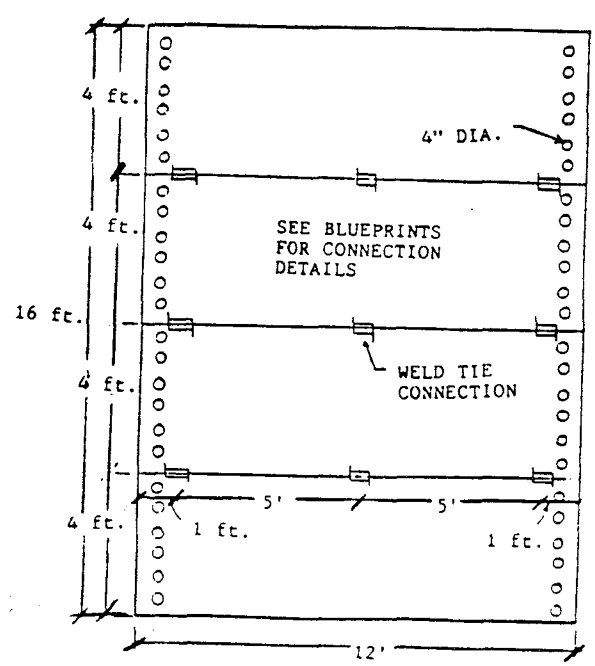
TEST #7

Aspect Ratio (1:1)
E-W Orientation
6" Span-deck



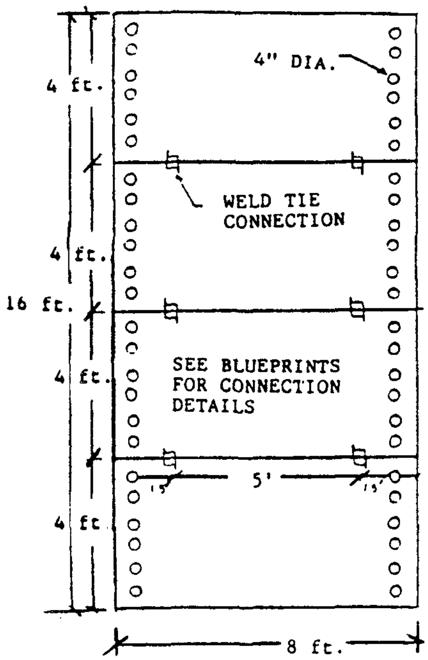
TEST #8

Aspect Ratio (1:1.33)
E-W Orientation
6" Span-deck



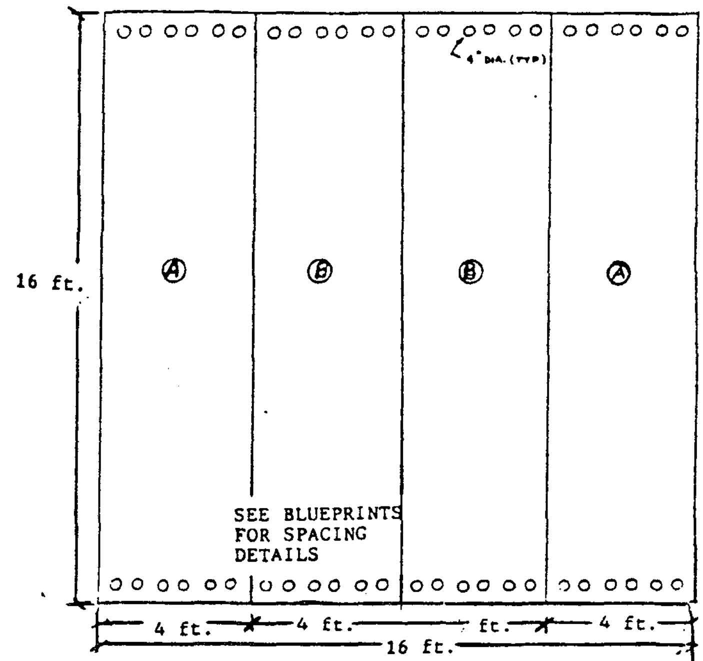
TEST #9

Aspect Ratio (1:2)
E-W Orientation
6" Span-deck



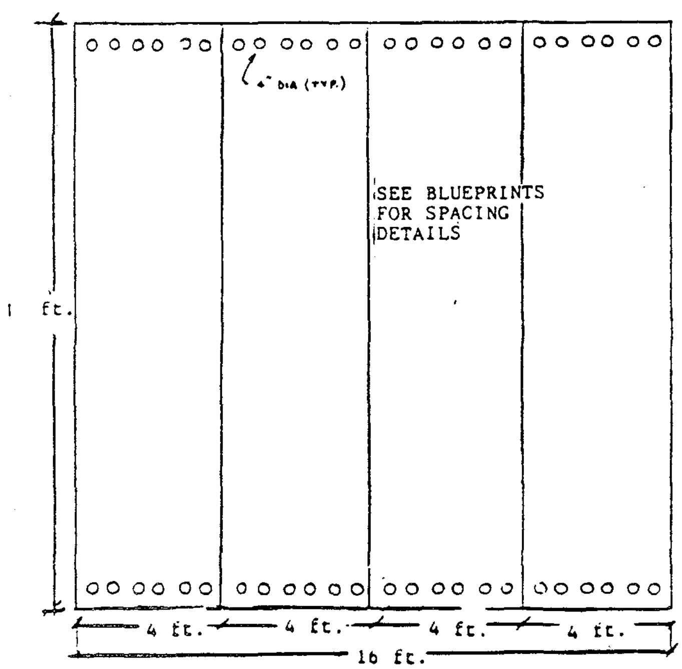
TEST #10

With Topping
6" Span-deck
N-S Orientation
Aspect Ratio (1:1)



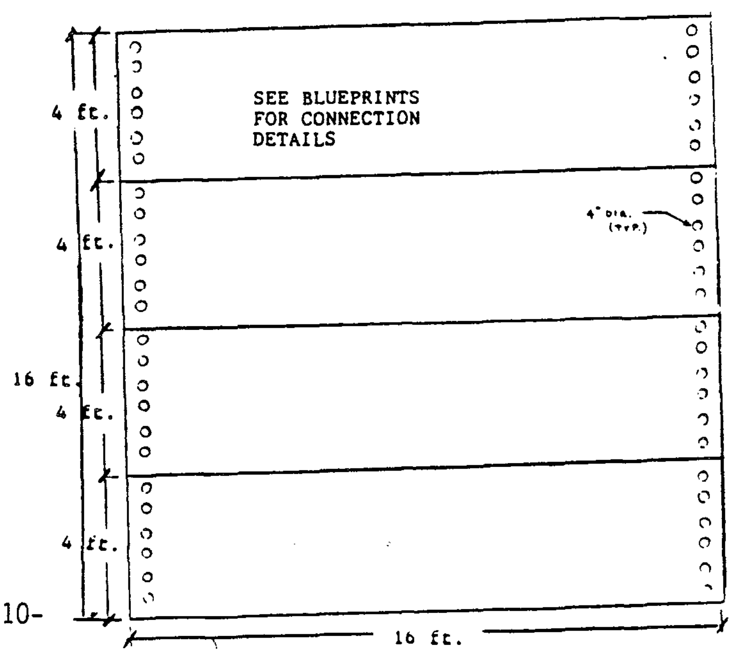
TEST #11

6" Slab Thickness
N-S Orientation
1:1 Aspect Ratio



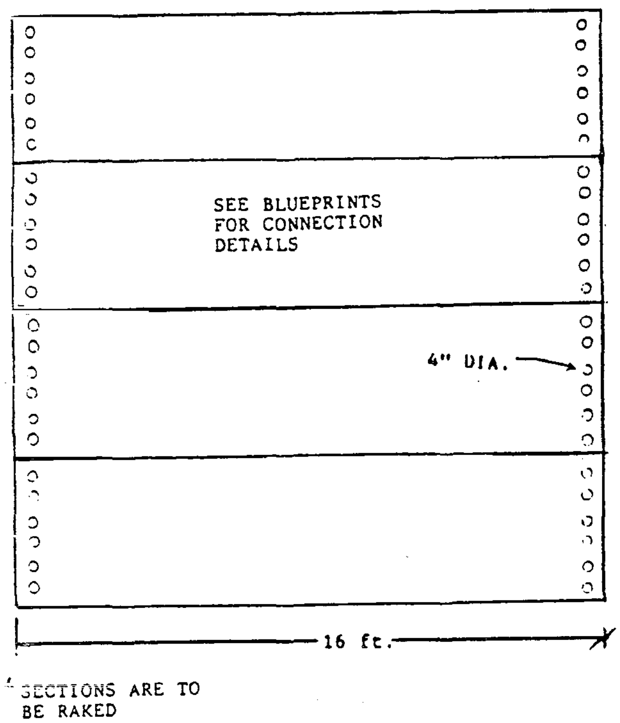
TEST #12

Untopped Sections
E-W Orientation
Aspect Ratio (1:1)
6" Span-deck



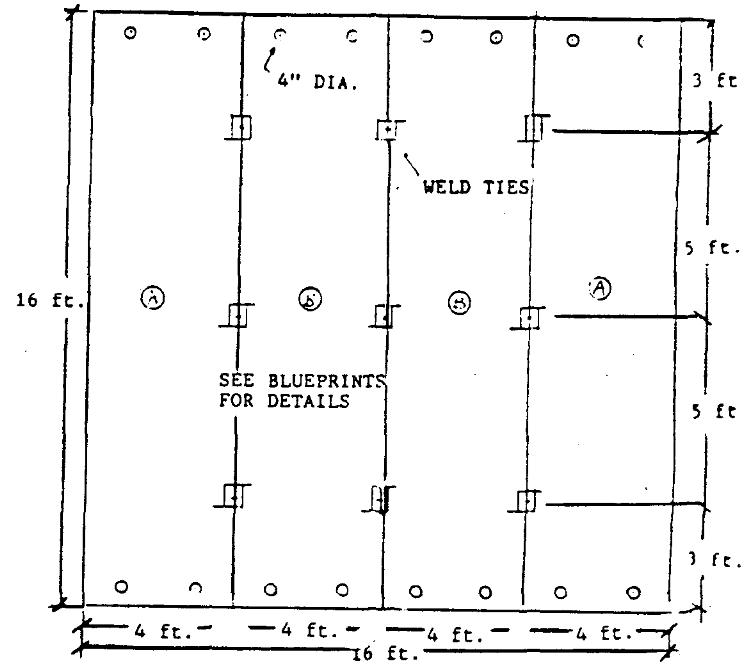
TEST #13

Topped Sections
E-W Orientation
Aspect Ratio (1:1)
6" Span-deck



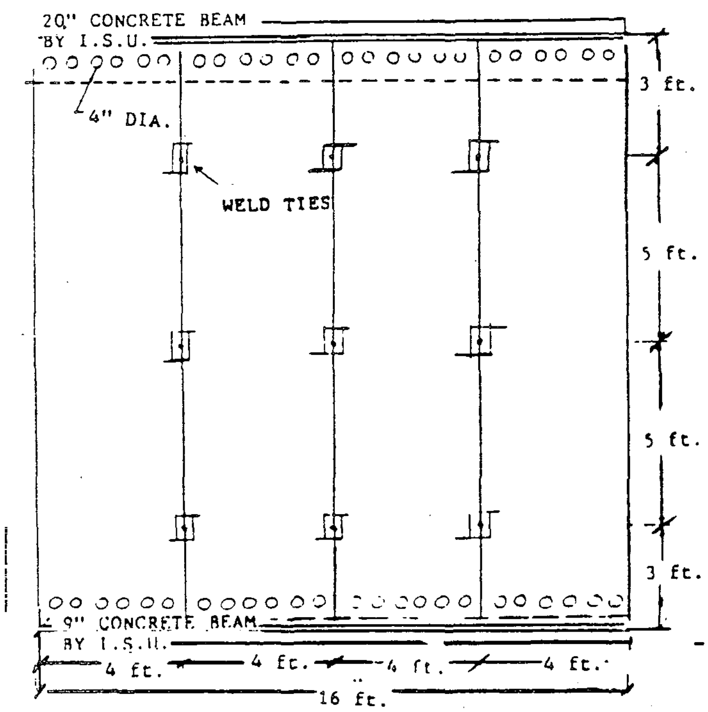
TEST #14

Edge Zone Failure
Aspect Ratio (1:1)
N-S Orientation
6" Span-deck



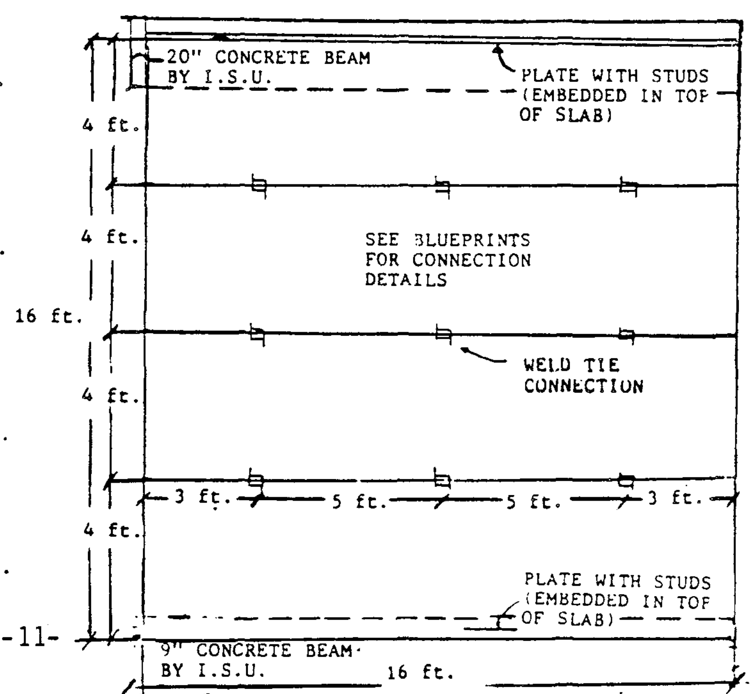
TEST #15

Beam Slab Connection
Aspect Ratio (1:1)
N-S Orientation
6" Span-deck



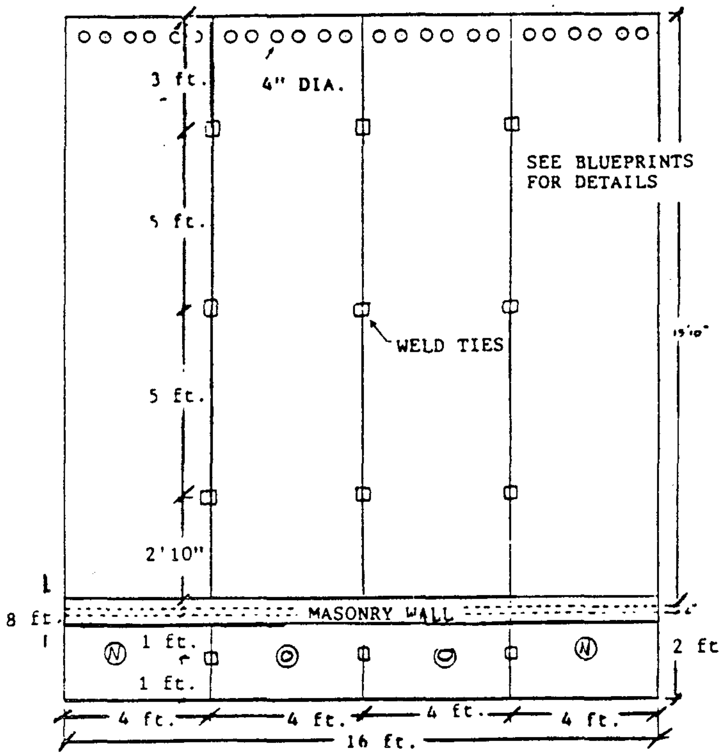
TEST #16

Beam Slab Connection
Aspect Ratio (1:1)
E-W Orientation
6" Span-deck



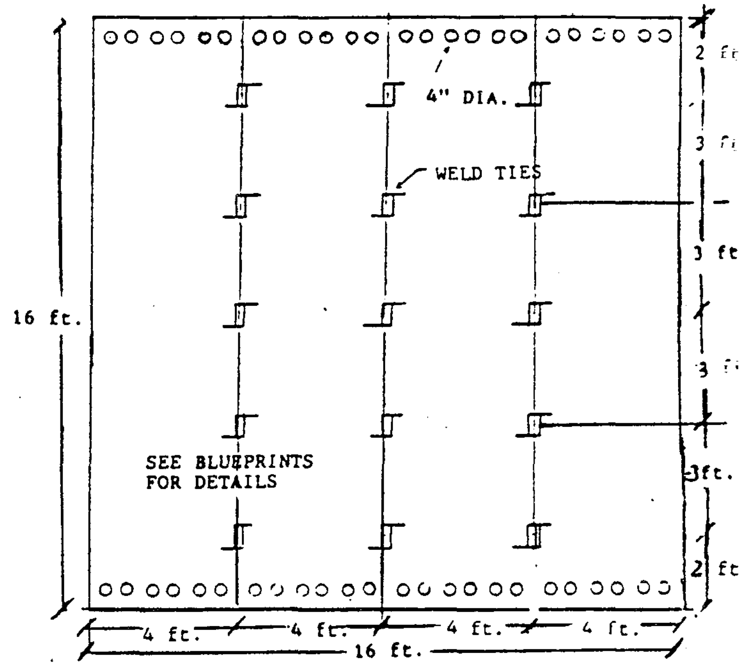
TEST #17

Masonry Wall Incorporated
Aspect Ratio (1:1)
6" Span-deck



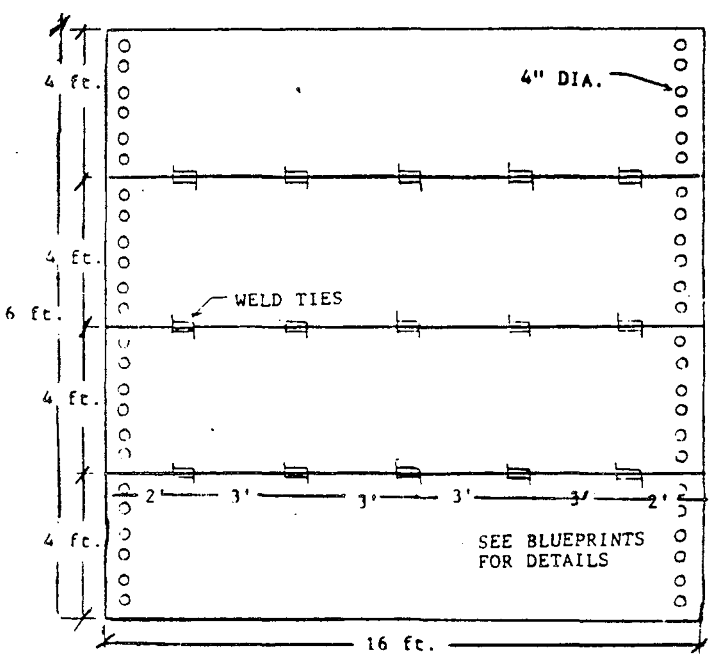
TEST #18

Aspect Ratio (1:1)
N-S Orientation
6" Span-deck



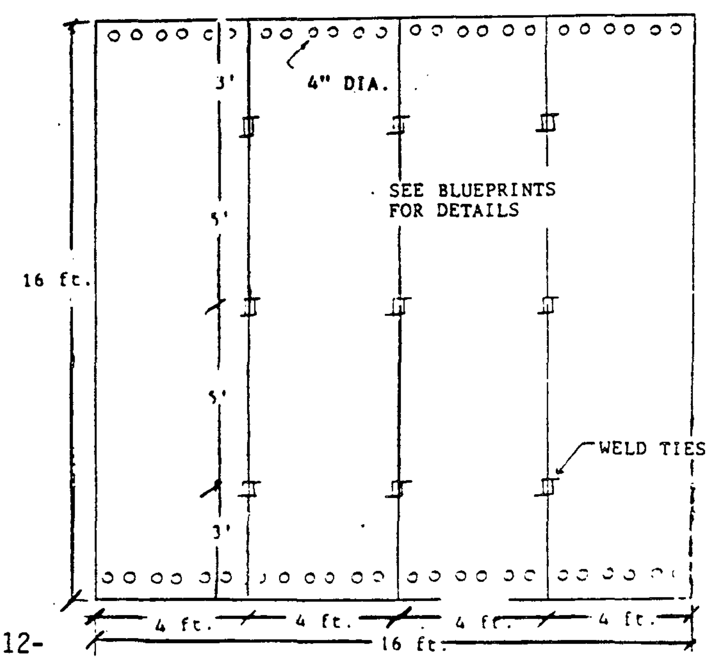
TEST #19

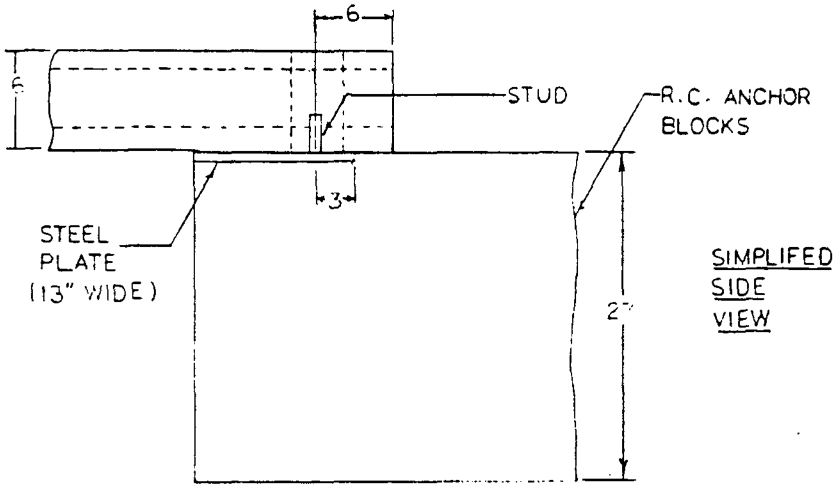
Weld Tie Spacing
E-W Orientation
6" Span-deck



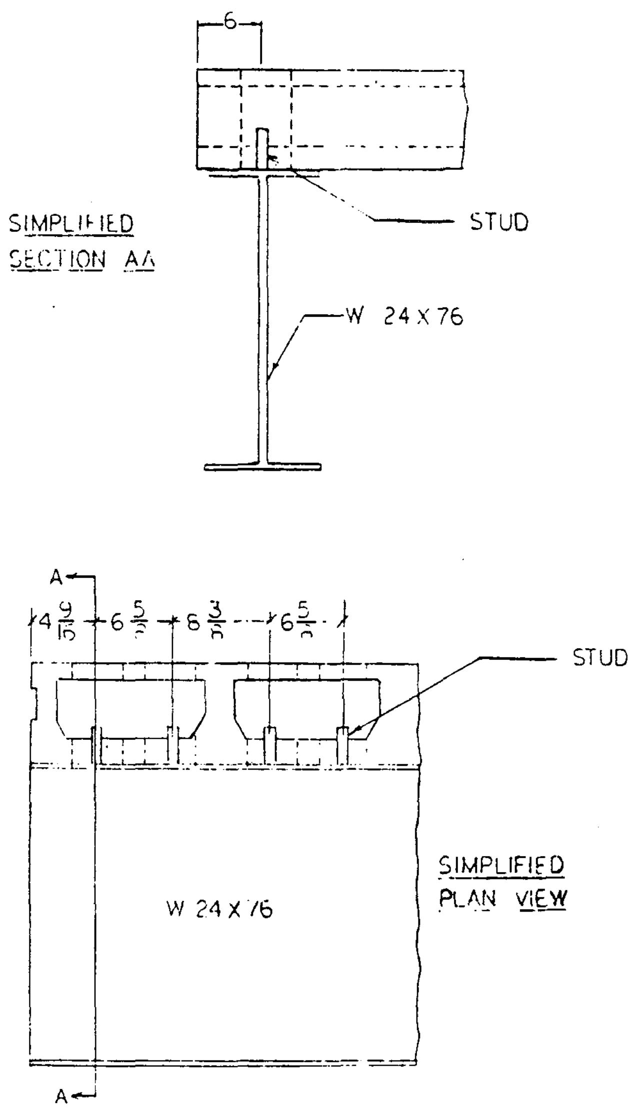
TEST #20

12" Slab Thickness
N-S Orientation
Aspect Ratio (1:1)

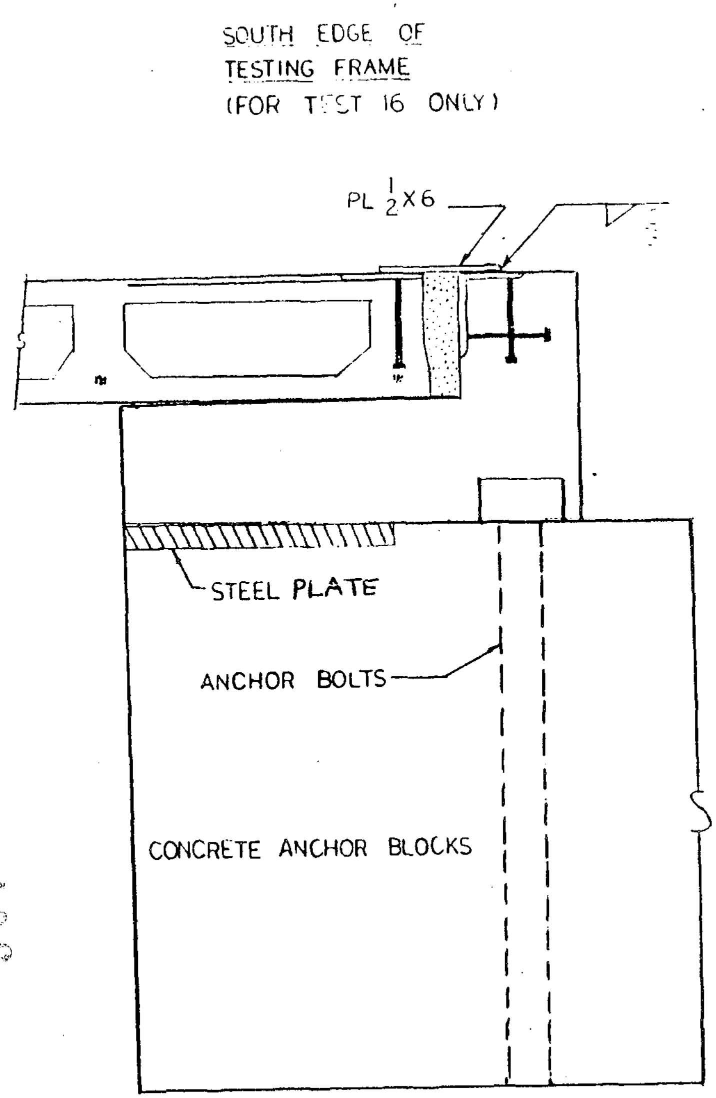


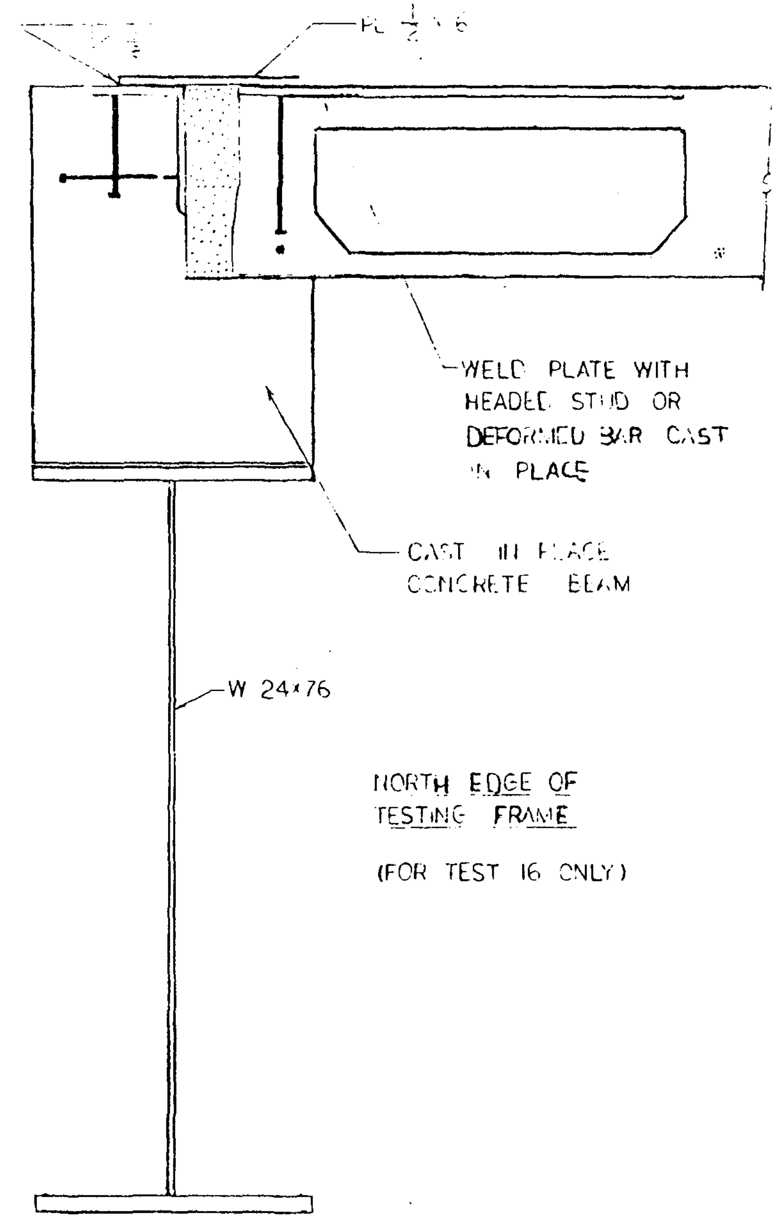


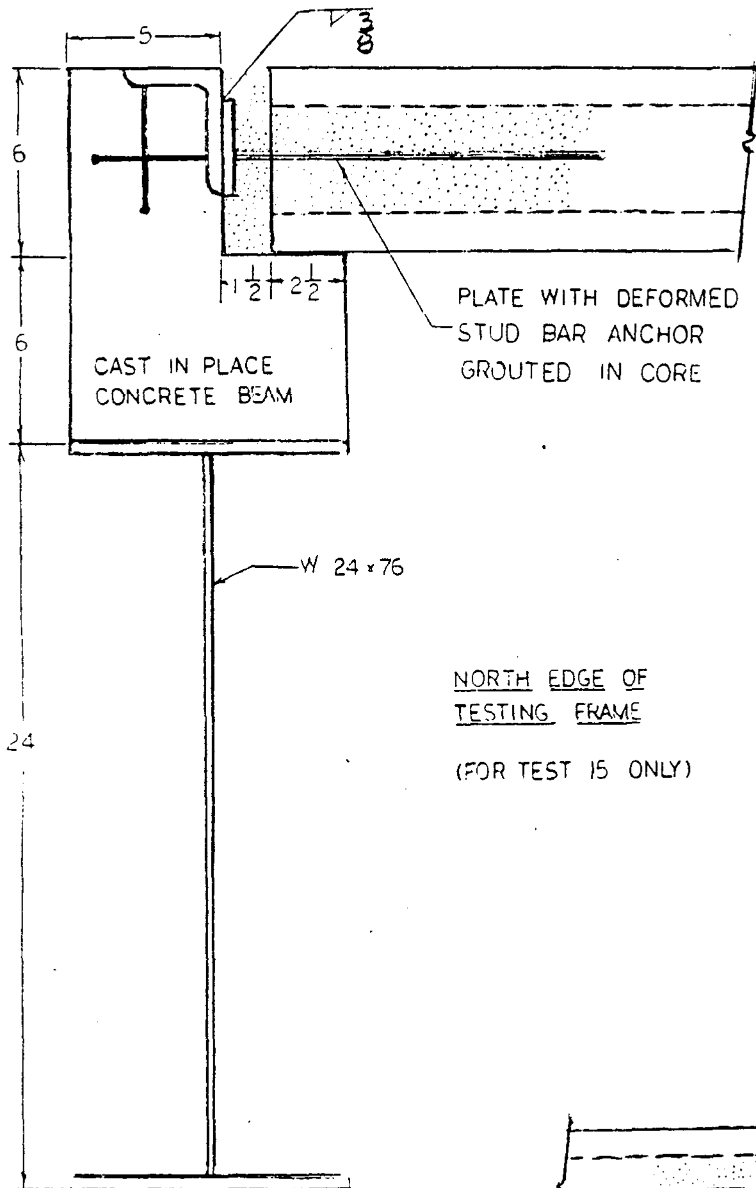
(SOUTH END OF TEST FRAME) STUD CONNECTION



(NORTH END OF TEST FRAME) STUD CONNECTION


SOUTH EDGE OF
TESTING FRAME
(FOR TEST 16 ONLY)
PL 1/2 X 6
STEEL PLATE
ANCHOR BOLTS
CONCRETE ANCHOR BLOCKS


WELD PLATE WITH
HEADED STUD OR
DEFORMED BAR CAST
IN PLACE
W 24x76
NORTH EDGE OF
TESTING FRAME
(FOR TEST 16 ONLY)

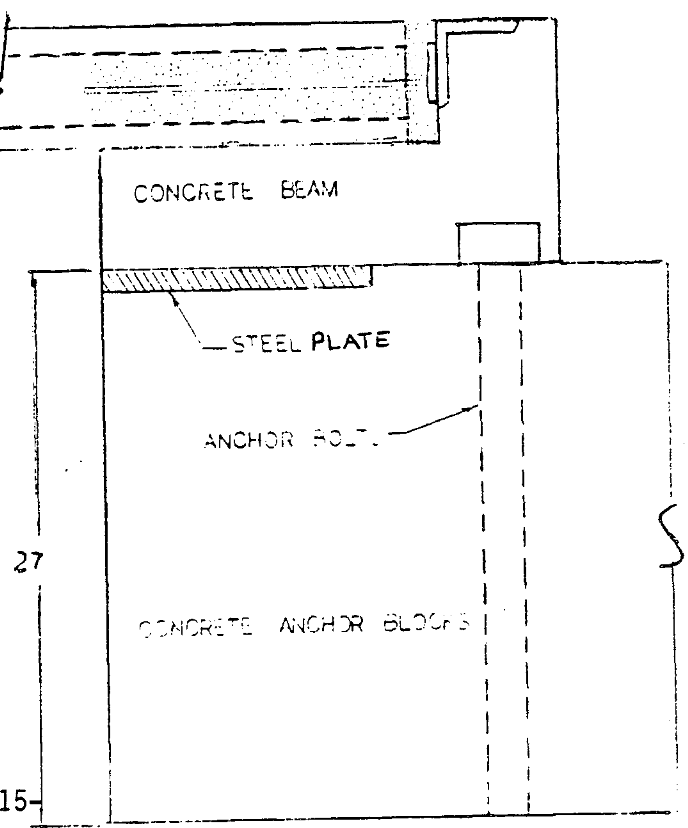


NORTH EDGE OF TESTING FRAME

(FOR TEST 15 ONLY)

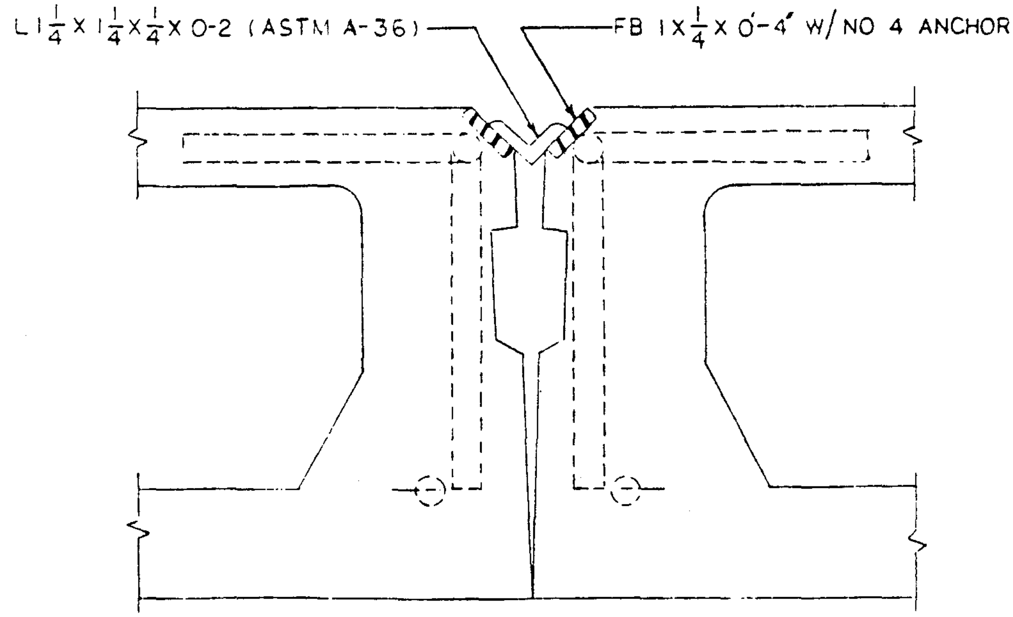
SOUTH EDGE OF TESTING FRAME

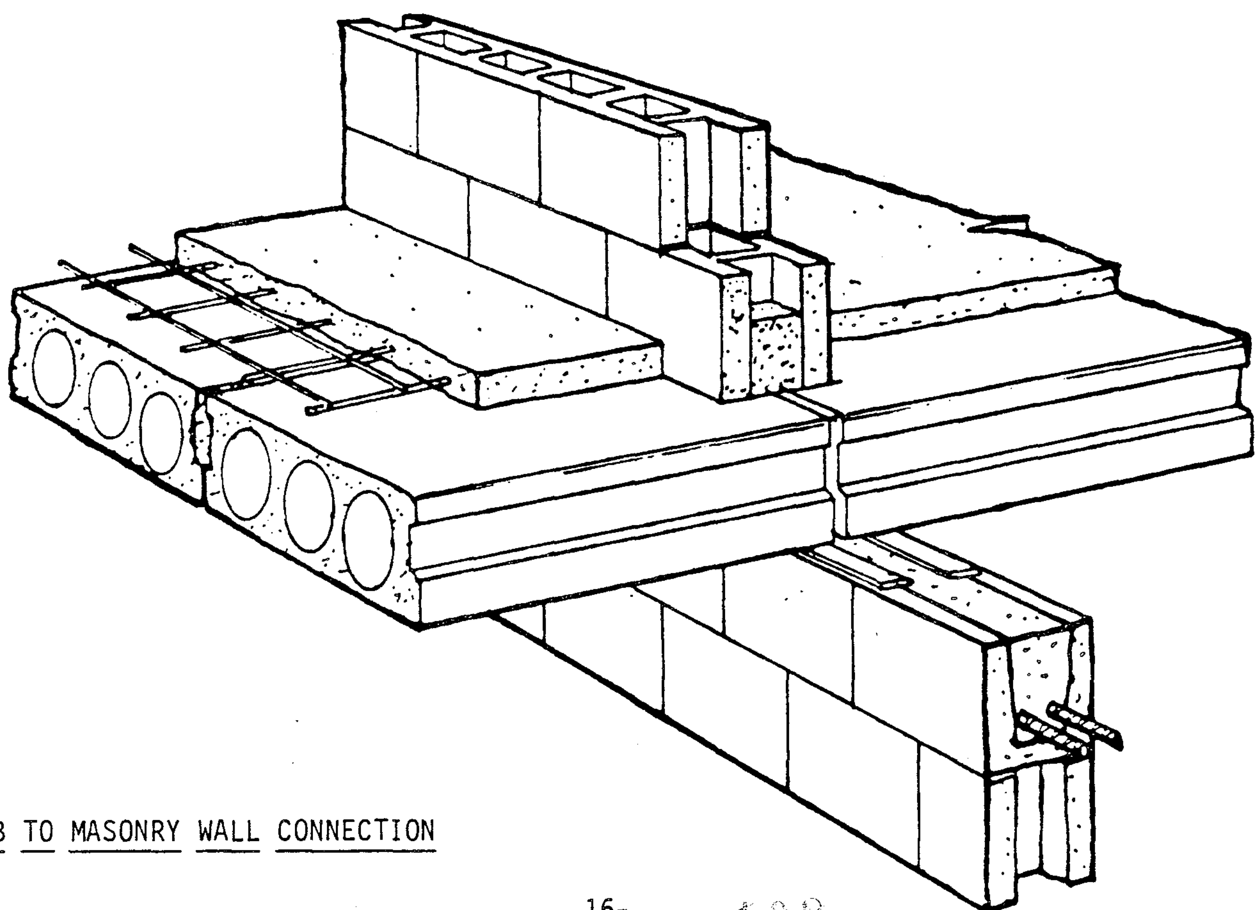
(FOR TEST 15 ONLY)



WELD TIE CONNECTION

SCALE 1"=2"





SLAB TO MASONRY WALL CONNECTION

DIAPHRAGM PROJECT PERSONNEL

Faculty

Max L. Porter, P.E., Ph.D. (Principal Investigator)

Carl E. Ekberg, Jr., P.E., Ph.D.

Graduate Research Assistants

Hassan Masslab

Paul Tremel

Ron Meyer

TCCMAR/U.S.

Task Status Report

10 July 1986

Category: 6.0

Task No.: 6.2

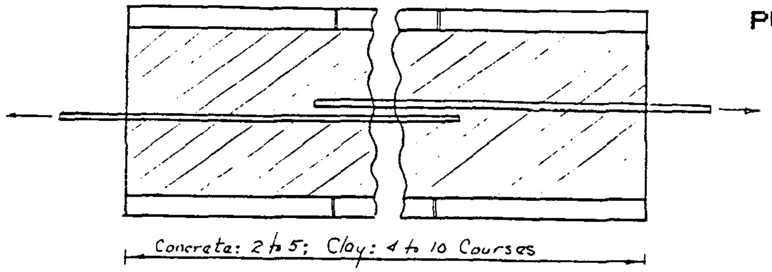
Task Title: Construction Practices Involving Bond & Splices in Reinforced Masonry.
(CU Prop. No. 0884.05.0651B)

I. Project Status.

A. Work to date.

The first phase of this project was originally scheduled to begin on 1st January 1985 but was not budgeted until 1st September 1985 with a starting balance of $46,773 for the period 9/1/85 through 7/31/86. A major remodeling and construction project had begun in the Structural Mechanics and Materials Laboratories of the Dept. of Civil, Environmental, and Architectural Engineering of the University of Colorado @ Boulder in mid-August 1985. This unfortunate conflict in timing necessitated the postponement of serious experimental work until the laboratories were returned to full operation. Thus efforts in Fall 1985 were directed toward planning and theoretical analysis with only minor experimental work.

Zorislav Soric, a Ph.D. candidate who had completed his comprehensive examinations in Spring 1985, was appointed as Research Assistant for this project beginning 1st September 1985. He devoted his efforts to a preliminary pilot study of reinforced concrete masonry beams to gain experience with the materials and techniques involved, and he tested several beam specimens under somewhat chaotic conditions because of the disruption caused by the construction activity. As a result of this preliminary study, a proposed experimental program was designed and described to the TCCMAR Group at its meeting in Colorado in October. That proposed experimental program was modified and expanded after incorporating comments received from the other TCCMAR researchers and consultants at the October meeting, and a much more detailed experimental plan was reported to the TCCMAR group at its meeting in February. That plan with minor modifications is being followed in the conduct of the research (see accompanying Tables and Figures).

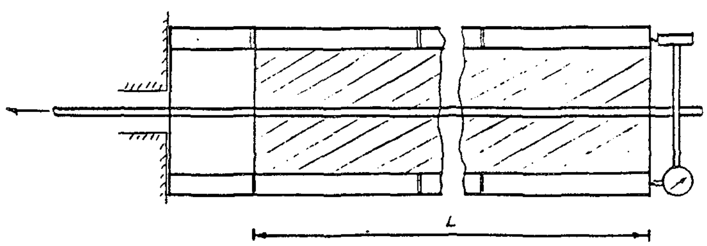


PULL-PULL SPECIMENS (30)

#	DESIGNTN	# GAGES	# SLIP WIRES	MATL	LENGTH	LOAD	DATE MORT	DATE GROUT
1	S4CO16MY	4	5	CO	16	M	6/20	6/23
2	S4CO16CN	–	5	CO	16	C	"	"
3	S4CL16MN	–	–	CL	16	M	"	"
4	N4CO16MY	3	4	CO	16	M	"	"
5	N4CO16CN	–	4	CO	16	C	"	"
6	N4CL16MN	–	–	CL	16	M	"	"
7	S4CO24MY	4	5	CO	24	M	"	"
8	S4CO24CN	–	5	CO	24	C	"	"
9	S4CL24MN	–	–	CL	24	M	6/24	6/26
10	S4CO32MY	6	7	CO	32	M	"	6/25
11	S4CO32CN	–	7	CO	32	C	"	"
12	S4CL32MN	–	–	CL	32	M	"	"
13	N4CO32MY	4	5	CO	32	M	"	"
14	N4CO32CN	–	5	CO	32	C	"	"
15	N4CL32MN	–	–	CL	32	M	"	"
16	N7CO16MY	3	4	CO	16	M	6/20	6/23
17	N7CO16CY	3	4	CO	16	C	"	"
18	N7CL15MN	–	–	CL	16	M	"	"
19	S7CO24MY	4	5	CO	24	M	"	"
20	S7CO24CY	4	5	CO	24	C	6/24	6/26
21	S7CL24MN	–	–	CL	24	M	"	"
22	N7CO32MY	4	5	CO	32	M	"	"
23	N7CO32CY	4	5	CO	32	C	"	"
24	N7CL32MN	–	–	CL	32	M	6/20	6/23
25	S7CO32MY	6	7	CO	32	M	6/25	6/26
26	S7CO32CY	6	7	CO	32	C	"	"
27	S7CL32MN	–	–	CL	32	M	6/24	6/25
28	S7CO40MY	6	7	CO	40	M	6/25	6/26
29	S7CO40CY	6	7	CO	40	C	"	"
30	S7CL40MN	–	–	CL	40	M	6/24	"
	TOTAL	67	131					

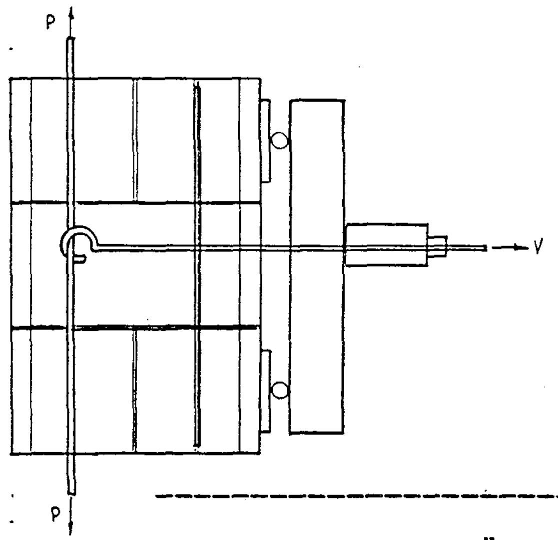
PUSH-PULL SPECIMENS (15)
(Same configuration as Pull-Pull specimens.)

#	DESIGNTN	# GAGES	# SLIP WIRES	MATL	LENGTH	LOAD	DATE MORT	DATE GROUT
1	PSH4N16Y	3	4	CO	16	C	7/9	7/10
2	PSH4Y16Y	4	5	"	16	"	"	"
3	PSH4Y32Y	6	7	"	32	"	"	"
4	PSH4N32Y	4	5	"	32	"	"	"
5	PSH4Y24Y	4	5	"	24	"	"	"
6	PSH7N16Y	3	4	"	16	"	"	"
7	PSH7N16N	–	4	"	16	"	"	"
8	PSH7N32Y	4	5	"	32	"	"	"
9	PSH7H32N	–	5	"	32	"	"	"
10	PSH7Y24Y	4	5	"	24	"	"	"
11	PSH7Y24N	–	5	"	24	"	"	"
12	PSH7Y32Y	6	7	"	32	"	"	"
13	PSH7Y32N	–	7	"	32	"	"	"
14	PSH7Y40Y	6	7	"	40	"	"	"
15	PSH7Y40N	–	7	"	40	"	"	"
	TOTAL	44	82					



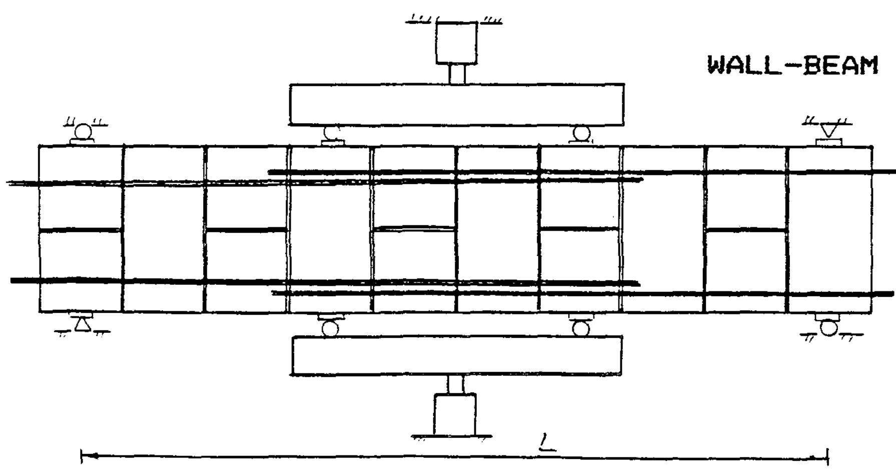
PULL-OUT SPECIMENS (6)

#	DESIGNTN	# GAGES	# SLIP WIRES	MATL	LENGTH	LOAD	DATE MORT	DATE GROUT
1	PO4CO16M	4	4	CO	16	M	7/7	7/8
2	PO4CO16C	–	4	CO	16	C	"	"
3	PO4CL16M	–	–	CL	16	M	"	"
4	PO7CO32M	6	6	CO	32	M	"	"
5	PO7CO32C	–	6	CO	32	C	"	"
6	PO7CL32M	–	–	CL	32	M	"	"
	TOTAL	10	20					



HOOK SPECIMENS (3)

#	DESIGNTN	# GAGES	# SLIP WIRES	LOAD	DATE MORT	DATE GROUT
1	SHYMSW	5	3	M	7/11	7/14
2	SHNCSW	–	3	C	"	"
3	SHNCNW	–	–	C	"	"
	TOTAL	5	6			



WALL-BEAM SPECIMENS (3)

#	DESIGNTN	# GAGES	# SLIP WIRES	DATE MORT	DATE GROUT
1	WB4YSW	7	7	7/11	7/14
2	WB4MNW	–	–	"	"
3	WB4NNW	–	–	"	"
	TOTAL	7	7		

During the period of time in which the construction activity hampered experimental work, efforts were directed toward the development of an analytical model which would describe the mechanics of interaction between reinforcing steel and grout and between grout and masonry unit. A thorough literature search was conducted and advantage was taken of experience in previous bond studies in reinforced concrete whenever it seemed applicable. In addition, after extensive discussion following the recommendations of Nigel Priestley and Richard Klingner, who had urged that a method of cyclic loading from tension through zero into compression without disturbing the specimen be incorporated into the testing procedure, a steel Push-Pull frame was designed and constructed. This frame was designed to lie in a horizontal position with the specimen under test resting on a lubricated surface on the laboratory floor while hydraulic jacks applied tensile forces to the steel or compressive forces to the masonry in a horizontal plane.

At the February TCCMAR meeting in California, there was considerable interest expressed in testing the capacity of reinforcing bar hooks embedded in grouted masonry. In an effort to evaluate the viability of such a determination, a simple model was designed to see whether useful information could be obtained without resorting to observation of an actual masonry wall under load. The proposed configuration of this simple model is shown at the top of the Hook Specimen Table. A prototype will be tested and evaluated. If circumstances so dictate, the configuration will be modified, but the goal of this sub-study will be to determine whether a simple, low-cost specimen can provide useable information.

B. Work Remaining.

Testing of the specimens will commence at the end of July and will continue through August and into September. All specimens will be at least 28 days old at time of test. Control specimens in the form of masonry prisms, 2 inch diameter grout cores and mortar cylinders will be tested at appropriate times during the course of the experimental program. In addition, steel properties such as yield point, ultimate strength, and percentage elongation will have been determined for all steel stock, and complete stress strain responses for several randomly selected steel specimens will also be obtained.

Interpretation and analysis of experimental results will be done during Fall. It is anticipated that replication of some of the experiments will be required in the event that inconsistencies or contradictions appear. Comparison of the experimental results with the analytical model predictions will be made, and if necessary the analysis will be adjusted to improve the match between the two. Spring and summer of 1987 will be devoted to the writing of a final report which will essentially be a condensation of the Soric Ph.D. thesis.

C. Technical Problem Areas.

There was considerable reluctance to install strain gages on the steel specimens because of anticipated interference with the bond between the grout and the rebar, particularly on the No. 4 rebar, for which the strain gage and its waterproofing would constitute a very large discontinuity in the transfer of load from grout to rebar. However, at the recommendation of the other TCCMAR researchers and consultants, extensive use of strain gages has been made. Of the 133 gages installed, 55 have been mounted on the No. 4 bars while the remaining 78 gages are on the No. 7 bars.

Strain gage installation proved to be a very tricky part of the specimen construction with a loss of 15 to 20 percent in gages before insertion into the masonry units and subsequent grouting. The success ratio after grouting is yet to be determined, but it would be unrealistic to expect 100 percent success. It is very likely that loss of strain gages will require the duplication of some of the tests.

Slip wire installation produced only very minor problems which were soon worked out with familiarity with the technique. There may still be some problems associated with take up of initial slack in the slip wires, but sufficient experience has not yet been gained to comment further.

The steel Push-Pull Frame is still untested at this stage. It may be necessary to go through a shake-down period with it before reliable data can be obtained, and if necessary, the frame will be modified.

II. Budget Status.

A. Project Duration and Budget.

This project has been funded by the National Science Foundation under Grant and Proposal No. ECE-8517029 in the amount of $46,773 for Phase I, beginning 1st September 1985 and ending 28th February 1987 (including a 6 month unfunded flexibility period.) This is a continuing grant which NSF expects to fund in the amount of $36,975 in FY(86) for Phase II ending in summer of 1987 for a total duration of approximately two years.

B. Expenditures.

As of 30th June 1986, the sum of $18,697 had been expended from project funds. This low level of expenditure was due to constraints on experimental activity produced by the construction and remodeling in the laboratory. Now that the laboratory has been brought up to essentially full operation, the tempo of activity has increased, and after examining encumbrances and projected expenditures during the summer, it is anticipated that $17,327 will be disbursed from project funds in July and August, bringing the total sum expended to $36,024 for the first phase of the project.

C. Proposed Schedule change.

Because of restricted laboratory activity during construction and remodeling, it is proposed that the budgets for Phase I and II be interchanged, so that $36,748 will be allocated to Phase I, ending 31st August 1986, and the remaining $46,773 of the $83,748 total budget be allocated to Phase II which will begin 1st September 1987 and will end on 31st August 1987 (with a 6 month unfunded flexibility period at the end of that term). If this modification of the original budget and schedule is adopted, 98% of the first phase budget will have been disbursed at the end of scheduled Phase I.

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John Kariotis, President, S.E.
Nels Roselund, Vice President, S.E.
Michael Krakower, S.E.

TCCMAR/U.S.

Task Status Report

Date: July 23, 1986

Category: 9.0

Task No.: 9.1

Task Title: Design of Research Building

I. Project Status

A. Work to Date. Reinforced masonry research building Type A and Type B have been designed. Building Type A represents a typical multi-story apartment/condominium occupancy. Reinforced masonry walls perpendicular to the in-plane test wall subdivide the units. Building Type B represents a hotel unit occupancy. The reinforced masonry walls perpendicular to the test walls are spaced to accommodate two hotel units between the bearing walls. The center of one laboratory strong wall is concurrent with the axis of the single reinforced masonry wall that is designated as the test wall.

The test wall has window and door openings. These openings occur at each level in an identical pattern. This opening pattern will include in the full scale test wall the following subtypes of shear walls:

- A shear wall with central opening, a wall intersection (flange) at one wall edge, minimal coupling beams at one wall edge.
- A cantilever shear wall with a wall intersection at the center of the pier section.
- A broad based cantilever shear wall with symmetrical openings through the wall. The spandrel section over the openings will provide substantial restraint to the piers between the openings.

- A flexible cantilever shear wall with minimal coupling beams at one edge and a wall intersection at one edge.

The configuration of the subassemblies of the test wall will stretch the ability of the analytical program to predict complete cyclic load-displacement relationships. It is our understanding that a loading-data acquisition method termed sequential dynamic displacements will be the test technique. A pseudo-dynamic displacement technique will be studied for its feasibility. The decision as to the test technique is not required at this time.

The construction materials of the test building are fully described in the attachment. Six inch concrete masonry units were selected to minimize the strength and stiffness of the test building. The test building is considered to be a segment of a multi-story building. The design of this segment will assume that the full prototype structure is located in a seismic risk zone other than the California, Nevada, and Alaska seismic zones.

The concrete masonry units will be fully grouted and reinforced for shear capacities in excess of flexural capacity. If the wall configuration makes this unpredictable, the shear reinforcement pattern will be that developed by element testing to have acceptable shear ductility. Splices in the vertical reinforcement were considered to be unacceptable in critical flexural zones. This restriction would require that open end blocks be used for placement around the vertical reinforcement. The Japan tests indicate that restrictions in splicing of vertical reinforcement may be minimized. A final decision in splicing of vertical reinforcement will be made after completion of element testing with splices.

Special planning for horizontal construction joints at the foundation and at each floor level has been noted on the attachment. These details deviate from usual construction practices that depend on omission of a part of the face shell of the unit at the vertical reinforcement for removal of accumulated debris. The method of construction of experimental wall elements should be nearly identical to the methods that are planned for the test building.

A preliminary finite element analysis of the UCSD test wall has confirmed that its elastic strength greatly exceeds the probable loading that will be required to displace the test building into the inelastic displacement range.

B. Work Remaining. A final finite element analysis of the UCSD test wall that includes probable post-tensioning losses and uncertainties will be made.

A preliminary analysis of the elastic strength of the test building will be made by comparison with completed research and extrapolation of design methods. The accuracy of these preliminary analyses is not expected to be adequate for other than indicating a range of horizontal strengths.

Methods of loading the five level building by equivalent inertial loads will be investigated. A preliminary search for a material with constant shear properties over an adequate displacement range has not discover a useful material. Analysis of possible methods of loading to better determine minimum properties of a loading system are part of future tasks.

C. Technical Problem Areas. This task will not give solutions to the technical problems of testing the full scale building. The task is preliminary in scope and is intended to define a prototype test building. This test building gives guidance for development of element testing.

Technical problem areas will be generally defined by this task. A preliminary list of problem areas now are:

Construction joints at each story level.

Spacing of vertical reinforcement.

Consolidation of grout in minimum size reinforced cells.

Distribution of applied loads to the test structure.

Shear transfer from the precast floor units to the test wall.

Shear transfer from the test building foundation to the laboratory floor.

Control of jacks for application of multi-level loads.

II. Budget Status

A. $21,920 has been awarded for this project. The award is effective October 1, 1985 to March 31, 1987, including a six month unfunded flexibility period.

B. Total expenditures as of June 30, 1986 were $8,421.24.

Attachment

APPENDIX 4

RESOLUTIONS FROM JOINT U.S.-JAPAN MEETINGS

RESOLUTIONS
OF THE FIRST WORKSHOP ON
U.S.-JAPAN MASONRY PROGRAM

RESOLUTIONS

1. The First U.S./Japan Workshop on Masonry, conducted under the auspices of the UJNR Panel on Wind and Seismic Effects - Task Committee B on Large-Scale Testing, was held at the Building Research Institute in Tsukuba Science City on March 16 and 17, 1984.

2. The workshop included presentations on results of technical studies, current research in progress, codes, recommendations and future studies to be conducted or sponsored by agencies in both countries. These presentations indicated future trends of earthquake engineering research in masonry and were beneficial to the participants.

3. The participants recommend that a Coordinated Masonry Research Program to be carried out under auspices of the UJNR Panel on Wind and Seismic Effects by initiated. Useful discussions were held on identification of general areas of research coordination. Specific areas of coordination will be determined in the near future for planning of studies to be conducted or sponsored by agencies in both countries.

4. The Joint Technical Coordinating Committee (JTCC) should be established for the coordinated masonry research program. The Masonry JTCC should take appropriate advantage of the experience of the JTCC from previous joint projects in concrete and steel.

5. At the 16th meeting of the UJNR, the Chairman of Task Committee B will request endorsement of the full UJNR Panel for proceeding with the implementation of a coordinated masonry research program.

6. Through the presentations and discussions, the participants have recognized the increasing need of research on masonry structures and identified many important areas of research on which both U.S. and Japanese researchers can coordinate the work together.

7. The participants have recognized that there are also some differences in masonry structural systems constructed in each country. It is believed that many problems can be jointly resolved between the two sides, and that the joint effort of the two parties can provide solutions to these problems.

8. Effort should be made to exchange researchers of the two countries as much as possible in order to enhance the mutual understanding between the individual research programs conducted in both countries.

9. The participants have recognized the importance of disseminating the results of the joint research efforts to countries that have the seismic hazard and can benefit from improved knowledge of masonry structures.

10. The second workshop on the masonry program, should be held in Japan in conjunction with the 17th UJNR meeting. A planning meeting should be held in the near future to discuss the next step in coordination of the research program.

THE FIRST JOINT TECHNICAL COORDINATING COMMITTEE ON MASONRY RESEARCH (JTCCMAR) MEETING

August 26 and 27, 1985
Tokyo, Japan

Resolutions

1. The First Joint Technical Coordinating Committee on Masonry Research (JTCCMAR) Meeting was held at the Architectural Institute of Japan in Tokyo on August 26 and 27, 1985. Eight U.S. researchers and twenty-eight Japanese researchers attended the meeting. (See the agenda and list of participants.

2. The participants have agreed that very useful technical exchange was made during the Meeting with respect to the material behavior of masonry units and assemblies, masonry construction procedures, structural behavior of masonry structural elements and assemblies, and testing procedures and facilities.

3. It was recognized that, in contrast to steel and reinforced concrete, there is currently insufficient information on the behavior of masonry.

4. Considering the worldwide need for masonry research, the participants recommend that sponsoring agencies take appropriate measures to enable such research to be performed.

5. The participants recognize that both countries have many common research needs regarding masonry construction as well as mechanical properties of masonry units and components.

6. The participants recognize that the similarities and differences between concrete and clay unit masonry must be established.

7. The participants recognize that continuous and in-depth effort is required to establish the seismic performance characteristics of existing masonry structures and to develop improved masonry construction and design procedures for new masonry structures.

8. The participants realize that the research programs of both countries primarily address central issues and that many other important issues exist which should be addressed.

9. The participants recognize that tests of masonry structures on full-scale specimens are necessary to understand the overall behavior and performance of masonry structural systems and recommend that each of the two countries proceed with plans to conduct at least one full-scale seismic test of a masonry structural system designed and constructed in accordance wi;th

the procedures adopted in each country.

10. Researchers should be exchanged as required to enable a meaningful exchange of concepts and information between similar individual research projects.

11. The participants realize the benefits of a continuous exchange of information and reports between the research programs in both countries.

12. The second JTCCMAR Meeting should be held in the U.S. at an appropriate time in the fall of 1986.

APPENDIX 5

REPORT ON A SITE VISIT TO THE BUILDING RESEARCH INSTITUTE,

MINISTRY OF CONSTRUCTION, TSUKUBA, JAPAN

REPORT ON A SITE VISIT TO BUILDING RESEARCH INSTITUTE
MINISTRY OF CONSTRUCTION, TSUKUBA, JAPAN
June 22 - July 5, 1986

Kyle Woodward
University of California, San Diego

At the request of Dr. James Noland, TCCMAR Coordinator, I visited the Large-scale Testing Laboratory of the Building Research Institute (BRI), Ministry of Construction, Tsukuba, Japan. The trip had two primary purposes, the first being to observe the test of a three-story reinforced brick wall being conducted as part of the Japanese program of research and the second purpose was to examine the Japanese laboratory equipment and methods. The latter purpose was in support of the planning of the large-scale tests (five-story building) to be conducted at the University of California, San Diego. This report summarizes the trip and my observations.

The trip was most helpful in establishing cordial relations between myself and the Japanese research engineers, but since the level of expertise was comparable, there was little opportunity to learn anything new. The Japanese operate their laboratory using no permanent technicians or support people. They contract for services and equipment which is then used, essentially as specified and delivered. This leads to a situation in which the engineers do not necessarily learn the theory of operation of the equipment. This made it difficult to explore much below the user methodology, and capabilities between the BRI system and that expected at the University to rule out applying the Japanese system. The Japanese equipment was rather old and the improvements have been primarily in the electronics. However, in order to continue using their older electronics, they have continued to use the same overall system concept. The situation expected for the U.S. building test is completely different. The system will use current equipment and so the concept will take computer software. The conclusion which I drew from the visit was that the Japanese have a system which they understand and can use to accomplish their objective. I did not feel that their system satisfied the requirements of the building test planned for the U.S.

The other purpose of the trip was to observe the three-story building test. Unfortunately, their estimate of the test start date was overly optimistic and the test did not begin until July 2. Instrumentation problems then delayed the test until July 4. I observed only the very preliminary loading stages. The load level was just sufficient to cause some inelastic behavior. As a result, I have no comments about the test results. The test method was simple, in-plane lateral displacement was applied only at the top of the wall. A nominal axial load was also applied at the top of the wall. There were several hundred channels of instrumentation, but comments from the researchers made it clear that they expect to actually utilize only a fraction of the data. In particular, they pointed to reinforcement strain measurements as being of little use based on their past experience. Their techniques were typical of any large, well-equipped laboratory. Observing the time involved with working on such a large specimen reinforced my own view that the corresponding project in the U.S. would take longer and be more expensive than even the most pessimistic estimate predicts.

In closing, my assessment of the trip was that while extremely useful in developing a working relationship with my Japanese counterparts, the trip did not produce much in the way of new information on test techniques or results from their three-story wall test.