CONFERENCIAS 2ª SESION

THE U.S.A. - JAPAN CORDINATED PROGRAM FOR MASONRY BUILDING RESEARCH (TCCMAR): U.S.A. RESULTS

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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 buildings of various sizes and in different regions of the U.S. Improved masonry structural technology is expected to make masonry buildings a more viable alternative to concrete and steel buildings, and thus stimulate competition and foster lower building costs.

2.0 PROGRAM OBJECTIVES

Primary program objectives are:

1) To develop design and criteria recommendations for limit state design of reinforced masonry buildings and components.

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2) To develop a consistent experimental database on the behavior of masonry materials, components and systems.

3) To develop analytical nonlinear models for research and design office use for detailed analysis, system analysis, and dynamic loads determination.

4) To develop improved material and subassemblage experimental procedures for obtaining masonry properties.

5) To develop improved masonry fabrication procedures and standards.

6) To develop an increased awareness among engineers, architects, code bodies, and the public of the capabilities of reinforced masonry in all seismic zones.

7) To work with standards development groups in support of a consensus limit state standard for masonry.

2.0 BACKGROUND

2.1 Current Status of Masonry Structural 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 developed by a joint committee of the ASCE and ACI also is 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 [3,4,5,6,7,8] 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.

Although a great amount of masonry research information exists in the U.S. [3,4,5,6,7] 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.

2.2 Technical Coordinating Committee for Masonry Research

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. Current TCCMAR researchers are listed in Table 1.

The initial TCCMAR purposes were:

- o to specifically define the research topics, both experimental and analytical, necessary to develop a consistent masonry structural technology for the U.S.A.
- o 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.

3.0 U.S. COORDINATED PROGRAM FOR MASONRY BUILDING RESEARCH

The U.S. program for masonry building research consists of many 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, so that 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.

TCCMAR/U.S. 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, structural dynamics, building codes, and earthquake engineering. TCCMAR researchers are listed in Table 1. TCCMAR participants defined the research program, conducted the research, and will analyze and interpret the results.

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.

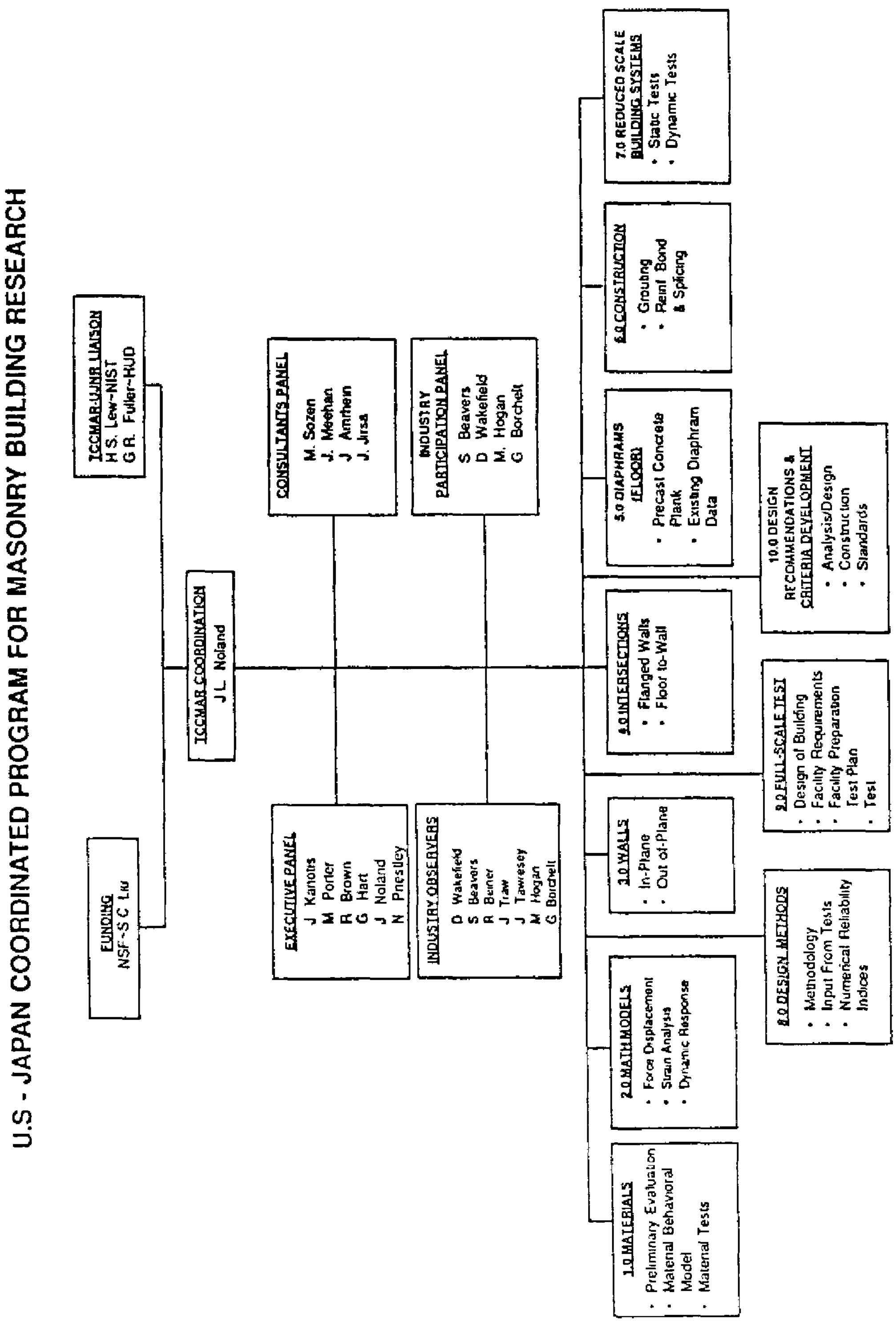


Figure 1 Organizational Structure of U.S. - TCCMAR Project

TABLE 1 - TCCMAR RESEARCHERS

Daniel Abrams
University of Illinois
Urbana, IL

Richard Atkinson
Atkinson-Noland & Associates
Boulder, CO

Robert Englekirk
Englekirk,Hart & Sabol
Los Angeles, CA

Ahmad Hamid
Drexel University
Philadelphia, PA

Gary Hart
Englekirk,Hart & Sabol/UCLA
Los Angeles, CA

John Kariotis
Kariotis & Associates
South Pasadena, CA

Ronald Mayes
Computech Engin. Services
Berkley, CA

Max Porter
Iowa State University
Ames, IA

Frieder Seible
Univ. of CA-San Diego
La Jolla, CA

Leonard Tulin
University of Colorado
Boulder, CO

Samy Adham
Agbabian Associates
El Segundo, CA

Russell Brown
Clemson University
Clemson, SC

Robert Ewing
Ewing & Associates
Rancho Palos Verdes, CA

Mike Hammons
US Army Corps of Engineers
Vicksburg, MS

Gilbert Hegemier
Univ. of CA-San Diego
La Jolla, CA

Richard Klingner
Univ. of Texas-Austin
Austin, TX

James L. Noland
Atkinson-Noland & Assoc.
Boulder, CO

M.J N. Priestley
Univ. of CA-San Diego
La Jolla, CA

P.B. Shing
University of Colorado
Boulder, CO

TABLE 2 - CONSULTANTS' PANEL

Mete Sozen	Professor of Civil Engineering, University of Illinois, Champaign-Urbana.
John Meehan	Research Director and Principal Structural Engineer, Structural Safety Section. Office of the State Architect, State of California. (Retired)
James Amrhein	Executive Director, Masonry Institute of America, Los Angeles, California
James Jirsa	Professor of Civil Engineering, University of Texas at Austin

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, California
Robert Beiner	Director of Engineering, International Masonry Institute, Washington, D.C.
Jon Traw	Vice President, Engineering, International conference of Building Officials, Whittier, California.
John Tawresey	Vice President of Finance and Consulting Engineer, KPFF, Seattle, Washington.
Mark Hogan	Director of Engineering, National Concrete Masonry Association, McLean, California.

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 professions, would be represented.

The specific research tasks which comprise the U.S. Coordinated Program for Masonry Building Research are listed in Table 4.

TABLE 4 -- RESEARCH TASKS

CATEGORY	TASK (Researcher)	TOPIC
1.0	1.1 **R.Atkinson** Atkinson-Noland & Assoc.	**PRELIMINARYMATERIALSTUDIES** -- 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 **A.Hamid** Drexel University **R.Brown** Clemson University	**MATERIAL MODELS** -- To evaluate K1, K2 and K3 for the flexural stress-block. To determine uniaxial and biaxial material properties for analytical models (Tasks 2.1 and 2.2) including post-peak behavior. To evaluate non-isotropic behavior.
1.0	1.3 **R.Atkinson** Atkinson-Noland & Assoc.	**MATERIAL TESTS** -- To critically review and assess existing tests of masonry material and assemblages to determine the usefulness of data produced with respect to the needs of analytical models and design methodology developed in the program. To revise existing tests as required and/or suggest new tests. The work will be done in coordination with Category 2 and 10 Tasks to establish accuracy requirements.
2.0	2.1 **R.Englekirk** Englekirk,Hart & Sabol	**FORCE-DISPLACEMENT MODELS FOR MASONRY COMPONENTS** -- To develop force-displacement mathematical models which accurately characterize reinforced masonry compo-

		nents 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 **R.Ewing** Ewing & Associates	**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 **J.Kariotis** Kariotis Associates	**DYNAMIC RESPONSE OF MASONRY BUILDINGS** -- To develop a generalized dynamic response model to predict inter-story 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(a) **M.Porter** Iowa State University	**DYNAMIC RESPONSE OF DIAPHRAGMS** -- To develop an analytical non-linear model of load displacement history of horizontal diaphragms to provide associated displacements and stiffnesses for an integrated dynamic spring model. This Task will provide a computer model extension using a lumped-parameter-mass parameter Spring No. 11 (or similar type of model) of the experimental data collected from Tasks 5.1 and 5.2 of the current TCCMAR program. The Task concentrates on developing a spring model from data

		collected on concrete plank slabs and concrete slabs reinforced with composite steel decking. This work will provide input for Task 2.3.
2.0	2.4(b) **R.Mayes** Computech Engineering	**DYNAMIC OUT-OF-PLANE RESPONSE OF REINFORCED MASONRY WALLS** -- To develop analytical models based upon the results of Task 3.2(b) which can be used to predict out-of-plane response of masonry walls of various shapes, sizes, and internal construction. To conduct response studies based on independent variation of parameters. The models will interface with the models of Tasks 2.3 and 2.4(a).
3.0	3.1(a) **B.Shing** University of Colorado Boulder	**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 various reinforcement ratios and patterns.
3.0	3.1(b) **G.Hegemier** **F.Seible** University of California San Diego	**DEVELOPMENT OF A SEQUENTIAL DISPLACEMENT ANALYTICAL AND EXPERIMENTAL METHODOLOGY FOR THE RESPONSE OF MULTI-STORY WALLS TO IN-PLANE LOADS**--To develop a reliable test methodology for investigating structural response, through integrated analytical and experimental studies of three-story reinforced hollow unit masonry walls. The methodology will be the basis of studying the response of a full-scale masonry research building in Task 9.4 Data from the 3-story shear wall tests will be used to develop analytic models in conjunction with Tasks 2.1, 2 2, and 2.3

3.0	3.1(c) **R.Klingner** University of Texas Austin	**RESPONSE OF REINFORCED MASONRY TWO-STORY WALLS TO FULLY REVERSED IN-PLANE LATERAL LOADS** -- To establish the behavior of two-story walls subjected to small and large amplitude reversals of in-plane lateral deflections, axial force and bending moments considering the effect of openings, floor-wall joint details, reinforcement ratios and coupling between shear walls. To develop analytic models in conjunction with Tasks 2.1, 2.2, and 2.3.
3.0	3.2(a) **A.Hamid** Drexel University **R.Mayes** Computech Engineering	**RESPONSE OF REINFORCED MASONRY WALLS TO OUT-OF-PLANE STATIC LOADS** -- 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) **S.Adham** Agbabian Associates **R.Mayes** Computech Engineering	**RESPONSE OF REINFORCED MASONRY WALLS TO OUT-OF-PLANE DYNAMIC EXCITATION** -- 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 **M.J.N.Priestley** University of California San Diego	**RESPONSE OF FLANGED MASONRY SHEAR WALLS TO DYNAMIC EXCITATION** -- To experimentally investigate the dynamic behavior of flanged shear walls, in particular, the behavior of T-section walls and the significance of dynamic,

		as opposed to static or quasi-static testing, for in-plane loading. To develop analytical models to investigate the flange-web shear lag phenomena, and to identify the interaction between flange width, height, reinforcement content, and ductility level. (In conjunction with Tasks 2.1, 2.2, and 2.3).
4.0	<u>4.2</u> **G.Hegemier** University of California San Diego	**FLOOR-TO-WALL INTERSECTIONS OF MASONRY BUILDINGS** -- To determine the effectiveness of intersection details to connect masonry wall components, to construct a nonphenomenological analytical model of intersection behavior for use in building system models.
5.0	<u>5.1</u> **M.Porter** Iowa State University	**CONCRETE PLANK DIAPHRAGM CHARACTERISTICS** -- To investigate experimentally concrete plank diaphragm floor diaphragms with stiff supports to determine modes of failure and stiffness characteristics including yielding capacity in terms of distortion as needed for masonry building models.
5.0	<u>5.2</u> **A.Johnson** S.B.Barnes & Assoc. **M.Porter** Iowa State University	**ASSEMBLY OF EXISTING DIAPHRAGM DATA**--To assemble extensive existing experimental data on various types of floor deforms, to reduce to a form required for static and dynamic analysis models.
5.0	<u>5.3</u> **M.Porter** Iowa State University	**CONCRETE PLANK DIAPHRAGM CHARACTERISTICS· CONTINUATION** -- To investigate experimentally concrete plank floor diaphragms with flexible supports to determine modes of failure and stiffness characteristics including yielding

capacity in terms of distortion as needed for masonry building models.

6.0	<u>6.1</u> **R.Atkinson** Atkinson-Noland & Assoc. **M.Hammons** U.S.Army Corps of Engineers	**ADVANCED MASONRY TESTS** -- To develop new masonry tests to provide material properties information required for limit state design, to develop detailed knowledge of reinforcing bar-masonry interaction and to develop recommendations regarding lap splicing of reinforcement consistent with the needs of limit state design.
6.0	<u>6.2</u> **L.Tulin** University of Colorado Boulder	**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	<u>7.1</u> **D.Abrams** University of Illinois Champagne-Urbana	**SMALL SCALE MODELS** -- To provide dynamic test data on the dynamic behavior of three-story reinforced concrete masonry buildings built with 1/4 scale hollow concrete units. To demonstrate the viability of constructing and dynamic testing of reduced scale building system models for basic behavior studies.
8.0	<u>8.1</u> **G.Hart** University of California San Diego	**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 limit states are investigated.
8.0	<u>8.2</u> **G.Hart** University of California San Diego	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 judgment. To complete development of the methodology.
9.0	<u>9.1</u> **J.Kariotis** Kariotis Associates	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 select a single configuration in consultation with TCCMAR which will be used as a basis for defining equipment and other laboratory facilities in displacements using methods developed in Category 2 tasks and the associated load magnitudes and distributions.
9.0	<u>9.2</u> **G.Hegemier** **F.Seible** **M.J.N.Priestley** University of California San Diego	FACILITY PREPARATION -- Define, acquire, install and check-out equipment required for experiments on a full-scale reinforced masonry research building.
9.0	<u>9.3</u> **G.Hegemier** **F.Seible** **M.J.N.Priestley** University of California San Diego	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 **G.Hegemier** **F.Seible** **M.J.N.Priestley** University of California San Diego	**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 **J.Noland** Atkinson-Noland & Assoc.	**DESIGN RECOMMENDATIONS AND CRITERIA DEVELOPMENT & TECHNOLOGY DOCUMENTATION & DISSEMINATION** -- 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 **J.Noland** Atkinson-Noland & Assoc.	**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.

A systems approach is being taken to guide and control the program, i.e., The U.S. Coordinated Program for Masonry Building Research is a cohesive entity 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 designed and conducted and the data to be obtained.

The 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.

4.0 PROPOSED SCHEDULE

The schedule for the remainder of the U.S. program is shown in Figure 3. The total time required to complete the program is estimated to be approximately seven-and-one-half years from the time the majority of the tasks began, i.e. fall 1985.

With the exception of the preliminary materials studies task, work began in the fall of 1985. The program as presently defined is expected to be complete by June 1993.

The schedule illustrates the parallel nature of experimental research and modeling. Modeling studies began in the fall of 1985 and will continue to March 1992. As data from the various experimental tasks becomes available, models will be progressively refined and calibrated.

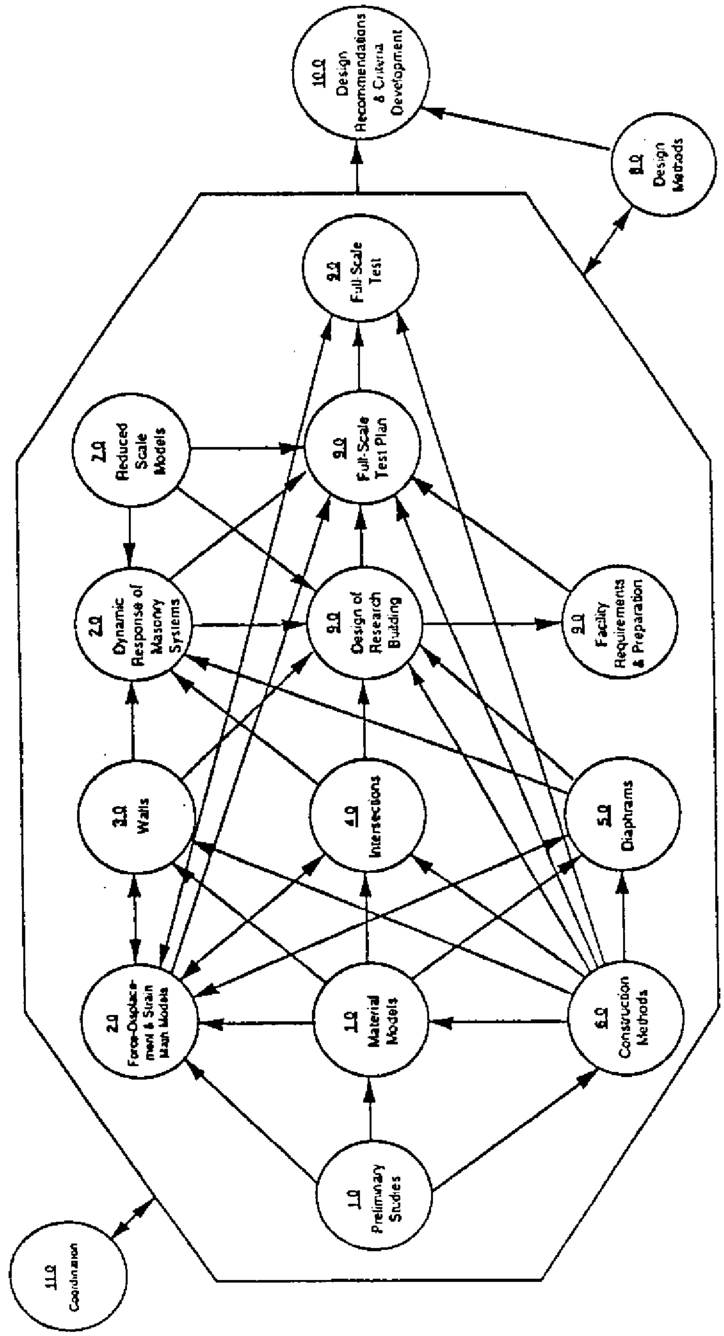
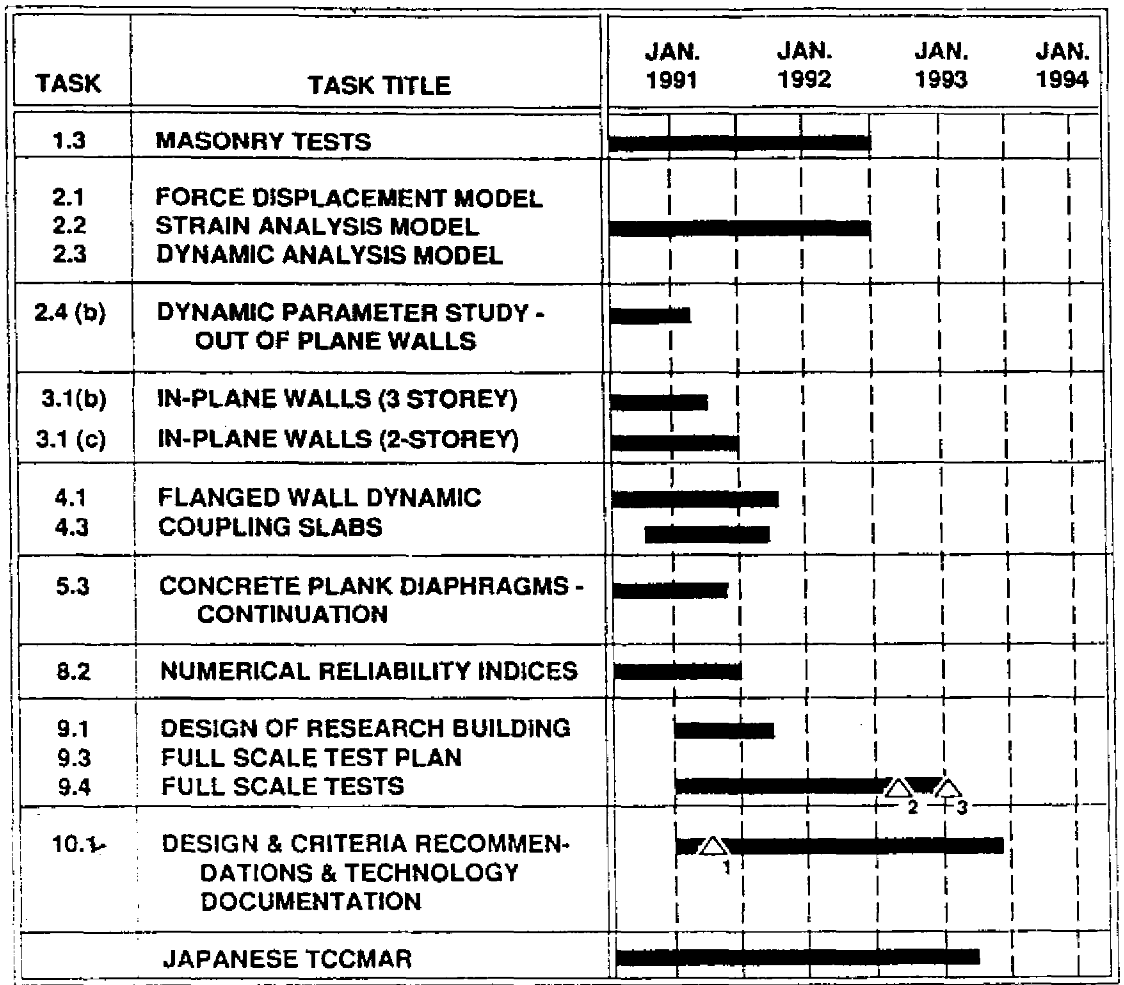


Figure 2 Task Interaction within U.S. TCCMAR Program

PROPOSED SCHEDULE TO COMPLETION
U.S. COORDINATED PROGRAM FOR MASONRY BUILDING RESEARCH



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NOTES

△ 1 DRAFT RECOMMENDATIONS
△ 2 TESTS COMPLETE
△ 3 REPORTS COMPLETE

Figure 3 Proposed Schedule for U.S. TCCMAR Program

5.0 PROJECT REPORTS

Many task reports have already been published by TCCMAR/U.S. They are listed below:

1.1-1: Atkinson and Kingsley, Comparison of the Behavior of Clay & Concrete Masonry in Compression, September 1985.

1.2(a)-1: Hamid, A.A., Assis, G.F., Harris, H.G., Material Models for Grouted Block Masonry, August 1988.

1.2(a)-2: Assis, G.F., Hamid, A.A., Harris, H.G., Material Models for Grouted Block Masonry, August 1989.

1.2(b)-1: Young, J.M., Brown, R.H., Compressive Stress Distribution of Grouted Hollow Clay Masonry Under Strain Gradient, May 1988.

2.1-1: Hart, G. and Basharkhah, M., Slender Wall Structural Engineering Analysis Computer Program (Shwall, Version 1.01), September 1987

2.1-2: Hart, G. and Basharkhah, M., Shear Wall Structural Engineering Analysis Computer Program (Shwall, Version 1.01). September 1987.

2.1-3: Nakaki, D. & Hart, G., Uplifting Response of Structures Subjected to Earthquake Motions, August 1987.

2.1-4: Hart, G., Sajjad, N., and Basharkhah, Inelastic Column Analysis Computer Program (INCAP, Version 1.01) March 1988.

2.1-5: Hong, W.K., Hart, G.C., Englekirk, R.E., Force-Deflection Evaluation and Models for University of Colorado Flexural Walls, December 1989.

2.1-6: Hart, G.C., Jaw, J.W., Low, Y.K., SCM Model for University of Colorado Flexural Walls, December 1989.

2.1-7: Hart, G , Sajid, N , Basharkhah, M , Inelastic Masonry Flexural Shear Wall Analysis Computer Program, February, 1990.

2.2-1: Ewing, R., El-Mustapha, A., Kariotis, J., FEM/I - A Finite Element Computer Program for the Nonlinear Static Analysis of Reinforced Masonry Building Components, December 1987 (Revised June 1990).

2.3-1: Ewing, R.; Kariotis, J.; El-Mustapha, A., LPM/I, A Computer Program for the Nonlinear, Dynamic Analysis of Lumped Parameter Models, August, 1987.

2.3-2: Kariotis, J., El-Mustapha, A., Ewing, R., Influence of Foundation Model on the Uplifting of Structures, July 1988.

2.3-3: Kariotis, J., Rahman, M., El-Mustapha, A., Investigation of Current Seismic Design Provisions for Reinforced Masonry Shear Walls, January 1990.

3.1(a)-1: Scrivener, J., Summary of Findings of Cyclic Tests on Masonry Piers, June 1986.

3.1(b)-1: Seible, F. and LaRovere, H., Summary of Pseudo Dynamic Testing, February 1987.

3.1(c)-1: Merryman, K., Leiva, G., Antrobus, N., Klingner, R., In-Plane Seismic Resistance of Two-Story Concrete Masonry Coupled Shear Walls, September 1989.

3.2(a): Hamid, A., Abboud, B., Farah, M., Hatem, K., Harris, H., Response of Reinforced Block Masonry Walls to Out-of-Plane Static Loads, September 1989.

3.2(b)-1: Agbabian, M., Adham, S., Masri, S., Avanessian, V., Traina, Out-of-Plane Dynamic Testing of Concrete Masonry Walls, Volumes 1 & 2, July 1989.

4.1-1: Limin, H., Priestley, N., Seismic Behavior of Flanged Masonry Shear Walls, May 1988.

4.2-1: Hegemier, G., Murakami, H., On the Behavior of Floor-to-Wall Intersections in Concrete Masonry Construction: Part I: Experimental.

4.2-2: Hegemier, G., Murakami, H., On the Behavior of Floor-to-Wall Intersections in Concrete Masonry Construction: Theoretical.

5.1-1: Porter, M., Sabri, A., Plank Diaphragm Characteristics, July 1990.

5.2-1: Porter, M., Yeomans, F., Johns, A., Assembly of Existing Diaphragm Data, July 1990.

6.2-1: Scrivener, J., Bond of Reinforcement in Grouted Hollow-Unit Masonry: A State-of-the-Art, June 1986.

6.2-2: Soric, Z. and Tulin, L., Bond Splices in Reinforced Masonry, August 1987.

7.1-1: Paulson, T., Abrams, D., Measured Inelastic Response of Reinforced Masonry Building Structures to Earthquake Motions, October 1990.

8.1-1: Hart, G., A Limit State Design Method for Reinforced Masonry, June 1988.

9.1-1: Kariotis, J.C., Johnson, A.W., Design of Reinforced Masonry Research Building, September, 1987.

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

9.2-2: Seible, F., Design and Construction of the Charles Lee Powell Structural Systems Laboratory, November 1986.

9.2-3: Seible, F., The Japanese Five-Story Full Scale Reinforced Masonry Building Test, January 1988.

11.1-1: TCCMAR, Summary Report: U.S. Coordinated Program for Masonry Building Research, September 1985 to August 1986.

6.0 INDUSTRY SUPPORT

Support of the masonry and masonry-related industry increased during the last year and was most welcome. Contributions have been in the form of materials, labor, and funds. Contributions include the Concrete Masonry Association of California and Nevada, Western States Clay Products Association, Masonry Institute of America, National Concrete Masonry Association, Delaware Valley Masonry Institute, Brick Institute of America - Region 12, and Prestressed Concrete Operations and the Council for Masonry Research.

7.0 ACKNOWLEDGEMENTS

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