DEVELOPMENT OF THE 7S-3000 STRESSED SKIN PANEL BUILDING SYSTEM (DETAILED REPORT)

by

Seven S Structures Inc.[1]

May, 1988

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[1]Grande Prairie, Alberta

DISCLAIMER

The study on which this report is based was funded in part under the Canada/Alberta Forest Resource Development Agreement.

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FOREWORD

This study was made possible with funding provided under the Innovative Housing Grants Program (IHGP) of Alberta Municipal Affairs and through the Canada/Alberta Forest Resource Development Agreement Subprogram B4 (FRDA).
The Innovative Housing Grants Program is intended to encourage and assist housing research and development which will reduce housing costs, improve the quality and performance of dwelling units and subdivisions, or increase the long term viability and competitiveness of Alberta's housing industry. At this time, priority areas for investigation include building design, construction technology, energy conservation, site and subdivision design, site servicing technology, residential building product development or improvement and information technology.
The Forest Resource Development Agreement program is intended:

1) to ensure the security of timber supplies and industry viability over the long term;
2) to promote the efficient utilization of forest resources and especially hardwood resources; and
3) to increase economic diversity and employment opportunities in the forest section.

The aim of this subprogram (B4) research funding is to provide a higher level of utilization of Alberta's aspen forests through improved methods and techniques of aspen management as well as product and market development.

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EXECUTIVE SUMMARY

This report outlines a test program undertaken to qualify 7S-3000 Stressed Skin Panel System to Canada Mortgage and Housing Corporation (CMHC) and Alberta Building Standards (ABC) requirements.

The report also gives some of the background of the development of the 7S-3000 stressed skin panels for structural components including walls, floors, and roofs, and discusses the potential uses for the panels. Structural, thermal and various other tests have demonstrated that 7S-3000 stressed skin panels may be used in residential and light commercial construction. Applications for product approval have been made to CMHC, the International Conference of Building Officials (ICBO) in the US, and various other agencies. It appears that formal approvals allowing general use of the 7S-3000 panels will be forthcoming. Various prototype structures including three residences, three farm buildings, and one light commercial project have been completed to date. Invaluable experience has been gained with these prototypes regarding improved fabrication and field erection procedures. A pilot plant located in Grande Prairie is the only production facility in place to date, and is capable of producing 90 m (300 lin. ft.) of wall panels per shift. This plant's production procedures and quality control program are being audited by Warnock Hersey Professional Services Ltd.

Seven S Structures Inc. is establishing a business and marketing plan to place manufacturing facilities in various locations, and to gain wide market acceptability for the 7S-3000 building system.

1.0 INTRODUCTION

1.1 Project Overview

This report describes the development of the 7S-3000 Stressed Skin Panel System, the certification requirements for this building product, the test program with test results, the panel production methods, and preliminary marketing and product distribution.

Grant funding from Alberta Municipal Affairs - Innovative Housing Grants Program and Canada/Alberta Forest Resource Development Agreement (Alberta Forestry, Lands and Wildlife) were made available to Seven S Structures Inc. so that certification testing which would lead to regulatory approval of the building system could be performed. The scope of the project covered by the funding is confined to: the identification of the tests required for approval by Canada Mortgage and Housing Corporation (CMHC) and Alberta Building Standards; the performance of these tests at a certified laboratory; and the submission to CMHC for evaluation.

The report contains information on the system and the company, which is not specifically within the scope of the project but which is provided to give the reader a better understanding of the 7S System.

1.2 Company Background

The company was incorporated on November 26, 1984 under the name of CANUS Industries Ltd. Due to a challenge by the Alberta Companies Branch, it was decided to eliminate any future problems by changing the name to Seven S Structures Inc. The Seven S name was derived from the following statement:

"a Stressed Skin Structure that is
Safe, Simple and of Superior Strength."

The company was incorporated to research and subsequently develop a modular factory manufactured system of stressed skin panels which incorporates a foamed in-place insulating core between oriented strand board skins.

This type of construction deviates significantly from the standard wood frame construction presently in use. A stressed skin panel uses less framing material and produces less conductance of heat or cold transfer through the wall/roof. The stressed skin panel concept

that was developed seemed to have potential and the company decided to test the idea further. Some panels constructed in-house indicated that the development of a stressed skin panel building system using the proposed design seemed practical and realistic.

In 1986, a Pilot Plant was established in Grande Prairie, Alberta, to produce panels for testing and for some prototype projects including residential, commercial and farm buildings. A company head office and pilot plant were subsequently built in Grande Prairie. A subsidiary business office has been set up in Edmonton.

Financing to date has been provided by various sources, including the founding shareholders, provincial government grant program and investors in a private placement share offering.

The company has identified its human and financial resource requirements and has developed a marketing strategy to enter the commercial phase of its operation.

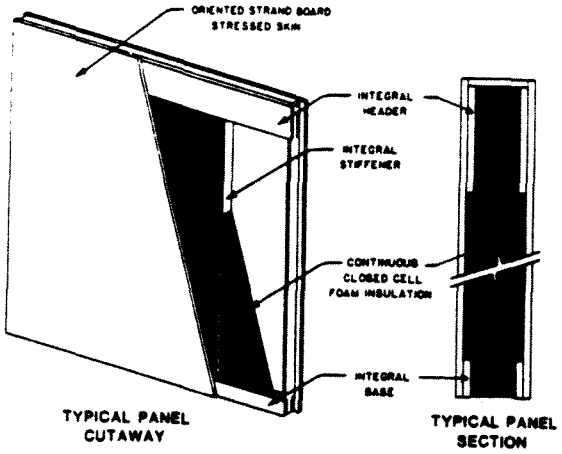
1.3 7S-3000 Building System

The 7S-3000 building system provides a fast, precise method of building energy-efficient houses and small commercial and farm buildings. The basic system is a stressed skin load-bearing panel having a continuous header, base, and top and bottom plates. The panel is very stiff and can be used vertically, horizontally, or on a slope (for roof applications). Panels are filled with polyurethane foam to provide an RSI 4.9 (R-28) insulation value using a 100 mm (4") thick panel. The continuous header permits the installation of windows and doors in almost any location without having to install additional headers. Figure 1 on the following page illustrates the basic panel components. (See also Appendix A, Panel Components.)

The 7S-3000 building system offers the following advantages:

1) ease and speed of installation;
2) precise sizing with no shrinking, warping or twisting;
3) high insulation value per inch of panel thickness;
4) easily sealed joints, minimizing air infiltration;
5) greater strength than conventional framed walls;
6) ease of transportation; and
7) sturdiness during moving and handling.

FIGURE 1:
BASIC PANEL COMPONENTS - 7S-3000 BUILDING SYSTEM



Panels can be manufactured in various sizes up to 7.32 m x 2.44 m (24'x8') in size offering versatility of use. Moreover, their manufacture and assembly require little training.

The 7S-3000 building system incorporates common products which have been successfully utilized for many years in similar applications. Currently, oriented strand board (OSB) is used for skins, spacers, reinforcing headers and baseplates. OSB is available locally and is manufactured from plentiful Alberta aspen. OSB is strong and stiff due to the oriented fibers and it can be produced at lower costs than conventional plywood. The polyurethane foam insulation is manufactured from derivatives of natural gas. It has excellent insulating qualities and provides additional strength to the panel.

1.4 Other Similar Systems

One of the first undertakings made on completion of the preliminary 7S-3000 panel design was a thorough investigation of the "state of the art" of insulated building panels. Information was obtained from numerous panel manufacturers in Europe, Canada and the US. Panel systems were investigated and studied:

- Nielsen Winter Insulated Panel systems of Mass, USA
- Nascor System by Cano Structures Ltd. of Calgary, Alberta
- Lenap Panel System by I.C.P. Inc. of Mass USA
- Chase Panel System of Wisconsin, USA
- Tups Panel System by Homasote Inc. of New Jersey, USA

- J-Deck Panels by J-Deck Inc. of Ohio, USA
- Foam Laminates of Vermont, USA
- Makro Building System of Helsinki, Finland
- Nailboard by N.R.G. Barriers Inc. of Maine, USA
- Futurebilt Panel Building System of Texas, USA
- Enercept Building System of Minnesota, USA
- Thermapan Roof/Wall System of Fonthill, Ontario
- Foam Home Building System of Texas, USA

As well as a thorough review of the above product lines, Seven S Structures Inc. also proceeded with a patent application for its panel system. As a result of this application, it became necessary to review all other existing patents for similar applications, and to compare these inventions with the 7S-3000 building system. In all cases reviewed to date, no similar building system was found to be identical to the 7S building system, although some of the 7S details have been used by other manufacturers. Compared to other competitive systems, the 7S-3000 building system appears to be unique and in our opinion superior to all other existing systems.

The system's integral header system and C-stud, and its method of assembly, were sufficiently distinctive to warrant patent status, which has been granted in the US. Patent applications have been made in Canada, Australia, and some European and Asian countries.

2.0 PRODUCT DEVELOPMENT

2.1 Stressed Skin Panel Concept

Stressed skin panels consists of webs (longitudinal framing members) covered on one or both sides with flanges (skins). The 7S-3000 panels consist of OSB webs and OSB skins, assembled in such a way that the skins are mechanically secured and glued to the webs to form an efficient structural unit. As a result of this form of construction, it is possible to reduce the size of the framing members in comparison to those of a similar unit in which the sheathing acts only as a surface covering. The resulting panel is specifically tailored to make the most efficient use of material. As the name implies, the loads and stresses are transmitted mainly through the skins, with the webs acting as spacers to separate the skins and to keep the skins parallel. The resultant structural component is similar to a box beam or plate girder. This stressed skin concept is used to produce the 7S-3000 wall, roof and floor panels.

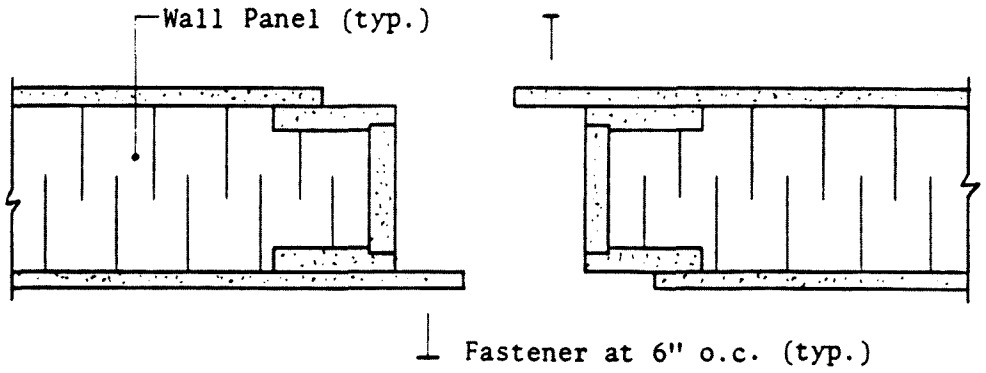
2.2 7S-3000 Wall System

The 7S-3000 wall system consists of 89 mm (3-1/2") wide OSB webs spaced at 610 mm (24") o/c. Both skins consisting of 9.5 mm (3/8") OSB, are glued to the web.

The panel core consists of a polyurethane foam insulation which is foamed in place after panel assembly is complete. Polyurethane foam is a thermoset cellular plastic consisting of a solid mass of unconnected small closed cells with densities ranging from 15-40 kg/cubic metre (1-2 lbs./cubic ft.). The 7S-3000 panel foam core has a density of approximately 30 kg/cubic metre (1.8 lbs./cubic ft.). In this density range, rigid urethane foam is an excellent thermal insulator; in fact, urethane foams are the most efficient insulating materials available today, with an insulation value of approximately RSI 4.9 per 100 mm of thickness (R7 per inch of thickness). The combination of small, unconnected, closed cells, and light weight enables rigid urethane foam to out-perform all other insulating materials. Other advantageous physical properties of urethane foam are its high strength-to-weight ratio, durability, lack of odour and dimensional stability. However, the foam has its limitations since during combustion it emits high levels of toxic smoke; and it deteriorates when exposed to temperatures greater than 80°C.

The wall panels are joined to each other using a spline or a lap joint as shown in Figure 2 below. (See also Appendix B, Sheet Panel Joint Detail). This lap is mechanically secured in the field to produce a continuous wall.

FIGURE 2:
LAP JOINT, 7S-3000 WALL SYSTEM



Vertical roof or floor point loads are transmitted to the wall by applying a field-installed top plate which transfers point loads into distributed loads. The application of this field-installed top plate is a requirement whenever roof trusses, roof joists or floor joists are applied to the top of the wall.

The wall panel is equipped with a continuous top header which allows the installation of windows and doors simply by cutting out the rough openings as required. Span limitations for opening widths must be adhered to as determined by the standard test results.

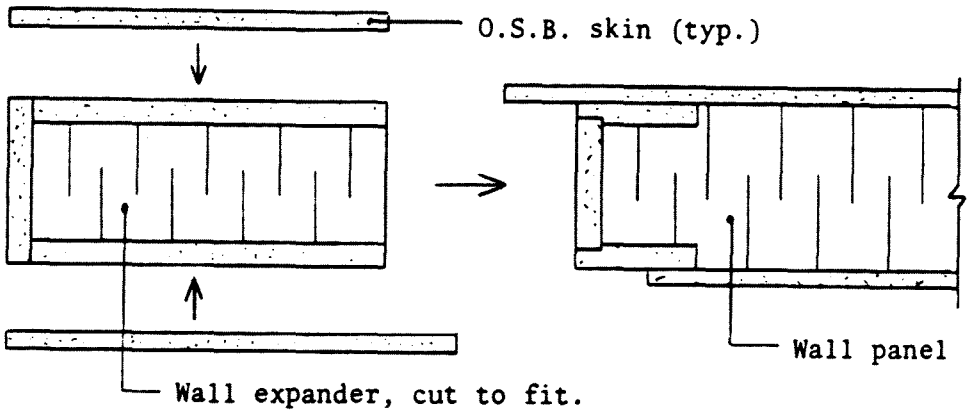
The panel sizes expected to be manufactured are as follows:

2440 mm high x 1220 mm wide (8'x4')
2440 mm high x 2440 mm wide (8'x8')
2440 mm high x 3660 mm wide (8'x12')
2440 mm high x 4880 mm wide (8'x16')
2440 mm high x 6096 mm wide (8'x20')
2440 mm high x 7315 mm wide (8'x24')

Any wall length can be produced by field cutting special 1220 mm (4') wide wall expanders. The installed wall

expander is similar to the wall panel except that it has a double skin. The outer skin is field installed. A wall expander may be considered as a wide spline which requires an additional skin on each side to match the regular wall panel width. The wall expander is illustrated in Figure 3.

FIGURE 3
WALL EXPANDER, 7S-3000 WALL SYSTEM



2.3 7S-3000 Roof System

The 7S-3000 roof system panels are similar to the wall panels but consist of 140 mm (5-1/2") wide OSB webs spaced at 610 mm (24") o/c with a 9.5 mm (3/8") OSB skin on either side glued to the spacers to produce a panel with an overall thickness of 159 mm (6-1/4"). The panel sizes will vary according to the roof span or the spacing of the supporting frames which support the panels. The design snow load will also affect the limitation of the total span.

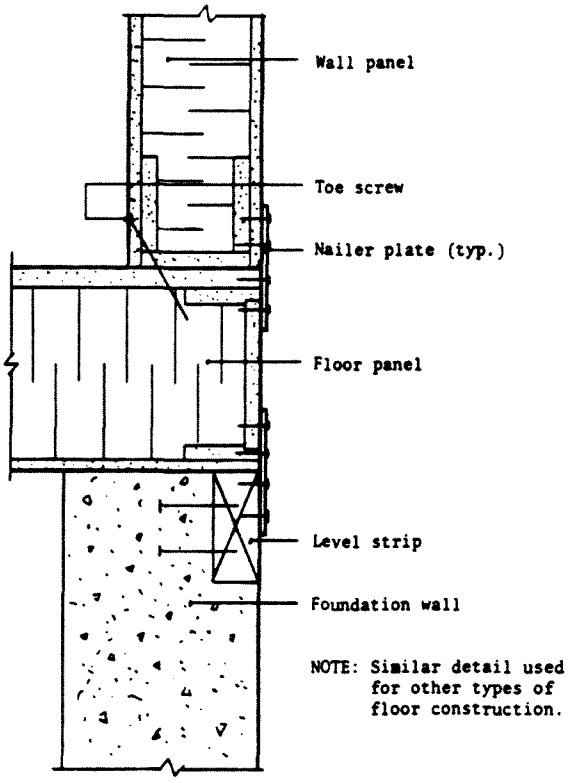
Like the wall panels, the roof panels have a framed-in-place polyurethane foam insulation core, which is foamed in place after panel assembly is complete, and they are also connected together with splines or lap joints. The R-value produced is approximately RSI 7.0 (R-40), depending on the foam type and density being used. 7S-3000 roof panels result in sloped interior ceilings. A finish can be applied directly to the inner side of the panels and exterior roofing can be applied directly to the outside. Since the panel is in fact the roof structure, attic spaces are eliminated. Vented overhangs are no longer necessary and condensation problems should be eliminated.

2.4 7S-3000 Floor System

The 7S-3000 floor system consists of 140 mm (5-1/2") wide OSB webs spaced at 400 mm (16") o/c with a 15.5 mm (5/8") OSB top skin and a 9.5 mm (3/8") OSB bottom skin. At the option of the Client, these panels may be urethane filled or may remain empty. These floor panels are also joined together with a lap splice or a spline connector, in the direction parallel to the web, and they are butted together over the support members in the direction perpendicular to the webs. These panels are standardized in 1220 mm (4') wide or 2440 mm (8') wide sections, with spans ranging from 1.2 m to 4.3 m (4' to 14'), depending on the loads for which they are designed.

The floor panels are supported on the perimeter foundation walls and intermediate wood or steel beams similar to a conventional joist floor system. They are secured to these members with screws or long shank nails, as specified in the construction detail drawing, Figure 4 below.

FIGURE 4:
SECURING OF FLOOR PANELS, 7S-3000 FLOOR SYSTEM



It is recommended that a final plywood or composite board overlay be installed before a finished flooring is applied to the panels.

2.5 Engineering Design Criteria

Span ratings for the 7S-3000 wall panels are indicated in Table 1 below and in Appendix C, Span Ratings.

TABLE 1:
SPAN RATINGS, 7S-3000 WALL SYSTEM

WALL PANELS Load 1.92 kPa (40 psf)

Wall Thickness	Deflection[1]	Max. Wall Height
108 (4-1/4")	L/180	4270 (14')
108 (4-1/4")	L/240	3890 (12'-9")
108 (4-1/4")	L/240	3380 (11'-1")
159 (6-1/4")	L/360	4490 (14'-9")

Span ratings for the 7S-3000 roof panels are as shown in Table 2 below and in Appendix C, Span Ratings.

TABLE 2:
SPAN RATINGS, 7S-3000 ROOF SYSTEM

ROOF PANELS WVE Load 1.92 kPa (40 psf)

For deflection[1] limitation of:

i)	Span/360, allowable maximum span	3200	(10'-6")
ii)	Span/240, allowable maximum span	3500	(11'-6")
iii)	Span/180, allowable maximum span	3500	(11'-6")

1. Deflection in this case refers to the maximum allowable deflection under the design live load (as opposed to the permanent weight of the structure). The desired allowable deflection depends on the buildings use.

The load and span capacities of the floor panels are limited to those indicated on the span table shown in Table 3 below and Appendix C, Span Ratings.

TABLE 3:
LOAD AND SPAN CAPACITIES, 7S-3000 FLOOR PANELS

FLOOR PANELS Load 1.92 kPa (40 psf) LIVING AREAS

For deflection limitation of:

i) Span/360[1], allowable maximum span 3890 mm (12'-9")
ii) Span/240, allowable maximum span 4040 mm (13'-3")

Load 1.44 kPa (30 psf) BEDROOM AREAS

i) Span/360, allowable maximum span 4160 mm (13'-8")
ii) Span/240, allowable maximum span 4390 mm (14'-5")

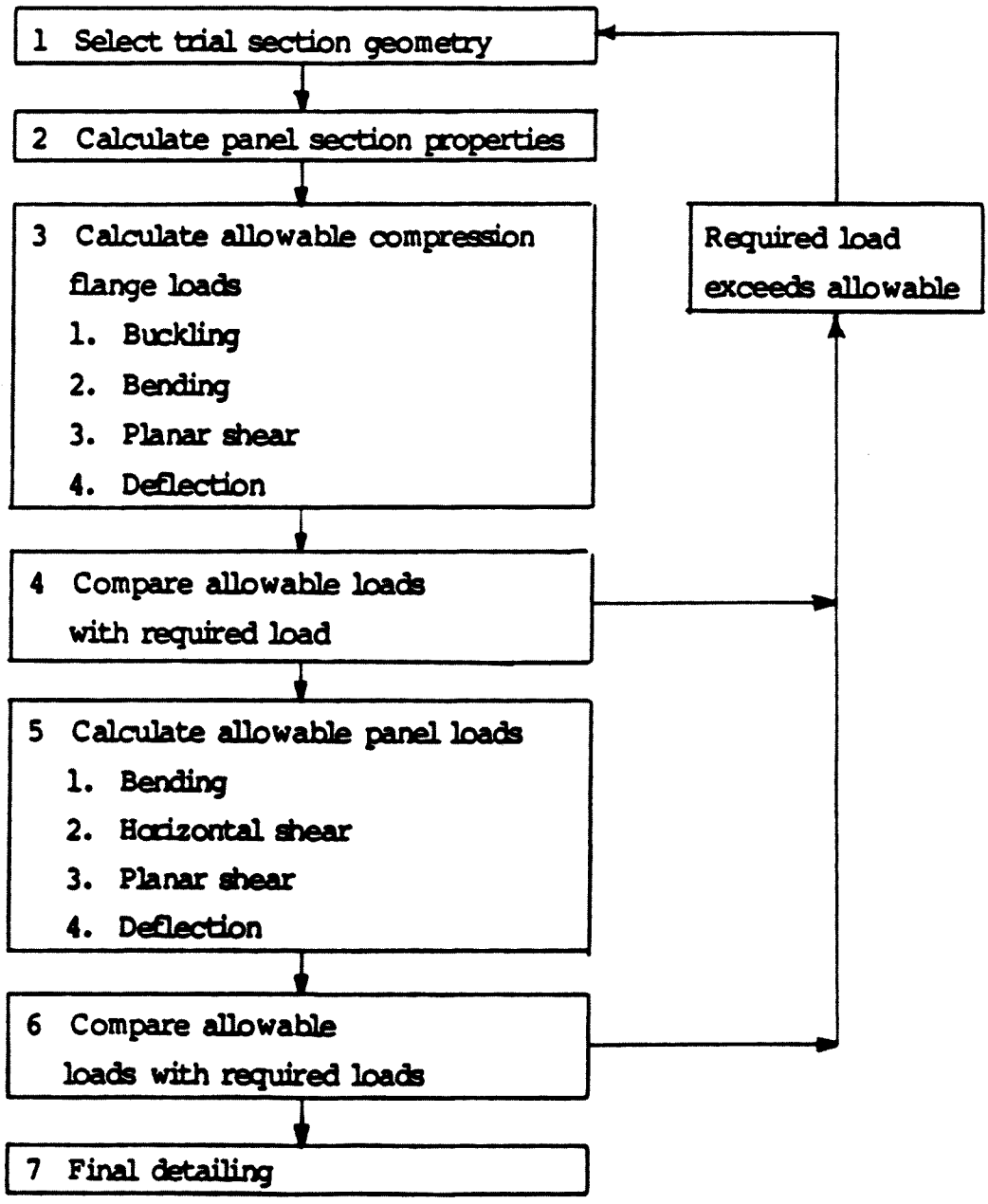
A general design method[2] for stressed skin panels is summarized in the sequence chart shown in Figure 5 on the following page. Depending on the designer's experience, steps may be combined or rearranged in sequence, but all basic operations must be carried out in the design process.

1. Span/360 refers to the allowable amount of deflection when the maximum live load is applied.

2. This design method is based upon "Design of Plywood Stressed Skin Panels", published by the Council of Forest Industries (COFI) of British Columbia, 1984.

FIGURE 5:

GENERAL DESIGN SEQUENCE, 7S-3000 STRESSED SKIN PANELS



In general, the flanges of a stressed skin panel are not uniformly stressed. The stress distribution is related to the span of the panel and the clear spacing between the webs. To account for this, correction factors are applied in the calculations on allowable loads. Section property calculations are based on the whole panel cross-section.

The final selection of the correct panel geometry and configuration is based on trial and error. When the panel section has been selected, the allowable properties for the webs and flanges must be determined in order to determine the ultimate loads, spans and deflections.

Calculation of Allowable Loads

The load-carrying capacity of the panel itself can be calculated using the applicable formula for the following conditions:

a) load-carrying capacity of the compression flange
   - buckling
   - transverse bending
   - planar shear
   - deflection

b) load-carrying capacity of panel
   - compression/tension in skins
   - bending in stiffeners
   - horizontal shear of panel
   - planar shear of panel
   - deflection of panel

Note that the values calculated for the panel sections are maximum total loads, that is, panel weight plus dead load plus live load. The applicable dead loads must be deducted from the total calculated load, to obtain the maximum safe live load the panel can carry.

These formulas do not include a safety factor. It is recommended that a safety factor of not less than 2 be applied. In this case, safety factor is defined as the ratio of panel strength to the expected maximum load. A safety factor of 3 has been applied to the 7S-3000 panels. Load capacities and span limitations were calculated and confirmed with test results for deflections of 1/360, 1/240 and 1/180 respectively.

Upon completion of all these calculations, the lowest calculated load was found to be the load governed by

deflection. According to the provisions of the National Building Code of Canada, this lowest calculated load can be used as the maximum live load for the panel.

2.6 System Features

In addition to the advantages listed in section 1.3, the 7S-3000 building system has some notable additional features.

STRENGTH

Structural tests completed to date indicate that the panel has superior strength. It is stiff and has good racking resistance compared to a standard wood-frame wall with sheathing on one side only. Because of stiffness, its deflections are limited and the panel may be used for walls under significant wind load conditions and as floors and roofs under significant transverse loadings, such as heavy snow loads.

PORTABILITY

Since all of the connection details specify that all joints are field screwed, it is possible to erect the structural shell, and then disassemble and re-erect the entire package without damage to the structure. It can be a reuseable and relocateable structure.

MOISTURE PERMEANCE

Permeance tests for the panel skin and core are within specified limits; consequently, no vapour barrier application is required on the interior perimeter walls.

FLEXIBILITY

All of the 7S-3000 wall panels include a continuous top header around the entire periphery of the exterior load-bearing walls. As a result, it is possible to cut openings for windows and doors at any desired location. Additional windows may be added simply by cutting a opening of appropriate size and installing the desired window. No additional framing is required around the opening, provided it does not exceed 1.8 m (6 ft.) in width.

3.0 CERTIFICATION REQUIREMENTS

3.1 Certification Procedures

In order that 7S-3000 System can be used for residential and small commercial construction without a complete engineering analysis performed for each structure, approval of certain building agencies must be obtained. Applicable approvals for the 7S-3000 System are the Central Mortgage and Housing Corporation (CMHC), the Building Standards Branch of Alberta Labour, the Canadian Standards Association (CSA), and in the U.S.A., the International Conference of Building Officials (ICBO) and affiliated organizations. Each organization has its own set of standards that must be met. From this information, a flow chart was established to outline the certification procedure to be followed:

1) Combine the certification procedures for all of the agencies and establish a master list of information required.
2) Identify all of the required tests, including
    a) structural tests,
    b) fire ratings and thermal barrier tests,
    c) permeability water vapour transmission test, and
    d) other tests.
3) Obtain certification data for each of the main components of the panel ie. (OSB, foam and glue).
4) Identify testing agencies qualified to perform the necessary tests.
5) Perform tests and obtain test data.
6) Prepare a quality control manual and designate a quality control agency to audit plant facilities.
7) Submit completed applications for certification to each of the agencies.
8) Following review of submitted application by each of the agencies, provide any additional information as requested.
9) Construct the necessary prototype projects required to satisfy the agencies.
10) Allow a period of four to six months for the certification agencies to review and respond to the application, and to prepare a product evaluation report.
11) Use the product evaluation report(s) according to the conditions and limitations set out in them.

Since ICBO and CMHC approvals may give easier access to three of the other agencies, they were sought first.

3.2 CMHC Requirements

CMHC requires that panel components be designed with the framing according to the requirements of the residential standards or part 9 of the National Building Code (NBC). Alternatively, CMHC will evaluate a new and innovative product on the basis of tests performed at a CMHC approved laboratory and associated engineering data. See Appendix F, CMHC Building Evaluation Report Technical Requirements.

Testing of the panels must be done, if applicable, in accordance with the test standard ASTM E72 "Standard Methods of Conducting Strength Test of Panels for Building Construction". Tests on the 7S-3000 panel system was performed at the Coquitlam, B.C. laboratory of Warnock Hersey Professional Services Ltd. This facility has CMHC approval.

Materials used in the construction of the panels must also meet standards. Foam must meet 51GP - 21M "Urethane Unfacted Test" and a surface burning test, as per CSA CAN4-S102-M80. The glue used must be certified as an exterior type of glue. The OSB has already been evaluated by CMHC.

CMHC's list of acceptance requirements included:

DOCUMENT NO.	TITLE	APPLICATION
06111 CMHC	Light Wooden structures framing	-Lumber quality -Lumber grade -Panel assembly
ME8307 CMHC	Diaphrams	-All aspects of design
06114 CMHC	Stress-skin panels (plywood)	-Reference standards
06110 CMHC	Framing and sheathing	-Testing plywood -Thickness -Nails
ME8305 CMHC	Sheathing membrane	-All aspects of vapour barrier

DOCUMENT NO.	TITLE	APPLICATION
07150 CMHC	- breather type	
07212 CMHC	Rigid board insulation	-Plastic rigid insulation quality
ME8309 CMHC	Floor framing Test procedures	-Floor and roof structural test required

CMHC requires that the panel components be designed with the framing according to the requirements of the Residential Standards or Part 9 of the National Building Code (NBC). (See Appendix F, CMHC Building Evaluation Report Technical Requirements.) Alternatively, the system can be engineered according to Part 4 of the NBC. In either case, the system would be limited to use in buildings of fewer than three storeys in height and 600 sq.m in area.

The strength of stress skin panels is to be based on structural stress limitations in CSA CAN3-086 "Engineering Design in Wood", and requires confirmatory structural strength tests according to load test requirements as defined in ASTM ME8309.

CMHC also requires that ten successful prototype structures be erected before approval is granted. To date, thirteen prototypes have been completed.

3.3 ICBO Requirements

ICBO together with its sister agencies CABO, BOCA and BCMC are the approval agencies for certification of building products in the US. The ICBO is responsible for the western US region.

The ICBO and affiliated organizations will accept a panel construction type based on either load tests or a rational analysis. Testing must be done by an approved testing agency. Required tests include structural tests in accordance with ASTM E72-80, density and water absorption tests as per ASTM C272. If the analysis route is chosen, supplemental panel tests may be necessary in order to verify design assumptions. In addition to the above, a quality control manual must be developed. (See Appendix G for the ICBO "Acceptance criteria for Sandwich Panels" and "Quality Control Manual Requirements".)

Under the direction of Warnock Hersey Professional Services Ltd., which is a recognized quality control agency and accredited testing laboratory in the US, Seven S Structures Inc. proceeded with an acceptance application for its 7S-3000 panel system.

In order to submit an application, ICBO requirements and acceptance criteria had to be satisfied, in accordance with the following documents:

- ICBO Research Committee
  Acceptance Criteria for Sandwich Panels,
  April 1977
  (See Appendix G.)

- ICBO Evaluation Service Inc.
  Quality Control Manual Requirements,
  April 1986
  (See Appendix G.)

Upon completion of this evaluation, an approved ICBO evaluation number will be issued and the product listed as an approved product in the ICBO Building Standards Evaluation Report Listing in its appropriate category. This will allow use of the product within the geographic area under the jurisdiction of the ICBO. A further submission can then be made to the National Evaluation Service Committee of the Council of American Building Officials. Approval from this agency will grant the 7S-3000 product a National Evaluation Reports (NER) listing. The NER listing provides the product with national approval across the US. Seven S will proceed to obtain an NER listing for the 7S-3000 Building System.

3.4 CSA Requirements

CSA is a non-profit private-sector organization, where standards are widely used by industry and commerce, and are often adopted into regulations by governmental authorities, particularly in the areas of safety, health and the environment. Seven S Structures Inc. contacted CSA to obtain the necessary acceptance requirements for its 7S-3000 Building System.

CSA does not approve building systems. It does perform evaluations of building products which are used in mobile homes. Acceptance of a building system by CMHC or Alberta Building Standards will normally render it acceptable for use in mobile homes.

CSA has advised that CMHC and Alberta Building Standards acceptance be obtained first, and that the system comply with the applicable sections of the NBCC. Once these acceptances are in place, CSA will perform its own evaluation, which will be minimal. Approval of the system will likely be granted subject to any condition unique to its application in mobile homes.

3.5 Alberta Building Standards Requirements

Seven S Structures Inc. contacted Alberta Labour, General Safety Services Division, Building Standards Branch, regarding its requirements for provincial approval, while Building Standards Branch requirements are essentially the same as those for CMHC, the Branch also requires adherence to the Alberta Building Code (ABC).

Initially, three major concerns were expressed by Alberta Building Standards:

1) The 7S-3000 building system appeared to require a fire barrier such as 12.7 mm gypsum board to protect the foamed plastic insulation, on the inside of the building.
2) They felt that all structural tests should be performed on panels without the foamed insulation.
3) Construction details, nailing schedules, connectors and caulking requirements have to be in accordance with the Alberta Building Code and related Standata.

Representatives of Alberta Building Standards attended a meeting to establish approval requirements and approval procedures for the 7S-3000 building system. This meeting established a complete list of structural tests in accordance with ASTM E72-80 which would satisfy all of the approval agencies. (See Appendix H, Quality Control Manual.)

3.6 Production Environment

To obtain CMHC and ICBO approvals, 7S-3000 panels must be produced in an exacting and certified manner. Such a process involves three elements: a quality control manual, a quality control supervisor and plant certification. The quality control manual identifies criteria product parameters and specifies special

testing and control systems. (See Appendix H, Quality Control Manual.)

Quality control of the product is maintained through an employer designated quality control supervisor. At Seven S Structures Inc. this position is held by the production manager, while the chief engineer oversees the development of quality control systems.

The firm of Warnock Hersey Professional Services Ltd. is retained by Seven S Structures Inc. to provide third-party quality assurance inspection and testing, in accordance with CMHC and ICBO requirements. This firm will make four random and unannounced inspection visits per year to the plant to ensure that the product is being manufactured in accordance with policies set forth in the quality control manual. During these visits, the firm will inspect production procedures and equipment, and ensure that the manual is current.

3.7 Certified Testing Agencies

For a product to be considered for certification, the necessary product tests must be performed by a certified testing agency recognized by the certification authority having jurisdiction. It is advantageous to choose a testing agency which is recognized by all of those agencies in order to avoid costly duplication of tests.

Testing agencies recognized by most of the certification authorities are:

- Warnock Hersey Professional Services Ltd.
  Coquitlam, BC, Canada
- Factory Mutual Research Corporation
  Norwood, MA, USA
- Underwriters Laboratories of Canada
  Scarborough, Ontario, Canada
- National Research Council of Canada
  Ottawa, Ontario, Canada

Seven S Structures Inc. sought an agency which can also provide the ongoing plant quality control service required to maintain ongoing certification of a manufactured product. For Western Canada, Warnock Hersey Professional Services Ltd. from Coquitlam, BC provides all the necessary services, and is recognized by all the certification authorities. As a result, this firm was chosen to perform all of the required tests, to produce the quality control manual and to carry out the ongoing quality control audit at the Grande Prairie pilot plant.

3.8 Certification Costs and Funding

The total certification costs were estimated to be about $125,000. These costs were related to the following items:

a) in-house testing
b) design and engineering costs
c) test panel fabrication transportation costs
d) laboratory testing costs
e) quality control manual costs
f) application fees
g) submission preparation costs
h) quality control plant inspections

It is expected that ongoing certification costs, per plant, will be $10,000 per year.

Funding for certification costs was provided by Seven S Structures Inc., and grants were provided by Alberta Municipal Affairs and Alberta Forestry.

All of the Innovative Housing Grant Program funding was used to pay for fire and thermal laboratory tests, the associated test panel construction and transportation costs. The Canada Alberta Forest Resource Development Agreement grant was used for physical testing and the preparation of the quality control manual. Receipt of these funds was subject to completion of the tests and preparation of the quality control manual.

4.0 TESTING PROGRAM

After Warnock Hersey Professional Services Ltd. was retained by Seven S to perform the required tests, their manager of field inspections and physical testing made a site visit to the Grande Prairie pilot plant and prepared a list of required tests. A tentative testing schedule running from September through November 1986 was established. The following test panels were constructed by Seven S and forwarded to Warnock Hersey for testing:

First Series - August 1986

Wall Panels	108 (4-1/4")	- 1220 x 2440 (4'x8') no foam - 9 each - 1220 x 2440 (4'x8') with foam - 6 each - 2440 x 2440 (8'x8') with foam - 6 each
Roof Panels	159 (6-1/4")	- 1220 x 4880 (4'x16') no foam - 3 each - 1220 x 2440 (4'x8') no foam - 3 each
Floor Panels	159 (6-1/4")	- 1220 x 4880 (4'x16') no foam - 3 each - 1220 x 2440 (4'x8') no foam - 3 each
Fire Test Panels	108 (4-1/4")	- 508 x 2440 (20"x8') with foam - 12 each
	108 (4-1/4")	- 4270 x 2740 (14'x9') with foam - 2 each
Water vapour Permeance	108 (4-1/4")	- 457 x 457 (18"x18") with spline - 4 each - 457 x 457 (18"x18") no spline - 4 each
Foam Splines	108 (4-1/4")	- 2440 (8') long 15 each
Header Beams	108 (4-1/4")	- 914 (3') long no foam - 3 each - 1220 (4') long no foam - 3 each - 1524 (5') long no foam - 3 each - 1830 (6') long no foam - 3 each

Second Series - December 1986

Basement Panels	108 (4-1/4")	- 2440 x 2440 (8'x8') with foam - 3 each
	159 (6-1/4")	- 2440 x 2440 (8'x8') with foam - 3 each
	203 (8")	- 2440 x 2440 (8'x8') with foam - 3 each

Tests performed on the panels consisted of structural, flame spread and fire endurance tests, as discussed in the following sections.

4.1 Structural Tests

Structural tests performed on the three types of 7S-3000 panels - wall, floor and roof were:

Transverse load - wall, floor and roof panels
Axial load - wall panels
Racking - wall panels

A copy of the test report on the above tests are given in Appendix D which indicates that these tests were passed.

The structural tests confirmed the suitability of the 7S panels for use in residential structures.

The results of the transverse load tests were used to establish a preliminary set of span tables. Results from the axial load and racking tests indicated that the 7S wall panel is not only strong enough to carry commonly encountered loads, but is actually stronger than a 2x4 stud wall of convention construction.

4.2 Thermal Tests

Three types of thermal tests have been performed on the 7S-3000 panels:

Fire endurance - wall panel
Fire endurance - wall panel with plaster
Flame spread - wall panel

Copies of the test reports on the above tests are given in Appendix E. The panels without a fire protective layer (for example, gypsum wallboard) passed the National Building Code requirements but failed the Alberta Building Code requirements.

To summarize the findings of these reports, the flame spread classification ranges from 126 to 140, with a smoke developed value of 465. By itself, a load-bearing wall was found to have a rating of seven minutes. An additional fire barrier, such as gypsum wallboard, is required in Alberta in order to bring it up to the required standard for use in residential construction of ten minutes.

4.3 Other Tests

Water vapour permeance tests for wall panels and structural tests (See Appendix I) on basement panels have also been performed. Two types of samples were tested. The first was a 450 mm x 450 mm (18"x18") sample without any joints. These were tested for approximately three months and showed a water vapour transmission of 0. The second included a standard joint running the full width of the specimen. This was tested for approximately three months and showed a water vapour transmission of 0. These results indicate that a separate vapour barrier is not necessary with 7S-3000 wall panels.

4.4 Modification and Retests

Based on the preliminary series of tests, two changes to the panels were made to increase panel strength and to simplify field erection. One was the development of a lap joint, as opposed to the spline joint previously in use. This proved to be a simpler and more convenient method of joining panels. The C-stud was also changed. Previously, the stud web was glued and stapled to the plain pieces of OSB used as flanges. A dado is now cut in the flange pieces to fit the web resulting in a stronger joint. Retests were done and the findings were incorporated in the test results.

4.5 Summary of Test Results

Structural, thermal and water vapour permeance tests were performed on the 7S-3000 panels. Detailed test results may be found in Appendices D and E.

STRUCTURAL TESTS

Structurally, the 7S-3000 panels can be used for housing and small buildings as governed by Part 9 of the

National Building Code. They may be used as walls, roofs and floors, subject to the span limitations established by the test results. The maximum transverse load allowed on a wall panel with a maximum allowable deflection is 28 kN/m (1900 lbs./lin. ft.). A 2.4 m (8 ft.) high wall panel is capable of withstanding a maximum wind load of 3.0 kPa (64 lbs./sq. ft.) for a deflection of 1/180. Maximum roof spans and floor spans for a live load of 1.92 kPa (40 lbs./sq. ft.) is 4.3 m (14 ft.).

Thermal tests indicate that the burn-through period for an unprotected load bearing wall panel is nine minutes. Flame spread characteristics of the panel are:

flame spread classification	- 126 to 140
smoke developed	- 465
fuel contributed	- 100

As a result, the foamed panel must be protected with a thermal/fire barrier equivalent to 12.7 mm (1/2") dry-wall on the inside of the building.

Water vapour permeance tests on all samples, including those with joints, were 0; this indicates that the panel does not require a vapour barrier application on the warm side of the panel.

5.0 PANEL PRODUCTION

The manufacture of a 7S-3000 panel can be divided into two parts: component cutting and manufacturing operation, and component assembly. Depending upon the intended application, a panel may be filled with polyurethane foam insulation.

The Grande Prairie plant currently combines both operations, although it is possible to have them in separate plants. This is expected to be the case in the future.

5.1 Manufacturing Methods

Raw materials consist mainly of sheets of oriented strand board (OSB), glue and foam chemicals. In the shop, the OSB is cut to size for use as panel skins, headers, base plates and C-studs. Components of the panel are glued and stapled together. If the panel is to be foamed, it is placed in a hydraulic press where the panel cavities are filled and allowed to cure. After curing, the panels are inspected and either shipped or culled.

5.2 Facility and Equipment Requirements

The current plant has an area of approximately 670 sq. m 7,200 sq.ft.). Equipment is comprised of saws, assembly tables for C-studs and panels, a hydraulic press, foam gun, and equipment for transporting and handling raw materials and finished panels, including an overhead crane, rollers and conveyors, and a forklift.

If the component cutting and manufacturing operation is set up separately from the assembly operation, the component cutting plant should be set up in a central location, close to material suppliers. At this plant, the OSB would be cut to shape for panel skins and C-studs, and C-studs assembled. Thus, equipment for large-scale cutting and dadoing would not be necessary at the assembly plants.

A number of assembly plants could be served by one component plant. The assembly plants would receive precut panel skins, C-studs, glue and foam from the component plant. The panels would be assembled, foamed if necessary, and shipped to customers.

6.0 MARKETING AND PRODUCT DISTRIBUTION

The 7S-3000 Building System is an innovative system with great potential, but to sell the product, the market must be identified and the product introduced to the market.

6.1 Potential Market

Major advantages of the 7S-3000 building system are its high insulation value and modular construction. These advantages make it particularly attractive for residential and small commercial structures in areas where temperature extremes can occur (most of North America falling within this category).

At the time of writing, 7S-3000 building system is still in the process of finding its way into residential and commercial structures. Some single-family dwellings and a warehouse have been constructed. These buildings have shown the system to be convenient and practical.

Some other potential applications include small apartment blocks, motels, house packages, mobile homes and construction camp trailers. Sales to individuals through building supply companies is also a possibility, although the panel size may be difficult to handle for those who don't have the appropriate equipment.

Currently, efforts are being made to promote the product in Alberta. The main thrust is toward house builders within shipping distance of the Grande Prairie pilot plant.

Sales of the 7S-3000 building system are currently limited by the relatively remote location of the pilot plant, which makes shipping costs a major deterrent to sales. Separating plant functions into component manufacturing plants and assembly plants, and locating the latter in central areas close to supplies and markets would reduce shipping costs while increasing capacity. Initially, a component and assembly plant may be set up in the Edmonton area, with future expansion to the rest of Alberta and other provinces.

6.2 Export Potential

Sales of the 7S-3000 building system to areas outside Canada seem to have great potential. Climatic conditions in the United States, Japan and Europe would

seem to provide a rich market for the panels. The system is also attractive for housing in tropical climates as the high insulation value keeps heat out quite effectively.

Historically, the European and Japanese markets have been difficult to penetrate. Japanese builders have been reluctant to accept new foreign types of construction; while within the European Economic Community, a number of competing energy-efficient housing systems are already being manufactured. Shipping costs to both areas would be considerable until local plants could be set up. The American market may prove to be more attractive and will be considered upon receipt of ICBO approval. The current low value of the Canadian dollar makes our prices attractive, although protectionist elements in the US may attempt to hinder sales through taxes and tariffs.

6.3 Franchise Distribution Network

Seven S Structures Inc. plans to sell manufacturing franchises to individuals or companies wishing to produce and sell the 7S-3000 building system. The franchise will entitle them to build a Seven S assembly plant in their market area.

The manufacturer will purchase panel components through Seven S, as well as supply plant facilities. A royalty on sales will be paid to Seven S, and sales will normally be restricted to a specific market area.

For its part, Seven S will provide panel components, assist franchisees with basic plant design, perform all required testing and obtain required approvals from various agencies. Seven S will also provide all specialized equipment necessary for a panel assembly plant and provides for plant start-up.

Promotion of the system will be a joint effort, with Seven S providing sales literature and sales management, and local promotion being handled by the manufacturer.

6.4 Present Marketing Status

A strategic marketing plan is being developed by Seven S Structures Inc., with the help of a marketing specialist. This plan will determine which segments of

the market should be catered to, and the manner in which these market segments can be accessed.

Currently, Seven S is handling its own promotion and sales. Prototype structures have been constructed in Creston, BC, in Grande Prairie and in Edmonton.
A brochure has been prepared and distributed to home builders across the province in order to make the 7S-3000 building system known. A catalogue of speculative building plans is being drawn up; plans include warehouses, shops, houses, cottages and mobile homes.

A promotional video is being prepared, as well as literature aimed at architects and engineers. This promotion will familiarize an influential segment of the construction industry with the 7S-3000 building system.

7.0 CONCLUSIONS AND PRODUCT STATUS

The 7S-3000 building system has great potential. The system has been successfully used in a number of prototype structures, and evaluation tests to date have been very promising. Warnock Hersey Professional Services Ltd., an approved testing laboratory for both CMHC and its American counterparts, ICBO, performed the test series on the panels, and adjudged them completely satisfactory for residential and small commercial buildings. Formal application for approval by CMHC and ICBO has been made.

CMHC is in the process of preparing the evaluation report for the system, which would allow it to be used as an acceptable building product in Canada, subject to the restrictions set out in the evaluation report.

ICBO is currently evaluating the system for general use as a standard building component subject to certain conditions and restrictions.

Based on the completed structural and thermal test results, a request for approval of the 7S-3000 building system has been submitted to Alberta Building Standards for its review and approval.

A patent for the 7S-3000 building system has recently been issued in the United States. Patent applications for Canada, Australia, and some European and Asian countries have also been submitted. The "7S-3000" trademark has been registered in Canada and application is being made in the US.

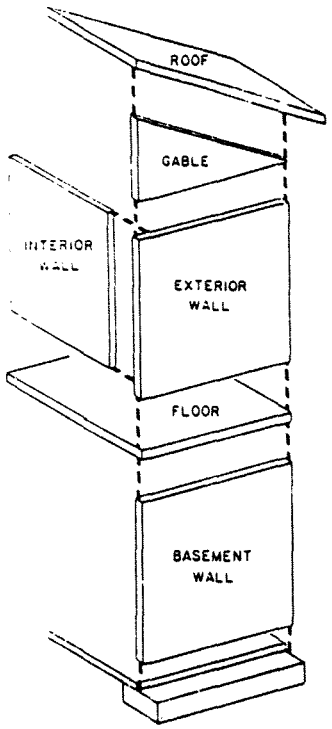
At present, interest in the 7S-3000 panel system is growing, in both the domestic and international markets. Orders have been received from as far away as the Caribbean, and negotiations for projects in eastern Canada are continuing. The future plans for Seven S Structures Inc. encompass a public stock offering, licensing of panel fabrication plants, and participation in foam blending and OSB manufacturing operations. This will all result in a self-sustaining company, with a bright future.

APPENDIX "A"

Panel Components

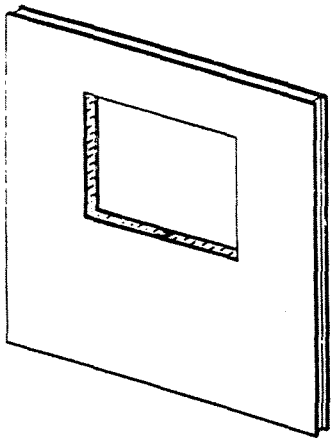
DETAILS: 7S -3000 BUILDING SYSTEM

1



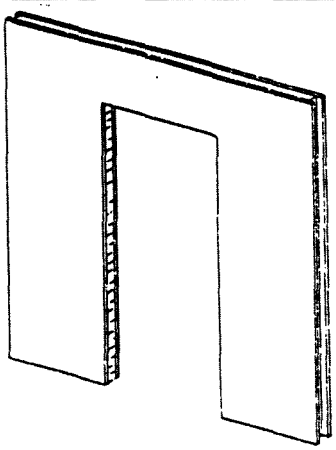
PANEL USES

3

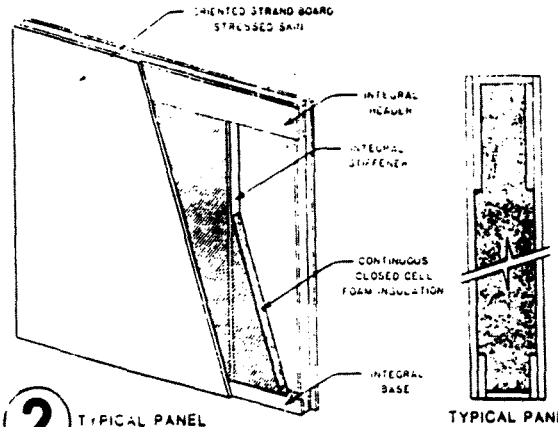


WINDOW OPENING CUT INTO WALL PANEL.

4



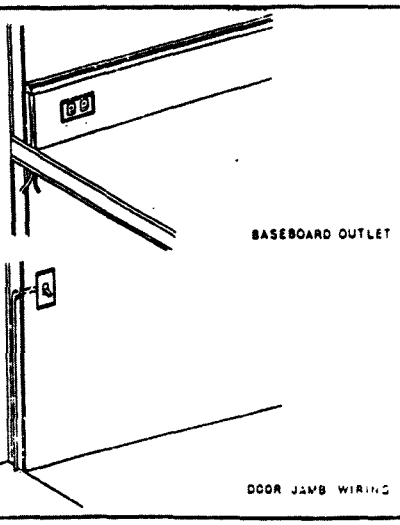
DOOR OPENING CUT INTO WALL PANEL.

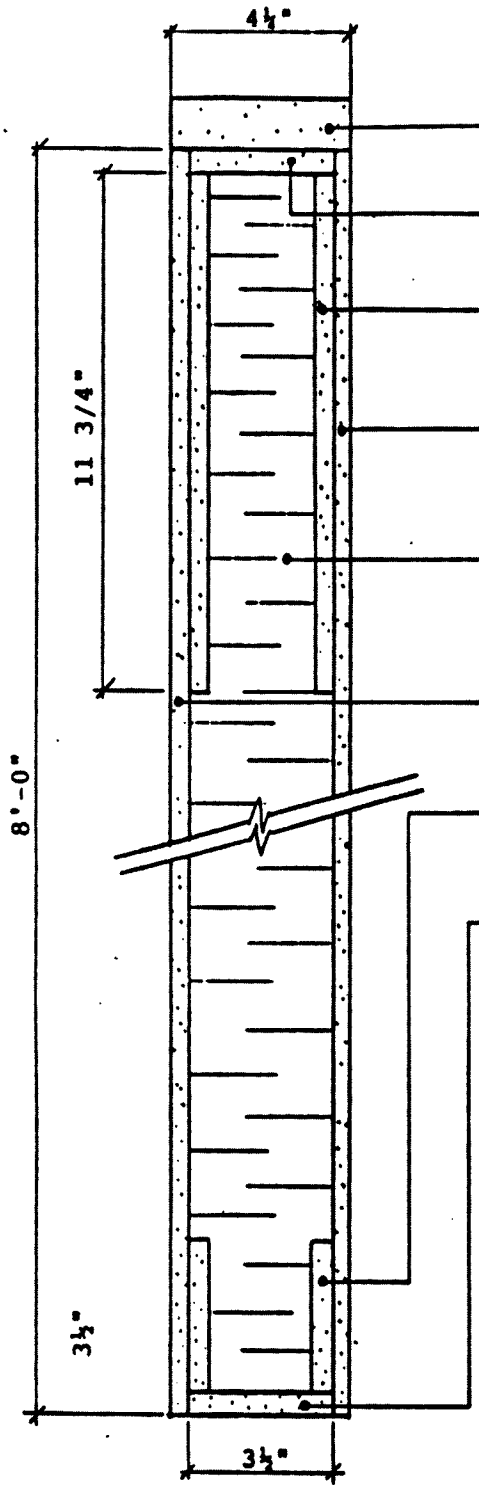


2 TYPICAL PANEL CUTAWAY

TYPICAL PANEL SECTION

5





SECOND TOP PLATE
1½" O.S.B. Field installed

FIRST TOP PLATE
½" O.S.B. Factory installed

TOP HEADER
½" O.S.B. glued to wall skin

INTERIOR WALL SKIN
3/8" O.S.B.

INTERIOR CORE
Polyurethane foam insulated R-28
Factory foamed in place.

EXTERIOR WALL SKIN
3/8" O.S.B.

STANDARD BASE PLATE
½" O.S.B. Base plate, glued to wall skins.

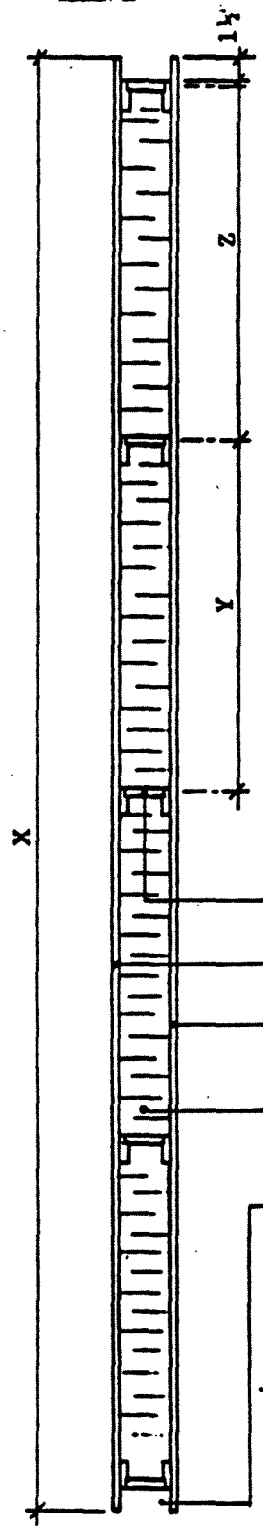
BOTTOM PLATE
½" O.S.B. Factory installed.

See Connection Details for connecting Wall Panels to floor systems and roof systems.

SEVEN S STRUCTURES INC.	STAMP	STAMP	REV
TITLE 7S-3000 EXTERIOR WALL PANEL VERTICAL SECTION			DWG. 001

A - 3

TYPE	STUDS	X	Y	Z
4WP	3	1200	555	-
8WP	5	2438	587	588
12WP	7	3658	595	-
16WP	9	4877	600	598
20WP	11	6096	601	600
24WP	13	7315	602	603



O.S.B C-STUD

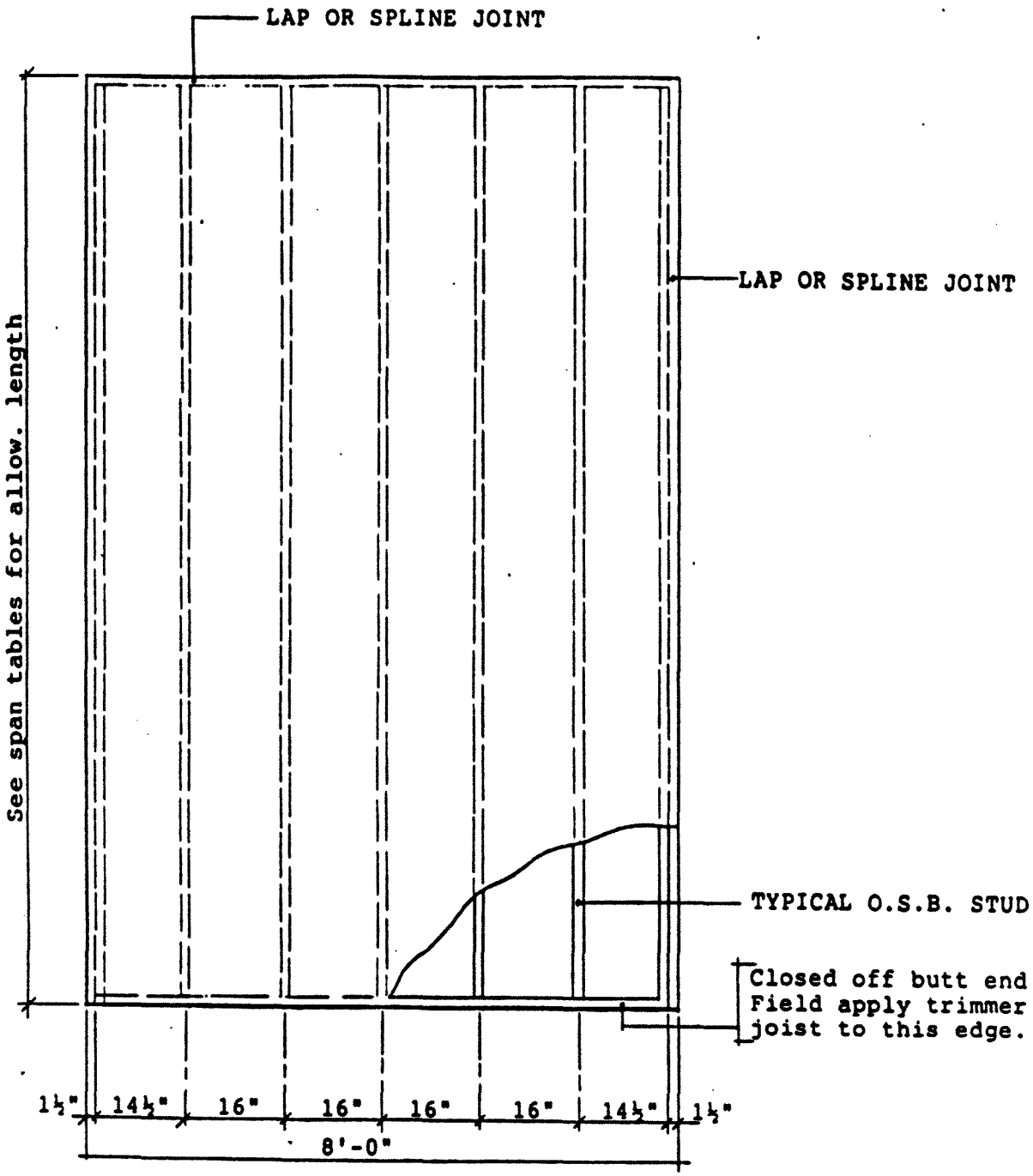
3/8" O.S.B. EXTERIOR SKIN

3/8" O.S.B. INTERIOR SKIN

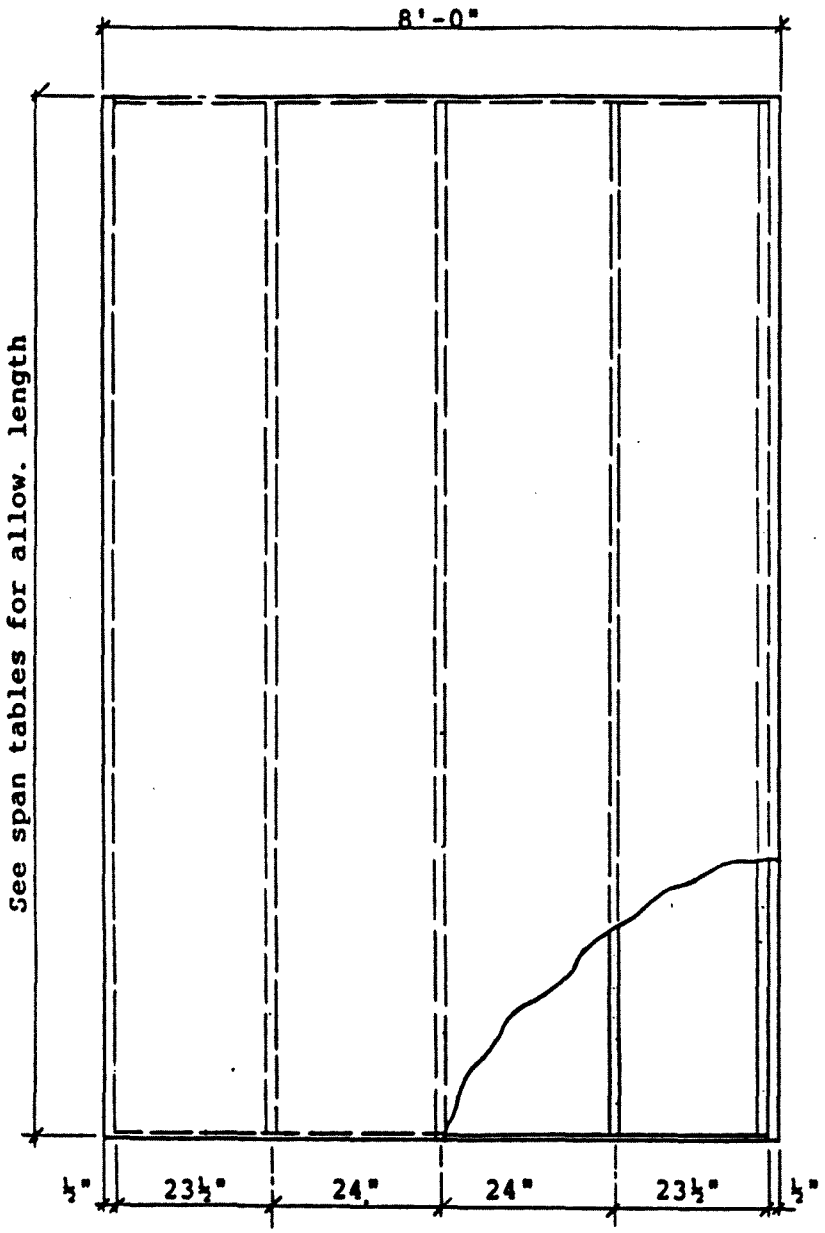
INTERIOR CORE
Polyurethane foam insulated R-28
Factory foamed in place

1½" PANEL LIP

SEVEN S STRUCTURES INC.	STAMP	STAMP	REV
TITLE 7S-3000 EXTERIOR WALL PANEL HORIZONTAL SECTION			DWG. 002



SEVEN S STRUCTURES INC.	STAMP	STAMP	REV.
TITLE TYPICAL FLOOR PANEL LAYOUT			DWG. 027



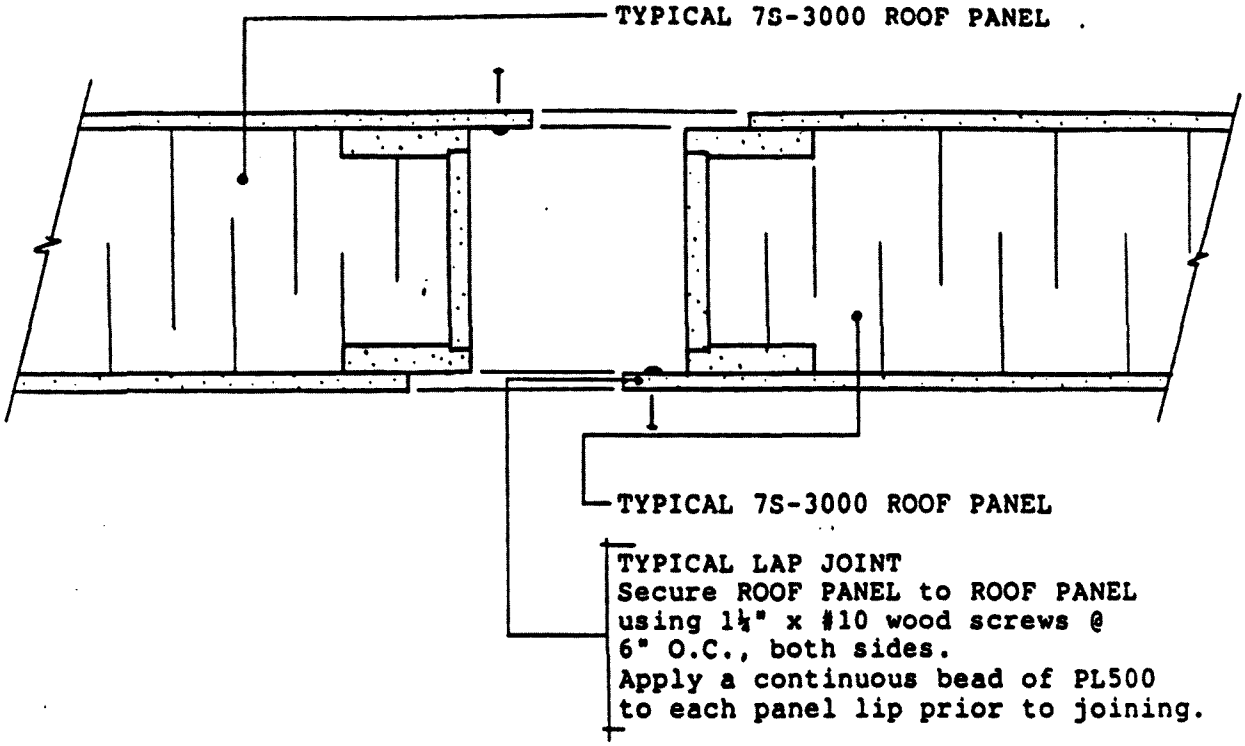
LAP OR SPLINE JOINT

TYPICAL O.S.B. STUD

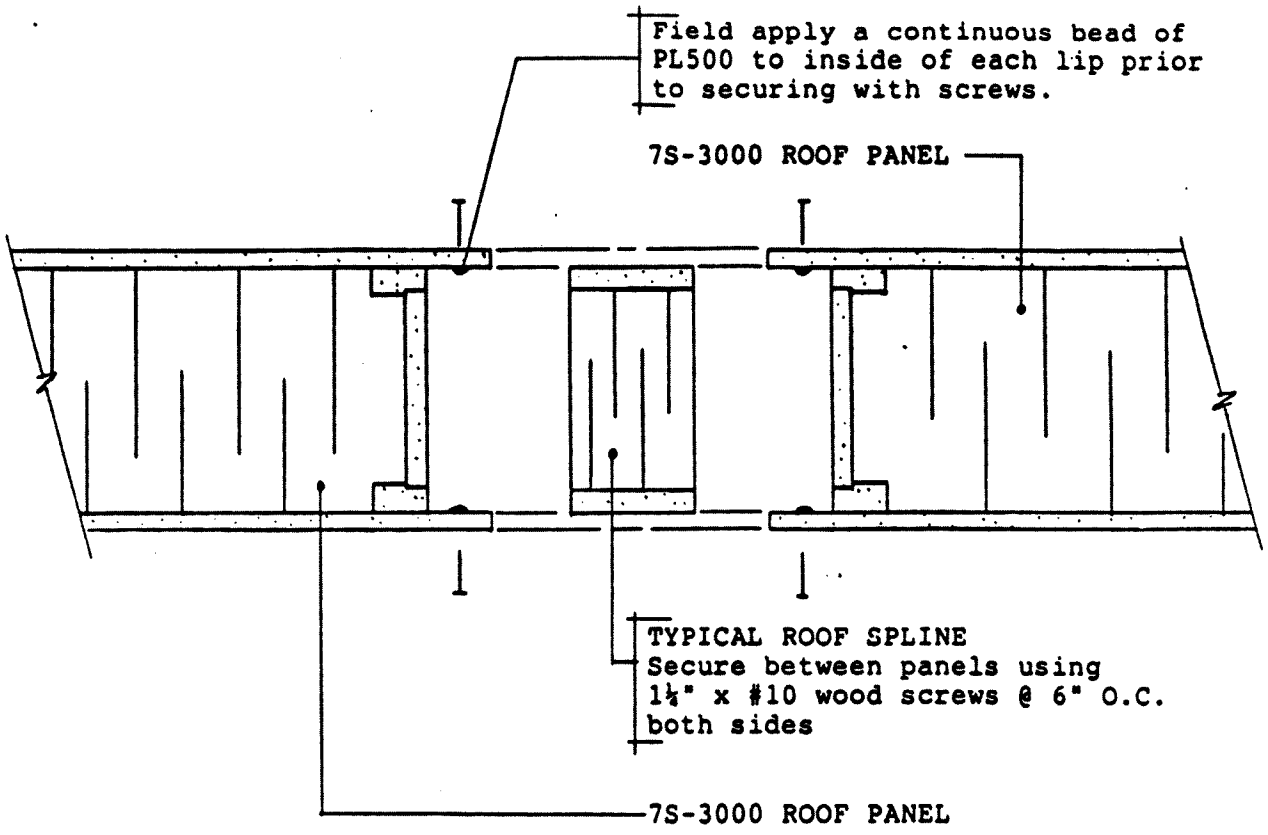
SEVEN S STRUCTURES INC.	STAMP	STAMP	REV.
TITLE TYPICAL 7S-3000 ROOF PANEL			DWG. 030

APPENDIX "B"

Panel Joint Detail



SEVEN S STRUCTURES INC.	STAMP	STAMP	REV.
TITLE ROOF PANEL TO ROOF LAP JOINT CONNECTION			DWG. 032



SEVEN S STRUCTURES INC.	STAMP	STAMP	REV.
TITLE TYPICAL ROOF CONNECTION USING SPLINE			DWG. 031

APPENDIX "C"

Span Ratings

Warnock Hersey Professional Services Ltd.
211 Schoolhouse St., Coquitlam, B.C. V3K 4X9 - (604) 520-3321 - Telex 04-351404

MAY 19 1987

REPORT OF: Transverse Load Test

AT: Coquitlam Laboratory

DATE May 14, 1987

PROJECT: 50489 C7 493600

REPORT NO.

REPORTED TO: Seven S Structures Inc.
10833 - 97th Avenue,
Grande Prairie, Alberta
T8V 4Y9

ORDER NO.

INTRODUCTION:

As requested, we have carried out transverse load tests on your 4" and 6" foundation wall panels. Tests were carried out with the polyurethane foam in the panel cavity and on an 8ft span with the plywood skin on top (i.e. in compression). These tests were carried to give an indication as to the structural contribution of the foam core to the panels overall strength and to give some indication as to whether the panels should be tested with foam in the cavity.

TEST RESULTS:

For 4" Walls - Foundation Wall

4' wide x 8' long sample
EI on 8' panel x 4' wide = 149.19×10^6 lb. m^2
EI for 1' wide = $\frac{149.19 \times 10^6}{4} = 37.30 \times 10^6$ lb. in^2

Maximum span (L) for 40 psf loading:

a) For deflection = L/180

$$L^3 = \frac{384 \times 37.30 \times 10^6}{180 \times 5 \times 3.33}$$

Therefore Span (L) = 14'0"

b) For deflection = L/240

$$L^3 = \frac{384 \times 37.30 \times 10^6}{240 \times 5 \times 3.33}$$

Therefore span (L) = 12'9"

.../2

Warnock Hersey Professional Services Ltd.

Seven S Structures Inc.
Page 2

TEST RESULTS: Continued

c) For deflection = L/360

$$L^3 = \frac{384 \times 37.30 \times 10^6}{360 \times 5 \times 3.33}$$

Therefore span (L) = 11'1"

1/4 pt Loading on 8 ft. Span

Maximum load applied 10,000 lbs. *

Maximum allowable based on Ultimate/3 = 104 lbs./sq.ft.

Maximum allowable based on L/360 = 107.9 lbs./sq.ft.

Therefore 104 lbs./sq.ft. governs

For 6" Wall - Foundation Walls

4' wide x 8' long sample
EI on 8' panel x 4' wide = 347.59×10^6 lb. in^2
EI on 1' width = 86.90×10^6 lb. in^2

Maximum span (L) for 40 psf load

Deflection = L/360

$$L^3 = \frac{384 \times 86.90 \times 10^6}{360 \times 5 \times 3.33}$$

Therefore span (L) = 14'9"

1/4 pt. Load on 8' Span

Maximum load applied = 10,000 lbs. *

Maximum allowable based on L/360 = 251 lbs/sq.ft. (8' span)

NOTE: * Neither wall broke at the maximum test load of 10,000 lbs.

.../3

Warnock Hersey Professional Services Ltd.

Seven S Structures Inc.
Page 3

WARNOCK HERSEY PROFESSIONAL SERVICES LTD.

for F. Mawani, P. Eng.,
Manager,
Field Inspections and Materials Testing

FM/tr/87.05.14

480.D4.PC

APPENDIX "D"

Structural Test Results

Warnock Hersey Professional Services Ltd.
211 Schoolhouse Street, Coquitlam, B.C. V3K 4X9 Tel: (604) 520-3321 Envoy WPM 8076

REPORT OF:

TRANSVERSE LOAD TEST

AXIAL LOAD TEST

RACKING LOAD TEST

ON

SEVEN S STRUCTURES INC.
PREFABRICATED O.S.B. WALL
PANEL SYSTEM

REPORT NO. 1/86

DATE: NOVEMBER 10, 1986

BY: F. Mawani

F. MAWANI, P. Eng.,
Manager,
Field Inspections & Physical Testing

Warnock Hersey Professional Services Ltd.

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INTRODUCTION:

As requested, we have carried out Structural Load tests on Seven S Structures Inc. prefabricated wall, roof, and floor panels. The tests were conducted in accordance with ASTM Standard E72-80 "Standard Methods of Conducting Strength Tests of Panels for Building Construction." The purpose of these tests was to determine the structural properties of the prefabricated panels developed by Seven S Structures Inc. All structural tests were conducted on panels without the polyurethane core.

DESCRIPTION OF THE SEVEN S STRUCTURES PREFABRICATED PANELS

a) The prefabricated wall panels are constructed with a 3/8" O.S.B. skin on either side, glued to the wall spacer with waterproof Phenol-Resoranol glue. Wall spacers are spaced at 24" o.c. The total panel thickness is 4 1/8".

b) The roof panels are constructed similar to wall panels except that the total thickness of the panel is 6 1/2".

c) The floor panel is constructed with a 5/8" O.S.B. skin on topside and 3/8" skin on the underside. Total thickness of the floor panel is 6 7/8" and the spaces are at 16" o.c.

Note: All structural tests were conducted on panels without the polyurethane foam.

TEST PROCEDURES:

1. TRANSVERSE LOAD TEST

Tests were carried out in accordance with ASTM E72-80. Tests were performed on three like specimen of the wall system without the polyurethane infill. The test specimens were submitted by Seven S Structures. Four feet by eight feet test panels without the polyurethane infill were placed horizontally in the test frame on a span of 90". Loads were applied at the quarter points, using a hydraulic ram and pump system. At each increment of the load, the deflection of the panel at mid span was measured, using dial indicators reading to one thousandth of an inch. An average of two readings (one on either side of the panel) was calculated. Load deflection data is tabulated and plotted. Stiffness of the four feet wide panel was calculated using linear regression and standard engineering formulas for loading conditions.

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CALCULATIONS FOR TRANSVERSE LOAD TEST

Note: All test results are calculated on deflections recorded immediately after load application at each load increment.

Stiffness EI of 4' wide section = $\frac{11P\ L^3}{2 \times \Delta \times 384}$

Where P = Total Load (lbs)
L = Span ins.
Δ = Deflection ins.

A. WALL PANELS

A.1 8 FEET SPAN

Test 1 EI = 65.7×10^6 lb.in^2 Ultimate Load = 2946 lbs.

Test 2 EI = 67.5×10^6 lb.in^2 Ultimate Load = 3122 lbs.

Test 3 EI = 65.1×10^6 lb.in^2 Ultimate Load = 2721 lbs.

Average EI = 66.17×10^6 lb.in^2 Ultimate Load = 2930 lbs.

$\therefore$ Average EI/Wall Column = $\frac{66.1 \times 10^6}{3}$

$= 22.03 \times 10^6$ lb.in^2

$\therefore$ From the above results, limiting loads for various spans have been calculated as below:

For wall panels with spacers at 24" o.c.

SPAN (L) FT.	ALLOWABLE LOAD (PSF) FOR DEFLECTION OF:	
	L/180	L/240
8	63.7	47.7
9	44.8	33.7
10	32.8	24.4

Note: Wind blowing at 75 mph exerts a load of 14 psf on the wall.

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B. ROOF PANELS

B1. 16 FEET SPAN

Test 1 EI = 164.2 x 10^6 lbs. in^2 Ultimate Load = 3340 lbs.

Test 2 EI = 171.8 x 10^6 lbs. in^2 Ultimate Load = 3335 lbs.

Test 3 EI = 160.8 x 10^6 lbs. in^2 Ultimate Load = 2924 lbs.

Average EI = 165.6 x 10^6 lbs. in^2 Ultimate Load = 3200 lbs.

$\therefore$ Average EI/Spacer Column = $\frac{165.6}{3} \times 10^6$

= 55.20 lb. in^2

$\therefore$ From the above results, limiting loads for various 16 feet spans have been calculated as below:

For roof panels with spacers at 24" o.c.

SPAN (L) FT.	ALLOWABLE LOAD (PSF) FOR DEFLECTION OF:		
	SPAN/180	SPAN/240	SPAN/360
16	20	15	10

B.2 8 FEET SPAN

Test No. 1 EI = 121.9 x 10^6 lb. in^2 Ultimate Load = 4622 lbs.

Test No. 2 EI = 135.8 x 10^6 lb. in^2 Ultimate Load = 3684 lbs.

Test No. 3 EI = 106.8 x 10^6 lb. in^2 Ultimate Load = 4254 lbs.

Average EI = 121.5 x 10^6 lb. in^2 Ultimate Load = 4187 lbs.

$\therefore$ Average EI/Spacer Column = $\frac{121.5 \times 10^6}{3}$

= 40.50 x 10^6 lb. in^2

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B.2 8 FEET SPAN: continued

From the above results, limiting loads for eight feet span have been calculated as below.

For roof panels with spacers at 24" o.c.

SPAN (L) FT.	ALLOWABLE LOAD (PSF) FOR DEFLECTION OF:		
	SPAN/180	SPAN/240	SPAN/360
8	117	88	59

C. FLOOR PANELS

C.1 16 FEET SPAN

Test No. 1 $EI = 196.1 \times 10^6$ lb.in^2 Ultimate Load = 3645 lbs.

Test No. 2 $EI = 185.6 \times 10^6$ lb.in^2 Ultimate Load = 3366 lbs.

Test No. 3 $EI = 195.3 \times 10^6$ lb.in^2 Ultimate Load = 3686 lbs.

Average $EI = 192.3 \times 10^6$ lb.in^2 Ultimate Load = 4557 lbs.

$\therefore$ Average EI/Spacer Column $= \frac{192.3}{4} \times 10^6$

$= 48.1 \times 10^6$ lb. in^2

From the above results limi ng loads for 16 feet span have been calculated as below.

For floor panels with spacers at 1 '" o.c.

SPAN (L) FT.	ALLOWABLE LOAD (PSF) FOR DEFLECTION OF:		
	SPAN/180	SPAN/240	SPAN/360
16	26.0	19.6	13.0

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C.2 8 FEET SPAN

Test No. 1 EI = 184.1×10^6 lb. in^2 Ultimate Load = 8467 lbs.

Test No. 2 EI = 171.6×10^6 lb. in^2 Ultimate Load = 7966 lbs.

Test No. 3 EI = 177.5×10^6 lb. in^2 Ultimate Load = 8031 lbs.

Average EI = 177.7×10^6 lb. in^2 Ultimate Load = 8155 lbs.

Average EI/spacer Column = $\frac{177.7}{4} \times 10^6$

$= 44.4 \times 10^6$ lb. in^2

From the above results limiting loads for eight feet span have been calculated as below:

SPAN (L) FT.	ALLOWABLE LOAD (PSF) FOR DEFLECTIONS OF:		
	SPAN/180	SPAN/240	SPAN/360
8	193	144	96

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Seven S Structures Inc.
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2. AXIAL LOAD TEST

Tests were carried out on the wall panels in accordance with ASTM E72-80. Tests were performed on three like specimen four foot wide by eight foot high. The specimen was placed in the load frame vertically and the load was applied with a hydraulic ram and pump system.

At each increment of the load, the deflection at the center of the wall was recorded and set after the load was removed at each increment. The results were tabulated and plotted.

TEST RESULTS:

	PANEL NUMBER			
	1	2	3	Average
Ultimate Load (lbs)	32,990	32,010	34,120	33,040
Ultimate Load (lbs/spacer col.)	10,996	10,670	11,373	11,013
Allowable Ultimate Load (lbs/spacer) with safety factor of 3.	3,665	3,557	3,791	3,671
Allowable Load lbs/lin ft.	1,832	1,779	1,896	1,835
Lateral Deflection of the Wall at centre at maximum allowable axial load.	0.091	0.053	0.066	0.070

Note: When designing wall panels, please ensure that allowable stress values for lumber species is not exceeded.

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3. RACKING LOAD TEST

Racking load test was performed on three like specimens. Tests were performed on eight feet by eight feet wall panels in accordance with ASTM Standard E72-80.

The panels were placed vertical in the test frame and the load was applied using a hydraulic ram and pump system. Deflections and sets were measured using a dial indicator reading to 0.001".

Test results were tabulated and plotted on a graph.

TEST RESULTS:

	PANEL NUMBER			
	1	2	3	Average
Ultimate Load (lbs)	12,800	14,040	13,060	13,300
Ultimate Load (lbs/lin.ft.)	1,600	1,755	1,685	1,680
Allowable Ultimate Load (lbs/lin.ft.) with safety factor of 3	533	585	562	560

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DISCUSSION OF TEST RESULTS

1. TRANSVERSE LOAD TEST

1.1 WALL PANELS

From the test results it can be seen that the wall panels can withstand a load of 47.7 psf on a span of eight feet with a deflection limit of span/240. Wind blowing at 75 m.p.h. exerts a force of 14 psf, so it can be seen that the wall panels are sufficiently strong to withstand wind loads commonly experienced. The wall panels are stronger than the common 2" x 4" stud wall at 16" o.c.

1.2 FLOOR PANELS

Floor panels on eight foot span can carry loads of up to 96 psf deflection limit of span/360, however at 16 foot span the allowable load falls down 13.0 psf and as such taking the lowest EI value into consideration, floor spans of 10 foot span with deflection limit of span/360 can carry loads up to 50 psf which falls within the common range of residential floor loads.

1.3 ROOF PANELS

Eight foot roof panels can support loads of 59 psf with deflection limits of span/360 and the load carrying capacity is greatly reduced at 16 feet span to 10 psf. Therefore it is recommended that to obtain a higher load carrying capacity on greater spans, the roof panels be designed with a stiffer section of spacer column.

2. AXIAL & RACKING SHEAR - WALL PANELS

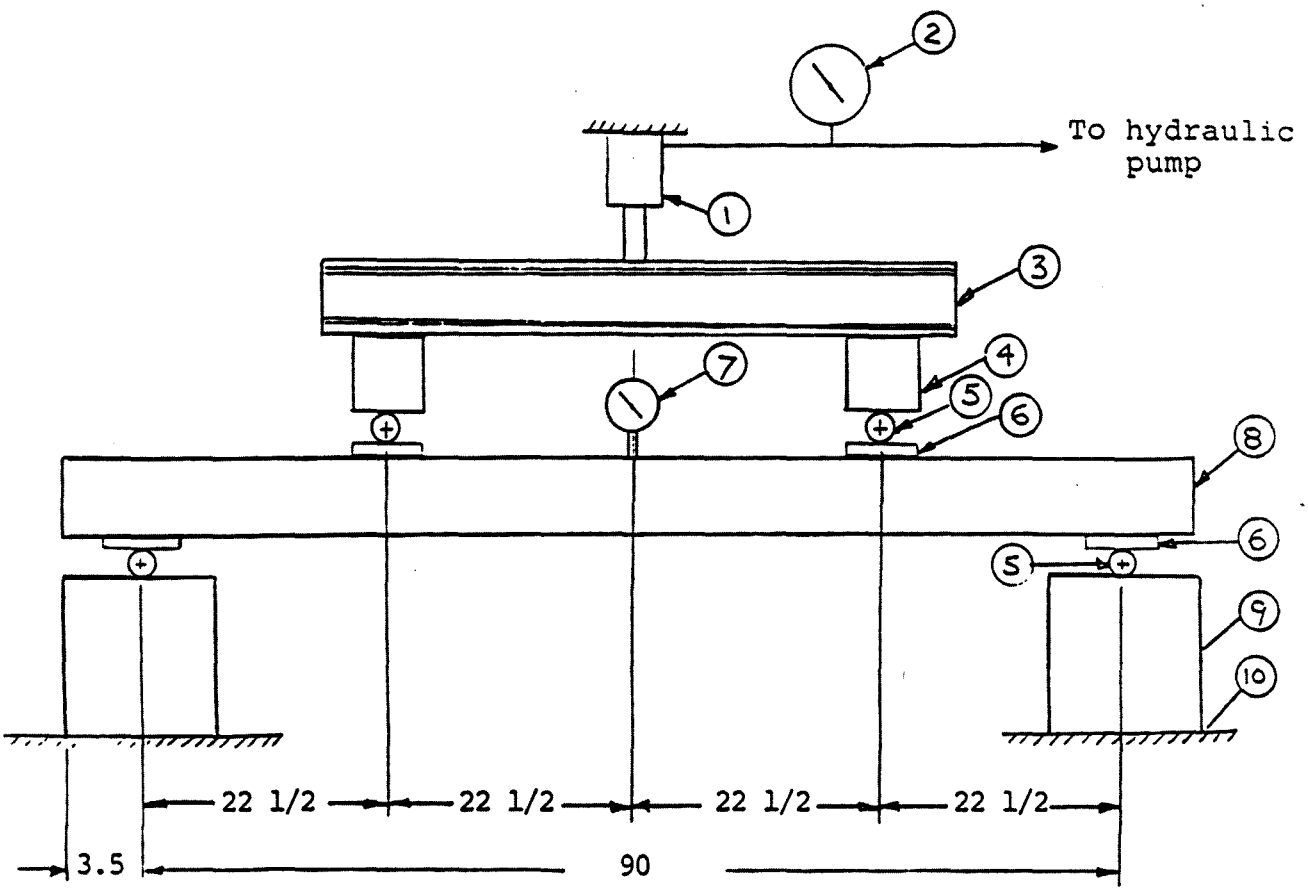
Axial and Racking shear test results indicate that the wall panel is capable of withstanding axial loads of 1835 lbs/lin ft. and 560 lbs/lin ft. of shear load. The allowable axial load is within the normal range of the loads encountered commonly in residential construction and the allowable racking is in excess of the loads that it would normally be subjected to.

FM/lsw 86.12.19

480.D6.PC

A P P E N D I X

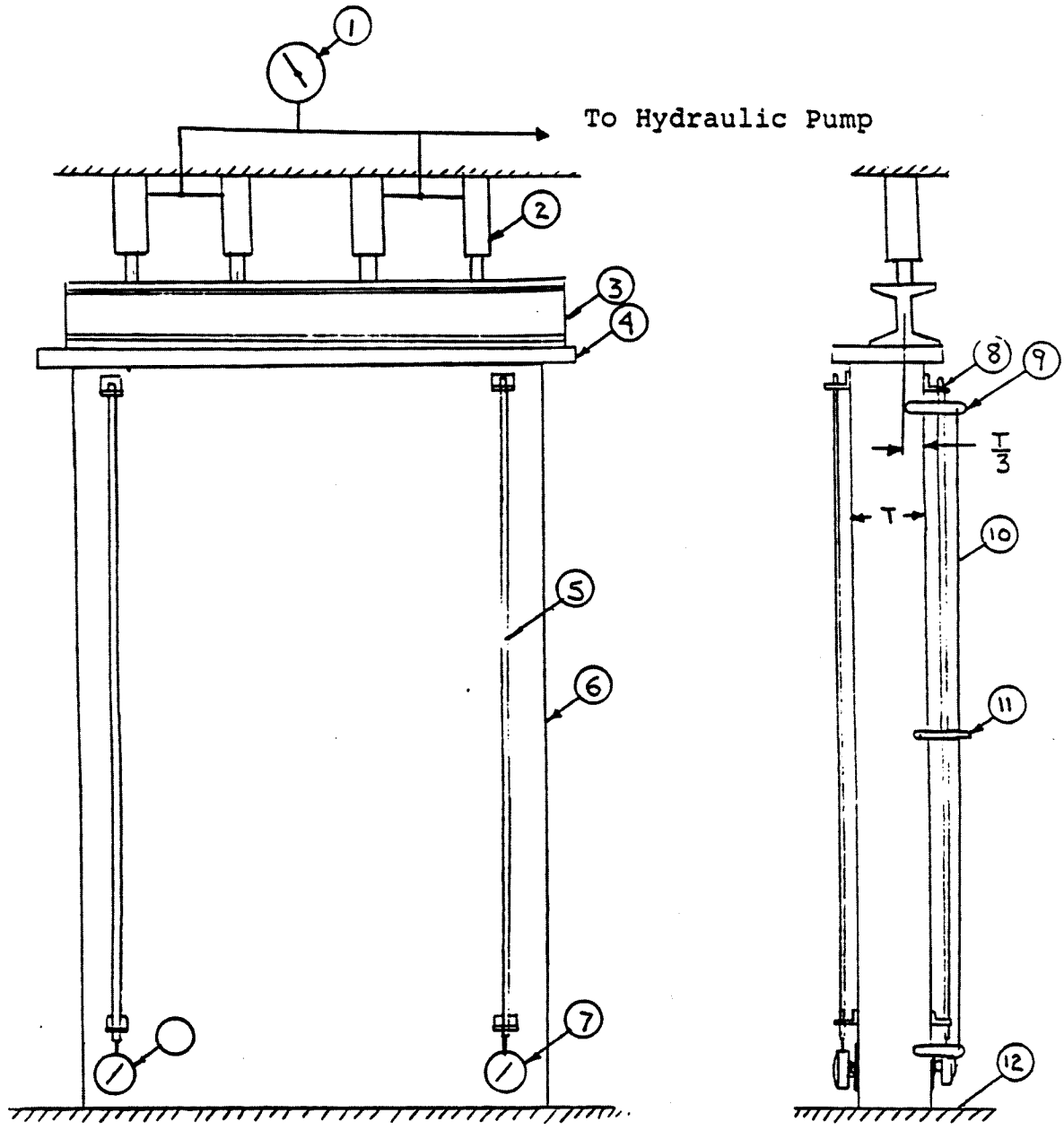
TRANSVERSE LOAD TEST DIAGRAM



1. Hydraulic Ram
2. Calibrated Pressure Gauge
3. 4" x 48" I Beam
4. 4 x 4 x 48" Beam
5. 1"x 48" Steel Roller
6. 1/4" x 3" x 48" Steel Plate
7. Dial Micrometer (1 each side, attached to reaction frame)
8. Test Specimen
9. Cement Block
10. Reaction Frame

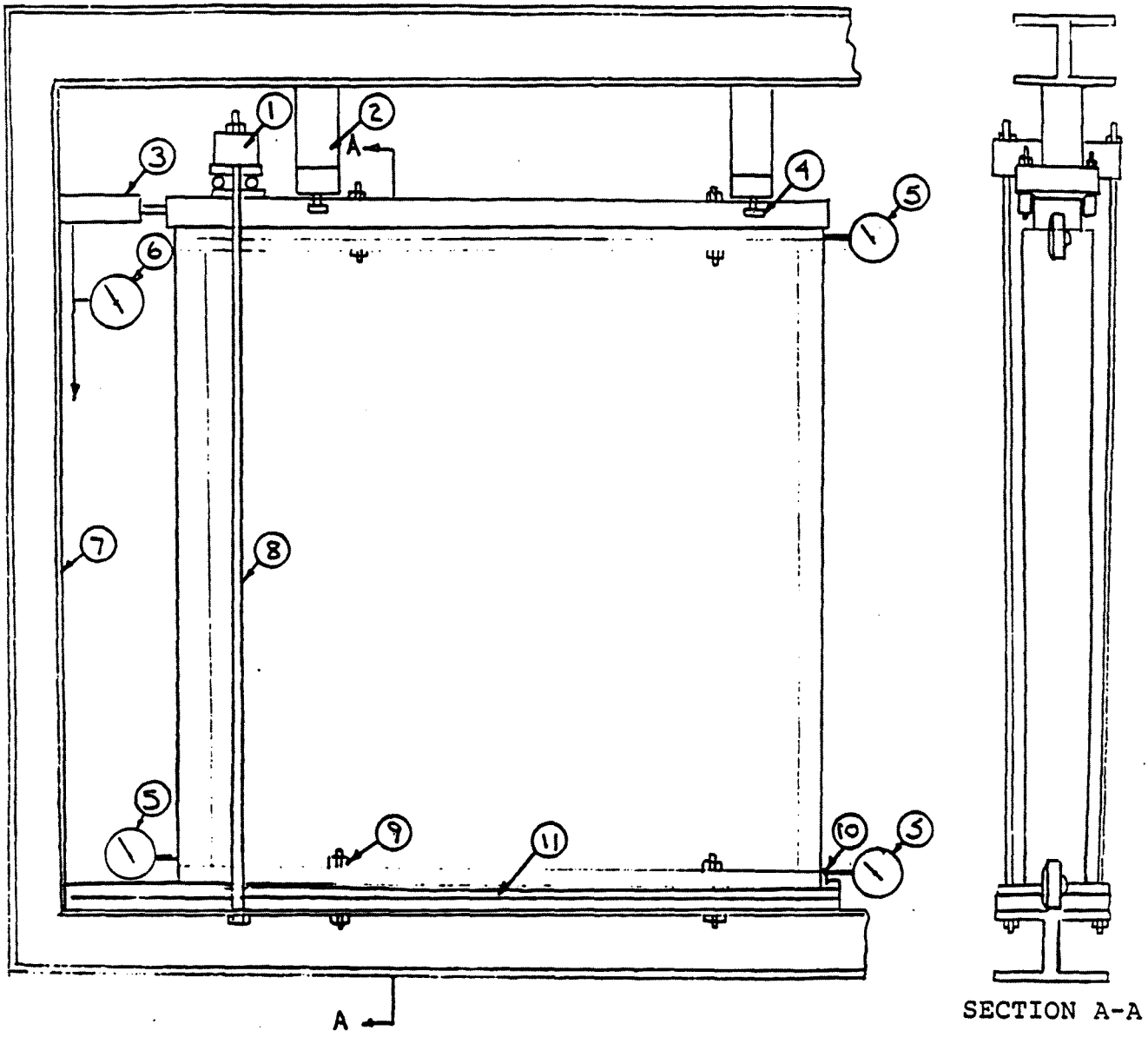
Note: All dimensions are measured in inches unless otherwise noted.

AXIAL LOAD TEST DIAGRAM



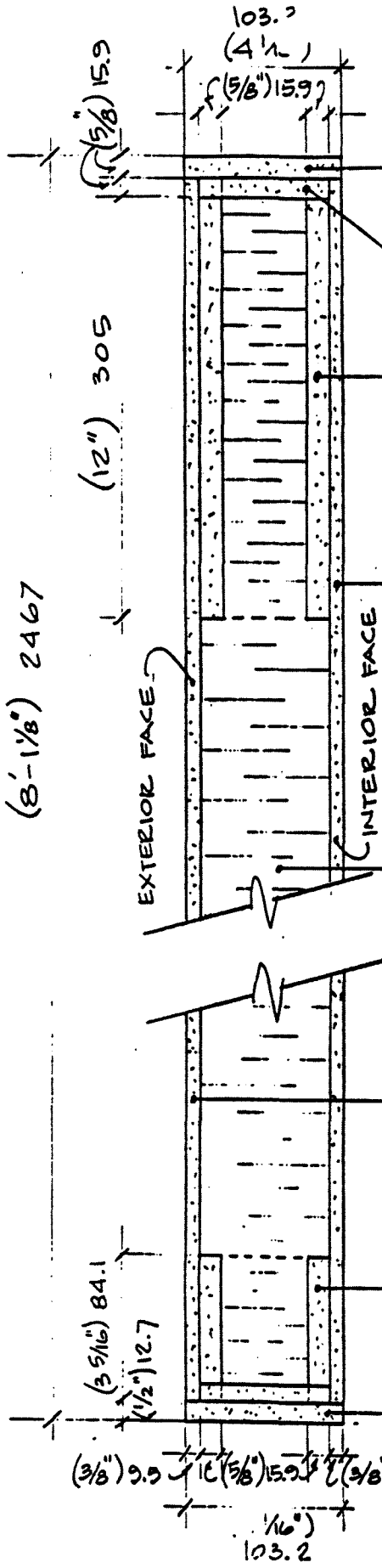
1. Calibrated Pressure Gauge
2. Hydraulic Rams
3. 4" x 48" I Beam
4. 1/4" x 6" x 48" steel plate
5. Steel Rod
6. Test Specimen 48 x 96
7. Dial Micrometers (4)
8. L. Bracket
9. Wire Clamp
10. Wire
11. Deflectometer
12. Reaction Frame

RACKING SHEAR TEST DIAGRAM



SECTION A-A

1. Hold down plate and roller
2. Lateral Guides
3. Hydraulic Ram
4. Roller
5. Dial Micrometer
6. Calibrated Hydraulic Gauge
7. Reaction Frame
8. Hold down rod
9. Bolts
10. Stop
11. 2 x 12 Timbers



SECOND TOP PLATE
(5/8")15.9 O.S.B.
field installed

FIRST TOP PLATE
(3/8")15.9 O.S.B.
factory installed

STANDARD TOP HEADER
2-(1/2")15.9 O.S.B.
wall skins are glued to header

INTERIOR WALL SKIN
(3/8")9.5 O.S.B.

LOW WALL PANEL (24'max.)
(3/8")9.5 O.S.B.
(3 5/16")polyurethane core
(3/8")9.5 O.S.B. outer skin

Note: polyurethane is foamed in place after vertical FOAMSTUDS have been inserted and glued to skins

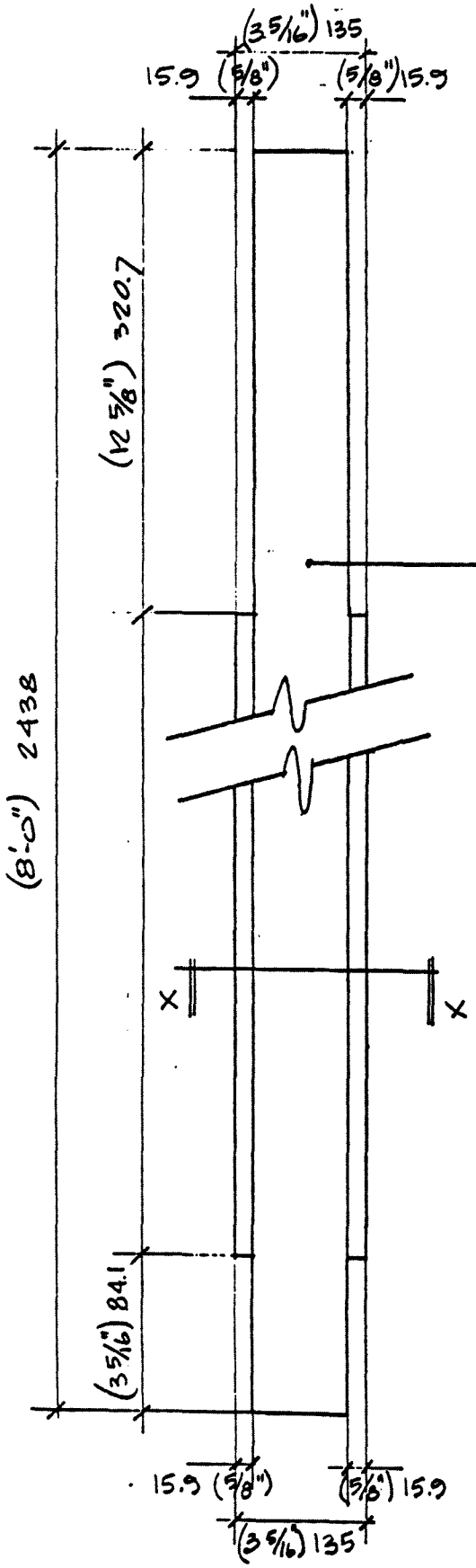
Window or door openings may be cut into wall panel anywhere below the top header

EXTERIOR WALL SKIN
3/8"9.5 O.S.B.

STANDARD BASE PLATE
2-(5/8")15.9 O.S.B.
wall skins are glued to plate

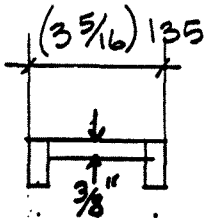
BOTTOM PLATE
(1/2")12.7 O.S.B.

FIGURE NO.1
LOW WALL PANEL (EXTERIOR)
VERTICAL SECTION



FACE VIEW
STANDARD
O.S.B. WALLSPACER

(5/8")15.9 O.S.B.



TYPICAL X-SECTION

FIGURE NO. 2A
O.S.B. WALLSPACER
FACE VIEW

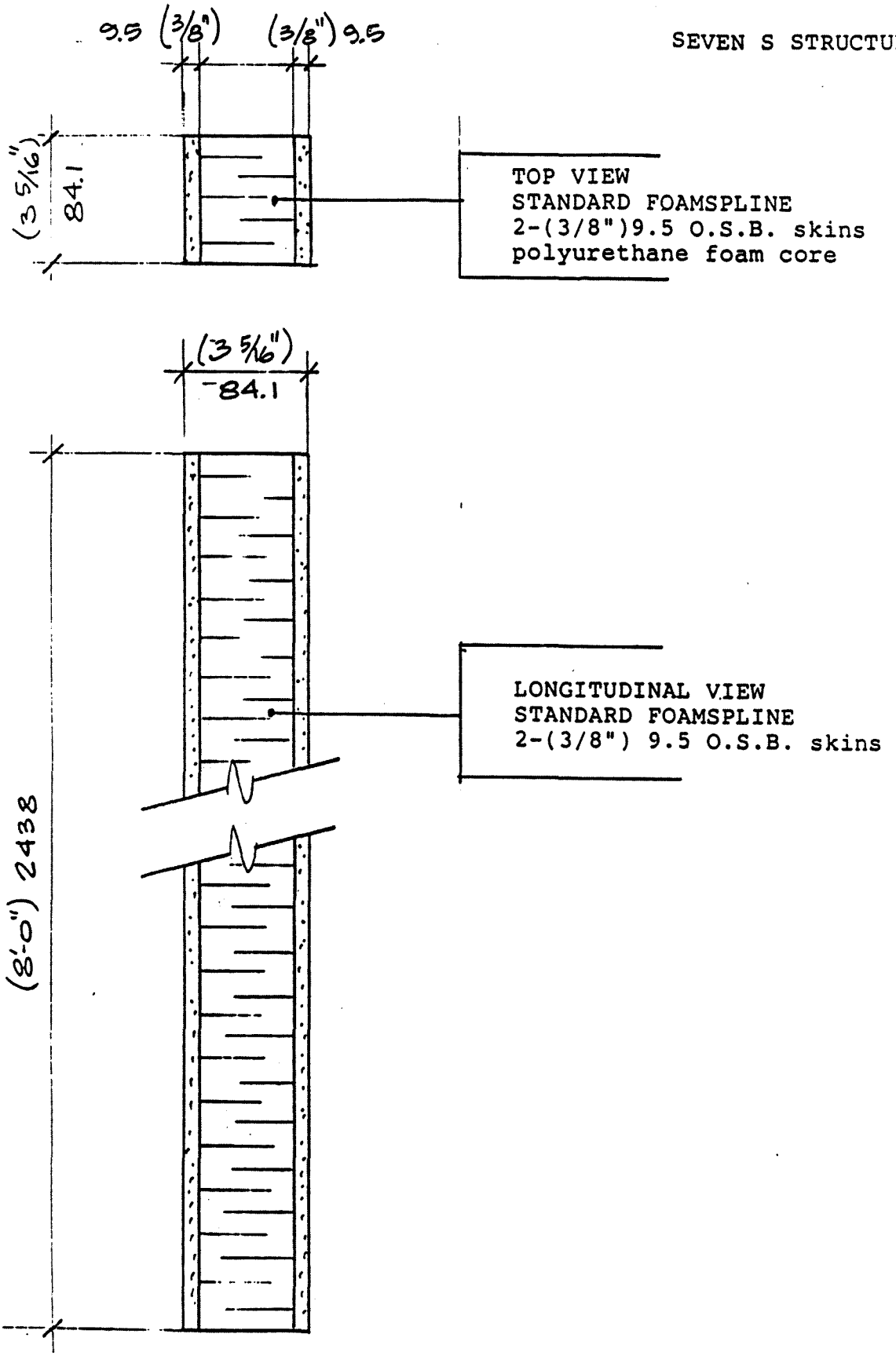


FIGURE NO.3
FOAMSPLINE
LONGITUDINAL SECTION

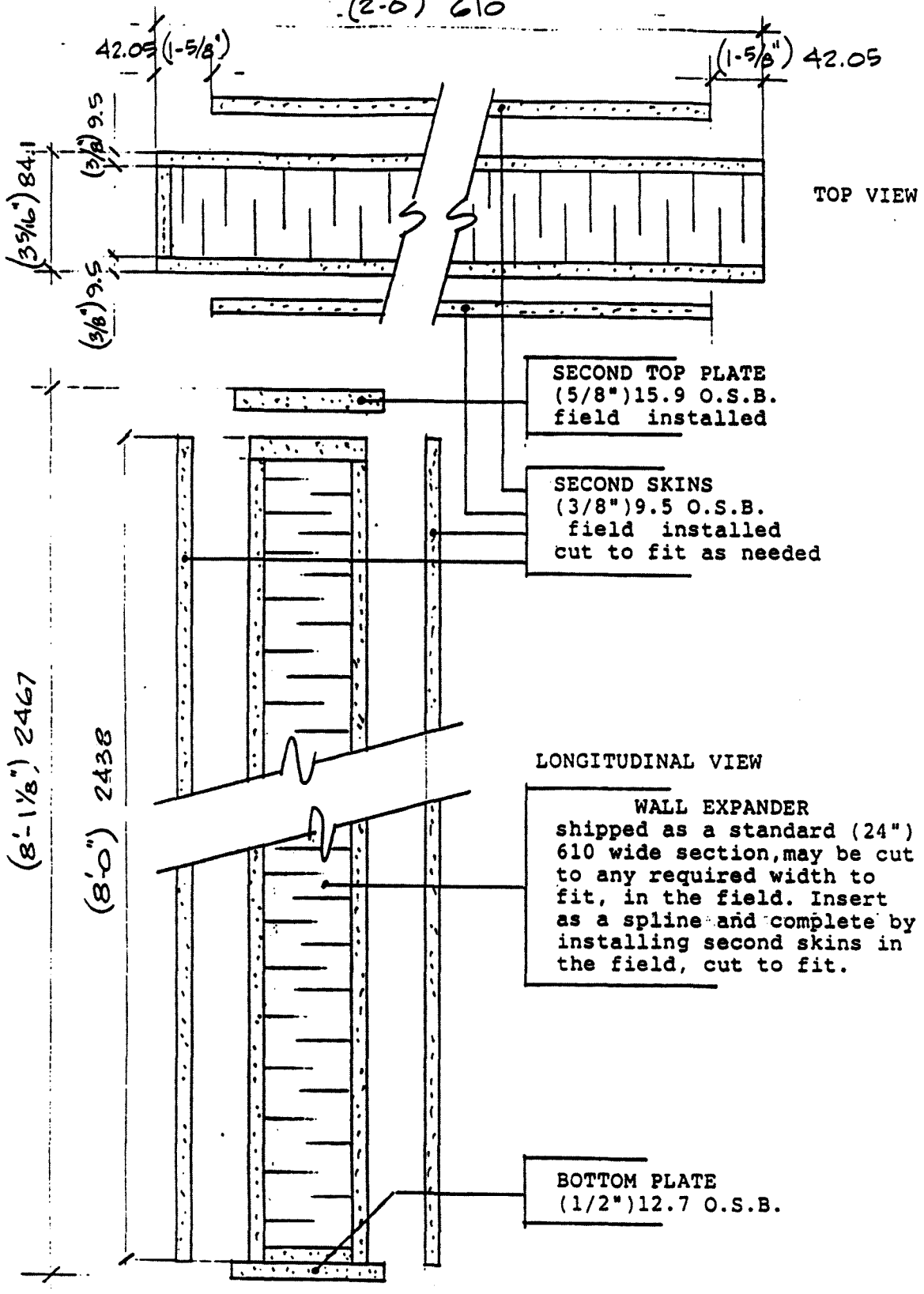
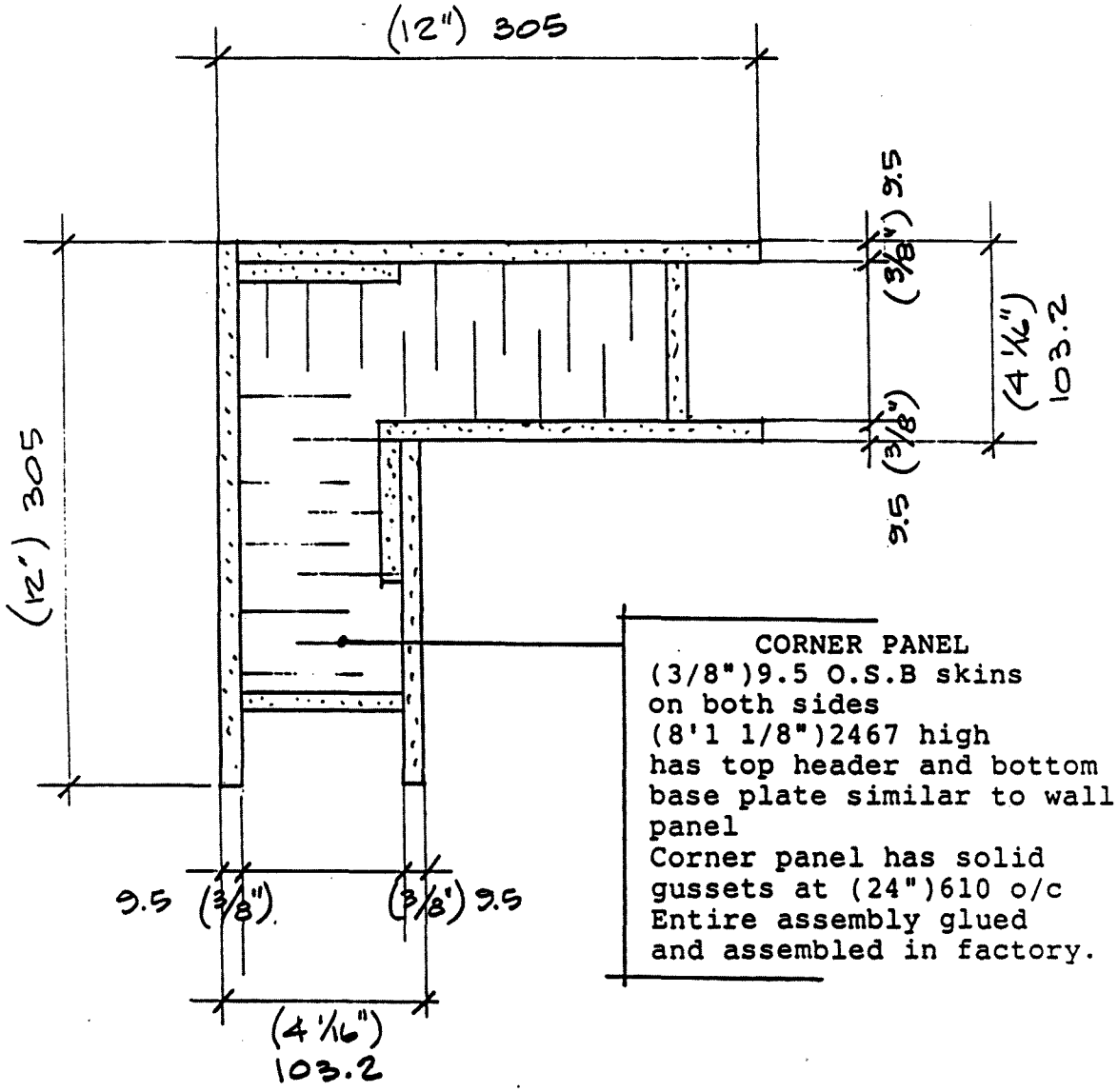


FIGURE NO.4
WALL EXPANDER
VERTICAL SECTION



CORNER PANEL
(3/8")9.5 O.S.B skins
on both sides
(8'1 1/8")2467 high
has top header and bottom
base plate similar to wall
panel
Corner panel has solid
gussets at (24")610 o/c
Entire assembly glued
and assembled in factory.

FIGURE NO.5
CORNER PANEL
HORIZONTAL SECTION

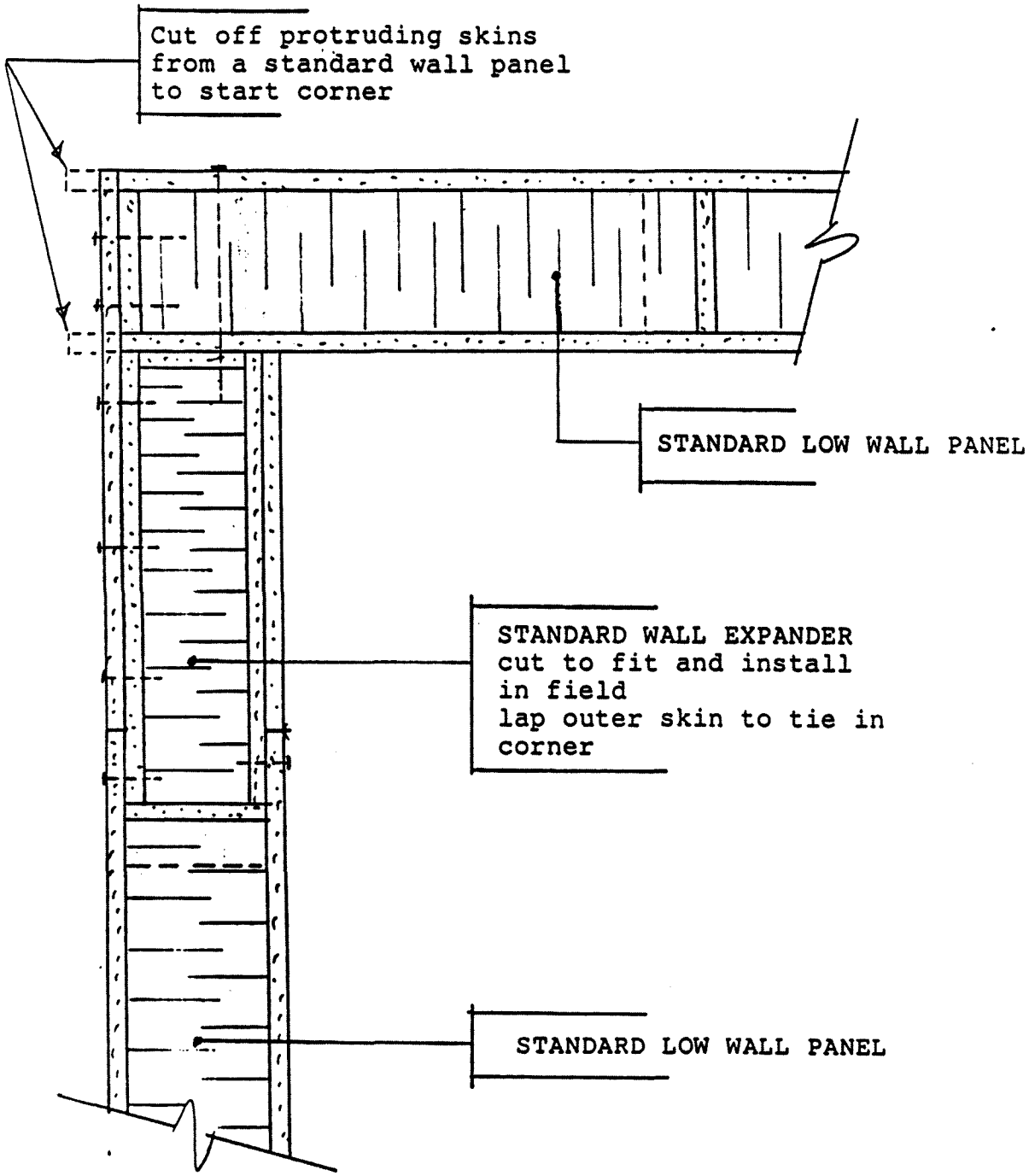


FIGURE NO.5A
ALTERNATE CORNER DETAIL
HORIZONTAL SECTION

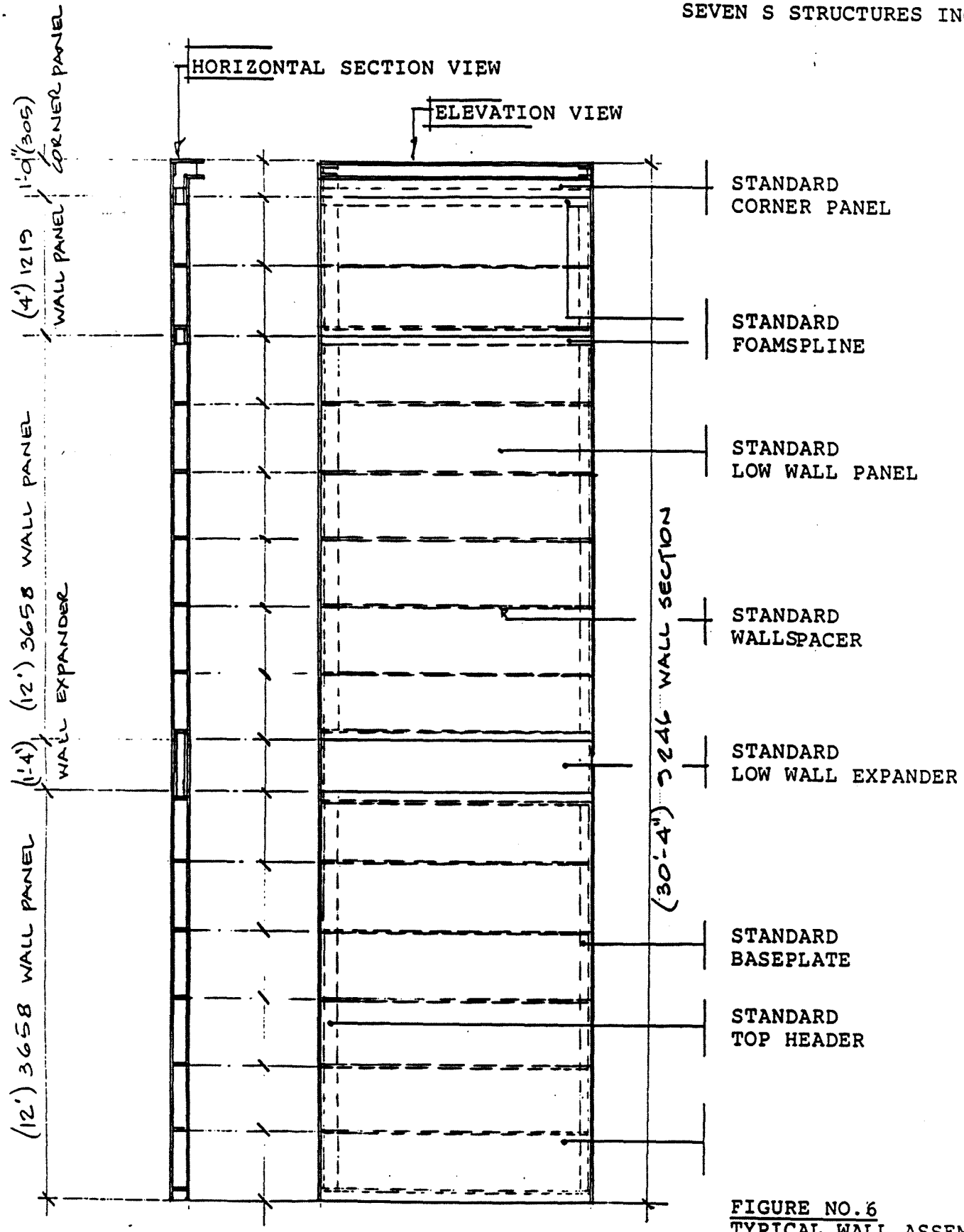
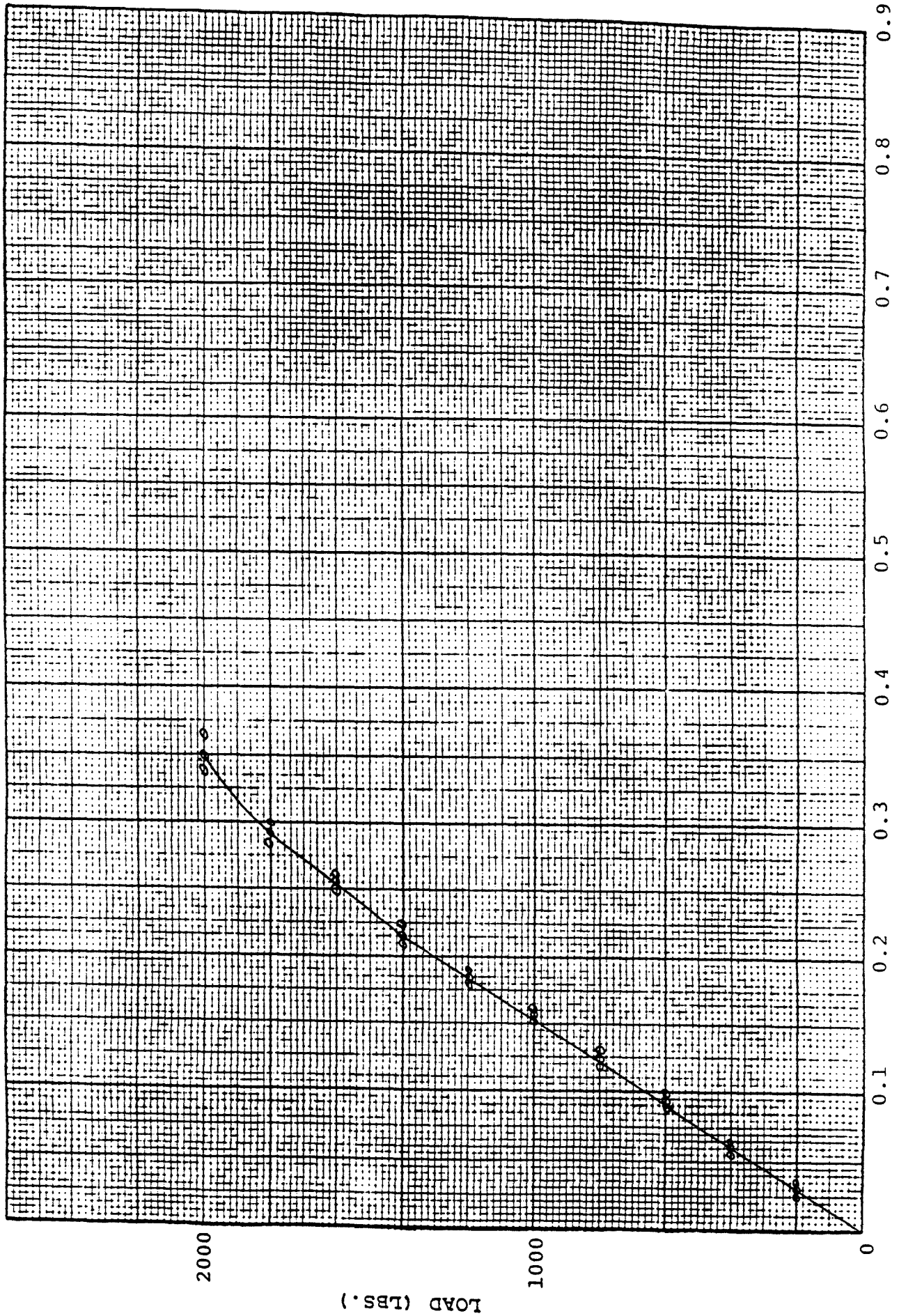
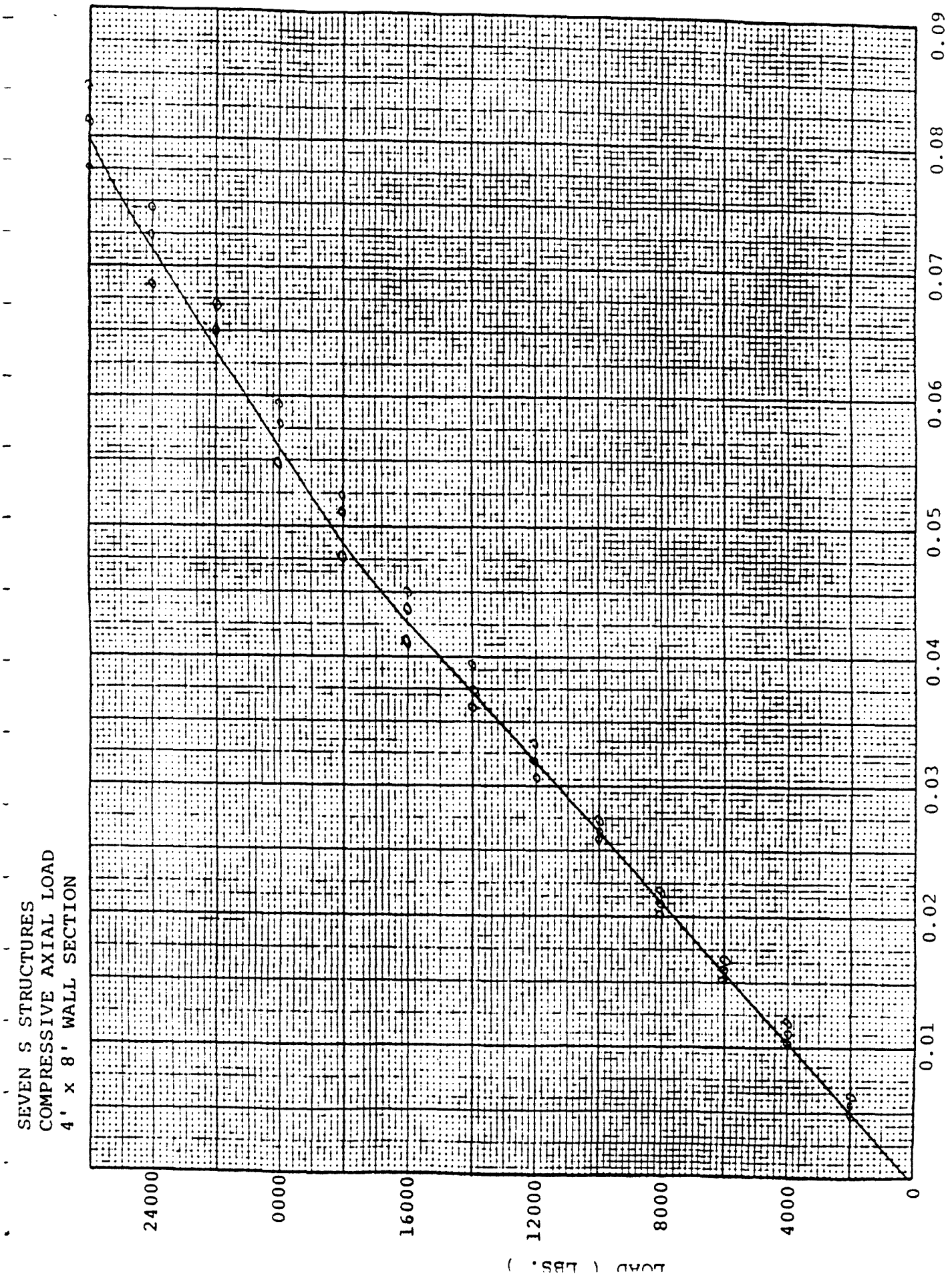
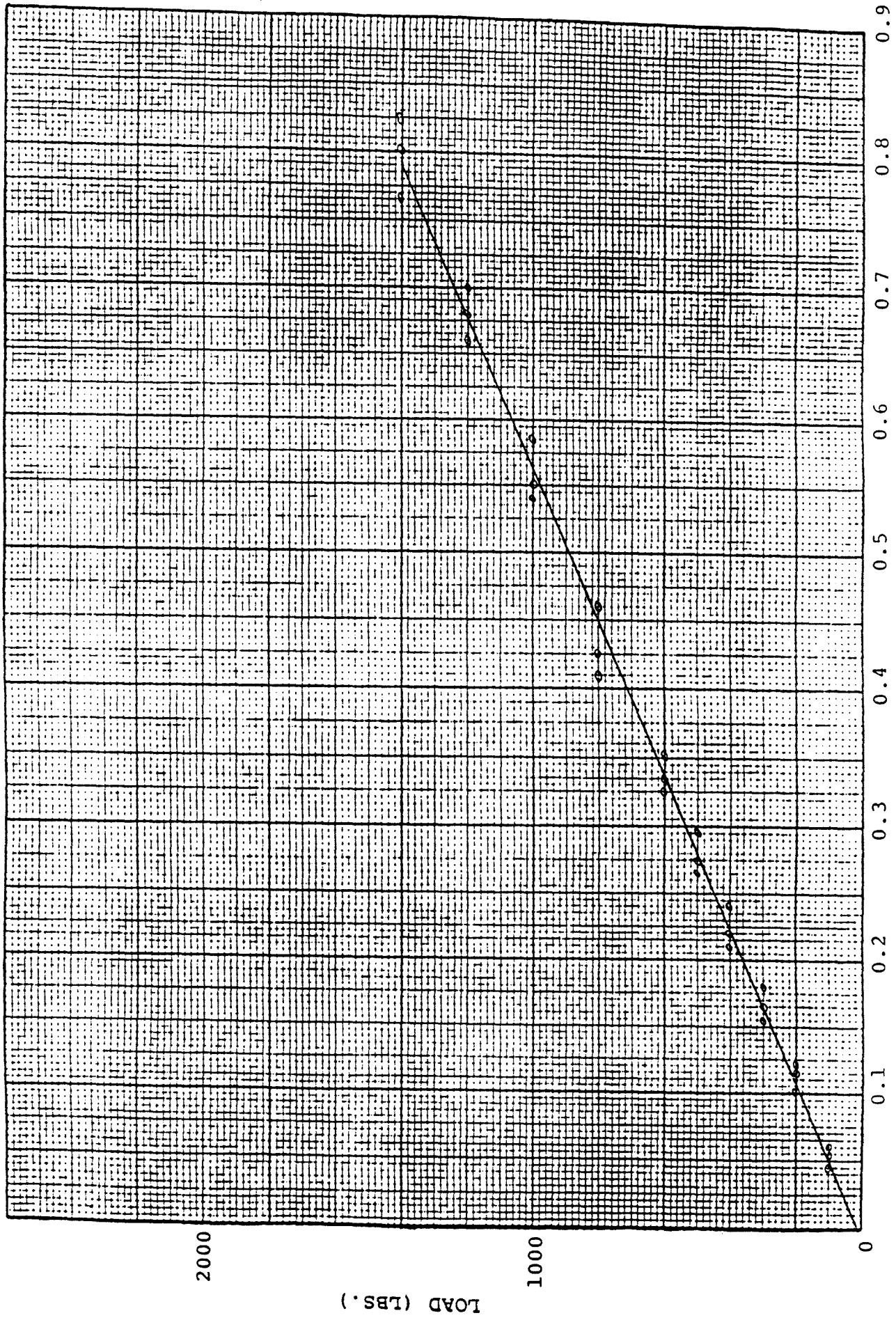


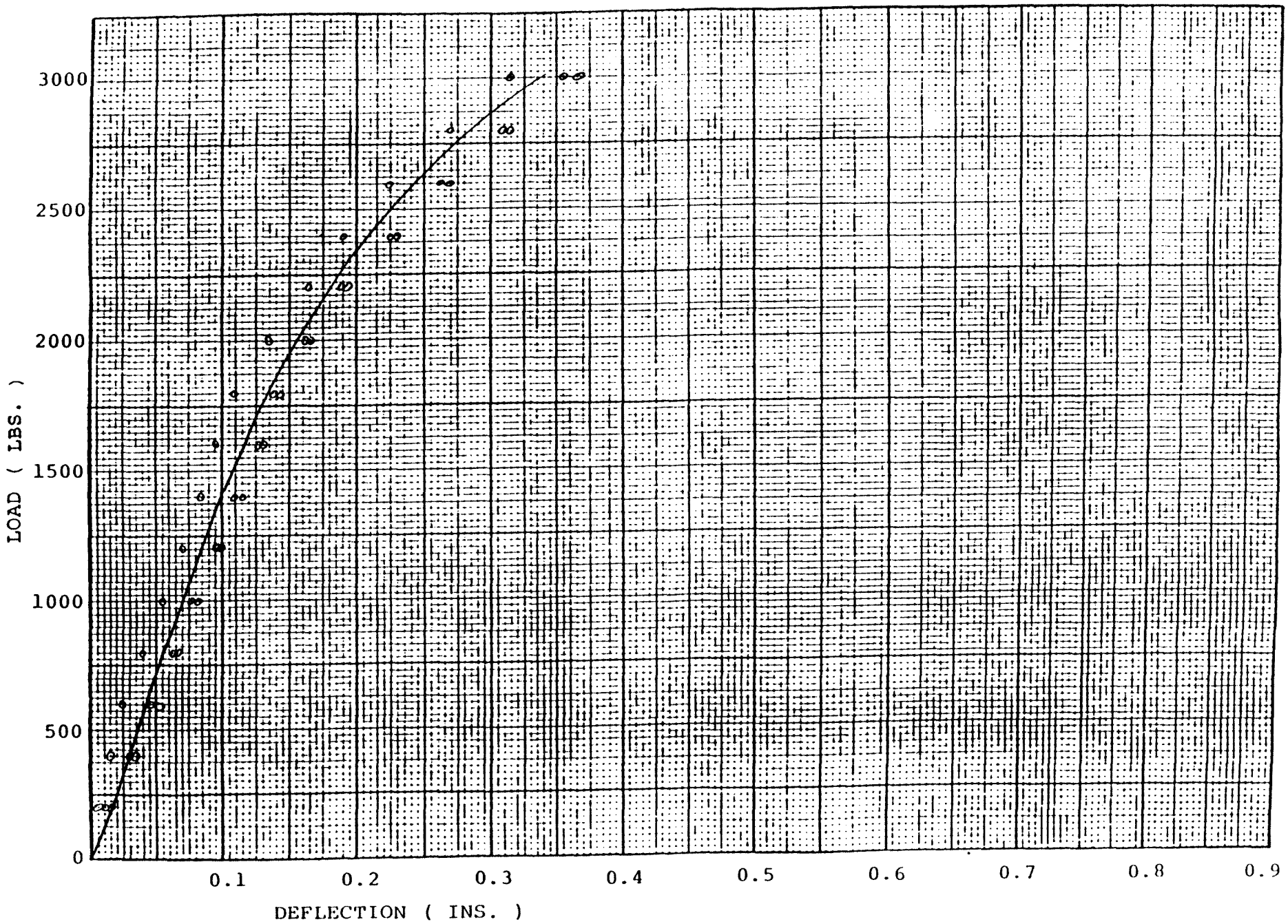
FIGURE NO.6
TYPICAL WALL ASSEMBLY
EXTERIOR WALL SYSTEM

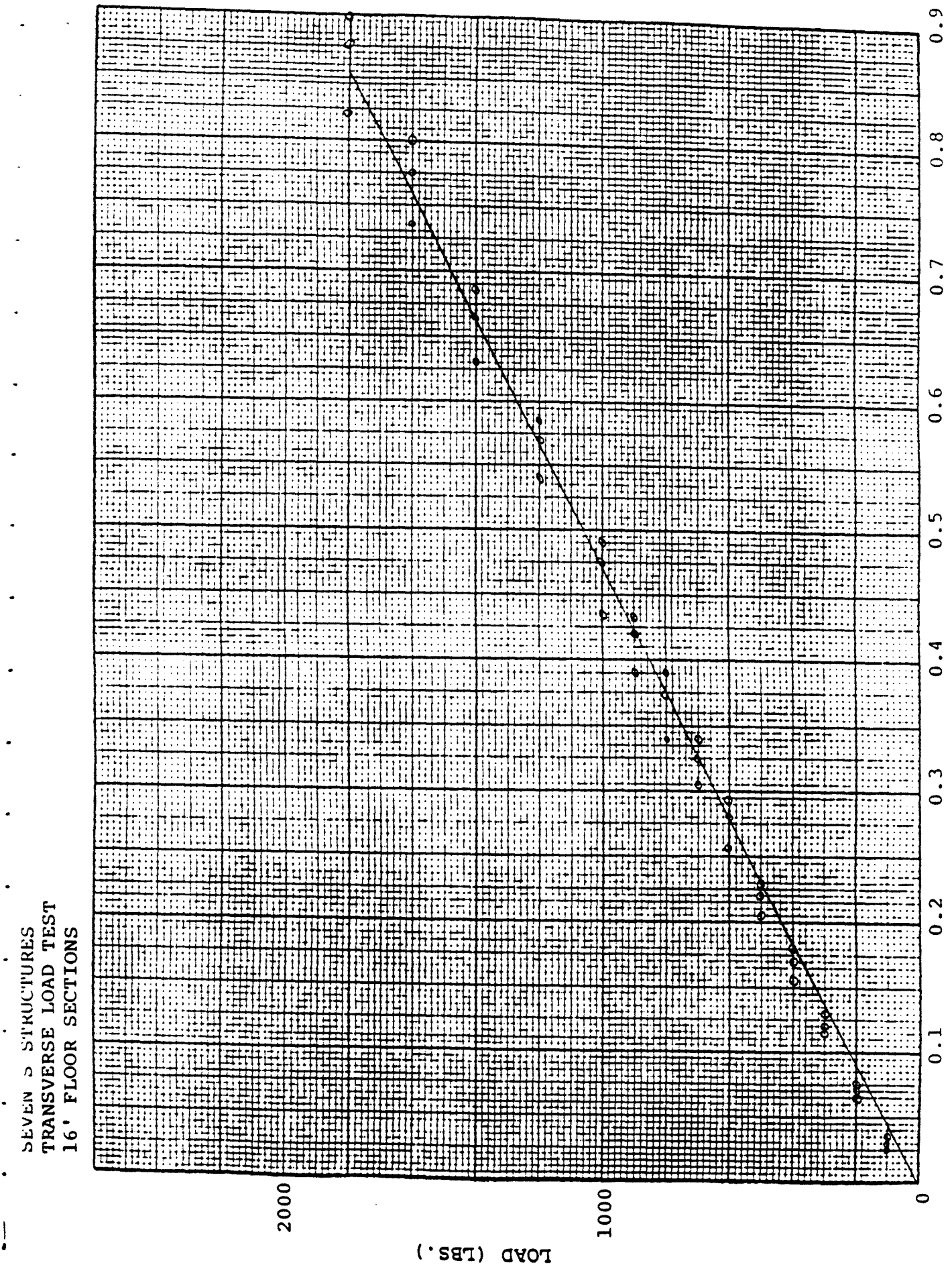

TRANSVERSE LOAD TEST
8' WALL SECTION
LOAD (LBS.)
2000
1000
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
Deflection (INS.)

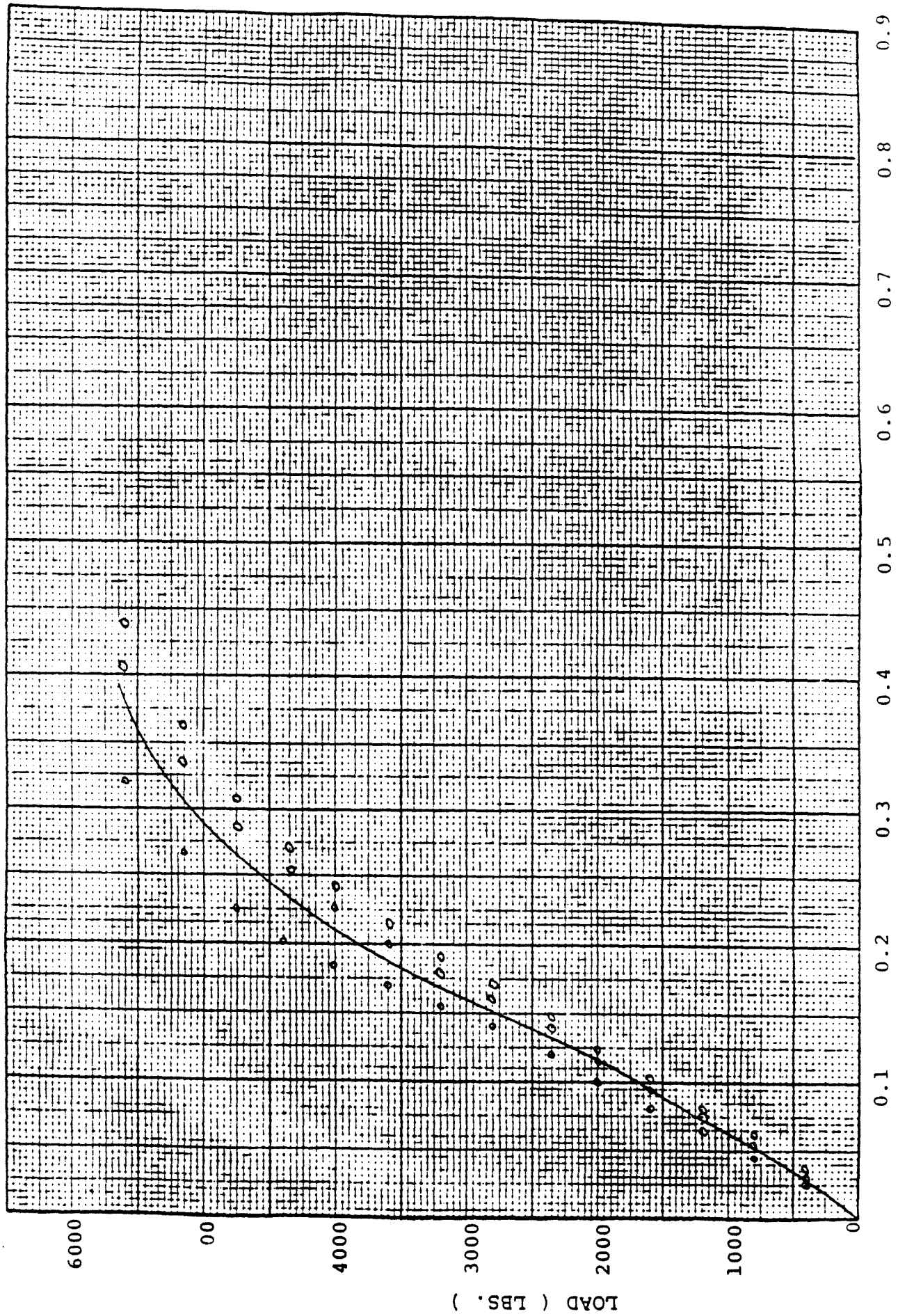

SEVEN S STRUCTURES
COMPRESSIVE AXIAL LOAD
4' x 8' WALL SECTION
LOAD (LBS.)
24000
20000
16000
12000
8000
4000
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
DEFLECTION (INS.)


TRANSVERSE LOAD TEST
16' ROOF SECTIONS
LOAD (LBS.)
2000
1000
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
Deflection (INS.)

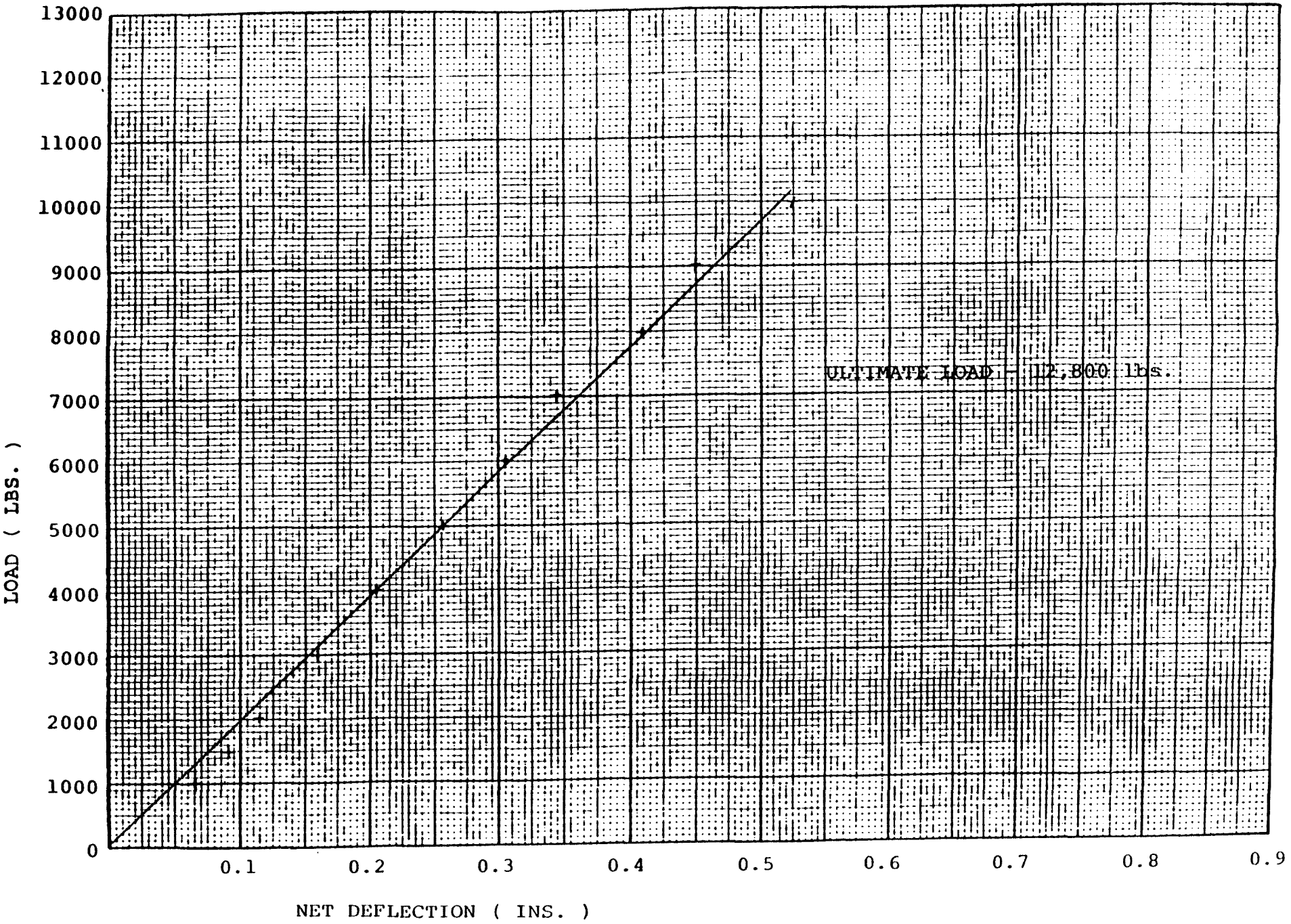
SEVEN S STRUCTURES
TRANSVERSE LOAD TEST
8' ROOF SECTIONS



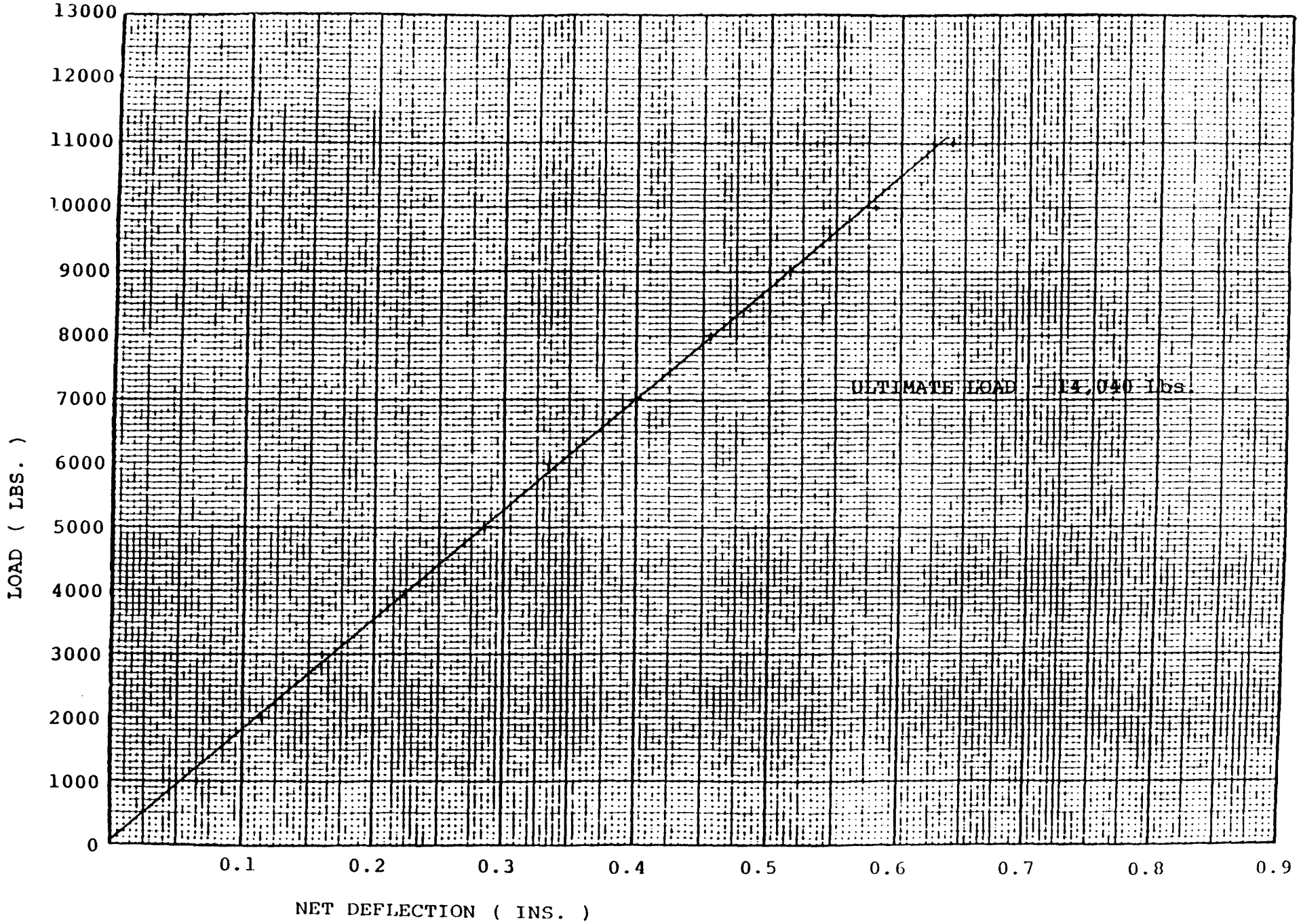

SEVEN 5 STRUCTURES
TRANSVERSE LOAD TEST
16' FLOOR SECTIONS
LOAD (LBS.)
2000
1000
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
Deflection (INS.)

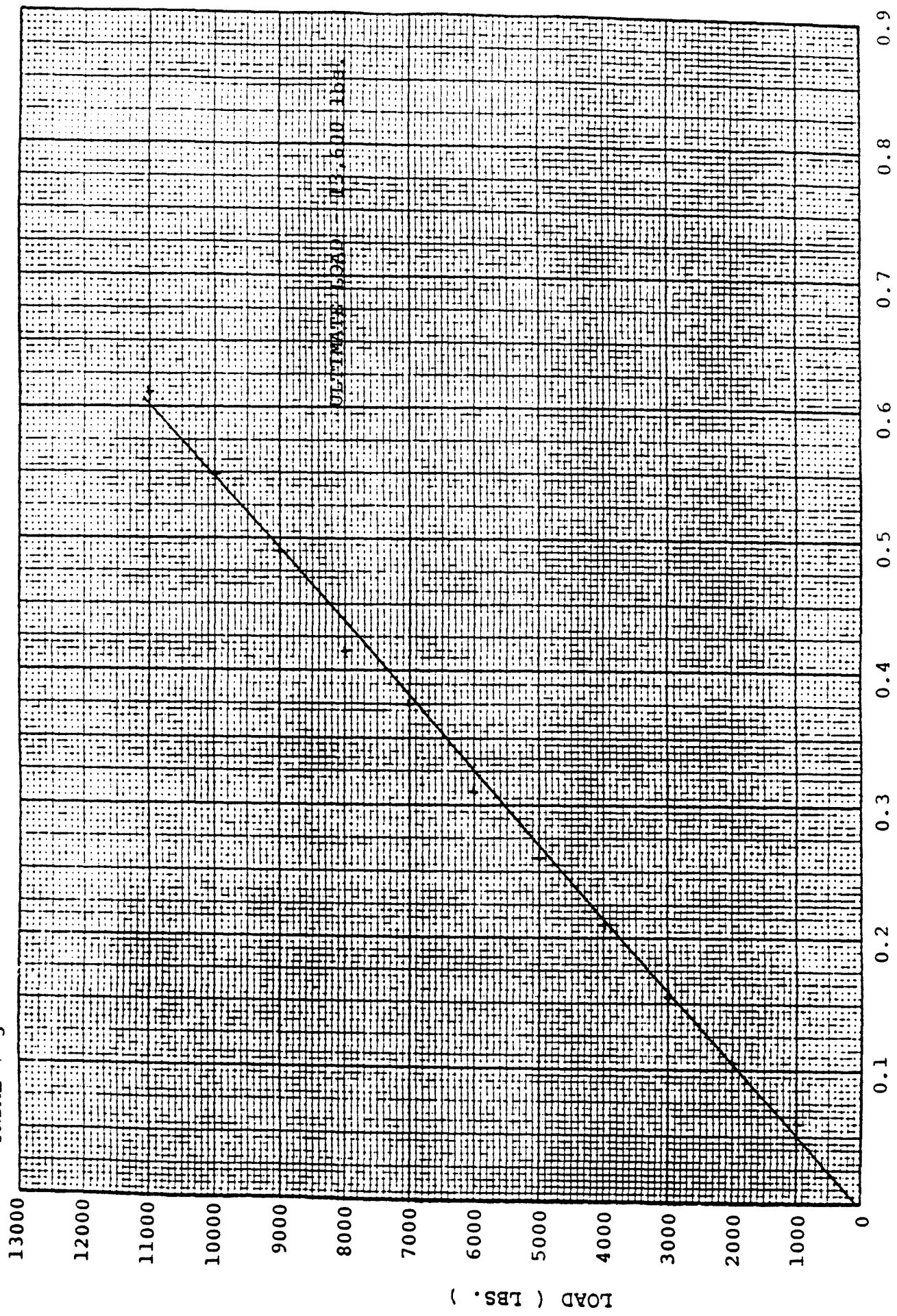

SEVEN S STRUCTURES
TRANSVERSE LOAD TEST
8' FLOOR SECTIONS
LOAD (LBS.)
6000
00
4000
3000
2000
1000
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
DEFLECTION (INS.)

SEVEN S STRUCTURES
8' x 8' WALL - RACKING SHEAR
TRIAL # 1



SEVEN S STRUCTURES
8' x 8' WALL - RACKING SHEAR
TRIAL # 2




SEVEN S STRUCTURES
8' x 8' WALL - RACKING SHEAR
TRIAL # 3
ULTIMATE LOAD = 11,600 lbs.
LOAD (LBS.)
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
NET DEFLECTION (INS.)

APPENDIX "E"

Thermal/Fire Test Results

Warnock Hersey Professional Services Ltd.
211 Schoolhouse Street, Coquitlam, B C V3K 4X9
Tel: (604) 520-3321 Telex 04-351404

STANDARD FIRE ENDURANCE TEST PROGRAM

CONDUCTED ON A

LOAD BEARING WALL WITH EXTERIOR PLASTER FINISH

CLIENT

SEVEN S STRUCTURES INC.
10833 - 97TH AVENUE,
GRAND PRAIRIE, ALBERTA
T8V 4Y9

REPORT PREPARED BY

WARNOCK HERSEY
FIRE LABORATORIES DIVISION
211 SCHOOLHOUSE STREET
COQUITLAM, B.C.
V3K 4X9

REPORT NUMBER: 4550

JOB NUMBER: 50491 C7 516200

DATE TESTED: October 2, 1986

TEST STANDARD: CAN4-S101 & ASTM E119

Warnock Hersey Professional Services Ltd.

PREFACE

This report describes the tests, standards and details of the test specimen as installed for this program.

The report does not imply product certification. Products must bear "WHI certification marks" in order to demonstrate Warnock Hersey certification.

Warnock Hersey Professional Services Ltd.

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- UNEXPOSED	5
THE HOSE STREAM TEST	6
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TABLE 1	
TABLE 2	
FIGURE 1	
FIGURE 2	
FIGURE 3	

Warnock Hersey Professional Services Ltd.

INTRODUCTION

On October 2, 1986 the Fire Laboratories Division of Warnock Hersey conducted a standard fire endurance test on a Load Bearing Wall supplied by Seven S Structures Inc. for a fire resistance rating. Testing was conducted in accordance with CAN4-S101-M82 and ASTM E119-84 Standard Method of Fire Endurance tests of Building Construction and Materials.

TEST INSTALLATION (CONSTRUCTION)

The test portion was assembled from two panels to form a wall 9' - 2 3/4" (2813 mm) high by 14'4" (4368 mm) wide. The larger panel was 8' wide. The smaller panel was 6'4" wide. The wall panels were assembled from studs, top and bottom plates, wall reinforcing and face panels, all of which were cut from various thicknesses of oriented strand board (O.S.B.) A vertical crossection of the wall is shown in Figure 1. The studs as shown in Figure 2 were installed on 24" maximum centers. These components were glued with Phenol Resorcenol from Borden at all joints. In addition the face panels were stapled. These staples were spaced at 3" on the end studs and along the bottom plate, and at 6" along intermediate studs. Three rows of staples spaced at 6" were used on the top header. Single sheets of O.S.B. formed the surface of each panel. The cavities between the studs were filled with polyurethane foamed in place. One surface of the panels was covered with 1/4" (6 mm) of acrylic plaster.

At the joints between the panels the facing extended 1 3/4" (44 mm) beyond the studs. The cavity at the joint was filled with a filler made from polyurethane foam covered on the outer sides with 3/8" (9.5 mm) O.S.B. PL400 caulking was applied to the filler before it was installed in the wall. Each face panel was screwed on 6" centers. The assembly was completed by attaching a 1 3/8" (34.9 mm) O.S.B. plate on the top of the wall with 2 1/2" wallboard screws spaced 24" and placing the wall on a similar plate at the bottom. On the plastered side of the wall the surface was finished with acrylic plaster at the joint. The wall was installed in the furnace with the plastered side exposed to the fire.

THE FIRE TEST

A load of 1500 lbs. per lineal foot was applied to the wall with hydraulic cylinders. This load was maintained throughout the test.

The moveable frame containing the test assembly was secured to the furnace. The pilot burners were ignited and burned until the temperature inside the furnace reached 20 ± 2°C (70 ± 3°F).

All burners were fired and timing was begun immediately upon achieving maximum high fire.

Observations were made throughout the fire exposure period.

The temperature inside the furnace was monitored by twelve uniformly distributed thermocouples. These readings were automatically plotted approximately once every minute. See Figure 3

Deflections were measured across the test assembly at midheight. See Table 2

Temperature on the unexposed surface of the wall were obtained according to the test standard. The temperature rise at each point was calculated. A summary of this data is shown in Table 1.

Warnock Hersey Professional Services Ltd.

FIRE TEST OBSERVATIONS

EXPOSED FACE

MINUTES:SECONDS	DESCRIPTION
1:40	Wall face smoking and starting to burn.
2:20	Full combustion in furnace. Vigorous burning of wall face.
7:00	Plaster coating flaked off and piled on sill.
7:42	Strand board falling off in small pieces.
10:39	Vigorous burning of wall face continues.
11:00	Pieces of strand board continues to drop off wall.
15:00	Fire test stopped.

Warnock Hersey Professional Services Ltd.

FIRE TEST OBSERVATIONS

UNEXPOSED FACE

MINUTES:SECONDS	DESCRIPTION
7:42	Foam "sizzling".
12:17	Smoking at two pin holes in face.
13:50	Burn through at left hand corner.
14:45	Wall is buckling and is unable to support the load. Burn through at several points.
15:00	Fire test discontinued.

THE HOSE STREAM TEST

A Hose Stream test was not conducted because the wall had already failed due to burn through during the fire test.

Warnock Hersey Professional Services Ltd.

CONCLUSIONS

To achieve the minimum rating of 20 minute a wall must not burn through and it must not allow water from the hose stream test to project through it. A load bearing wall must support the load for the rating period of 20 minutes.

This wall had burned through in 9 minutes and at this point would have allowed water to penetrate. At 14 minutes 45 seconds the wall was unable to support the applied load.

Therefore the Load Bearing Wall did not meet the requirements of the CAN4-S101-M82 and ASTM E119-84. test standard.

TESTED BY: G L Marks

G.L. Marks, A.Sc.T.
Fire Laboratories Division

REVIEWED BY: H Grisack

H.A. Grisack, A.Sc.T.
Manager - Western Region
Fire Laboratories Division

HG/lsw 86.11.17

490.D5.PC

Warnock Hersey Professional Services Ltd.

TABLE 1

TEMPERATURE RISE ON UNEXPOSED SURFACE (°C)

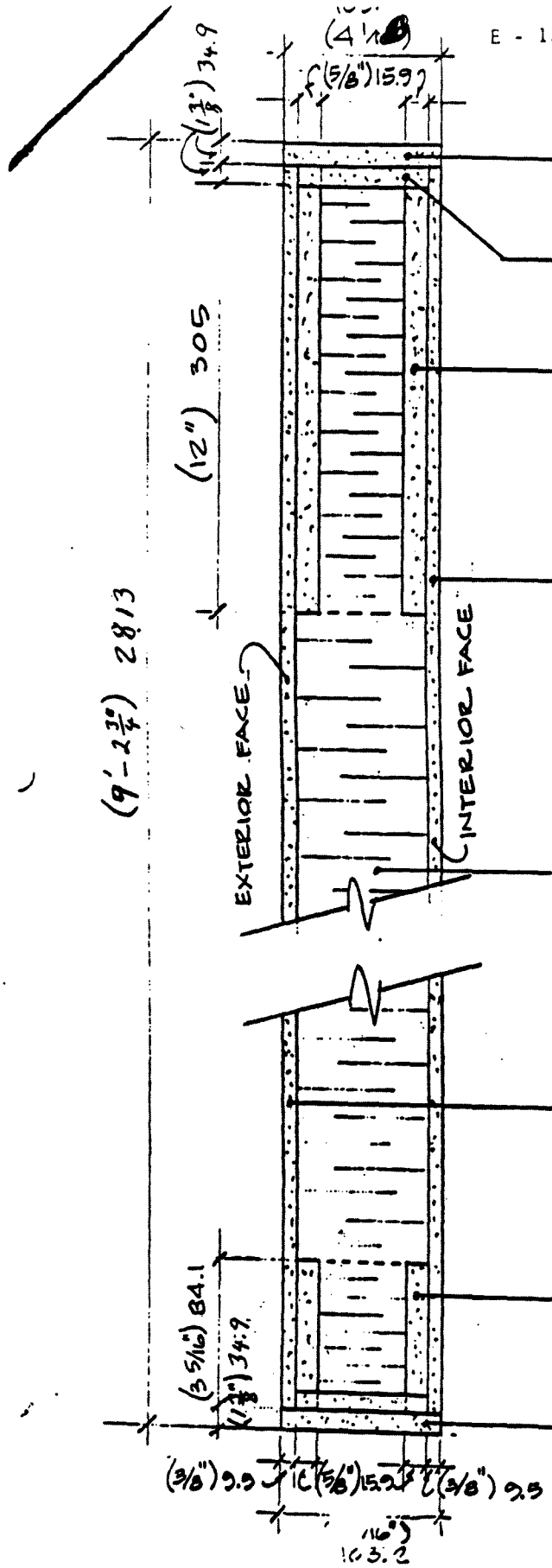
	MINUTES				
Thermocouple	5	11	13	14	15
1	-1	-1	-1	0	1
3	0	-1	-1	0	6
5	-1	-1	-1	19	20
7	-1	-1	27	60	34
9	0	1	0	0	75
11	0	-1	-1	-1	-1
13	-1	-1	-1	11	-
15	-1	-1	-1	0	-
17	0	0	1	6	-

TABLE 2

DEFLECTIONS mm (in)

(- indicates movement away from the furnace chamber)

LOCATION	LOADED	5 minutes	10 minutes
A	-7 (-.27)	-12 (-.47)	-14 (-.55)
B	-5 (-.2)	-13 (-.51)	-22 (-.86)
C	-6 (-.24)	-14 (-.55)	-27 (-1.06)
D	-5 (-.2)	-12 (-.47)	-26 (-1.02)
E	-5 (-.2)	-8 (-.31)	-19 (-.75)
F	- 6 (-.24)	-11 (-.43)	-19 (-.75)
G	- 5 (-.2)	-9 (-.35)	-16 (-.63)
H	- 5 (-.2)	-10 (-.39)	-17 (-.67)



SECOND TOP PLATE
(1 3/8") 34.9 O.S.B.
field installed

FIRST TOP PLATE
(5/8")15.9 O.S.B.
factory installed

STANDARD TOP HEADER
2-(5/8")15.9 O.S.B.
wall skins are glued to header

INTERIOR WALL SKIN
(3/8")9.5 O.S.B.

CANUS LOW WALL PANEL
(3/8")9.5 O.S.B.
(3 5/16")polyurethane core
(3/8")9.5 O.S.B. outer skin

Note: polyurethane is foamed in place after vertical CANUS FOAMSTUDS have been inserted and glued to skins

EXTERIOR WALL SKIN
3/8"9.5 O.S.B.

STANDARD BASE PLATE
2-(5/8")15.9 O.S.B.
wall skins are glued to plate

BOTTOM PLATE
(1 3/8") 34.9 O.S.B. FIELD INSTALLED

FIGURE NO.1
CANUS LOW WALL PANEL (EXTERIOR)
VERTICAL SECTION

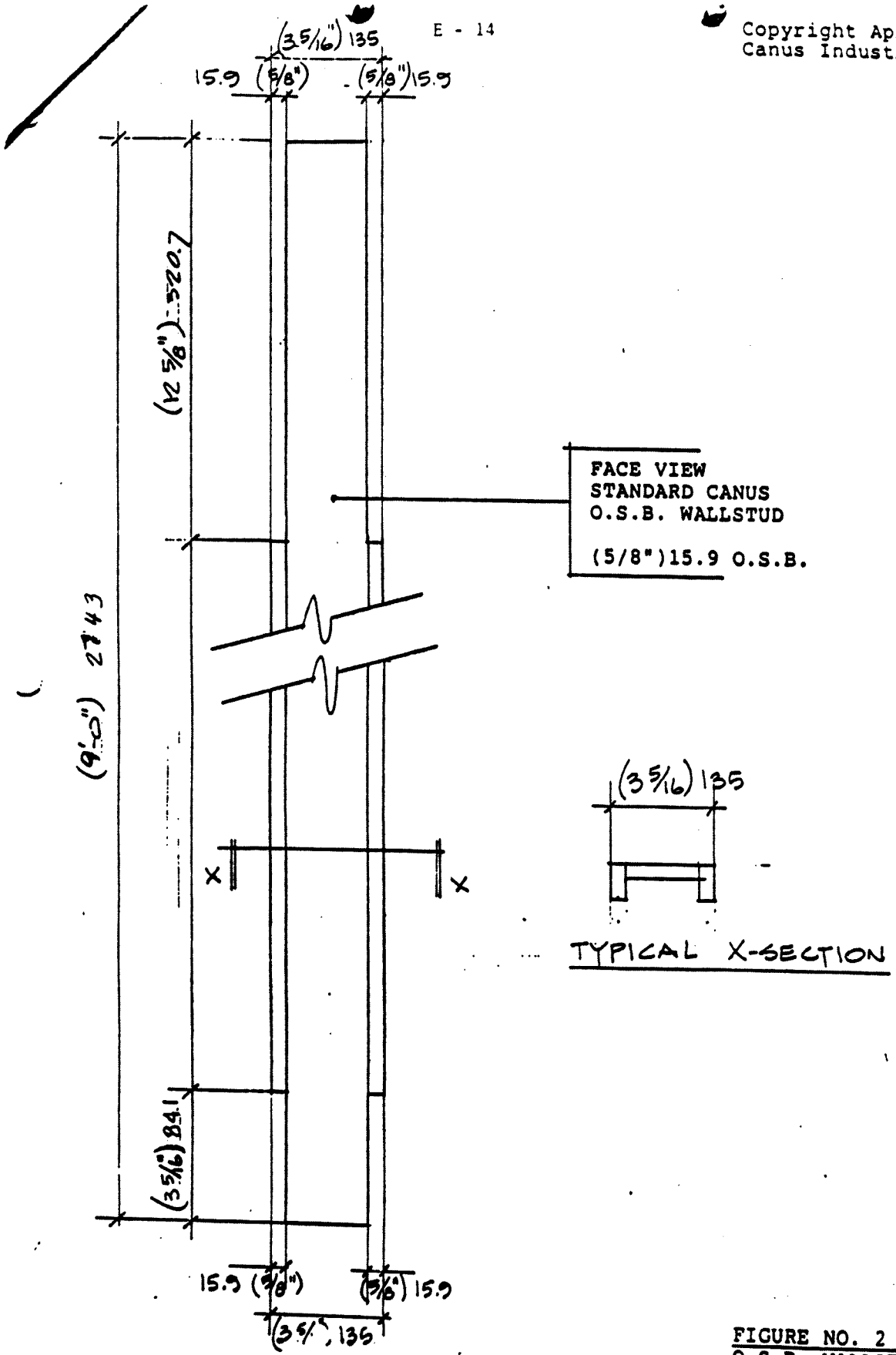
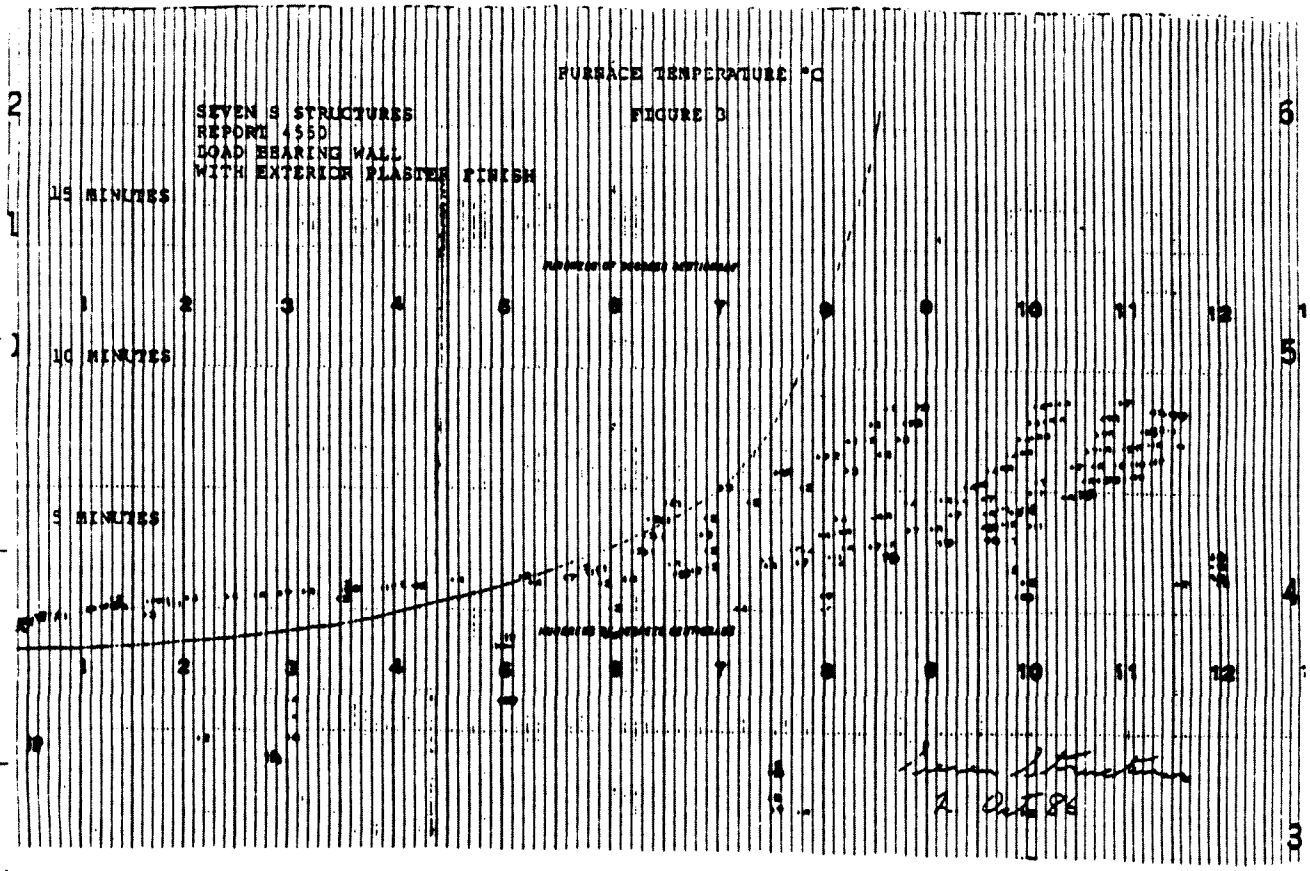


FIGURE NO. 2
O.S.B. WALLSTUD
FACE VIEW


FURNACE TEMPERATURE °C
SEVEN S STRUCTURES
REPORT 455D
LOAD BEARING WALL
WITH EXTERIOR PLASTER FINISH
FIGURE 3
15 MINUTES
10 MINUTES
5 MINUTES

FIRE LABORATORIES DIVISION

Warnock Hersey Professional Services Ltd.
211 Schoolhouse Street, Coquitlam, B.C V3K 4X9
Tel (604) 520-3321 Telex 04-351404

REPORT OF A FLAME SPREAD TEST PROGRAM

CONDUCTED ON

ORIENTED STRAND BOARD WALL PANELS
WITH URETHANE FOAM CORE INSULATION

CLIENT

SEVEN S STRUCTURES
10833 - 97 AVENUE
GRANDE PRAIRIE, ALBERTA
T8V 4Y9

REPORT PREPARED BY

WARNOCK HERSEY
FIRE LABORATORIES DIVISION
211 SCHOOLHOUSE STREET
COQUITLAM, B.C.
V3K 4X9

REPORT NUMBER: 5148

VANCOUVER JOB NUMBER: 50493-C7-514800

DATE TESTED: SEPT 9/86

TEST STANDARDS: CAN4-S102-M83
ASTM-E84-84a

Warnock Hersey Professional Services Ltd.

PREFACE

This report describes the tests, standards and details for the sample of prefabricated walls manufactured by Seven S Structures.

The report does not automatically imply product certification. Products must bear WHI labels in order to demonstrate Warnock Hersey certification.

Warnock Hersey Professional Services Ltd.

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SMOKE DEVELOPED CURVES	

Warnock Hersey Professional Services Ltd.

INTRODUCTION

On September 9, 1986 the Fire Laboratories Division of Warnock Hersey conducted a test program to determine the surface burning characteristics of Seven Structures "Prefabricated Walls".

Testing was conducted in accordance with CAN4 S102 M83 and ASTM E84 "Standard Test Method for Surface Burning Characteristics of Building Materials."

Upon receipt of the samples at the Warnock Hersey laboratory they were placed in the conditioning room where they remained in an atmosphere of 23 $\pm$ 3°C (73.4 $\pm$ 5°F) and 50 $\pm$ 5% relative humidity until they reach a constant weight.

3 trial runs were conducted on the sample.

MATERIAL SPECIFICATIONS

The material tested was selected and submitted by the client. It was constructed with 1/2" pelican mills oriented strand board and 3 1/2" urethane foam core.

TEST PROCEDURE

The results of the test are expressed by three indexes. Each index expresses the characteristics of the sample under test relative to that of select grade red oak flooring and asbestos-cement board.

(A) FLAME SPREAD CLASSIFICATION:

This index relates to the rate of progression of a flame along a sample in the 25 foot tunnel.

A natural gas flame is applied to the front of the sample at the start of the test and drawn along the sample by a draft kept constant for the duration of the test.

An observer notes the progression of the flame front relative to time.

The flame spread classification for red oak flooring is 100, and 0 for asbestos-cement board.

CALCULATIONS:

According to the test standard, the flame spread classification is equal to $\frac{5363}{(195-A_t)}$ when A_t is the total area beneath the spread curve, if this area exceeds 97.5 minute-feet.

If the area beneath the curve is less than or equal to 97.5 minute-feet the classification becomes .564 x A_t.

ASTM E84 Calculations are based on factors of $\frac{4900}{(195-A_t)}$ and 0.515 x A_t.

TEST PROCEDURE Cont'd:

(B) SMOKE DEVELOPED:

A photocell is used to measure the amount of light which is blocked off by the smoke passing down the tunnel duct.

When the smoke from a burning sample blocks the light beam, the output from the photocell decreases. This decrease with time is recorded and compared to the results obtained for red oak which is 100.

CALCULATIONS:

$$\frac{10{,}000 - (\text{smoke integrator reading}) \times 100}{630} = \text{smoke developed}$$

(C) FUEL CONTRIBUTED:

This is a measure of how much heat energy is given off by the burning of the sample in addition to that which is supplied by the natural gas burners.

The air temperature at the vent end of the tunnel is monitored throughout the test and the results are plotted versus time and compared to the results for red oak.

CALCULATIONS:

$$\frac{[1.5 \times (\text{temperature integrator reading})] - 4968 \times 100}{4195.5} = \text{fuel contributed}$$

TEST RESULTS

FLAME SPREAD

The resultant flame spread classifications, is as follows: (rounded to nearest 5)

FLAME SPREAD CLASSIFICATION

Trial #	Area under Time Temperature Curve	F.S.C. (S102)	F.S.C. (E84)
#1	159	154	136
#2	157	144	129
#3	152	127	114
Avg.	156	140	126

SMOKE DEVELOPED

The areas beneath the smoke developed curve and its related classification, is as follows: (rounded to nearest 5)

TRIAL #	AREA UNDER CURVE	SMOKE DEVELOPED
#1	3525	559
#2	2400	380
#3	2900	460
Avg.	2942	465

TEST RESULTS: Cont'd:

FUEL CONTRIBUTED:

The resultant areas under the time/temperature curve and its related classification, is as follows: (rounded to nearest 5)

TRIAL #	AREA UNDER CURVE	FUEL CONTRIBUTED
#1	6363	109
#2	6236	104
#3	5875	91
Avg.	6158	100

CONCLUSIONS

The sample of Oriented Strand Board Structural Panels submitted by Seven Structures exhibited the following flame spread characteristics, when tested in accordance with CAN4 S102 and ASTM E84 Standard for Surface Burning Characteristics of Building Materials.

FLAME SPREAD CLASSIFICATION	SMOKE DEVELOPED	FUEL ** CONTRIBUTED
140	465	100
126	465	100

** This is an apparent value, not a real value

WARNOCK HERSEY

TESTED BY: F. Yasuda

F. Yasuda

REVIEWED BY: H. Grisack

H.A. GRISACK, A.Sc.T.
Manager - Western Region
Fire Laboratories Division

HAG/cw

490.D5.PC

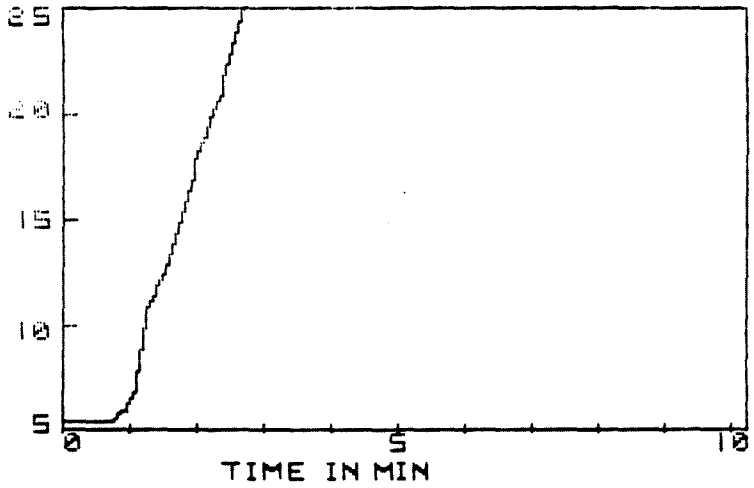
********** WARNOCK HERSEY **********

FLAME SPREAD RESULTS FOR :

SEVEN STRUCTURES

PRODUCT: WALL PANELS / URETHANE CORE
TEST DATE: 09/09/86
TEST STANDARD: CAN4 S102 M83
WORK ORDER: 50493-C7-514800
RUN NUMBER: 1

******* FLAME TRAVEL IN FEET vs TIME IN MINUTES *******



********** TEST RESULTS **********

AREA UNDER TIME TEMPERATURE CURVE 159 FT-MIN

FLAME SPREAD CLASSIFICATION FSC1 154

SMOKE DEVELOPED	559
FUEL CONTRIBUTED	109
MAXIMUM DISTANCE REACHED	25 FT. AT 160 SEC.

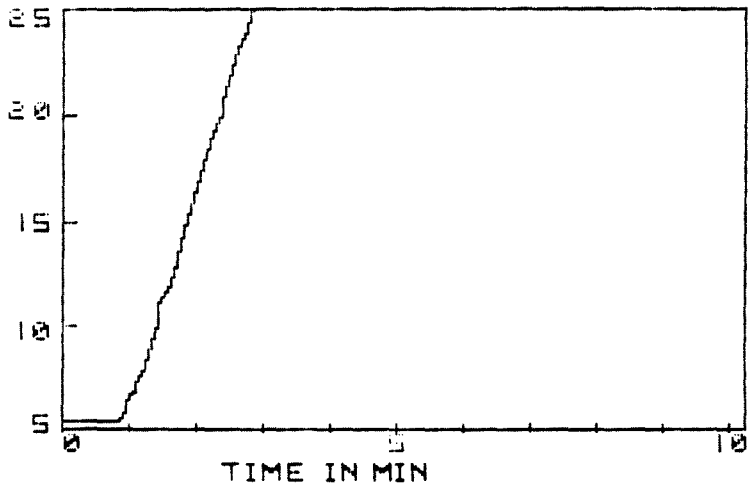
********** WARNOCK HERSEY **********

FLAME SPREAD RESULTS FOR :

SEVEN STRUCTURES

PRODUCT: WALL PANELS / URETHANE CORE
TEST DATE: 09/09/86
TEST STANDARD: CAN4 S102 M83
WORK ORDER: 50493-C7-514800
RUN NUMBER: 2

******* FLAME TRAVEL IN FEET vs TIME IN MINUTES *******



********** TEST RESULTS **********

AREA UNDER TIME TEMPERATURE CURVE 157 FT-MIN

FLAME SPREAD CLASSIFICATION FSC1 144

SMOKE DEVELOPED	380
FUEL CONTRIBUTED	104
MAXIMUM DISTANCE REACHED	25 FT. AT 168 SEC.

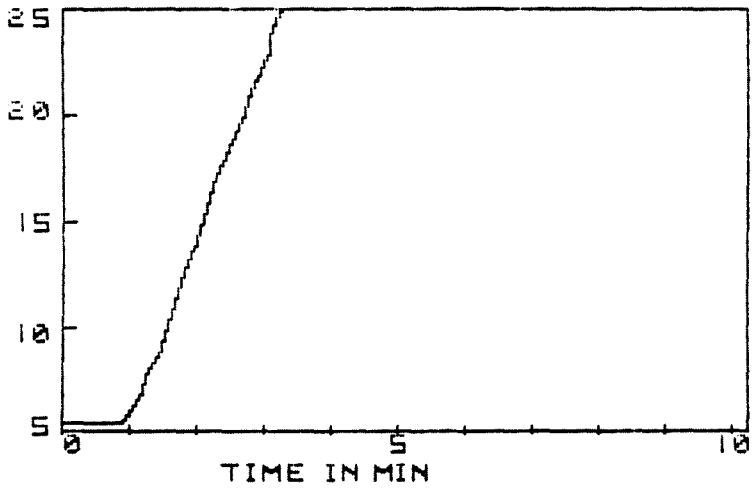
********** WARNOCK HERSEY **********

FLAME SPREAD RESULTS FOR :

SEVEN STRUCTURES

PRODUCT: WALL PANELS / URETHANE CORE
TEST DATE: 09/09/86
TEST STANDARD: CAN4 S102 M83
WORK ORDER: 50493-C7-514800
RUN NUMBER: 3

******* FLAME TRAVEL IN FEET vs TIME IN MINUTES *******

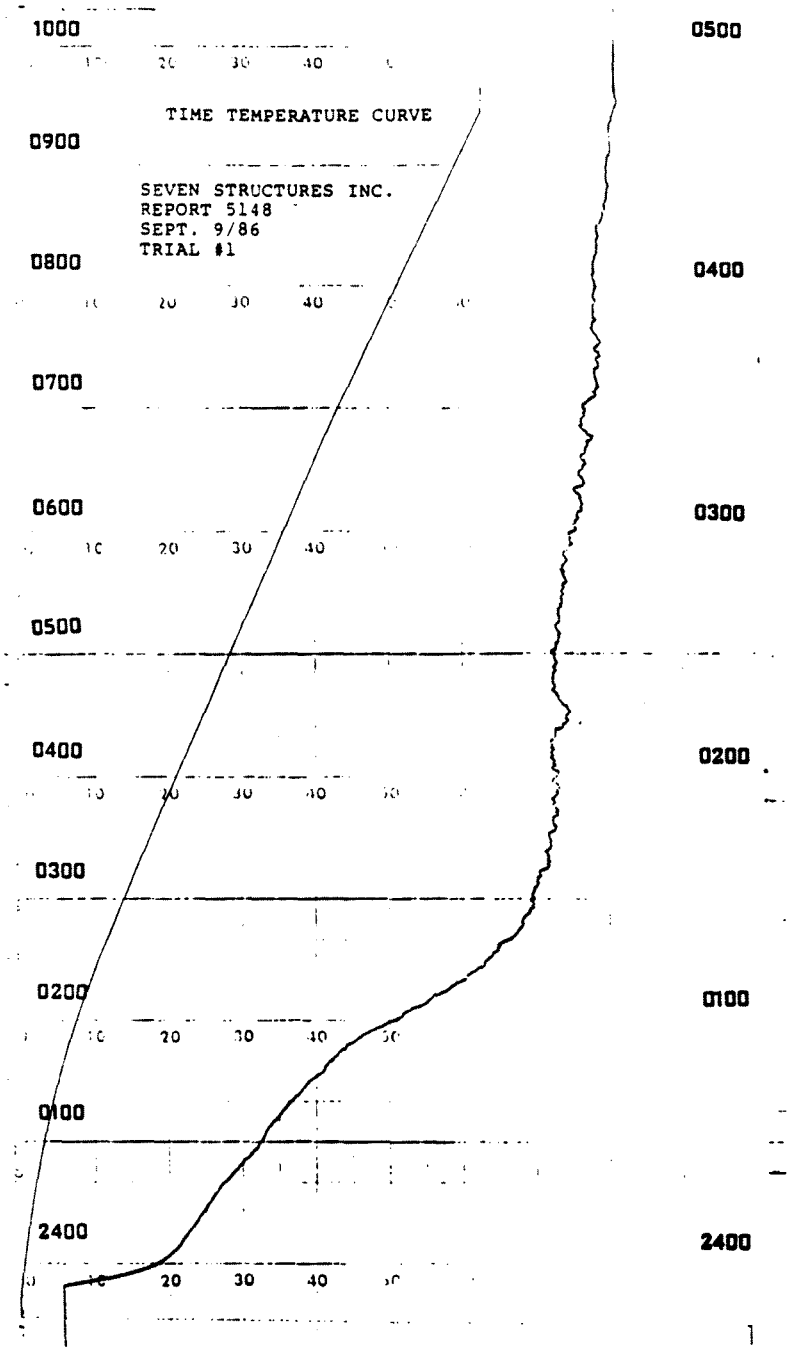


********** TEST RESULTS **********

AREA UNDER TIME TEMPERATURE CURVE 152 FT-MIN

FLAME SPREAD CLASSIFICATION FSC1 127

SMOKE DEVELOPED	460
FUEL CONTRIBUTED	91
MAXIMUM DISTANCE REACHED	25 FT. AT 192 SEC.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SEVEN STRUCTURES INC.
REPORT 5148
SEPT. 9/86
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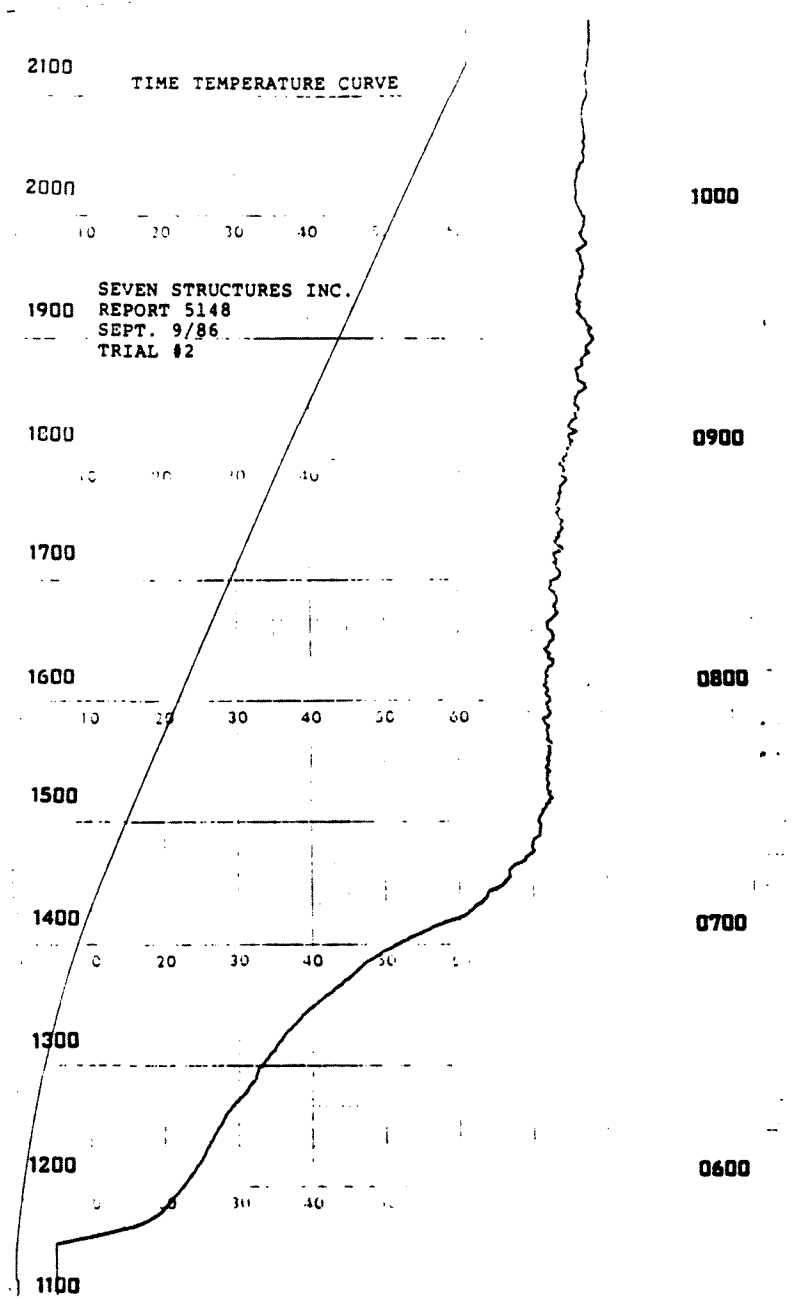
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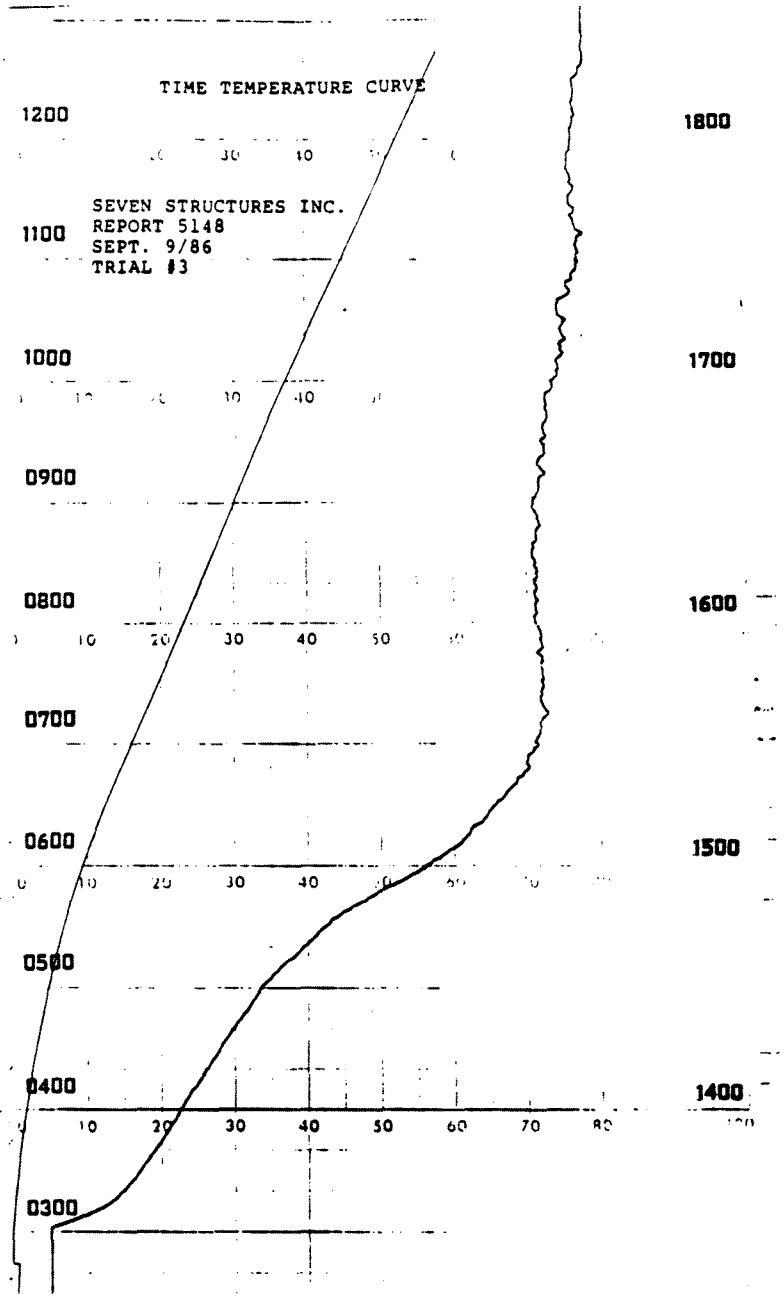
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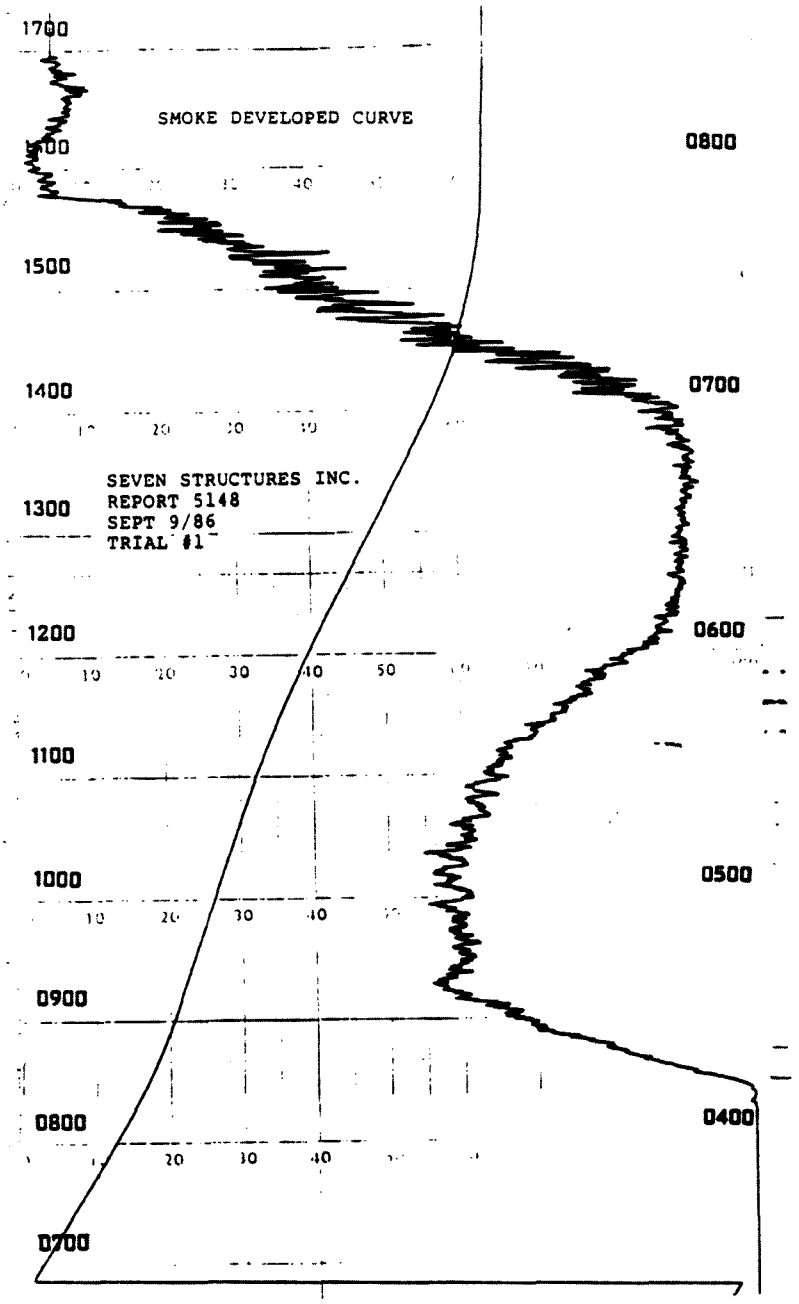
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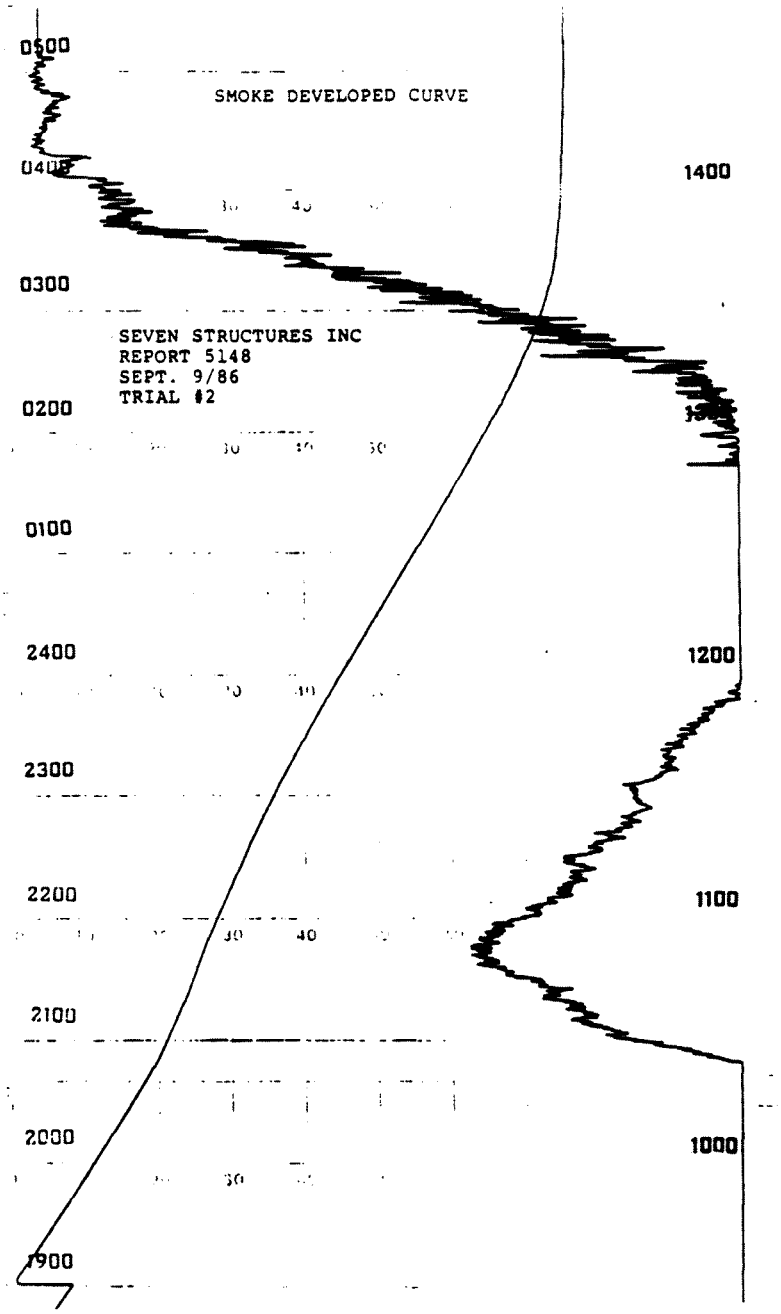
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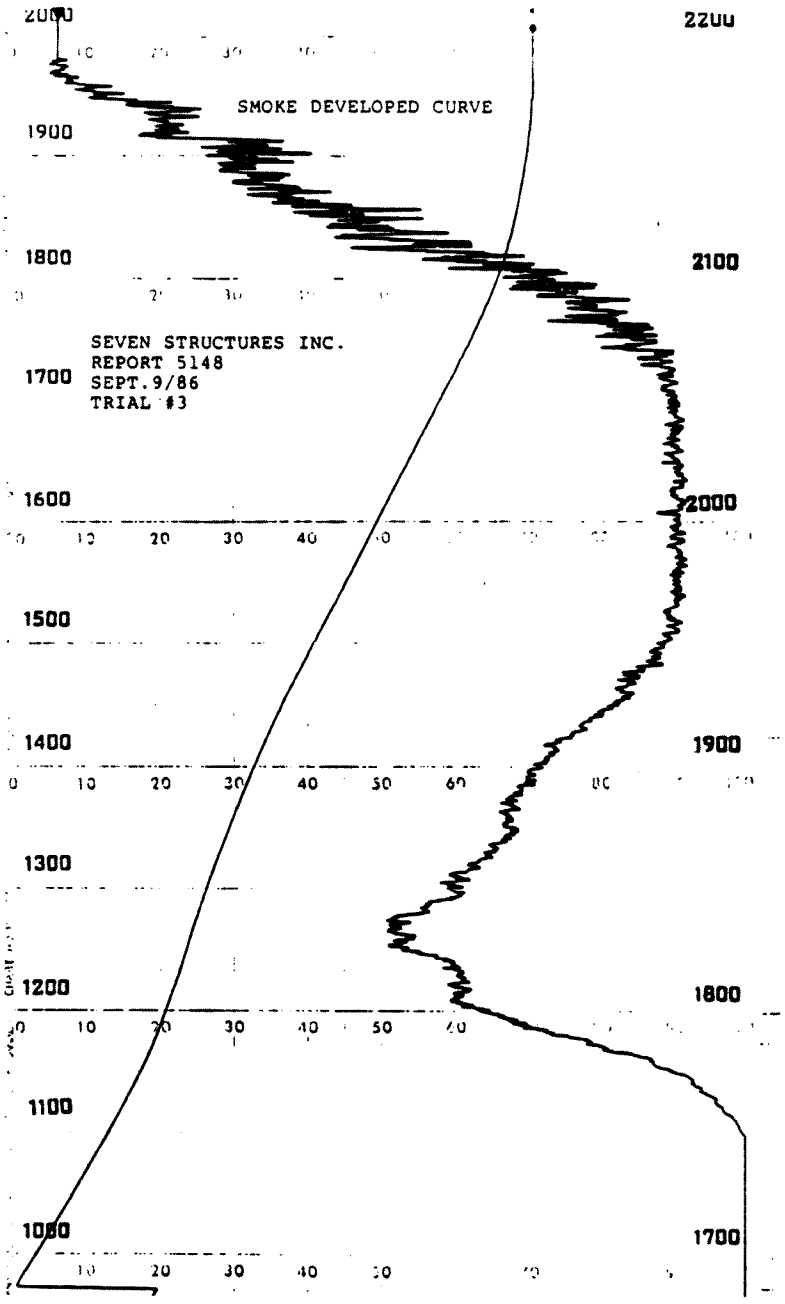
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0 10 20 30 40 50 60
0 10 20 30 40 50 60
0 10 20 30 40

NOV 24 1986

Warnock Hersey Professional Services Ltd.
211 Schoolhouse Street, Coquitlam, B.C. V3K 4X9
Tel: (604) 520-3321 Telex 04-351404

STANDARD FIRE ENDURANCE TEST PROGRAM

CONDUCTED ON A

LOAD BEARING WALL

CLIENT

SEVEN S STRUCTURES INC.
10833 - 97TH AVENUE,
GRAND PRAIRIE, ALBERTA
T8V 4Y9

REPORT PREPARED BY

WARNOCK HERSEY
FIRE LABORATORIES DIVISION
211 SCHOOLHOUSE STREET
COQUITLAM, B.C.
V3K 4X9

REPORT NUMBER: 4550(a)

JOB NUMBER: 50491 C7 516200

DATE TESTED: September 30, 1986

TEST STANDARDS: CAN4-S101 & ASTM E119

Warnock Hersey Professional Services Ltd.

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THE HOSE STREAM TEST	6
CONCLUSION	7
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FIGURE 1	
FIGURE 2	
FIGURE 3	

Warnock Hersey Professional Services Ltd.

PREFACE

This report describes the tests, standards and details of the test specimen as installed for this program.

The report does not imply product certification. Products must bear "WHI certification marks" in order to demonstrate Warnock Hersey certification.

Warnock Hersey Professional Services Ltd.

Report No. 4550(a) Page 1

INTRODUCTION

On September 30, 1986 the Fire Laboratories Division of Warnock Hersey conducted a standard fire endurance test on a Load Bearing Wall supplied by Seven S Structures Inc. for a fire resistance rating. Testing was conducted in accordance with CAN4-S101-M82 and ASTM E119-84 Standard Method of Fire Endurance tests of Building Construction and Materials.

TEST INSTALLATION (CONSTRUCTION)

The test portion was assembled from two panels to form a wall 9' - 2 3/4" (2813 mm) high by 14' - 4" (4368 mm) wide. The larger panel was 8' wide. The smaller panel was 6'4" wide. The wall panels were assembled from studs, top and bottom plates, wall reinforcing and face panels, all of which were cut from various thicknesses of oriented strand board (O.S.B.) A vertical crossection of the wall is shown in Figure 1. The studs as shown in Figure 2 were installed on 24" maximum centers. These components were glued with Phenol Resorcenol from Borden at all joints. In addition the face panels were stapled. These staples were spaced at 3" on the end studs and along the bottom plate, and at 6" along intermediate studs. Three rows of staples spaced at 6" were used on the top header. Single sheets of O.S.B. formed the surface of each panel. The cavities between the studs were filled with polyurethane foamed in place.

At the joints between the panels the facing extended 1 3/4" (44 mm) beyond the studs. The cavity at the joint was filled with a filler made from polyurethane foam covered on the outer sides with 3/8" (9.5 mm) O.S.B. PL400 caulking was applied to the filler before it was installed in the wall. Each face panel was screwed on 6" centers. The assembly was completed by attaching a 1 3/8" (34.9 mm) O.S.B. plate on the top of the wall with 2 1/2" wallboard screws spaced 24" and placing the wall on a similar plate at the bottom.

THE FIRE TEST

A load of 1500 lbs. per lineal foot was applied to the wall with hydraulic cylinders. This load was maintained throughout the test.

The moveable frame containing the test assembly was secured to the furnace. The pilot burners were ignited and burned until the temperature inside the furnace reached 20 ± 2°C (70 ± 3°F).

All burners were fired and timing was begun immediately upon achieving maximum high fire.

Observations were made throughout the fire exposure period.

The temperature inside the furnace was monitored by twelve uniformly distributed thermocouples. These readings were automatically plotted approximately once every minute. See Figure 3

Deflections were measured across the test assembly at midheight. See Table 2

Temperature on the unexposed surface of the wall were obtained according to the test standard. The temperature rise at each point was calculated. A summary of this data is shown in Table 1.

Warnock Hersey Professional Services Ltd.

FIRE TEST OBSERVATIONS

EXPOSED FACE

MINUTES:SECONDS	DESCRIPTION
1:10	Face ignited. Furnace filled with orange flame.
6:60	Foam burning. Furnace still filled with orange flame.
7:40	Pieces of strand board flaking off the samples.

FIRE TEST OBSERVATIONS

UNEXPOSED FACE

MINUTES:SECONDS	DESCRIPTION
9:00	Smoke venting from pin holes in face.
10:20	Ignition of unexposed face at various locations. The wall buckled and the load was released.

THE HOSE STREAM TEST

A Hose Stream test was not conducted because the wall had already failed due to burn through during the fire test.

Warnock Hersey Professional Services Ltd.

CONCLUSIONS

To achieve the minimum rating of 20 minutes a wall must not burn through and it must not allow water from the hose stream test to project through it. A load bearing wall must support the load for the rating period of 20 minutes.

This wall had burned through in 9 minutes and at this point would have allowed water to penetrate. At 10 minutes 20 seconds the wall was unable to support the applied load.

Therefore the Load Bearing Wall did not meet the requirements of the CAN4-S101-M82 and ASTM E119-84 test standards.

TESTED BY: _____

G.L. Marks, A.Sc.T.
Fire Laboratories Division

REVIEWED BY: _____

H.A. Grisack, A.Sc.T.
Manager - Western Region
Fire Laboratories Division

HG/lsw 86.11.17

490.D5.PC

TABLE 1

TEMPERATURE RISE ON UNEXPOSED SURFACE 'C

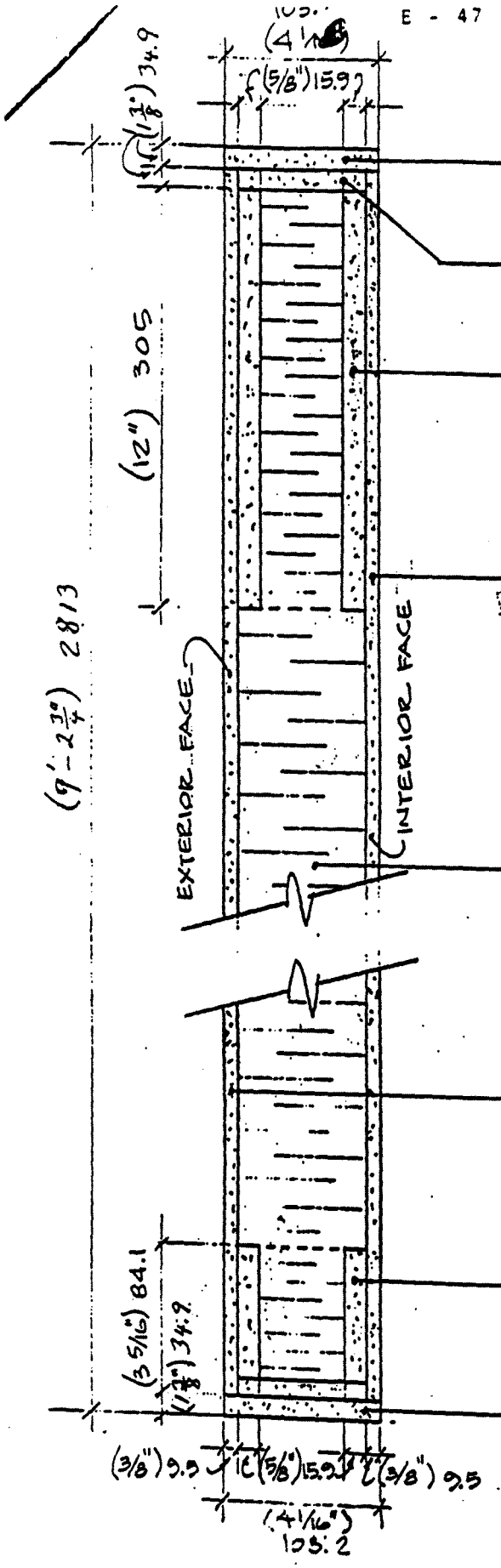
Thermocouple	MINUTES 1	5	8
3	0	0	0
4	0	0	0
5	0	0	0
8	0	0	0
10	0	0	0
13	0	0	0
14	0	0	0
15	0	0	0
17	0	0	0

TABLE 2

DEFLECTIONS mm (in)

(- indicates movement away from the furnace chamber)

LOCATION	LOADED	5 minutes	8 minutes
A	-1 (0)	-14 (-.55)	-16 (-.63)
B	-2 (-.1)	-19 (-.75)	-27 (-1.06)
C	0 (0)	-20 (-.79)	-28 (-1.1)
D	-5 (-.2)	-26(-1.02)	-30 (-1.18)
E	-2 (-.1)	-	-
F	- 3 (-.12)	-	-28 (-1.1)
G	- 1 (0)	-19 (-.75)	-27 (-1.06)
H	- 2 (-.1)	-13 (-.51)	-18 (-.71)



SECOND TOP PLATE
(1 3/8") 34.9 O.S.B.
field installed

FIRST TOP PLATE
(5/8")15.9 O.S.B.
factory installed

STANDARD TOP HEADER
2-(5/8")15.9 O.S.B.
wall skins are glued to header

INTERIOR WALL SKIN
(3/8")9.5 O.S.B.

CANUS LOW WALL PANEL
(3/8")9.5 O.S.B.
(3 5/16")polyurethane core
(3/8")9.5 O.S.B. outer skin

Note: polyurethane is foamed in place after vertical CANUS FOAMSTUDS have been inserted and glued to skins

EXTERIOR WALL SKIN
3/8"9.5 O.S.B.

STANDARD BASE PLATE
2-(5/8")15.9 O.S.B.
wall skins are glued to plate

BOTTOM PLATE
(1 3/8") 34.9 O.S.B. FIELD INSTALLED

FIGURE NO.1
CANUS LOW WALL PANEL (EXTERIOR)
VERTICAL SECTION

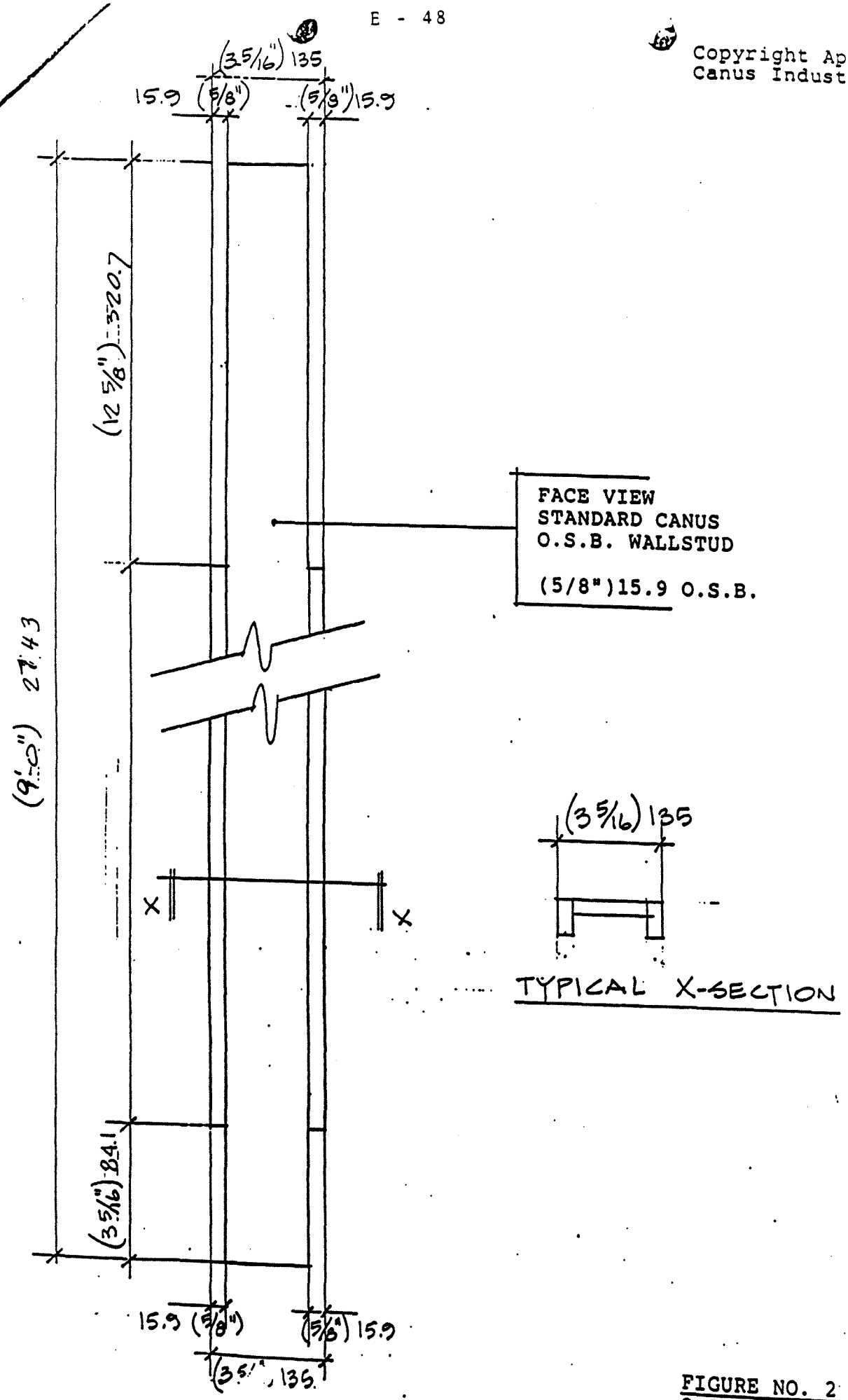
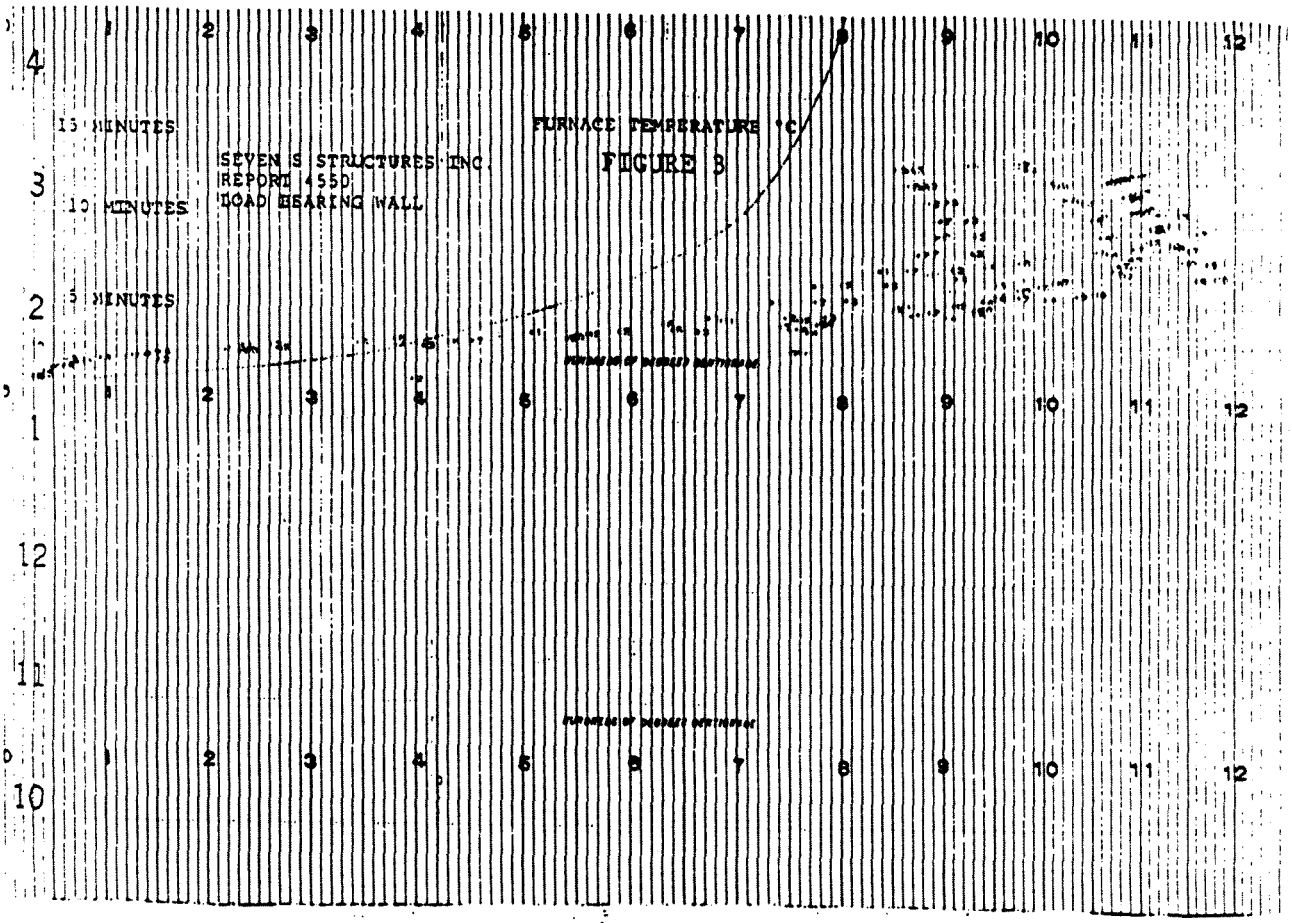


FIGURE NO. 2
O.S.B. WALLSTUD
FACE VIEW


15 MINUTES
10 MINUTES
5 MINUTES
SEVEN S STRUCTURES INC.
REPORT 4550
LOAD BEARING WALL
FURNACE TEMPERATURE °C
FIGURE 3

APPENDIX "F"

C.M.H.C. Building Evaluation Report Technical Requirements

BUILDING MATERIALS EVALUATION REPORTS
TECHNICAL REQUIREMENTS

1. Standards

The materials of Diaphragms - Stressed Skin Panels must meet the requirements of the following standards to be eligible for an evaluation.

(A) Plywood shall conform to one of the following:

CSA 0115-1967, "Hardwood Plywood";
CSA 0121-M 1978, "Douglas Fir Plywood";
CSA 0151-M 1978, "Canadian Softwood Plywood"; or
CSA 0153-M 1980, "Poplar Plywood".

(B) Insulating materials shall conform to the following:

CSA A101-M 1977, "Mineral Fibre Thermal Building Insulation";
CSA A247-M 1978, "Insulating Fibreboard";
CGSB 51-GP-20M (1978), "Thermal Insulation, Expanded Polystyrene"; or
CGSB 51-GP-21M (1978), "Thermal Insulation, Urethane and Isocyanurate, Unfaced".

(C) Adhesives shall conform to:

CSA 0112-M Series 1977, "CSA Standards for Wood Adhesives"

We recommend that the adhesive is a plastic resin or a phenol formaldehydes which is a waterproof structural adhesive.

(D) Lumber:

Lumber shall be identified by a grade stamp to indicate its grade as determined by the 1978 NLGA Grading Rules for Canadian lumber. The moisture content shall be not greater than 19% at the time of installation.

The stressed skin panels as a system have to undergo the following appropriate tests.

(1) Strength tests in accordance to ASTM E72-80 "Standard Methods of Conducting Strength Tests of Panels for Building Construction".

BUILDING MATERIALS EVALUATION REPORTS
TECHNICAL REQUIREMENTS

(2) Test for Fire Resistance Rating and Sound Transmission Class Rating if the Diaphragms Stressed Skin Panels are installed in a location where certain ratings are required in the National Building Code of Canada 1980 and Residential Standards 1980. The Sound Control can be tested to ASTM E90-75, "Laboratory Measurement of Airborne - Sound Transmission Loss of Building Partitions", or ASTM E336-77, "Measurements of Airborne Sound Insulation in Buildings". The fire resistance rating has to be tested to ULC-S101-1977 "Standard Methods of Fire Endurance Test of Building and Materials".

These standards may be purchased from:

Canadian General Standards Board
c/o Supply and Services Canada
Place du Portage, Phase III, 2B3
11 Laurier Street
Hull, Québec
K1A 0S5

The Canadian Standards Association
Standards Sales
178 Rexdale Boulevard
Rexdale, Ontario
M9W 1R3

American Society for Testing Materials
1916 Race Street
Philadephia, Pennsylvannia
19103

2. Laboratory Testing

Testing, which is at the expense of the manufacturer, must be conducted in Canada by a recognized independent testing agency.

(1) Sound Control

Sound transmission class ratings must be determined at the facilities of:

Division of Building Research
National Research Council of Canada
Montreal Road
Ottawa, Ontario
K1A 0R6

BUILDING MATERIALS EVALUATION REPORTS
TECHNICAL REQUIREMENTS

(2) Fire Control

Fire resistance ratings must be conducted by:

Underwriters Laboratories of Canada
7 Crouse Road
Scarborough, Ontario
M1R 3A9

or

Speakman Centre for Materials Evaluation
2395 Speakman Drive
Sheridan Park Research Community
Mississauga, Ontario
Canada
L5K 1B3

or

Warnock Hersey Professional Services Ltd.
3210 American Drive
Mississauga, Ontario
L4V 1B3

(3) Remaining Test

The remaining tests must be conducted by the Speakman Centre for Materials Evaluation or Warnock Hersey Professional Services Ltd.

Proponents should contact the testing laboratories in order to obtain information regarding fees and samples required for testing. The manufacturers must authorize the laboratories to send copies of test reports directly to CMHC.

3. Submission Package

(a) **A completed form, "Application for Building Material Evaluation Report".**

(b) **Confirmation that the proponent is an authorized representative of a legally constituted company.**

BUILDING MATERIALS EVALUATION REPORTS
APPLICATION PROCEDURES

Evaluation Reports may be withdrawn if, in the opinion of the Materials Evaluation Department, the level of performance, in-situ, of the product is unsatisfactory or if the proponent fails to fulfill his obligations as set out in these documents.

8. Canada Mortgage and Housing Corporation reserves, to itself, its copyright with respect to Evaluation Reports except that the proponent of a product holding a valid Evaluation Report may reproduce the Report for his own purposes, providing the report is reproduced in its entirety without alteration. Alternatively, the proponent may refer to the Evaluation Report using the following phrase: "See CMHC Evaluation Report No. ( )."

9. In keeping with the Canadian Construction Industry's intention to convert to the metric system of measurement, Evaluation Reports will be published using metric units. Imperial equivalents will be shown in a secondary position if requested by the proponent.
To facilitate the evaluation process, data should be presented using metric units of measurement.

APPENDIX "G"

L.C.B.O. Acceptance Criteria for Sandwich Panels

L.C.B.O. Quality Control Manual Requirements

International Conference of Building Officials
Research Committee

ACCEPTANCE CRITERIA FOR SANDWICH PANELS

April, 1977

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1. SCOPE: The intent of this Criteria is to provide uniform acceptance criteria for sandwich panel construction except where specifically regulated by the Uniform Building Code. Alternate procedures which comply with the intent of this Criteria will be considered.

1.1 Panel Justification Options:

1.1.1 Panels may be justified by load tests as described in Paragraph 4. Justification by this method limits their use to sizes and materials used in the tests. Allowable loads determined may be used for shorter spans or heights but extrapolation is not permitted.

1.1.2 Panels may be justified by a rational analysis based on allowable stresses developed as described in Paragraph 5.

1.2 All testing must be done by an approved testing agency. Tests may be conducted by the proponent provided all phases are monitored by a qualified independent observer, with no financial interest, as determined by the Research Committee prior to testing.

1.2.1 Testing procedures must include proper justification that test specimens comply with specifications submitted as a part of the research report application. Fabrication must be observed by a qualified representative of the testing agency.

1.2.2 Test reports must be complete, including panel description, test set-ups, manner of testing, observations, all test readings, etc. Test summaries are not acceptable.

1.3 Factors of Safety:

1.3.1 Factors of safety are set forth in subsequent sections and are based on the materials involved, test procedure, panel deformation, and variation of results.

1.3.2 Allowable values developed under Paragraph 1.3.1 are not subject to increases due to duration of loading unless specifically allowed. This includes wind and seismic forces.

1.3.3 Where loading conditions result in several modes of related stressing, the sum of the ratios of actual loads over allowable loads shall not exceed one. Wind on a bearing wall is one example of requiring this consideration.

1.4 Supplementary information may be included in the research report, provided it relates to the Uniform Building Code and is properly justified. This includes sound transmission insulation as specified in Chapter 35 of the Uniform Building Code Appendix and thermal transmission data.

2. PANEL DESCRIPTION: The panel description is to include the following information:

2.1 Thickness, width and length for each panel type.

2.2 Panel Facing Material:

2.2.1 The material must be acceptable under a current research report, a national product standard, the Uniform Building Code, or be justified to the satisfaction of the Research Committee. The material must be clearly identified to determine compliance.

2.2.2 Panel skins classified as weather-exposed surfaces under Section 424 of the Uniform Building Code must comply as a weather-resistive barrier.

2.2.3 Panel skins subject to axial or racking shear loads must have approved values for fasteners. Where no values are recognized by the Research Committee, fastener tests must be conducted for both shear and nail-head pull-through at the minimum edge distances contemplated. Allowable values for fasteners may control allowable panel loads when they are more restrictive than the panel test values. Specimens shall be conditioned and, where skins are subject to wetting, shall be additionally tested in that manner. Sections 41 through 67 of ASTM D-1037 serve as a guide for test procedures which must be approved prior to testing.

5360 SO. WORKMAN MILL ROAD • WHITTIER, CALIFORNIA 90601 • (213) 699-0541

2.2.4 Panel facings must have flame spread and smoke density as specified in Section 4202 (b) and Section 5202 of the Code. When these characteristics are affected by the core material of the panel, the combined section shall be tested when deemed necessary by the Research Committee.

2.3 Panel Cores:

2.3.1 Honeycomb specifications are to include a detailed description or illustration noting the thickness, cell size, kraft paper weight or metal thickness, direction of the paper or metal ribbon, percent impregnation of materials, etc.

2.3.2 Foamed plastic specifcations are to include the density, thickness, whether it is a preformed slab, frothed or expanded, foam manufacturer and the type, catalog number, etc. The position of the panel during the frothing or pouring operation is to be specified.

2.3.3 Other core materials with specifications and descriptions will be considered.

2.3.4 Any adhesives used must comply with U.B.C. Standard No. 25-19 or the Research Committee Standard for Sandwich Panel Adhesives. Adhesive specifications are to include the type, class, thickness of application, number of coats, assembly instructions, etc.

2.3.5 When the core material does not completely fill the portion between panel facings, voids must be detailed or properly described. Voids formed by honeycomb cells are not regulated by this subsection. The method used to maintain voids during foaming or bonding must be described.

2.3.6 Core materials classified as noncombustible must be justified under Section 415 of the Code. Combustible core materials, including plastic, must have a minimum Class III flame-spread classification and smoke density not exceeding 450 when tested under U.B.C. Standard No. 42-1 in the thickness intended for use.

2.4 Wood plates, splines, studs, blocking, etc., are to have wood species, grades, preservative treatments and maximum moisture contents at time of panel manufacture specified. Lumber must be stress graded or equivalent rated material. Lumber bonded to panel facings with adhesives must have a moisture content not in excess of that recommended by the adhesive manufacturer, between 7 and 16 percent, or not exceeding a difference of 5 percent between the two materials bonded, whichever is more restrictive. Complete cross-sectional details, dimensions and sectional properties of the members are required.

2.5 Connections must be detailed or adequately described. Fasteners must be properly specified including size, length and location.

2.6 Details for door and window openings must be provided to clarify the manner of supporting axial, transverse and/or racking shear loads. This includes the method of resisting wind loads at door and window jambs.

3. MISCELLANEOUS PANEL INFORMATION:

3.1 No substitution of materials is allowed unless approved by the Research Committee.

3.2 Field cutting of wall openings is not allowed unless specific openings or design parameters are approved by the Research Committee.

3.3 Test loads and manner of application of full structures shall be specified by the Research Committee when design parameters for the full structure cannot be readily determined by accepted engineering principles.

3.4 Wall panel facings and top facings of floor and roof panels shall have sufficient strength to resist concentrated loads and prevent damage to the core material under loads to which they may be subjected.

3.5 Plumbing and waste lines may extend at right angles through the wall panels but are not permitted vertically within the core. Lines shall not interrupt splines or panel plates unless specifically approved by the Research Committee.

3.6 Electrical outlet boxes and raceways may be installed in the panels during fabrication at predetermined locations only. Electrical systems are limited to a single 1-inch maximum (outside of diameter) vertical raceway at a minimum of 4 feet on center, which is shop installed with no more than three outlet box openings 4 inches by 4 inches in size. Two ½-inch vertical raceways may be substituted for the single 1-inch raceway provided they are maintained parallel and within 2 inches of each other.

3.6.1 Voids other than those specified in Paragraph 3.6 will be permitted for field or shop installation of electrical wiring provided the voids were in the panels tested. See Paragraph 3.2 for field cut openings.

3.6.2 Where electrical raceways interrupt or reduce the cross section of wall plates, a method of strengthening the plate at that point for both lateral and plate axial loads must be developed, detailed and submitted for evaluation.

3.7 Flashing and other weatherproofing details are required for panel joints, wall openings, etc.

4. PANEL LOAD TEST OPTION:

4.1 In lieu of determining structural and mechanical properties of panel components for rational design purposes, load tests may be conducted to determine reasonable ultimate values to which factors of safety are applied.

4.2 General:

4.2.1 The tests are to be conducted as set forth under Paragraph 1.2.

4.2.2 Except for the impact test, three tests of each type are required with none varying more than 15 percent from the average of the three, unless the lowest test value is used. The average result based on a minimum of five tests may be used regardless of the variations. The results of two tests may be used when the higher value does not exceed the lower value by more than 5 percent and the lower value is used with the required factors of safety.

4.2.3 Where tests are not conducted to failure, the highest load achieved for each test will be assumed as ultimate.

4.2.4 Factors of safety are dependent on the consistency of materials, the range of test results and the load deformation characteristics of the panel. Generally, a minimum factor of safety of three is applied to the ultimate load based on the average of three tests. Lower factors of safety may be assigned to panels or systems employing steel or aluminum having consistent physical properties.

4.2.5 Allowable loads will be limited by established fastener values or deflection limitations if lower than values from panel loading tests.

4.2.6 Splines or stiffeners, when utilized along the edges of the panel in tests, shall be only that portion of the typical construction relative to the panel being tested and not supplemented by adjacent panel spline areas.

4.2.7 Load tests shall be conducted with connection details intended in field installations. The testing agency is to report any variations.

4.3 Transverse Load Tests—Wall Panels:

4.3.1 With the designed wind load imposed, exterior wall panel deflections shall not exceed $L/180$. Positive and negative pressure conditions shall be considered. Wall panels with different facing materials on opposite faces must be tested for loads acting both inwardly and outwardly where there is a question of the most critical direction.

4.3.2 With a 5-pound-per-square-foot horizontal loading imposed, interior wall panel deflections shall not exceed $L/120$ of the span for flexible skin material such as metal, plywood, particleboard and gypsum wallboard. A deflection limitation of $L/240$ of the span is required for brittle skin materials such as plaster.

4.3.3 All wall panels shall be loaded in increments to failure with deflections taken to obtain deflection and set characteristics. Where preloading is applied, the loading, deflection and recovery shall be noted. The amount of preloading shall not exceed 10 percent of the final allowable load unless approved by the Research Committee.

4.3.4 Transverse load tests on panels having window or door openings are required unless subject to rational analysis. Load application must be done in a manner that reflects field loading conditions.

4.4 Axial Load Tests—Wall Panels:

4.4.1 Load-bearing wall panels must support an axial loading applied with an eccentricity of one-sixth the panel thickness to the interior or towards the weaker facing material of an interior panel.

4.4.2 The test panels must have wall sill and cap plate details with connections matching the proposed field installation. Axial loads must be applied uniformly or at the anticipated spacing of the floor or roof framing.

4.4.3 The bottom edges of the panel facing material shall be held at least ¾ inch above the base of the sill plate to insure no direct bearing of the facings against test equipment framing. Panels may be inverted during testing if desired to meet the above loading requirements. If, due to deflection, the ¾-inch panel base clearance is dissipated, the load at this point shall be specified.

4.4.4 Lintel sections shall meet the deflection criteria of Table No. 23-D of the Code.

4.4.5 All wall panels shall be loaded in increments to failure with deflections taken to obtain deflection and set characteristics. Where preloading is applied, the loading, deflection and recovery shall be noted. The amount of preloading shall not exceed 10 percent of the final allowable load unless approved by the Research Committee.

4.5 Racking Shear Tests—Wall Panels:

4.5.1 Racking shear tests in accordance with ASTM E-72, as amended by this Standard, are required for shear walls which resist wind and seismic forces.

4.5.2 The allowable shear load is determined from the racking load at which a net horizontal deflection of ½ inch occurs, the ultimate load divided by a factor of safety determined in accordance with Paragraph 4.2.4, or the allowable fastener loads, whichever is the lower. The test panel must be constructed and installed as intended in the field, including connections. Reference is also made to Paragraph 4.2.6 of this Standard.

In reference to Paragraph 4.5.7, hold-down rods may be used provided allowable net horizontal deflections are reduced to ¼ inch.

4.5.3 The "stop" detailed in the ASTM E-72 procedure for installation against the toe of the test panel should be located in such a manner that reactive forces are imposed against the end of the sill plate and clear of the panel spline and facing material.

4.5.4 The bottom edges of the panel facing material must be held at least ¼ inch above the base of the sill plate to insure against direct vertical bearing or fricitional shear resistance of the facings against test equipment framing. The testing laboratory shall indicate the load at which the ¼-inch panel base clearance from the test frame is dissipated.

4.5.5 The panel top horizontal timber suggested for the test panel in the ASTM E-72 sketch shall not be used. The racking shear load should be applied directly against the typical wall panel top plate member or members that duplicate actual field construction unless otherwise approved.

4.5.6 All wall panels shall be loaded in increments to failure with deflections taken to obtain deflection and set characteristics. Where preloading is applied, the loading, deflection and recovery shall be noted. The amount of preloading shall not exceed 10 percent of the final allowable load unless approved by the Research Committee.

4.5.7 The standard racking shear hold-down rods shall not be used. Panel elements and connections to the base shall resist the uplift forces. See Paragraph 4.5.2 for alternate.

4.6 Impact Tests:

4.6.1 Impact tests shall be conducted when required by the Research Committee.

4.6.2 The tests are to be conducted in accordance with ASTM E-72 Equipment and Principles for "Impact Load Specimen Horizontal" to determine the point at which the panel facing becomes deformed or delaminated from the core material. The test utilizes a 60-pound sand bag drop. Full-size sandwich panels, usually 4 by 8 feet in size, are cut in two, forming two 4- by 4-foot test panels. The half-panels are supported along the two sides and end remaining from the full-size panel, leaving the cut edge unsupported. The test panels are restrained over their supports with a spring-loaded frame to reduce "jump" after impact. The amount of restraint shall be no less than 10 times the weight of the half-panel. The point of impact for both tests shall be the geometric center of the half-panel face, except when a spline or rib occurs at that section. When this occurs, the target shall be moved to impact midway between any splines or ribs.

4.6.3 The 60-pound standard sand bag is dropped from a height of 7 feet a total of four times. The target area is then cut into 12-inch squares, cornered on the middle of the impact area to determine if delamination has occured. The second half-panel is tested and inspected in the same manner. Should no delamination or deformation be found in either panel at the point of impact or elsewhere along the cut edge of the panel, the panel facing is considered satisfactory with the specific core material.

4.6.4 If one of the panels fails, a total of four half-panels shall be tested in the same manner. Three of the four panels shall not delaminate from the facing material to be considered satisfactory.

4.6.5 Impact tests on panels having single or double curvature such as in shells or domes are to be tested with the convex surface upward. The panels shall closely approximate the 4- by 4-foot flat test panel. Longer spans are not permitted due to their greater energy absorption characteristics. Tests shall otherwise be the same as for the flat panels.

4.6.6 Panels having metallic facings which are excessively deformed by the sand bag without rebounding to their original position are considered unsatisfactory.

4.6.7 When there is a question of brittle panel facings, supplementary tests may be necessary, as determined by the Research Committee.

4.7 Transverse Load Tests—Roof and Floor Panels:

4.7.1 Allowable loads for roof and floor panels are determined under Paragraphs 4.2.2 to 4.2.7. Panels shall comply with the deflection requirement of Table No. 23-D of the Code. Additionally, roof panels shall be limited to a maximum deflection of the span divided by 180 when subjected to roof live load or snow load, whichever governs.

4.7.2 Deflection readings are to be taken at mid-span at each edge and the center of the panel. Panels tested over a double span are to have the same three deflection readings taken at the expected maximum deflection point based on analysis.

4.7.3 Roof panels having different facing materials on the same panel are to be tested so each facing material will be in compression and tension. Floor panels or panels tested on a two-span condition need not be tested in both directions.

4.7.4 The "Bag Method," vacuum chamber or a uniform loading of known unit weights shall be used for transverse tests.

4.8 Density-Water Absorption Tests—Foamed Plastic Core Material

4.8.1 The density and water absorption characteristics of foamed-in-place cores are to be determined from the load test panels after completion of tests. The test procedure in ASTM C-272 is to be utilized with the following revisions.

4.8.2 The conditioning temperature of Section 4.1.1 of ASTM C-272 is to be increased to 158 degrees Fahrenheit, plus or minus 2 degrees, in lieu of the specified 122 degrees Fahrenheit.

4.8.3 Representative specimens shall be taken from panels that have been adequately cured. The report shall specify curing procedures. Panels indicating obvious discrepancies in load test results due to insufficient curing shall not be used.

4.8.4 Six specimens shall be taken from a representative panel of each set subjected to the transverse loading test.

4.8.5 The density-water absorption specimens are to be obtained as follows, assuming a 4- by 8-foot panel. The previously tested full size solid panels are cut across the 4-foot dimension 4 to 8 inches from each end and then longitudinally down the middle of the remaining center portion. Three-inch-square samples are cut from each outside quarter point of the end sections and one sample cut from each of the two remaining center portions, totaling six samples from each panel. The samples are to be cut a minimum of 1 inch away from any splines. A sketch is to be included in the laboratory report locating and numbering the location of each specimen.

4.8.6 The 3-inch-square samples are cut to maintain the entire panel thickness including facings. The volumetric dimensions are measured "as received" and after removal of facings in accordance with Paragraph 3 of ASTM C-272. The density and water absorption tests are conducted in accordance with ASTM C-272 with the facing removed. Care must be taken to assure that a minimal core material is removed. Dimensions are taken after the first oven curing and after each conditioning of the absorption tests. After the final oven drying, the specimen dimensions are recorded.

4.8.7 The two-hour immersion linear measurements required by ASTM C-272 may be omitted.

4.8.8 Foam density variations for the different sample locations may not vary by more than 25 percent from any other sample taken from the same panel based on the lower value of the two being compared.

4.8.9 Subsequent density-water absorption tests in conjunction with quality control or re-examinations by the Research Committee must follow the same test procedure as used initially to assure the validity of comparing results.

4.9 Density Tests—Preformed Foamed Plastic Core Material. Panels having preformed foam cores bonded in place with an adhesive are to have density tests conducted in accordance with ASTM C-271. Two samples are to be cut from one of each set of panels subjected to the axial transverse loading and racking shear tests, respectively. The samples are to have the facing material removed, together with any adhesive impregnated core material prior to the density determination. The average density values are to be based on a minimum of six samples. Panels with window and door openings are to have their cores treated in a similar manner.

4.10 Density, shear and other tests for other than foamed plastic cores shall be determined by the Research Committee.

4.11 Substantial differences in coefficients of expansion between core and facing materials require justification that this will not be detrimental to the panel integrity. Testing under ASTM C-393 after aging under Cycle B, ASTM C-481 shall be considered sufficient to determine this quality. Heated dry air shall be increased to 182 degrees Fahrenheit, plus or minus 2 degrees, in Cycle B.

4.12 Substantial differences in temperature between facings of panel with high coefficients of expansion require justification that it will not be detrimental to the panel integrity.

5. PANEL ANALYSIS OPTION:

5.1 To provide flexibility in panel size with minimal full scale panel esting, the characteristics and allowable stresses for each material used in panels may be determined to permit a rational analysis. Supplemental .s on actual panels will be necessary only to verify design assumptions and criteria.

5.2 Each facing material, unless allowable working stresses are established in the Uniform Building Code or are acceptable to the Research Committee, is to have the following characteristics determined by representative tests. Waiver of any of the following characteristics must be with the concurrence of the Research Committee.

5.2.1 Modulus of elasticity (bending).

5.2.2 Tension parallel to surface.

5.2.3 Tension perpendicular to surface.

5.2.4 Modulus of rupture.

5.2.5 Compression parallel to surface.

5.2.6 Shear parallel to surface.

5.2.7 Density.

5.2.8 Shear modulus.

5.2.9 Fastener values in shear and, where applicable, nail- or screw-head pull-through for each facing material as set forth in Paragraph 2.2.3.

5.3 Panel cores shall have the following characteristics established:

5.3.1 Modulus of elasticity (bending).

5.3.2 Tension perpendicular to surface.

5.3.3 Compression perpendicular to surface.

5.3.4 Shear parallel to surface.

5.3.5 Shear modulus (in each direction for honeycomb and foam materials).

5.3.6 Density for foams and related products, core size, weight and degree of impregnation for paper honeycomb or the standard identification specification for aluminum or light gauge steel honeycomb.

5.4 Tests to determine the facing and core characteristics are as follows:

5.4.1 Tension—ASTM C-297, "Tension Test of Flat Sandwich Construction in Flatwise Plane," for core material, and ASTM D-1037, "Evaluating the Properties of Wood Base Fiber and Particle Panel Materials," Sections 20 to 26 and 27 to 32, for facing material.

5.4.2 Compression—ASTM D-1037, "Evaluating the Properties of Wood Base Fiber and Particle Panel Materials," Sections 104 to 110, Procedure 3, for facing material.

5.4.3 Shear and Shear Modulus—ASTM C-273, "Shear Test in Flatwise Plane of Flat Sandwich Construction or Sandwich Cores," for core and facing material by tension tests.

5.4.4 Modulus of Rupture—ASTM C-393, "Flexure Tests of Flat Sandwich Construction," for evaluation of facing materials in sandwich construction.

5.4.5 Density—Paragraph 4.8 for frothed or poured-in-place foams and ASTM C-271, "Density of Core Materials for Structural Sandwich Constructions," for slab-type foams bonded in place in the panels.

5.4.6 Modulus of Elasticity—ASTM C-393, "Flexure Test of Flat Sandwich Constructions," for facing materials in sandwich construction.

5.4.7 Fastener Values—ASTM D-1037, "Evaluating the Properties of Wood-Base Fiber and Particle Panel Materials," Sections 41 to 67.

5.4.8 Compression—ASTM C-365, "Flatwise Compressive Strength of Sandwich Cores," Method "B" for core material.

5.5 Adhesives are to comply with U.B.C. Standard No. 25-19 or the Research Committee Standard for Sandwich Panel Adhesives.

5.6 Racking shear loads must be determined under Paragraph 4.5. Density and water absorption tests on six specimens from one panel in conformance with Section 4.8 are required for foamed panels.

5.7 Coefficients of expansion of core and facing materials shall be investigated as noted in Paragraphs 4.11 and 4.12.

6. ADDITIONAL FABRICATOR QUALIFICATION PROCEDURES: The following procedures are necessary for recognition of supplementary fabricating facilities:

6.1 A qualified representative of an approved testing agency shall select at least three panels at random of each panel core type. The panels are to be permanently identified by the laboratory personnel and shipped to the testing agency facility.

6.2 Each of the three panels selected shall be subjected to a transverse load test in accordance with Section 4.3 or 4.7. The test results shall be no lower than 85 percent of the average original plant transverse test results.

6.3 For foamed-in-place cores, one panel is to be selected for each panel type and six density-water absorption specimens cut from the panel and tested in accordance with Sections 4.8 and 4.9. The density-water absorption test average shall be no lower than 85 percent of the original plant test average nor shall any specimen vary more than 25 percent in density from any other sample taken from the same panel, based on the lowest value.

6.4 The preformed core panel density shall agree with the original core density.

7. PANEL IDENTIFICATION: Panels shall bear the company name, research report number and other information deemed necessary by the Research Committee. The identification must be visible after the panels are erected. Exterior panels must have the exterior face clearly identified.

8. QUALITY CONTROL: Quality control procedures with monitoring inspections by an approved inspection agency shall be developed for each fabrication facility based on the panel construction, application, volume of production, etc. The procedures shall be included in a quality control manual which must be developed jointly by the fabricator and inspection agency. Panel fabrication is not sanctioned until quality control procedures have been approved.

ICBO Evaluation Service, Inc.
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QUALITY CONTROL MANUAL REQUIREMENTS

(Adopted April, 1986)

I. GENERAL:

The quality control manual must be prepared by the manufacturer in consultation with a quality control agency recognized by the ICBOES.

Follow-up inspection frequency must be as specified by the quality control agency but not less than four inspections per year for facilities in operation during the entire year. Consideration of fewer inspections will require the written concurrence of the ICBOES. Since plants employing seasonal production schedules are more exposed to quality control related problems because of the inactive periods, the quality control agency may require supplemental inspections during each start-up period. The supplemental inspections and other special requirements must be specified in the manual.

In administering a quality control program on a product covered by an ICBOES evaluation report, the inspection agency has the responsiblity of taking necessary action in the event of violations. The determination of a major or minor problem of quality control is by the inspection agency, who in turn, must advise the ICBOES in writing of a major violation. The ICBOES defines a major violation as a production discrepancy, contrary to quality control procedures, that presents a potential hazard to the user.

Total control by the inspection agency of identification methods specified in evaluation reports is necessary in order that the quality control agency can better monitor production of the listed item. This requires that the entire process be administered by the agency. Printing of labels may be done by others with the proper control.

II. ADMINISTRATIVE SECTION:

a. Signatures which confer legitimacy to the document. Both the manufacturer and the quality control agency must sign and date the manual.

b. Scope.

c. Table of contents keyed to consecutively numbered pages.

d. Company quality control policies.

e. Organizational charts, resume of key personnel and responsibility pertinent to the quality function for both the manufacturer and the quality control agency.

f. Provision for keeping the manual current, e.g., annual review, revisions, etc.

g. Glossary of terms used where unique to the product or manufacturing process.

h. Name, address and telephone number of the manufacturing facility and individual responsible for supervision of quality control.

i. Frequency of follow-up inspections by the quality control agency including specific details on supplemental inspections for plants employing seasonal production schedules.

j. Identification: Facsimile of identification label and details on label control as noted in Section I.

k. Postmanufacture: Information on packing and storage if deemed necessary for product performance.

l. A statement that ICBOES will be notified in writing prior to cancellation of the inspection agreement with the quality control agency.

m. A statement that ICBOES will be notified in writing of major deviations discovered by the quality control agency, including disposition thereof.

n. A statement that the manufacturer will notify the quality control agency when production is halted and when resumption is planned. Start up is not permitted until authorized by the quality control agency.

o. A statement that ICBOES will be notified in writing if follow-up inspections have not been conducted in accordance with the approved manual.

p. A statement that the manufacturer and the quality control agency will promptly investigate and respond to the ICBOES when appraised of field complaints concerning product performance.

III. TECHNICAL SECTION:

a. Production flow chart and resume of production methods.

b. Product specification, assembly drawings, manufacturing tolerances.

c. Classification of defects: Clear delineation of major and minor defects must be included.

d. List of major production equipment.

e. Incoming inspection and tests.

f. In-process quality controls, final inspection and test, visual and other sensory standards.

g. Nonconforming Materials: Identification, segregation, classification of defects, material review board, corrective action.

h. Measuring Equipment: Type, model, range, accuracy, calibration.

i. Data Systems: Collection of inspection and test data, recording, summary, analysis and reporting, covering all the foregoing activities including samples of forms, check lists and reports for both the inspection agency and the manufacturer.

CPR:ec