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Certification Program for Bridge Temporary Works

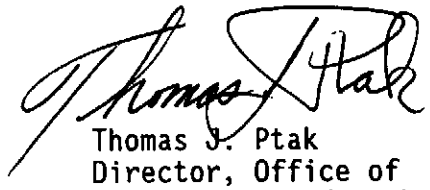
U.S. Department of Transportation
Federal Highway Administration

Research and Development
Turner-Fairbank Highway Research Center
6300 Georgetown Pike
McLean, Virginia 22101-2296

FOREWORD

This study is part of the Federal Highway Administration's Temporary Works Research Program, conducted as a result of the falsework collapse of the Route 198 bridge over the Baltimore/Washington Parkway, Maryland. This report was developed by the industry to act as a certification program for manufactured falsework systems supplied to bridge construction projects. This certification program is aimed at the supplier of equipment to bridge sites, be that the manufacturer or the contractor. It is also intended for the State highway agencies to use in developing their own specification. This program will be of interest to bridge owners, contractors, and manufacturers and suppliers of falsework components to bridge projects.

Additional copies may be obtained from the National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161.



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NOTICE

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FHWA Program Manager for Bridge Temporary Works: Sheila Rimal Duwadi

16. Abstract

Following the collapse of the Route 198 bridge over the Baltimore/Washington Parkway in 1989, the FHWA established the temporary works research program. The program was guided by the Scaffolding, Shoring, and Forming Task Group as formed by the FHWA. The objective of this report is to develop a certification program aimed at the supplier of falsework equipment to the bridge site.

This report is a series of reports produced under this program. The other reports in this series are:

FHWA-RD-91-062	Synthesis of Falsework, Formwork, and Scaffolding for Highway Bridge Structures
FHWA-RD-93-031	Guide Standard Specification for Bridge Temporary Works
FHWA-RD-93-032	Guide Design Specification for Bridge Temporary Works
FHWA-RD-93-034	Construction Handbook for Bridge Temporary Works

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PREFACE

Following the collapse of the Route 198 bridge over the Baltimore/Washington Parkway in 1989, the Federal Highway Administration (FHWA) established the temporary works research program. The program was guided by a task group established by the FHWA. The task group was comprised of representatives from the FHWA, the American Association of State Highway and Transportation Officials, the Transportation Research Board, the American Road and Transportation Builders Association, the Associated General Contractors, the American Society of Civil Engineers, and the Scaffolding, Shoring, and Forming Institute (SSFI). This certification program was prepared by the Shoring Engineering Committee of the SSFI at the request of the FHWA.

The certification program was developed to ensure that the equipment used at a jobsite is identifiable and in a condition to perform the intended task. The document addresses all factory-fabricated components of vertical shoring towers used to support bridge construction. It provides for testing vertical shoring towers that have structural components manufactured by one source and components that are intermixed from several manufacturers.

The program also addresses the proper documentation, inspection, and certification needed by the equipment owner and the contractor's engineer prior to placing concrete.

SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
AREA				
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yards	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
VOLUME				
fl oz	fluid ounces	29.57	milliliters	ml
gal	gallons	3.785	liters	l
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3

NOTE: Volumes greater than 1000 l shall be shown in m^3.

MASS				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg
TEMPERATURE (exact)				
°F	Fahrenheit temperature	5(F-32)/9 or (F-32)/1.8	Celcius temperature	°C
ILLUMINATION				
fc	foot-candles	10.76	lux	l
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
FORCE and PRESSURE or STRESS				
lbf	poundforce	4.45	newtons	N
psi	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
AREA				
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	ac
ha	hectares	2.47	acres	mi^2
km^2	square kilometers	0.386	square miles	
VOLUME				
ml	milliliters	0.034	fluid ounces	fl oz
l	liters	0.264	gallons	gal
m^3	cubic meters	35.71	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
MASS				
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg	megagrams	1.103	short tons (2000 lb)	T
TEMPERATURE (exact)				
°C	Celcius temperature	1.8C + 32	Fahrenheit temperature	°F
ILLUMINATION				
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
FORCE and PRESSURE or STRESS				
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	psi

(Revised August 1992)

* SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.

TABLE OF CONTENTS

I. SYSTEMS CERTIFICATION

All factory-fabricated components of vertical shoring towers used to support bridge construction shall be either tested or analyzed to determine that it is a certified system capable of supporting a specific allowable design load. Bridge shoring layouts may utilize multiple-load capacity towers (e.g., 20 kips (89 kN), 100 kips (445 kN), etc.).

Each shoring tower class shall be tested, analyzed, and marked in accordance with the following procedures:

A. The testing of vertical shoring towers shall be accomplished by one of the following methods:

1. A representative vertical shoring tower that consists of all structural components manufactured by one source shall have been tested in accordance with the Scaffolding, Shoring, and Forming Institute (SSFI) test procedure (see appendix) to determine allowable loads. These allowable loads shall be certified by the single source manufacturer through his representative to the bridge contractor.

2. A vertical shoring tower system that consists of components obtained from several manufacturers shall have been tested in accordance with the SSFI test procedure to determine allowable loads. These allowable loads shall be certified by the supplier (equipment owner) of the intermixed equipment to the bridge contractor.

3. An alternate to I.A.2. (above): A representative vertical shoring tower(s) of intermix component systems shall be on-jobsite tested by the contractor following the SSFI test procedure with the exception that on-site loading may be substituted for the use of laboratory or specially designed test machines. The supplier of the intermix components or the contractor, if he is the owner of the equipment, shall have the on-site engineer certify the test procedure and determine the allowable design loads using the SSFI recommended factors of safety.

B. The analysis of the system shall be accomplished by a complete three-dimensional structural analysis. In many cases, some test loading may be warranted to determine joint parameters to be used in conjunction with the three-dimensional analysis. The manufacturer, supplier, or contractor who uses the analysis method for determination of allowable loads shall certify these allowable loads to the bridge contractor.

This analysis method may also be used for single source suppliers.

C. The marking of the system for certification shall consist of the following:

1. The manufacturer of all new components manufactured after the date of this publication shall place on each component a marking indicating his name as manufacturer. In case I.A.2. and I.A.3. (above), the supplier and/or owner of the equipment shall mark each component with their own identification, indicating that the components that they have supplied have been tested to determine the allowable loads that they are certifying.

II. CONTRACTOR'S ENGINEER DOCUMENTATION

A. A bridge shoring layout is to be submitted by the contractor, and must include the following:

1. Shoring tower components identification by the manufacturer and/or supplier and/or contractor.

2. The allowable tower leg load requirements.

3. Verification of shoring leg loadings so that the sills, cribbing, or piles can be designed of sufficient size to support the shoring loads as determined by jobsite soil conditions.

4. Specification of internal shoring bracing furnished by the manufacturer.

5. Specification of any external bracing (guys, etc.) required by the supplier and furnished by the contractor.

B. Prior to installation the contractor shall document that:

1. All components contain manufacturer, supplier, or contractor's identification.

2. Each component is in satisfactory condition, i.e. not bent, broken, distorted, welds not cracked, and parts not corroded. Surface rust is acceptable.

3. Moving parts operate (locks work, jack handles turn, etc.).

4. Coupling pins must effectively align the frame or panel legs.

5. Pivoted cross braces must have center pivot securely in place.

C. Prior to load application:

1. Each shoring tower per I. (above) shall contain the components as specified by the certification as to manufacturer/supplier. The certification shall include the name of the company that is certifying the system.

a. Check to see that there is a sound footing, or sill, under every leg of every frame on the job. Check also for possible washout due to rain.

b. Check to make certain that all base plates or adjustment screws are in firm contact with the footing or sill. All adjustment screws should be snug against the legs of the frame.

c. Obtain a copy of the shoring layout that was prepared for this specific job. Make sure that the spacings between towers and the cross brace spacing of the towers do not exceed the spacings shown on the layout. If any deviation is necessary because of field conditions, consult with the engineer who sealed the drawings for his approval of the actual field setup.

d. Check for plumbness in frames in both directions. The maximum allowable tolerance for a frame that is out of plumb is 1/8 inch in 3 ft (3.175 mm in 0.9 m). The total tower frame leg out of plumb dimension shall not exceed the diameter of the frame leg. If the frames exceed this tolerance, bases must be adjusted until the frames are within the tolerance.

e. Check for gaps between the lower end of one frame and the upper end of another frame. Gaps indicate that one adjustment screw must be adjusted to bring the frames in contact. If this adjustment does not eliminate the gap, then it indicates the frame is out of square and must be replaced.

f. Check that when two or more tiers of frames are used, each shall be braced to at least one adjacent frame.

g. While checking the cross braces, also check the locking devices to ensure that they are all in their closed position or that they are all tight.

h. Check each upper adjustment screw or shore head to ensure that it is in full contact with the formwork. If it is not in contact, it should be adjusted or shimmed until it is.

i. Check to see that the obvious mistakes of omitting joists, using the wrong size ledger, or timber placed flat have not been made. Check the print to see that the lumber used is equal to that specified on the shoring layout. Check the general formwork scheme to make sure that it follows good standard practice for formwork.

j. If the shoring layout specifies exterior bracing for lateral stability, check to see that this bracing is in place in the locations specified on the drawing. Check to make sure that the devices that attach this bracing to the equipment are securely fastened to the legs of the shoring equipment. If tubing clamps are used, make sure that they have been properly tightened.

If devices for holding timber have been used, check to see that a sufficient number of nails have been used to hold the bracing securely to the frame legs.

III. FORMWORK

Reference *Guide Design Specification for Bridge Temporary Works*, Publication No. FHWA-RD-93-032, Federal Highway Administration, Washington, DC, January 1993.

Reference ANSI A10.9 Concrete and Masonry Construction.

APPENDIX:

SCAFFOLDING, SHORING, AND FORMING INSTITUTE

TEST PROCEDURE

January 31, 1986
Publication No. S102

Recommended Procedure

for

COMPRESSION TESTING OF WELDED FRAME SCAFFOLDS AND SHORING EQUIPMENT

Scope

1. This procedure is intended to cover the compression testing of equipment used for scaffolding and vertical shoring.

Definition of Terms

2. The definition of terms below, relating to the compression testing of equipment used for scaffolding and shoring should be considered as applying to the terms used in these methods of compression testing.

ACCESSORIES - Those items other than frames, braces, or post shores used to facilitate the construction of scaffold and shoring.

ADJUSTMENT SCREW - A leveling device or jack composed of a threaded screw and an adjusting handle used for the vertical adjustment of the scaffolding, shoring and formwork.

ALLOWABLE LOAD - The ultimate load divided by factor of safety.

BASE PLATE - A device used to distribute the vertical load.

COUPLER OR CLAMP* - A device for locking together the component parts of a tubular metal scaffold.

COUPLING PIN - An insert device used to connect lifts or tiers vertically.

CROSS BRACING - A system of members which connect frames or panels of scaffolding or shoring laterally to make a tower or continuous structure.

DEAD LOAD SHORING - The load of forms, stringers, joists, reinforcing rods, and the actual concrete to be placed.

EXTENSION DEVICE - Any device, other than an adjustment screw, used to obtain vertical adjustment of shoring or scaffolding equipment.

FACTOR OF SAFETY - The ratio of ultimate load to the allowable load.

FORMWORK - The material used to give the required shape and support of poured concrete, consisting primarily of:
Sheathing - material which is in direct contact with the concrete such as wood, plywood, metal sheet or plastic sheet.
Joists - Members which directly support sheathing.

Stringers or ledgers - members which directly support the joists, usually wood or steel load-bearing members.

FRAME OR PANEL* - The principal prefabricated, welded structural unit in a tower.

HORIZONTAL SHORING - Metal or wood load-carrying beams of fabricated trussed section used to carry a shoring load from one bearing point, column, frame, post, or wall to another.

JOISTS - See Formwork

LIFTS OR TIERS* - The number of frames erected one above each other in a vertical direction.

LIVE LOAD - The total weight of workmen, equipment, buggies, vibrators, and other loads that will exist and move about on the scaffold or shoring equipment.

LOAD BEARING MEMBER - Any component of a scaffold or shoring structure which is directly subjected to load.

LOCKING DEVICE - A device used to secure the cross brace to the frame or panel.

POST SHORE or POLE SHORES* - Individual vertical member used to support loads.

a. Adjustable Timber Single Post Shore - Individual wooden timers used with a fabricated clamp to obtain adjustment and not normally manufactured as a complete unit.

b. Fabricated Single Post Shores - Type I; Single all-metal post, with a fine adjustment screw or device in combination with pin and hole adjustment or clamp.

Type II; Single or double wooden post members adjustable for a metal clamp or screw and usually manufactured as a complete unit.

c. Timber Single Post Shores - Wood timber used as a structural member for shoring support.

RE-SHORING - A system used during the construction operation in which the original shores are removed and replaced in a sequence planned to avoid any damage to partially cured concrete.

SAFE LEG LOAD - The load which can safety be directly imposed on the frame leg. (See Allowable Load).

SCAFFOLD LAYOUT - A design diagram for scaffolding.

SHOCK LOAD - Impact of material such as the concrete as it is released or dumped during placement.

SHORE HEADS - Flat or formed metal pieces which are placed and centered on vertical members.

SHORING LAYOUT - A design drawing prepared prior to erection showing arrangement of equipment for shoring.

SILL OR MUD SILL* - A footing (usually wood) which distributes the vertical loads to the ground or slab below.

SPAN - The horizontal distance between posts, columns, or upright support members.

STRINGERS OR LEDGERS* - see formwork.

TESTING APPARATUS OR FIXTURE - A special purpose device fabricated for the express purpose of testing scaffolding and shoring.

TESTING MACHINE - A compression testing machine of a type usually found in Universities, Colleges, and reputable Testing Laboratories.

TIMBER STRESSES - Stress-grade lumber conforming to recommended tables in "Wood Structural Design Data Book", by National Lumber Manufacturers Association, Washington, D.C.

TOWERS - A composite structure of frames, braces and accessories.

TUBE AND COUPLER EQUIPMENT - An assembly used as a load-carrying structure consisting of tubing or pipe which serves as posts, braces, and ties, a base supporting the posts, and special couplers which serve to connect the uprights and join the various members.

ULTIMATE LOAD - The maximum load which may be placed on a structure before its failure due to buckling of column members or failure of some component.

Calibration of Testing Devices

3. (a) The device used to determine loads applied shall be calibrated and certified either immediately before or after the testing by a reputable testing laboratory.

   (b) Testing machines used for compression testing shall be calibrated in accordance with ASTM Specification E4 of current revision during the preceding 12 month period.

Test Specimens

4. (a) Scaffold and shoring components shall be selected at random from inventory and shall exhibit approximately the same variations in measurements as would be expected from random sampling including mill tolerances on thickness of various members.

*(These terms may be used synonymously.)

(b) Measurements of specimens. Thickness measurements, when required, shall be made with a suitable micrometer. All other dimensions shall be made with a commerically obtainable measuring tape and all dimensions reported to the nearest 1/16 inch.

Procedure of Test

5. (a) The scaffold or shoring tower or shore to be tested shall be erected in such a manner as to simulate field conditions and aligned vertically so that it is not out of plumb more than 1/8" in three feet. No greater attempts should be made to adjust the components concentrically then would be expected in actual use.

(b) The load shall be applied directly on the load bearing member or members by use of load transfer beams or cross head of testing machine; or directly by hydraulic jacks in an approved testing apparatus or fixture.

Duration of Test

6. The scaffolding tower or shore shall be subject to increasing loads until the ultimate load is reached.

Speed of Testing

7. (a) The allowable limits for rate of loading on scaffolding towers shall be not less than 5,000 lbs. per minute nor more than 10,000 lbs. per minute.

(b) The allowable limits for rate of loading on Post Shore shall not be less than 1,000 lbs. per minute nor more than 2,000 lbs. per minutes.

(c) The rate of loading in each test shall remain constant.

Types of Tests

8. (a) Shoring leg loading shall consist of frames erected into towers composed of four (4) vertical legs with a normal bracing, base plates, and/or adjustment screws. When adjustment screws are used they shall be extended equally on the top and equally on the botton; but top and bottom extensions need not be the same. All four load bearing legs shall be subjected to simultaneous loading until the ultimate load is reached by the weakest leg. Tests according to this method are "A" series tests.

(b) Post Shores shall be tested individually at their minimum and maximum heights and at every foot throughout their operating range. The shores may be tested in both a braced condition and an unbraced condition with the individual test data displayed as a graph showing allowable load versus overall height with the manner of bracing, if any, clearly indicated. Loading shall be continued until ultimate load is reached. Tests performed according to this method are "B" series tests.

(c) Extension devices - shall be positioned in or upon the legs of the shoring and tested in the manner outlined in paragraph 8 (a). The extension devices may be tested extended from the top, bottom or both ends of the legs, and also in a braced or unbraced condition. The devices shall be tested at their maximum and minimum height and at every foot through their operating range with the individual test data displayed as a graph showing allowable load versus extended length and the manner of bracing, if any, clearly displayed. Tests performed according to this method are "C" series tests.

(d) Welded Frame Wall Scaffolds - Welded frame wall scaffolds shall be tested one (1) frame wide and two (2) cross brace lengths long. The frame scaffold components shall be erected into the above configuration composed of six (6) vertical legs with normal manufacturer's recommended bracing, and with base plates or adjusting screws on the botton. The six (6) legs of the test configuration are to be loaded to the scaffold's anticipated allowable leg load and held at that value. Loading shall be continued on the two legs of the center fram until the ultimate load of these two legs is reached. The ultimate load of the center frame legs shall be the ultimate leg load for the welded frame scaffold system. Tests performed according to this method are "D" series tests.

(e) Scaffold Component Testing - All load-bearing individual scaffold components shall be tested independently to obtain their ultimate load. When components are supported by other scaffold members, a test fixture of design similar to these supporting members shall be used to support the components being tested to assure that the test load can be transferred to the adjacent members. All components shall be tested to ultimate load and horizontal being components shall have their ultimate load as well as their total center deflection recorded. Tests performed according to this method are "E" series tests.

Witness of Test

9. All tests must be witnesses by a reputable independent testing laboratory, University, or a registered Professional Engineer, who must attest that the test was performed in accordance with applicable provisions of this standard.

Report of Test Results

10. Test results shall be reported on Form A (see attached) including drawing of test setup with the following:

    (a) Ultimate Total Test Load
    (b) Ultimate Leg Load or Component Test Load as Applicable
    (c) Type of Test
    (d) Laboratory
    (e) Witness

ssfi
revised 8/85
jpb/llj

TEST SUMMARY FORM

1. Tested by: Date of Test_____

_____ Test Number

_____ Component Tested_____

2. Type of Test (Machine_____, or Apparatus_____)

   a. Series (A), (B), (C), (D), (E)

   b. Number of Tiers_____

   c. Adjustment Beyond Leg
      Top_____,_____,_____,_____
      Bottom_____,_____,_____,_____

   d. Extension Beyond Leg
      Top_____,_____,_____,_____
      Bottom_____,_____,_____,_____

   e. Extension, (Top_____) (Bottom_____)
      (Braced_____, or Unbraced_____)

   f. Ultimate Total Test Load_____

   g. Utlimate Load - Each Leg:
      _____,_____,_____,_____ (Average_____)

   h. Ultimate Shore Load_____

   i. Ultimate Ledger Load_____,_____

3. Witness to Test

   a. Company Representative_____

   b. Independent Representative_____

   c. Other Witness_____

   d. Other Witness_____

4. Certification

I certify that the above described test was performed in accordance with the applicable provisions of the Procedure for Compression Testing of Welded Frame Scaffolds and Shoring Equipment as published by the Scaffolding, Shoring & Forming Institute, Inc.

_____

_____

5. Attach Sketch of Test

*U.S. G.P.O.:1993-301-717:80357