A REPORT OF ENGINEERING RESEARCH AND PRODUCT DEVELOPMENT

FOR

KORFIL, INCORPORATED

STRUCTURAL TESTS FOR THE DETERMINATION OF COMPARATIVE CHARACTERISTICS BETWEEN GROUTED CONCRETE MASONRY SPECIMENS CONTAINING KORFIL II INSERTS AND CONVENTIONAL CONSTRUCTIONS

NATIONAL CONCRETE MASONRY ASSOCIATION

CONDUCTED BY

NATIONAL CONCRETE
MASONRY ASSOCIATION
RESEARCH AND DEVELOPMENT LABORATORY

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INTRODUCTION

This Report describes research conducted for Korfil, Inc.* concerning structural characteristics of reinforced wall specimens containing expanded polystyrene inserts (Korfil II), as shown in Figure 1. The objective of this investigation is to compare the structural load carrying capacity of the Korfil insulated system with that of conventional construction and to provide experimental data so that behavior of similar constructions may be predicted by the use of rational analysis.

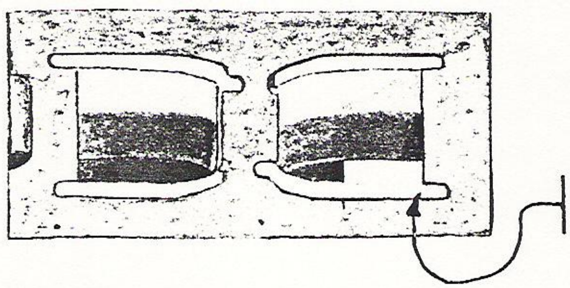

Figure 1: Schematic Korfil II Insulated Block

To quantify the structural performance, and to determine the interaction of steel, grout, and block with that of the Korfil II insert; 30 full-scale wall specimens and 15 flexural beam specimens were constructed and tested as outlined in Table I. The discussion of test results and the evaluation of the comparative data is presented in the section, "Test Results and Discussion." These experimental comparisons are developed from partially grouted wall configurations containing both minimal and increased reinforcing.

In addition to the tests described in Table 1, all materials, i.e., block, mortar, and grout were tested for their respective properties. Detailed information on materials, equipment and procedures are discussed in the following sections of this report.

* Korfil is a registered trademark of KORFIL, INC.

SERIES DESCRIPTION	TEST NO.	SPECIMEN DESCRIPTION (See Figure 1)	PURPOSE OF TEST
SERIES 1 ASTM E-72 Flexural Strength-Vertical Span	1	Steel Area Grouted: Without Korfil: Reinforced with one #4 at 24" on center & Bond Beam Top & Bottom with one # 4.	Simulate Conventional Construction with Minimal Reinforcing
	2	Steel Area Grouted: Containing Korfil:Reinforced with one #4 at 24" on center & Bond Beam Top and Bottom with one #4	Compare to No. 1 above.
	3	Steel Area Grouted: Without Korfil: Reinforced with one #6 at 24" on center & Bond Beam Top & Bottom with one #4.	Simulate Conventional Construction with Increased Reinforcing
	4	Steel Area Grouted: Containing Korfil:Reinforced with one #6 at 24" on center & Bond Beam Top and Bottom with one #4.	Compare to No. 3 above.
	5	Steel Area Grouted: Containing Korfil:Reinforced with one #4 at 24" on center & Bond Beam Top and Bottom and 6th Course from Top.	Compare to Nos. 1 and 2 above.
SERIES 2 ASTM E-519 Diagonal Tension (Shear) Strength	6	Steel Area Grouted: Without Korfil: Reinforced with one #4 at 24" on Center.	Simulate Conventional Construction with Minimal Reinforcing
	7	Steel Area Grouted: Containing Korfil:Reinforced with one #4 at 24" on Center.	Compare to No. 6 above.
	8	Steel Area Grouted: Without Korfil: Reinforced with one #6 at 24" on Center.	Simulate Conventional Construction with Increased Reinforcing
	9	Steel Area Grouted: Containing Korfil:Reinforced with one #6 at 24" on Center.	Compare to No. 8 above.
SERIES 3 ASTM E-72 Compressive Strength	10	Steel Area Grouted: Containing Korfil:Reinforced with one #4 at 24" on Center.	Compare to Conventional Construction
SERIES 4 ASTM 518 (Modified) Flexural Beam Strength	11	Grouted: Without Korfil:Reinforced with one #4.	Simulate Conventional Construction
	12	Grouted: Containing Korfil: Reinforced with one #4	Compare to No. 11 above
	13	Grouted: Without Korfil: Reinforced with one #6	Simulate Conventional Construction
	14	Grouted: Containing Korfil: Reinforced with one #6	Compare to No. 13 above
	15	Grouted: Containing Korfil: Unreinforced	Compare to Nos. 11 thru 14 above.

MATERIALS

The regular concrete masonry units used in this program were supplied to the laboratory by Korfil, Inc. Bond Beam Units were standard production, lightweight block manufactured by a local area block producer. Properties of the concrete masonry units were determined in accordance with ASTM C 140-75, "Standard Methods of Sampling for Testing Concrete Masonry Units."

The mortar used in all specimens was Type S, portland cement-lime mortar mixed in accordance with the proportion specifications of ASTM C 270-73, "Mortar for Unit Masonry." The average compressive strength of the mortar was determined in accordance with ASTM C 109-73, "Standard Method of Test for Compressive Strength of Hydraulic Cement Mortars."

The grout used in all specimens was coarse, portland cement-lime grout mixed in accordance with the proportion specifications of ASTM C 476-71, "Mortar and Grout for Reinforced Masonry." Compressive strength of grout was determined in accordance with Uniform Building Code Standard No. 24-22, "Field Test for Grout and Mortar."

Unit properties of block, mortar, and grout are shown in Table II:

TABLE II - MATERIAL PROPERTIES

CONCRETE MASONRY UNITS			
Compressive Strength, psi, Gross Area	=		1360
Compressive Strength, psi, Net Area	=		2710
Absorption, lb/cu. ft.	=		11.8
Unit Weight lb/cu. ft.	=		93.3
Minimum Faceshell Thickness, inches	=		1.25
Minimum Web Thickness, inches	=		1.00
Equivalent Web Thickness, in/ft.	=		2.34
Net Area, Percent	=		50.1
Mortar			
Average Compressive Strength psi (2" cubes)	=	Flexural Walls	2520
		All Other Specimens	1850
Grout			
Average Compressive Strength, psi (3" x 3" x 6" Specimens)	=		3360
*Reinforcing Steel	=		Grade 60

*editorially added 1/29/79

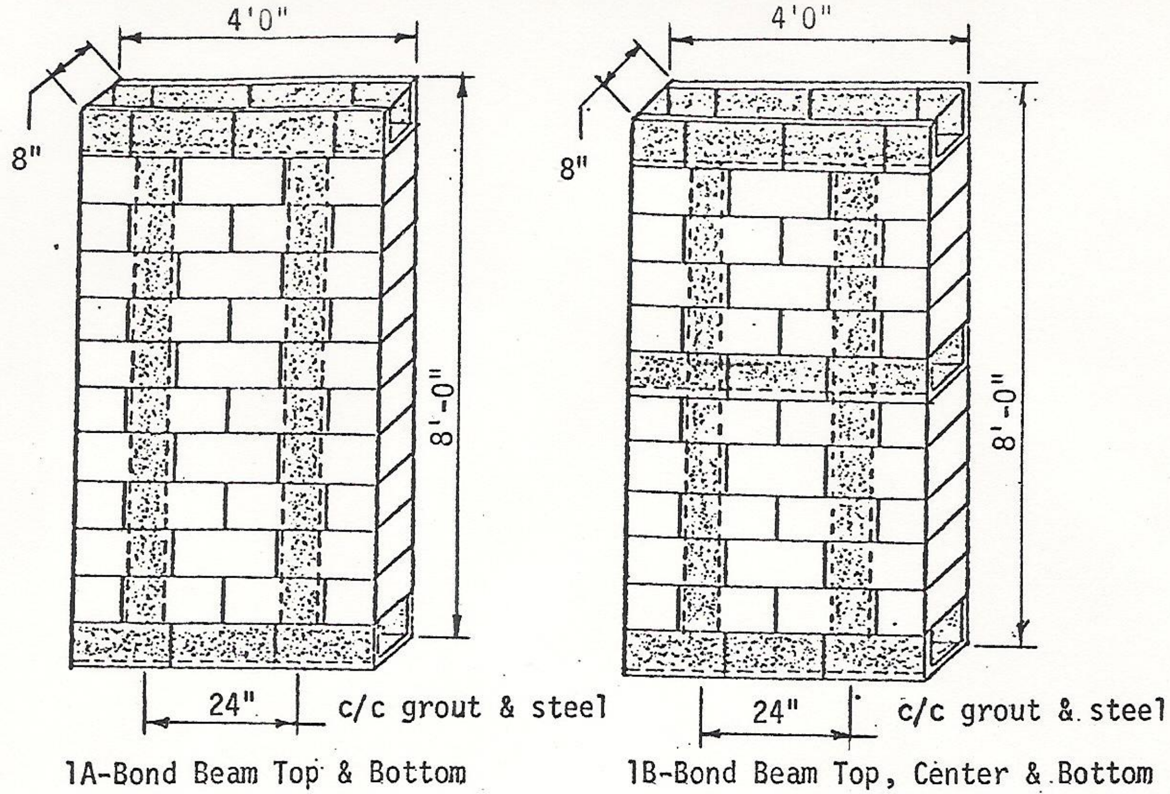

Figure 2: GROUT AND BOND BEAM LOCATIONS FOR THE FLEXURAL WALL SPECIMENS (shaded areas indicated location of grout)

CONSTRUCTION OF TEST SPECIMENS

All test specimens were constructed by an experienced mason under contract to the NCMA Research and Development Laboratory. Specimens were laid in running bond using full mortar bedding (see Figure 13) and air cured in a laboratory environment. Mortar joints on both faces were tooled. Mortar was mixed in a contractor type paddle blade mortar mixer to a workable consistency determined by the mason. Walls were grouted and reinforced on 24" centers as shown in Figure 2 and described below. Grout was mixed in a 5 cu. ft. contractor type concrete mixer with sufficient water to produce a slump between 10 and 11 inches.

Flexural Wall Specimen

For the construction of Series 1 specimens (see Figure 2) the first and last course was composed of a U shape bond beam containing one No. 4 Rebar, placed approximately ½" from the bottom of the unit. The Test No. 5 specimens, shown in Figure 1B, contained an additional bond beam course to provide a typical 4 ft. vertical spacing of horizontal steel. Grout was placed in two 4 ft. high lifts and plastic netting was used to confine the flow of grout (see Figures 10 thru 12). After pouring of the first lift, grout was vibrated using a 1" "pencil" vibrator. Reinforcing, in accordance with the headings shown in Tables III, IV and V, was then inserted and centered as near as practical along both the transverse and longitudinal axes. The second lift was then poured and vibrated taking care to insure the rebar held its position. Additional construction photographs appear in Figures 10 thru 14.

Diagonal Tension (Shear)

Racking specimens were constructed to form nominal 4 ft. high panels and grouted in a single lift. After placement of each of the No. 4 and No. 6 rebar in accordance with the headings shown in Table VI, grout was vibrated taking care to insure the reinforcing held its position. No bond beams were used for the Diagonal Tension Specimens.

Compression Wall Specimens

Compression wall specimens were constructed in a similar manner to that described for Series 1, except without the use of bond beams. Reinforcing consisting of No. 4 rebar at 24 inches on center was placed and grout poured and vibrated as previously described. Only specimens containing Korfil inserts were constructed for the compression tests.

Flexural Beam Specimens

The Series 5 flexural beam specimens were constructed using half block in stack bond to form nominal 8"x8"x48" high specimens. Reinforcing, in accordance with the schedule in Table VIII, was put in place, grout poured (in a single lift) and vibrated taking care to insure the rebar held its position. Reinforcing was centered as near as practical along both the transverse and longitudinal axes. Korfil inserts included in the beam specimens, were all aligned in the same direction.

TEST PROCEDURES

The Series 1 flexural tests were conducted in accordance with ASTM E 72-74, "Conducting Strength Tests of Panels for Building Construction". Application of the uniform transverse load on wall specimens in the vertical span, was obtained by pressurizing an air bag located between the test wall and the rigid test frame. Padded 6" steel pipes served as the reactions that tied the top and bottom of the wall to the frame. The distance between reaction points (test span) was 90". Deflections at both sides of each wall panel were measured at various load increments with mechanical strain gages graduated to .001 inches. Test frame and specimens are illustrated in figures later in this report.

The Series 2 racking tests were conducted in accordance with ASTM E 519-74, "Standard Test Method for Diagonal Tension (Shear) in Masonry Assemblages." Load was applied through the same test frame described below for Series 3 - Compression Wall Specimens. Racking specimen gage lengths were 54" vertically and 42" horizontally with strain measurements obtained using mechanical strain gages graduated to .001 inches. Measurements were recorded on both sides of the wall. Testing machine and specimen instrumentation are illustrated in figures 19 through 25.

The compressive strength tests for Series 3 were conducted in accordance with ASTM E 72-74 "Conducting Strength Tests of Panels for Building Construction." Load was supplied through a 3" steel plate with five 60-ton calibrated hydraulic rams. The top of the compression walls were capped prior to placement in the test frame, and the bottom of the walls were capped in the machine under a preload of 2,000 pounds applied prior to hardening of the capping compound. The capping material was hydrostone, that at capping consistency obtained a compressive strength of not less than 3,500 psi at an age of two hours when tested as 2" cubes. Load eccentricity was obtained by locating a

4" steel half-round at t/6" from the center of the wall. Compression specimen gage lengths were 80" with strain measurements obtained using mechanical strain gages graduated to .001 inches. Testing machine and specimens are illustrated in Figure 26.

The Series 4 flexural beams were tested similar to ASTM E 518-76, "Standard Test Methods for Flexural Bond Strength of Masonry," utilizing the method of third point loading. Specimen lengthwise set at 48", however span length for testing was based on a beam length of 32" (see Figure 3). Since the relative interaction between grout insert and block was a primary feature being determined, the beam length was increased to insure adequate bond of reinforcement.

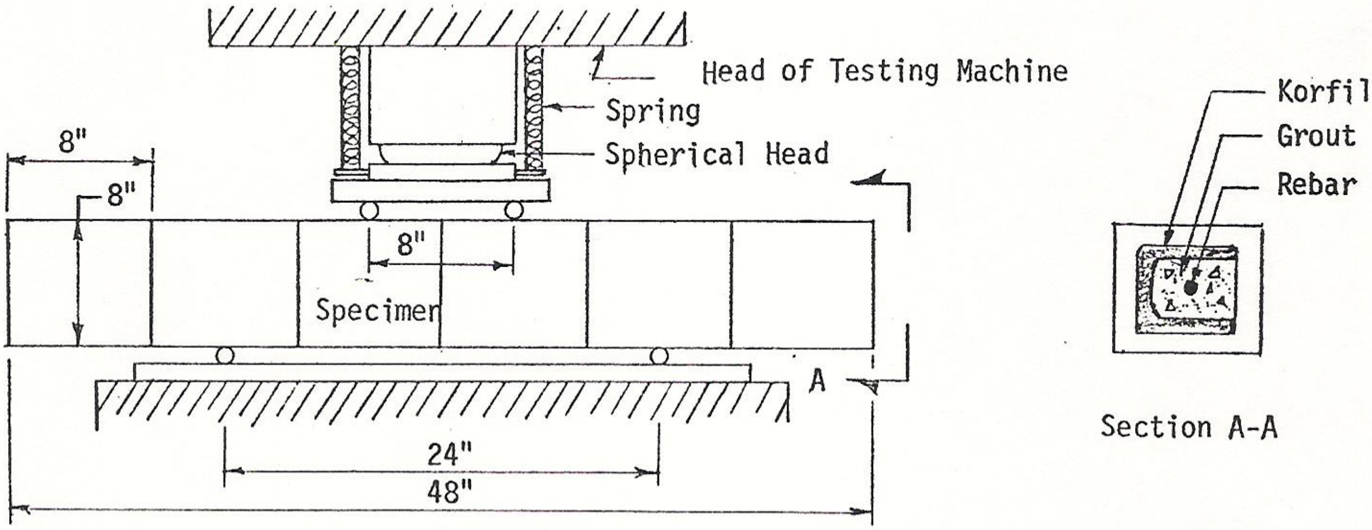

FIGURE 3: DIAGRAM OF TEST APPARATUS AND ORIENTATION OF KORFIL INSERT FOR THE SERIES 4 FLEXURAL BEAM TESTS

TEST RESULTS AND DISCUSSION

The objective of this investigation is to examine the comparative structural characteristics between grouted reinforced wall configuration of conventional construction and specimens containing Korfil-II inserts. To provide these experimental comparisons and produce results that may also be applicable to wall configurations not part of this program, two different percentages of reinforcing were selected, as discussed below.

To be considered reinforced, masonry walls must contain an area of steel not less than .002 times the cross-sectional area of the wall, and not more than two-thirds of which may be used in either direction. Since the full scale wall specimens were nominally 8 inches x 48 inches in cross-section, the minimal vertical reinforcing, for consideration as reinforced masonry construction, was determined as follows:

Gross Area Wall, sq. in.: $A_g = 47.625 \times 7.625 = 363$

Minimal Steel Requirement, sq. in.: $A_{s\ min.} = .002 \times 363 = .726$

Maximum Vertical Steel, sq. in.: $A_{s\ vert.} = .667 \times .726 = .484$
(based on 2/3 requirement)

To maintain symmetry and furnish the minimal vertical steel requirement without exceeding As vert, No. 4 rebars at 24 inches on center were used. The additional steel necessary to meet As min. could be placed in the horizontal direction.

The design of reinforced masonry is also predicated on the principal assumption that reinforcement is completely surrounded by and bonded to masonry material, so that they work together as a homogeneous system within the range of working stress. Since the Korfil insert reduces the available bond between grout and masonry, increasing the steel area, should magnify the interaction of the various elements. The greater the reinforcing, the more paramount the expected effect on bond between grout, block, and steel and the more amplified the difference between structural characteristics of the two (insulated and conventional) methods of construction. No. 6 rebar at 24 inches on center was selected as a common rebar size and to provide the condition creating greater load carrying capability.

Flexural Wall Tests

Results of the Vertical Span Flexural Tests are presented in Tables III through V and graphically illustrated in Figures 4 through 6. Results are displayed in a manner to provide direct comparison between the Korfil insulated system and conventional construction.

Utilization of bond beams and horizontal reinforcing as shown in Figures 2, 11 and 14, were specifically provided to simulate a tied condition as would be expected in normal construction practice. To assure flexural capacity would be unaffected by installation of additional horizontal reinforcing, Test 5 of Series 1, provided an additional reinforced bond beam course. Comparing the tabular results of Table V (Bond Beams Top, Bottom and Center) and graphical representation shown in Figure 6, to the similar reinforced specimens of Table III (Bond Beams Top and Bottom), and Curve A in the graphical representation shown in Figure 4, load deflection and permanent set characteristics are very similar.

Further examination of Figure 4 also demonstrates close similarity of the Korfil specimens to those of conventional construction. The maximum deflection variation at any point in load appears to be .065 inches, with the insulated construction being the larger. Also, as shown, the maximum variance in permanent set is approximately .030 inches again with conventional construction being slightly more rigid. These maximum variances occur in loads in excess of 120 lbs. per sq.ft. and do not substantially change thereafter. At laods of 40 lbs. per sq.ft. or less, load deflection and permanent set characteristics appear virtually identical for both systems.

For minimally reinforced construction, sufficient bond has been developed between grout and block to produce a condition that affects capacity only to the extent of the difference in the rigidity of the specimen. Increasing the steel area will reduce the variance in load deflection and increase the similarity in

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For minimally reinforced construction, sufficient bond has been developed between grout and block to produce a condition that affects capacity only to the extent of the difference in the rigidity of the specimen. Increasing the steel area will reduce the variance in load deflection and increase the similarity in flexural characteristics between the insulated and conventional constructions. Table IV and the graphical representation of Figure 5 compares these characteristics for specimens tested with increased reinforcing. The difference in load deflection and permanent set characteristics between the Korfil and conventional specimens appears almost negligible throughout the entire range of load. In general, the flexural strength of the Korfil constructions appears to be on a par with those of its conventional counterparts.

Diagonal Tension (Shear)

The results of the Series 2 diagonal tension shear strength tests are presented in Table VI and load-strain characteristics graphically illustrated in Figure 7. Since ASTM E 519 measures shear capacity indirectly as a measure of diagonal tension, Table VI provides comparative data at various increments of load as well as ultimate load. Shear strain at various increments of load was computed as follows:

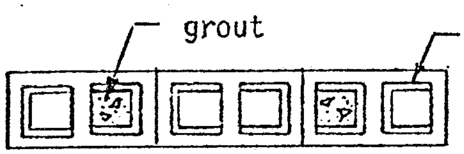
$$\gamma = \frac{\Delta V}{g_v} + \frac{\Delta H}{g_h}$$

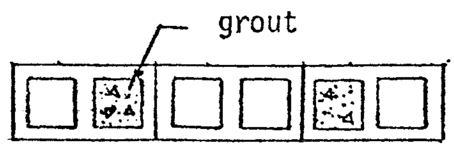
Where: γ = Shearing Strain, inches/inch V = Vertical Shortening, inches

g_v = Vertical Gage length, inches H = Horizontal Extension, inches

g_h = Horizontal gage length, inches

As seen from the Table VI and Figure 7, the percentage of vertical reinforcing appears to have only minimal effect on load-carrying capacity and load-strain characteristics. The average maximum load in diagonal tension for .110% and .242% vertical reinforcing of the insulated constructions was 51.1 kips to 52.2 kips, respectively. Similarly, comparing the conventionally constructed specimens, there exists an average maximum of 72.8 kips for those specimens containing #4 Rebar and 77.1 kips for specimens containing the increased steel area with No. 6 Rebar. Since the percentage of vertical reinforcement does not appear to substantially affect the behavior of specimens subjected to diagonal tension removing this variable, the effect of the Korfil inserts can be directly compared to conventional construction. Area for the determination of shearing stress can be calculated as follows:





A Korfil = 228^{in^2} A Conventional = 243^{in^2}

(A Korfil is the average cross-sectional area of Korfil Insert calculated from measurements made at the top and bottom mortar bed planes = 7.5 sq. in. per insert)

Although a reduction in ultimate capacity is apparent for the insulated specimens, the calculated shear strength at ultimate capacity, when compared to an allowable stress of 50 psi results in a ratio equal to 3.17 (see below).

Maximum Load from Table VI (.110% vertical reinforcing) = 51.1 kips

A Korfil = 228^{in2}

Ss = .707P, where Ss = Shearing Stress or net area psi
P = Applied load lbs.
A = Net Area sq. in.

$$Ss = \frac{.707 \times 51,100}{228} = 158.5 \text{ psi}$$

$$\frac{\text{Ultimate Stress}}{\text{Allowable Stress}} = \frac{158.5}{50} = 3.17$$

In addition, the introduction of joint reinforcing and/or reinforced bond beams would be expected to provide an increase in maximum load-carrying capacity further reducing the affect of the insulating material.

Compression Tests

Results of the compression tests are given in Table VII and load deformation (shortening) in Figure 8. The average ultimate gross area compressive strength for the eccentrically (t/6) loaded specimens was 781 psi. Specimen number

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K4Cl-3, however, apparently prematurely failed through crushing of the top corner block (see Figure 26). Eliminating this specimen from the test results and considering only specimens K4CI-1 and K4CI-2, the average gross area compressive strength would increase to 882 psi. Utilizing the same cross-sectional area previously calculated for shearing stress, the average net area compressive strength (based on the gross area strength of 781 psi) would result in the following:

$$\frac{A_{gross}}{A_{Korfil}} = \frac{348}{228} \times 781 = 1{,}192 \text{ psi}$$

From the net area block strength (2710 psi) taken from Table II, a compressive strength of masonry equal to 1,600 psi may be assumed. The allowable axial load may then be determined by the following formula:

$$F_a = 0.20\ f'm\ (1-(h/40t)^3)$$

$$\text{Substituting: } .20 \times 1{,}600 \times (1-(96/320)^3)$$

$$F_a = .20 \times 1{,}600 \times .973$$

$$F_a = 311 \text{ psi}$$

Based on the average net area compressive strength of 1,192 psi, a ratio of ultimate capacity to allowable may be calculated as follows:

$$1{,}192 \div 311 = 3.83$$

<u>Flexural Beam Tests</u>

Results of the Series 4 flexural beam tests are shown in Table VIII and load deflection curves in Figure 9. Load deflection behavior for both the insulated and conventional constructions was very similar. The beam tests give comparisons at failure load in flexure for the various types of constructions since this was not achieved for the full-scale wall tests. Although less ultimate capacity exists for the insulated when compared to conventional reinforced constructions, the similarity in the load deflection curves of Figure 9 coincide with the similarity of the load deflection curye for the full scale flexural wall specimens.

CONCLUSIONS

The purpose of this investigation was to compare certain structural characteristics of reinforced grouted concrete masonry specimens containing Korfil II Inserts and Conventional Constructions. Throughout this investigation the insulated Korfil specimens performed similar to their conventional counterparts. On the basis of these test results, it appears reasonable to assume that use of rational engineering analysis corroborated by experimental evidence may be applied to insulated Korfil wall configurations not yet tested.

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Mr. Jerry Lusk of Korfil Inc. was witness to several of the Flexural Wall Specimens.

Gary D. Schoenfeld, Manager
Research and Development

APPROVED BY:

Thomas B. Redmond, P.E., Vice President
Technical Services Department

Date: 12 Jan 1979

TABLE III - FLEXURAL STRENGTH
LOAD/DEFLECTION CHARACTERISTICS
(Bond Beams Top and Bottom)

#4 Rebar @ 24" on Center Containing Korfil Inserts

Load psf	Deflection/(Set) "in." K4FI-1	K4FI-2	K4FI-3	Average
41.6	.007 (.005)	.002 (.000)	.002 (.000)	.004 (.002)
83.2	.030 (.022)	.022 (.018)	.026 (.018)	.026 (.019)
124.8	.078 (.037)	.069 (.034)	.068 (.035)	.072 (.035)
145.6	.108 (.043)	— —	— —	.108 (.043)
166.4	.152 (.057)	.191 (.081)	.129 (.057)	.157 (.065)
187.2	.201 (.069)	— —	— —	.201 (.069)
208.0	.259 (.082)	.287 (.097)	.259 (.098)	.268 (.092)
228.8	.311 (.092)	— —	— —	.311 (.092)
249.6	.361 (.100)	.383 (.112)	.343 (.113)	.362 (.108)
270.4	.413 (.107)	— —	.417 (.126)	.415 (.117)
291.2	.476 (.120)	.499 (.130)	.470 (.129)	.482 (.126)
312.0	.540 (.126)	.620 —	.505 (.136)	.555 (.131)
Age at Test "Days"	29	29	29	

INSULATED CONSTRUCTION
(.110% Vertical Reinforcing)

#4 Rebar @ 24" on Center Without Korfil Inserts

Average	Deflection/(Set) "in." K4F-1	K4F-2	K4F-3	Load psf
.002 (.001)	.002 (.001)	.002 (.002)	.001 (.000)	41.6
.004 (.001)	.005 (.001)	.005 (.003)	.003 (.000)	83.2
.008 (.002)	.009 (.001)	.010 (.005)	.005 (.000)	124.8
.044 (.017)	— —	.037 (.015)	.050 (.019)	145.6
.097 (.031)	— —	.074 (.025)	.119 (.037)	166.4
.160 (.047)	.157 (.047)	.112 (.036)	.208 (.057)	187.2
.195 (.055)	Gauges became detached	.143 (.049)	.247 (.061)	208.0
.252 (.071)		.183 (.058)	.321 (.084)	228.8
.325 (.081)		.227 (.066)	.423 (.096)	249.6
.362 (.087)		.251 (.073)	.473 (.101)	270.4
.431 (.111)		.286 (.079)	.575 (.142)	291.2
.502 (.162)		.321 (.080)	.682 (.244)	312.0
	27	27	28	Age at Test "Days"

CONVENTIONAL CONSTRUCTION
(.110% Vertical Reinforcing)

—Indicates deflection was not recorded at that increment of load.

(FROM TABLE III, VERTICAL REINFORCING - No. 4 Rebar @ 24" on Center)

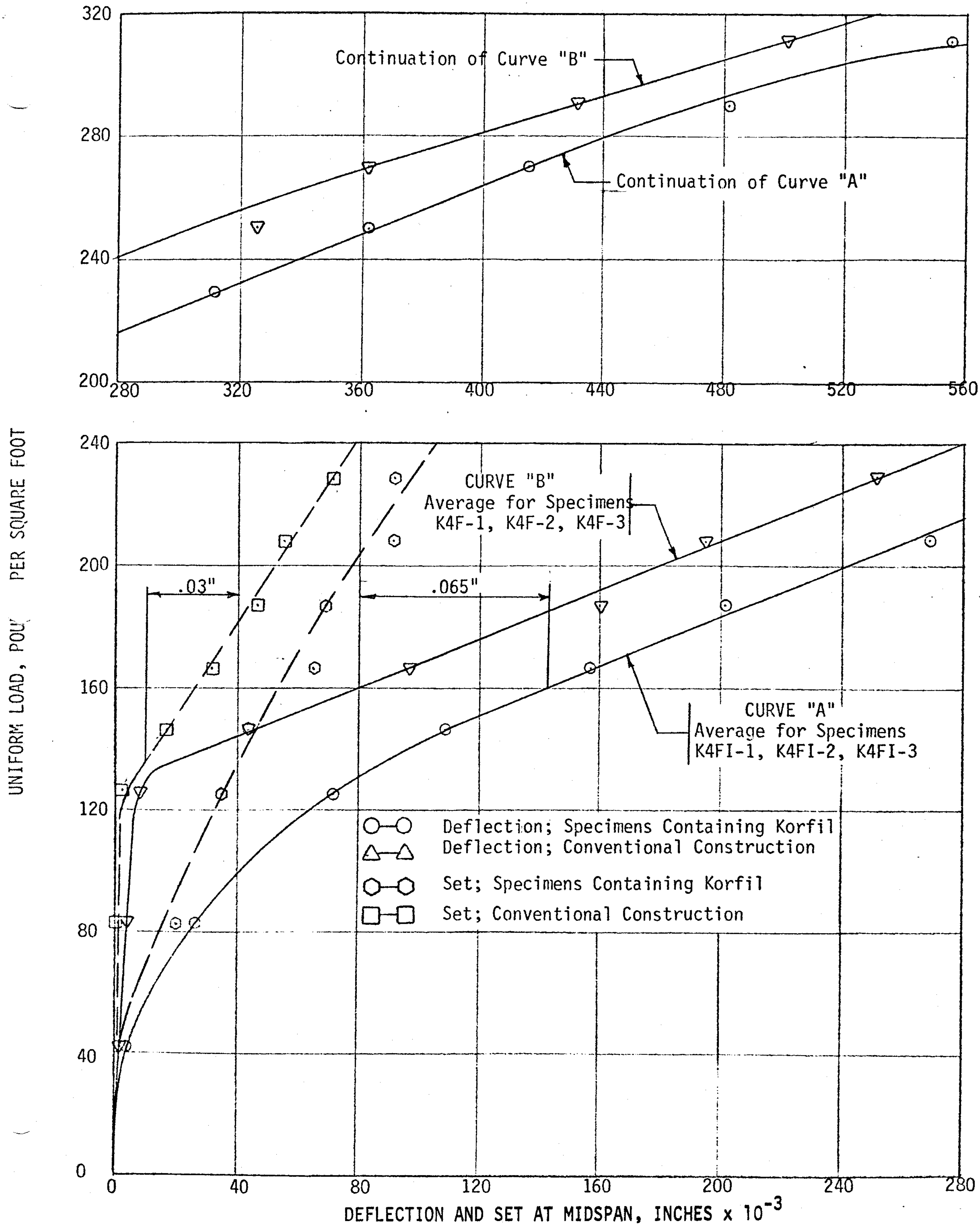


TABLE IV - FLEXURAL STRENGTH
LOAD/DEFLECTION CHARACTERISTICS
(Bond Beams Top and Bottom)

#6 Rebar @ 24" on Center Containing Korfil Inserts

Load psf	Deflection/(Set) "in."			Average
	K6FI-1	K6FI-2	K6FI-3	
41.6	.003 (.003)	.002 (.001)	.001 (.000)	.002 (.001)
83.2	.010 (.008)	.007 (.001)	.004 (.003)	.007 (.004)
124.8	.016 (.009)	.009 (.002)	.012 (.007)	.012 (.006)
145.6	.019 (.010)	.027 (.010)	.018 (.009)	.021 (.010)
166.4	.026 (.018)	.042 (.014)	.023 (.010)	.030 (.014)
187.2	.036 (.013)	.056 (.020)	.031 (.011)	.041 (.015)
208.0	.060 (.017)	.084 (.021)	.081 (.024)	.075 (.021)
228.8	.068 (.021)	.107 (.022)	.093 (.026)	.089 (.023)
249.6	.106 (.030)	.139 (.033)	.117 (.032)	.121 (.032)
270.4	.116 (.027)	.180 (.041)	.136 (.033)	.144 (.034)
291.2	.133 (.030)	.207 (.042)	.199 (.052)	.180 (.041)
312.0	.176 (.040)	.235 (.045)	.236 (.059)	.216 (.048)
Age at Test "Days"	28	28	29	X

INSULATED CONSTRUCTION
(.242% Vertical Reinforcing)

#6 Rebar @ 24" on Center Without Korfil Inserts

Average	Deflection/(Set) "in."			Load psf
	K6F-1	K6F-2	K6F-3	
.001 (.001)	.001 (.001)	.001 (.001)	.002 (.002)	41.6
.003 (.003)	.002 (.002)	.002 (.001)	.005 (.005)	83.2
.006 (.004)	.003 (.002)	.004 (.001)	.010 (.009)	124.8
.007 (.004)	.004 (.002)	.004 (.001)	.012 (.010)	145.6
.008 (.005)	.005 (.003)	.004 (.001)	.015 (.010)	166.4
.015 (.008)	.010 (.007)	.007 (.004)	.027 (.013)	187.2
.027 (.010)	.013 (.007)	.033 (.009)	.034 (.014)	208.0
.087 (.031)	.068 (.030)	.073 (.026)	.119 (.038)	228.8
.123 (.040)	.130 (.048)	.089 (.026)	.149 (.045)	249.6
.161 (.049)	.182 (.055)	.113 (.035)	.188 (.057)	270.4
.195 (.053)	.240 (.063)	.139 (.041)	.207 (.056)	291.2
.218 (.057)	.263 (.070)	.158 (.042)	.233 (.059)	312.0
X	28	28	29	Age at Test "Days"

CONVENTIONAL CONSTRUCTION
(.242% Vertical Reinforcing)

FIGURE 5 : AVERAGE LOAD DEFLECTION CURVES - VERTICAL SPAN FLEXURAL TESTS (FROM TABLE IV, VERTICAL REINFORCING - NO. 6 REBAR AT 24" ON CENTER)

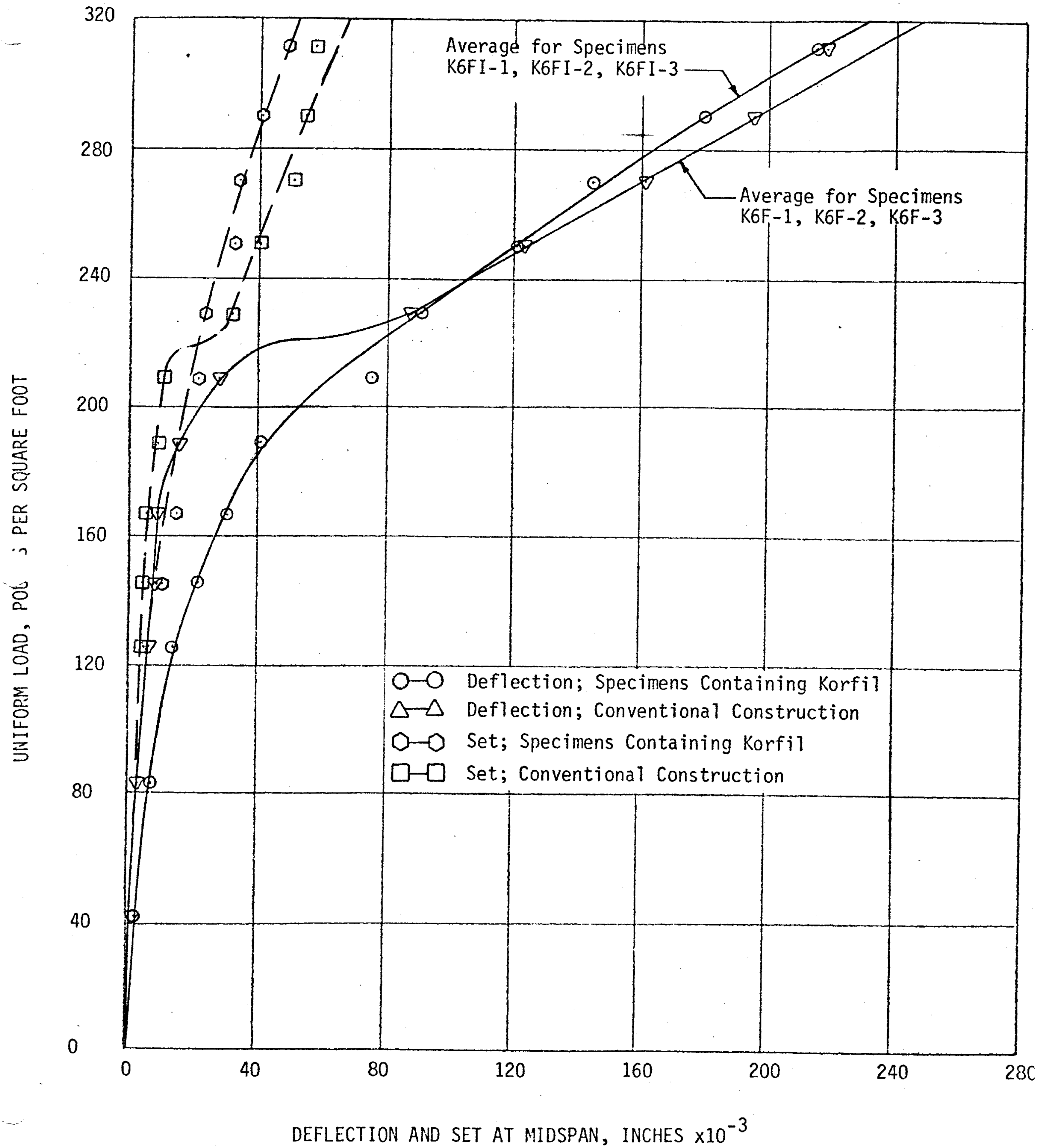


TABLE V - FLEXURAL STRENGTH
LOAD DEFLECTION CHARACTERISTICS
(Bond Beams Top, Bottom
and Center)

#4 Rebar @ 24" on Center Containing Korfil Inserts				
Load psf	Deflection/(Set) "in."			Average
	KI4FH-1	KI4FH-2	KI4FH-3	
41.6	.003 (.002)	.002 (.002)	.004 (.004)	.003 (.003)
83.2	.013 (.006)	.008 (.004)	.013 (.010)	.011 (.007)
124.8	.055 (.025)	.020 (.010)	.089 (.039)	.055 (.025)
145.6	.082 (.030)	.067 (.028)	.146 (.055)	.098 (.038)
166.4	.118 (.045)	.173 (.055)	.192 (.063)	.161 (.054)
187.2	.169 (.050)	.269 (.066)	.306 (.114)	.248 (.077)
208.0	.210 (.059)	.316 (.071)	.389 (.114)	.305 (.081)
228.8	.284 (.079)	.427 (.089)	.468 (.124)	.393 (.097)
249.6	.323 (.079)	.514 (.107)	.541 (.128)	.459 (.105)
270.4	— —	— —	.628 (.152)	.628 (.152)
291.2	.424 (.093)	.812 (.272)	.764 (.180)	.666 (.182)
312.0	— —	— —	— —	— —
Age at Test "Days"	29	32	28	
INSULATED CONSTRUCTION (.110% Vertical Reinforcing)				

— Indicates deflection was not recorded at that increment of load.

FIGURE 6 : AVERAGE LOAD DEFLECTION CURVE - VERTICAL SPAN FLEXURAL TESTS
(FROM TABLE V, VERTICAL REINFORCING: NO. 4 REBAR @ 24" on CENTER) (BOND BEAM-TOP, BOTTOM AND CENTER)

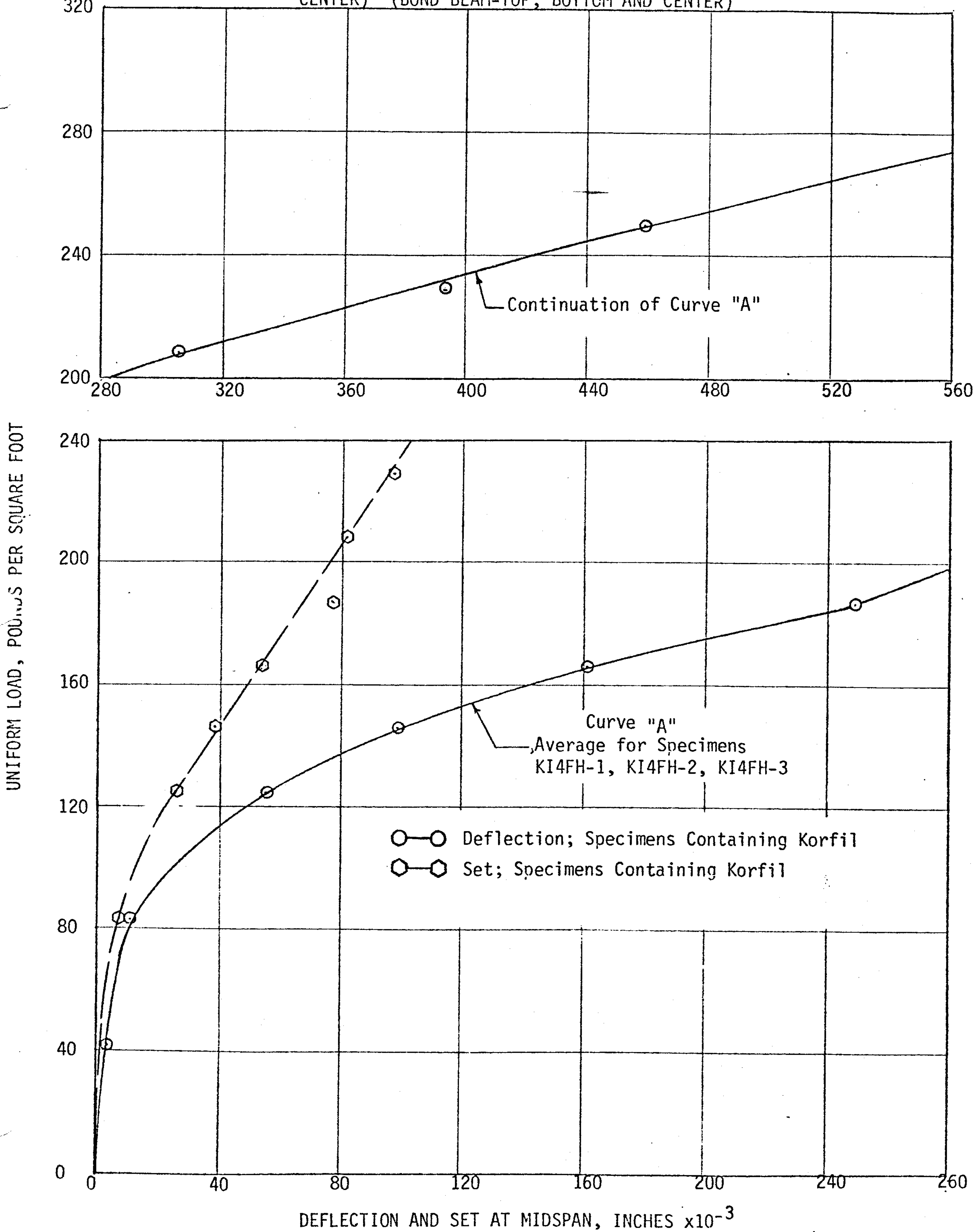


TABLE VI - DIAGONAL TENSION (SHEAR)
LOAD/STRAIN CHARACTERISTICS

#4 Rebar @ 24" on Center
Containing Korfil Inserts

Load "Kips"	Strain in/in x10^{-5}			Average
	K4RI-1	K4RI-2	K4RI-3	
6.5	6.1	3.7	3.7	4.5
13.0	19.6	11.7	17.8	16.4
19.6	29.3	19.6	25.6	24.8
26.1	33.6	27.5	31.2	30.8
32.6	41.5	35.4	39.1	38.7
39.1	43.9		48.9	46.4
45.6				
52.2				
Max. Load	45.6	48.9	58.7	51.1
Age at Test "Days"	28	30	36	

INSULATED CONSTRUCTION
(.110% Vertical Reinforcing)

#4 Rebar @ 24" on Center
Without Korfil Inserts

Average	Strain in/in x10^{-5}			Load "Kips"
	K4R-1	K4R-2	K4R-3	
1.9	1.9	1.9	1.9	6.5
9.8	9.8	9.8	9.8	13.0
12.3	11.7	13.5	11.7	19.6
19.5	21.5	21.5	15.4	26.1
26.6	27.5	27.0	25.2	32.6
31.8	31.2	33.0	31.2	39.1
37.7	39.1	38.6	35.4	45.6
46.8		48.4	45.2	52.2
72.8	71.7	71.7	75.0	Max. Load
	28	28	28	Age at Test "Days"

CONVENTIONAL CONSTRUCTION
(.110% Vertical Reinforcing)

#6 Rebar @ 24" on Center
Containing Korfil Inserts

Load "Kips"	Strain in/in x10^{-5}			Average
	K6RI-1	K6RI-2	K6RI-3	
6.5	3.7	3.7	3.7	3.7
13.0	14.1	11.7	11.7	12.5
19.6	20.1	17.8	17.8	18.6
26.1	29.9	29.9	25.2	28.3
32.6	37.8	33.6	31.2	34.2
39.1		41.5	39.1	40.3
45.6				
52.2				
Max. Load	48.9	52.2	55.5	52.2
Age at Test "Days"	30	33	33	

INSULATED CONSTRUCTION
(.242% Vertical Reinforcing)

#6 Rebar @ 24" on Center
Without Korfil Inserts

Average	Strain in/in x10^{-5}			Load "Kips"
	K6R-1	K6R-2	K6R-3	
1.3	1.8	1.9	0	6.5
5.8	5.6	5.6	6.1	13.0
10.4	9.8	11.7	9.8	19.6
14.3	11.7	15.4	15.9	26.1
20.8	19.6	19.1	23.8	32.6
25.5	25.6	25.2	25.6	39.1
31.5	31.7	31.2	31.7	45.6
36.7	35.4	37.3	37.3	52.2
77.1	75.0	78.2	78.2	Max. Load
	29	29	29	Age at Test "Days"

CONVENTIONAL CONSTRUCTION
(.242% Vertical Reinforcing)

FIGURE 7: DIAGONAL TENSION (SHEAR)
LOAD/STRAIN CHARACTERISTICS (FROM TABLE VI)

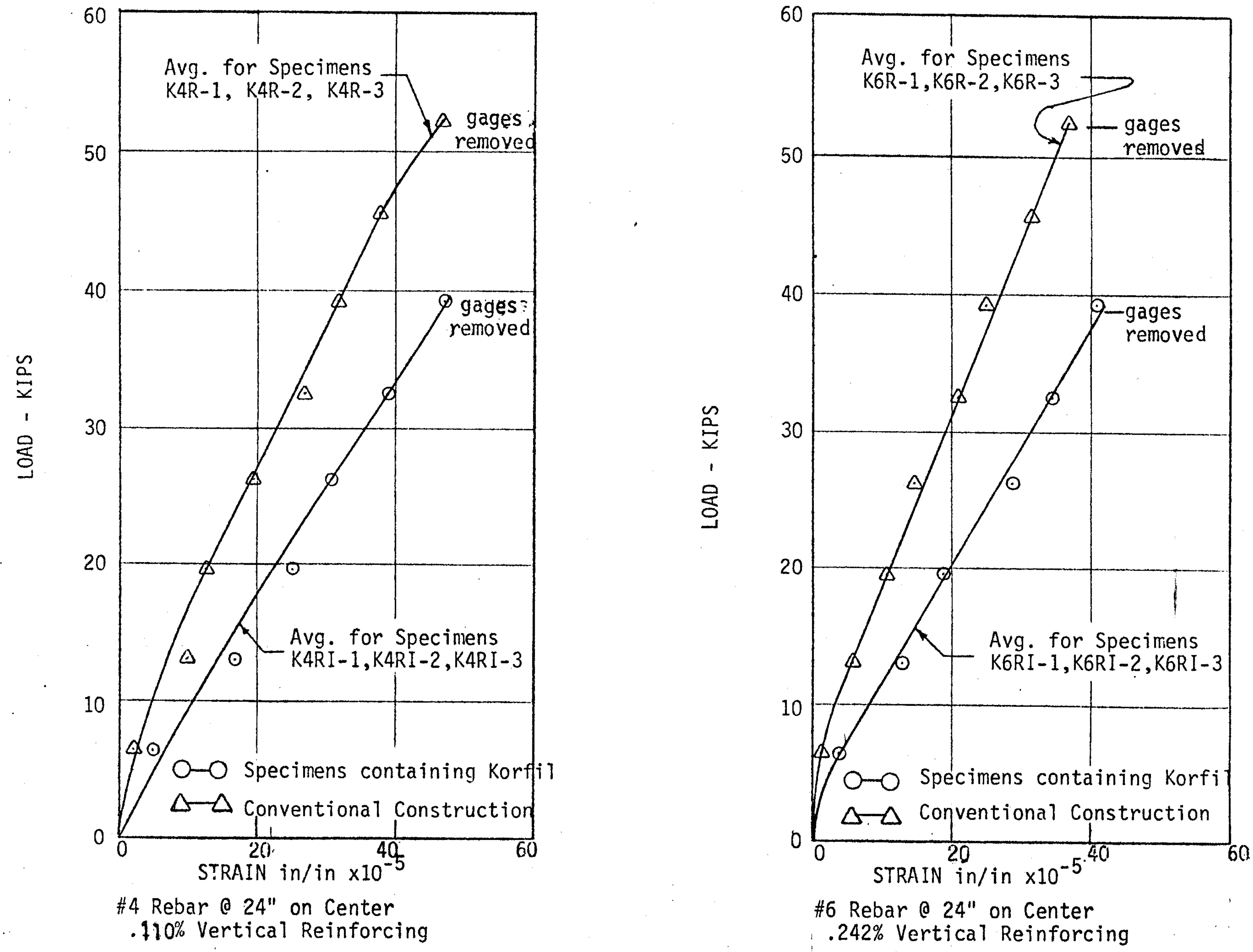


TABLE VII - COMPRESSIVE STRENGTH TESTS

#4 Rebar @ 24" on Center = .110% Vertical Reinforcing

Insulated Construction - Specimens Containing Korfil Inserts

Specimen Number	Age at Test "Days"	Ultimate Load Lbs.	Compressive Strength Gross Area psi	Compressive Strength Average psi
K4CI-1	27	295,000	847	
K4CI-2	28	319,200	917	781
K4CI-3	27	201,600*	579*	

Gross Area Wall = 363 - 15** = 348 in^2

* Low Value may have been caused by premature failure in top course (See Figure 26).

** Area Korfil from previous calculation.

TABLE VIII - BEAM TESTS (FLEXURE)

(See Figure 3 for loading details)

Specimen Number	Age at Test "Days"	Reinforcing	Ultimate Load Lbs.	Average Load Lbs.	Remarks
KB4I-1	28	1 #4	9,900		
KB4I-2	28	1 #4	14,400	11,900	Contains Korfil
KB4I-3	28	1 #4	11,300		
KB4-1	28	1 #4	15,800		
KB4-2	28	1 #4	16,500	14,800	Conventional Construction
KB4-3	28	1 #4	12,200		
KB6I-1	28	1 #6	18,200		
KB6I-2	28	1 #6	15,800	16,100	Contains Korfil
KB6I-3	28	1 #6	14,200		
KB6-1	28	1 #6	18,700		
KB6-2	28	1 #6	14,600	17,500	Conventional Construction
KB6-3	28	1 #6	19,200		
KBI-1	28	none	2,850		
KBI-2	28	none	3,100	3,150	Contains Korfil
KBI-3	28	none	3,500		

FIGURE 8 : COMPRESSIVE STRENGTH
LOAD vs. DEFORMATION

(VERTICAL REINFORCING - NO. 4 REBAR @ 24" ON CENTER)

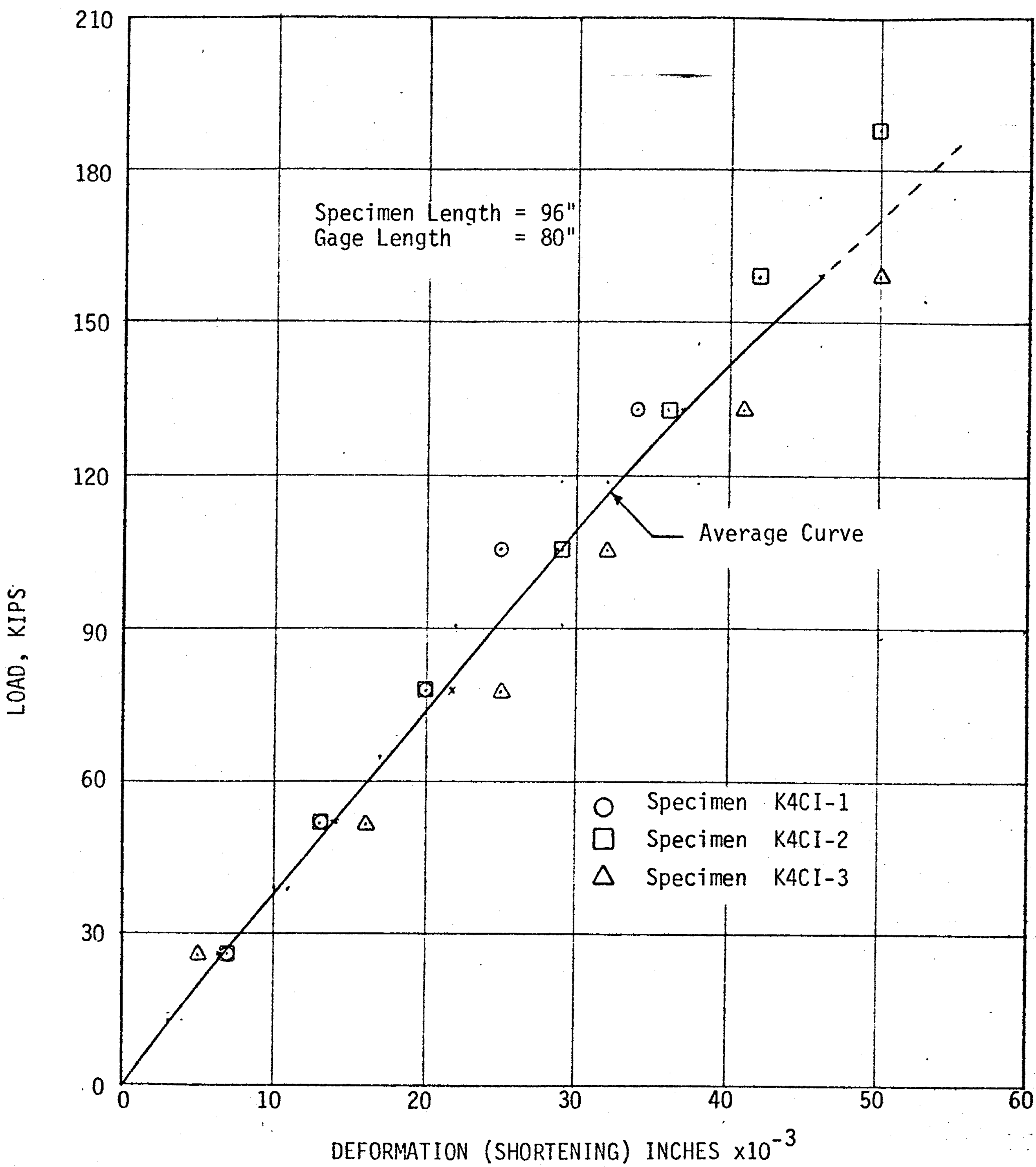
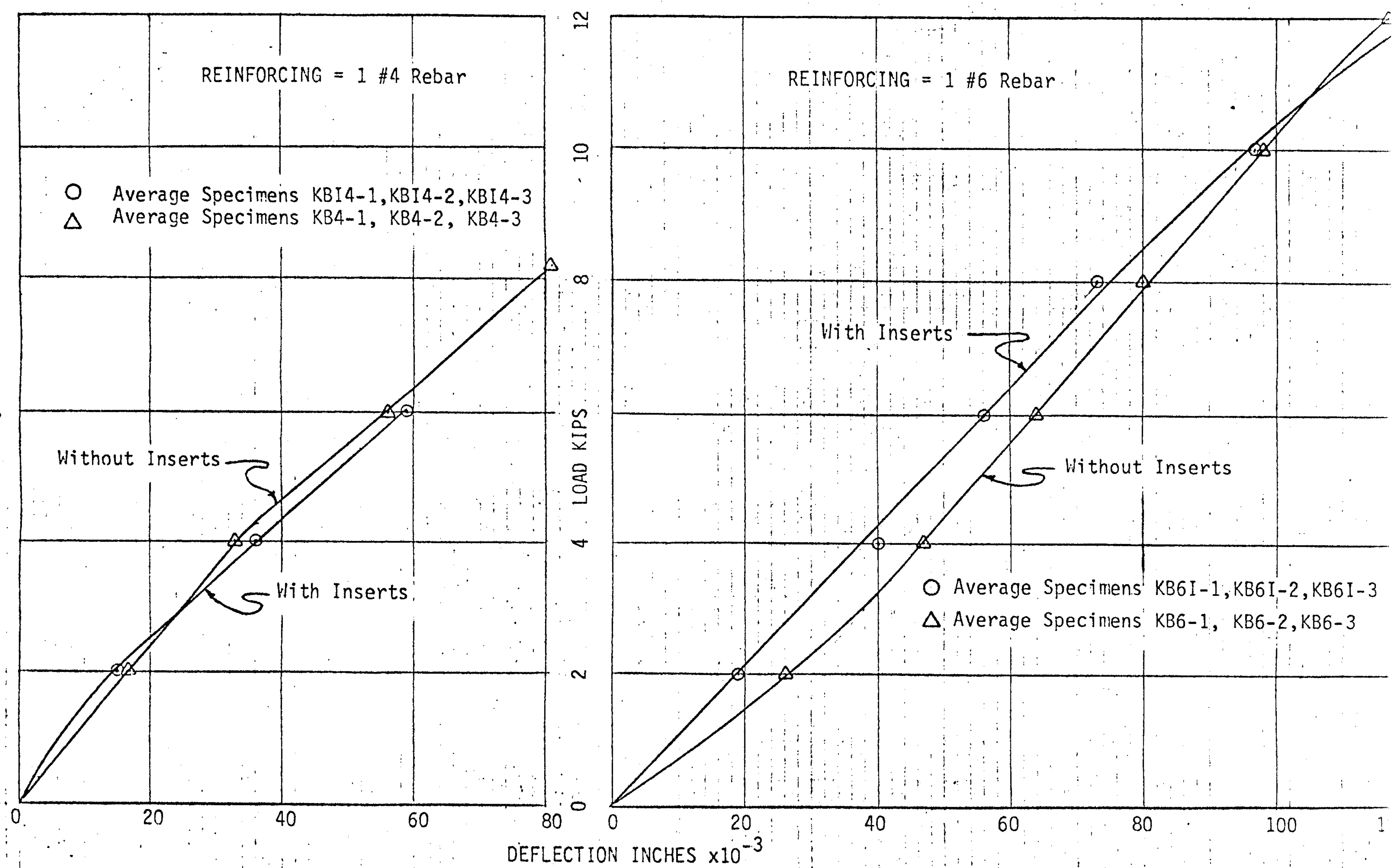


FIGURE 9 : LOAD/DEFLECTION CURVES FLEXURAL BEAM TESTS
(SEE TABLE VIII)



TYPICAL CONSTRUCTION OF FLEXURAL WALL SPECIMENS

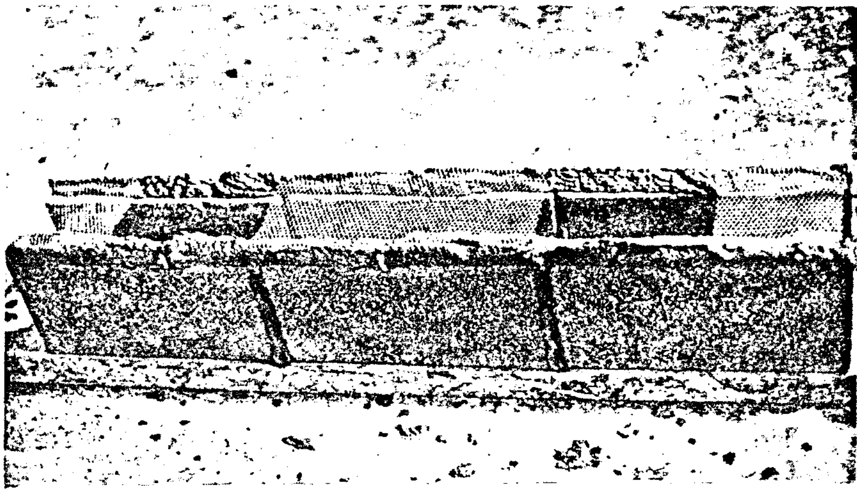


Figure 10: Initial bond beam course showing plastic netting used to confine grout flow.

Figure 11: End view after installation of second course.

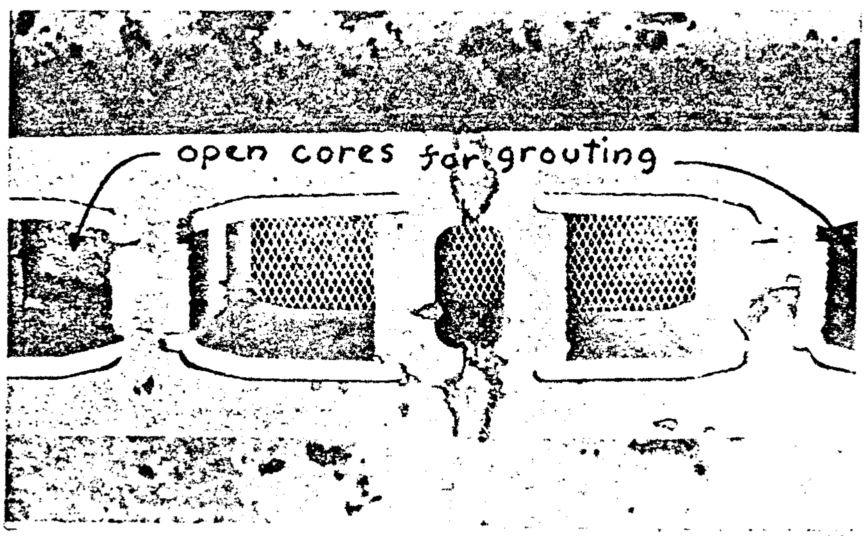


Figure 12: Top view of second course illustrating area to be grouted, Korfil Block and Inserts.

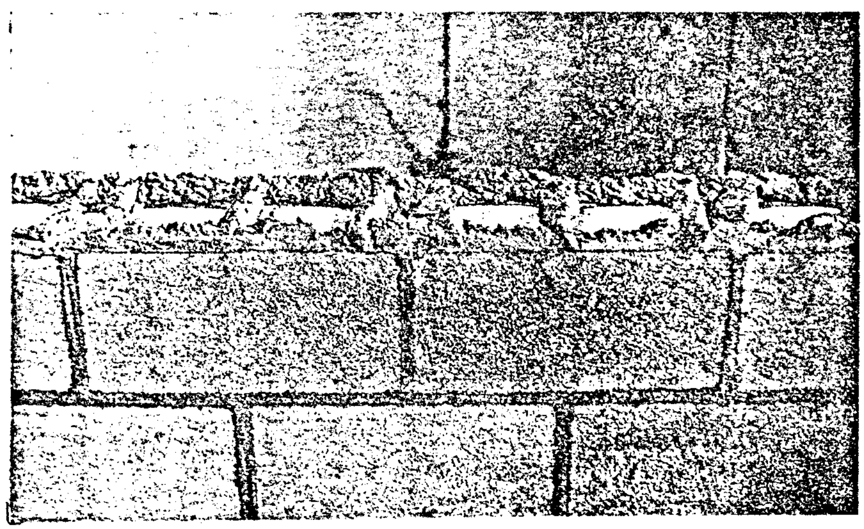


Figure 13: Shows typical mortar bedding used for all wall specimen construction.

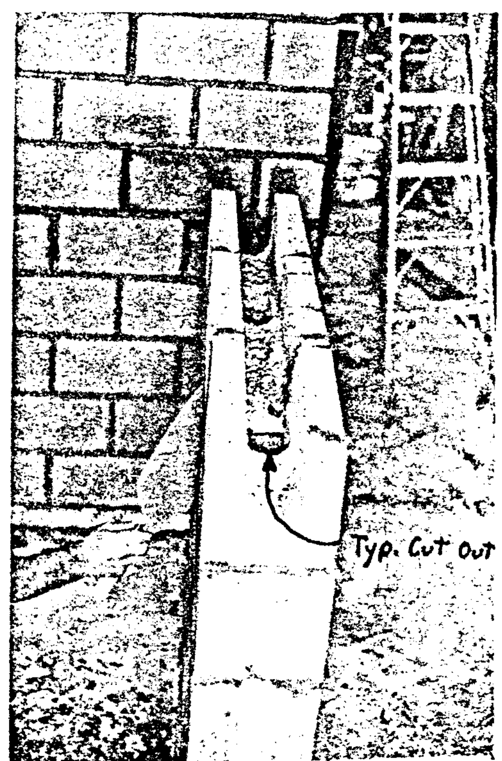


Figure 14: Illustrates typical bond beam cut outs to permit grouting of vertical cores.

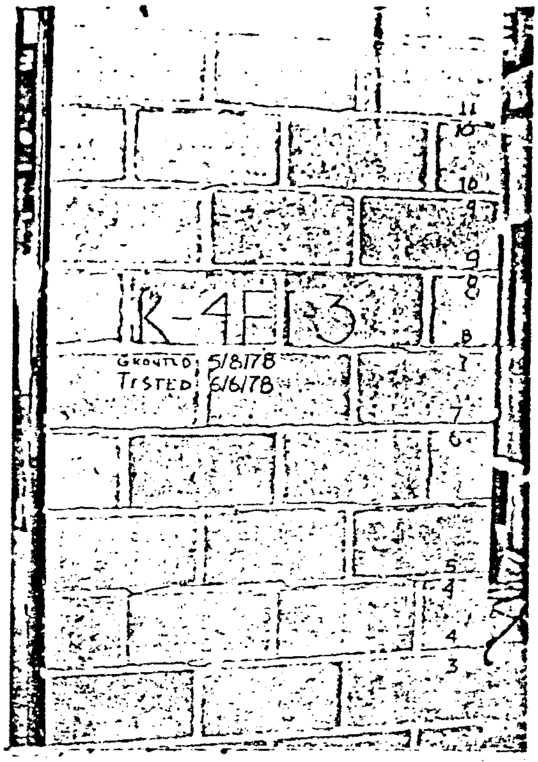


Figure 15: Typical Mortar Bond Separations for specimens containing Korfil Inserts and Reinforced with 1 #4 at 24" on Center.

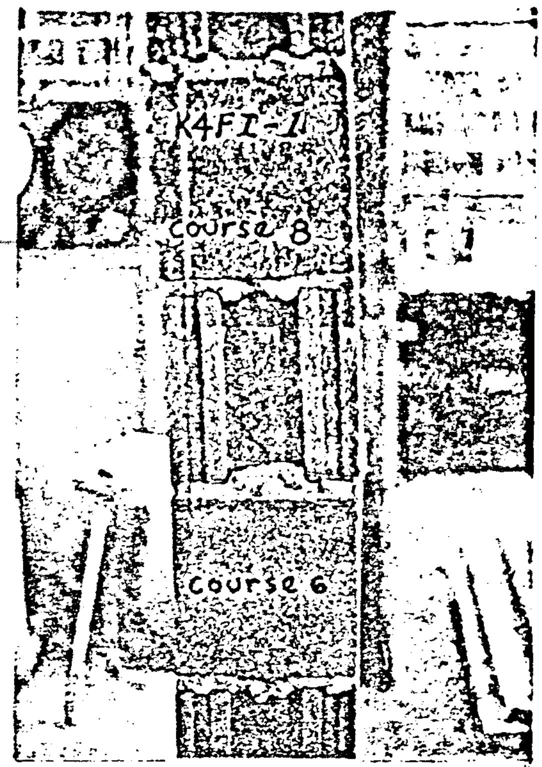


Figure 16: Crack propagating towards compression face appeared in two of the K4FI walls. Specimen contained Korfil Inserts and was Reinforced with 1#4 at 24" on center.

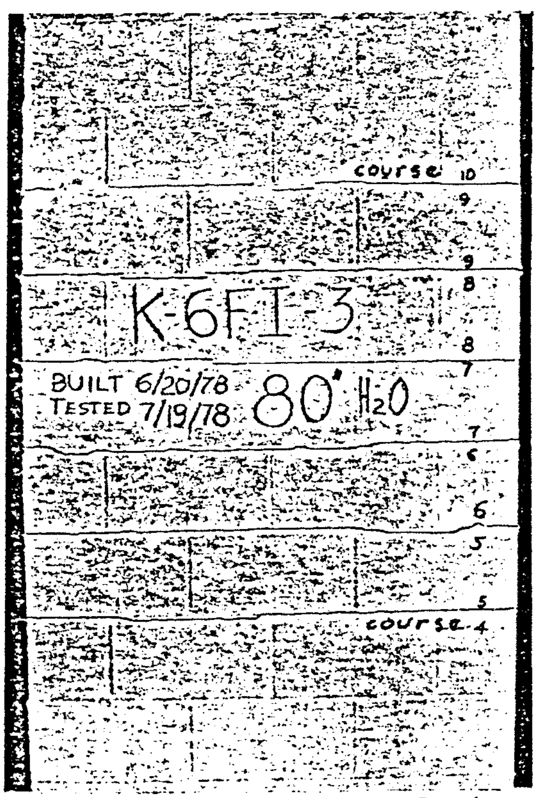


Figure 17: Typical Mortar Bond separations for specimens containing Korfil Inserts and Reinforced with 1 #6 at 24" on Center.

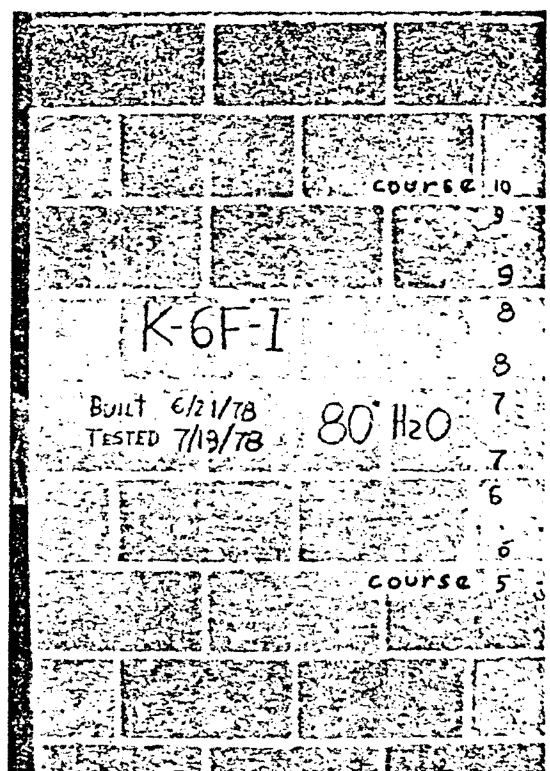


Figure 18: Typical Mortar Bond separations (at numbered courses) for conventionally constructed specimens (without Korfil Inserts) and Reinforced with 1 #6 at 24" on center

Figure 19: Racking Test at failure. Specimen contains Korfil Inserts & is Reinforced with 1 #4 at 24" on center.

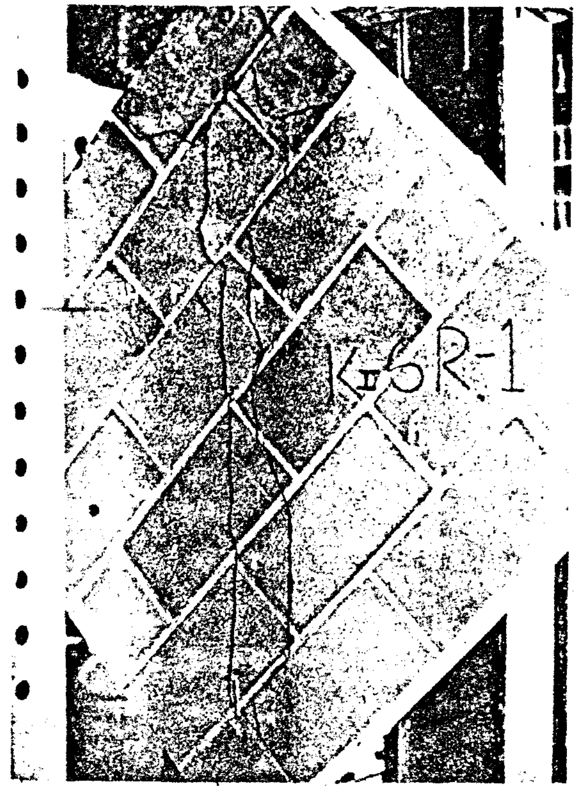


Figure 20: Racking Test showing different failure pattern. Specimen contains Korfil Inserts and is Reinforced with 1 #6 at 24" on center.

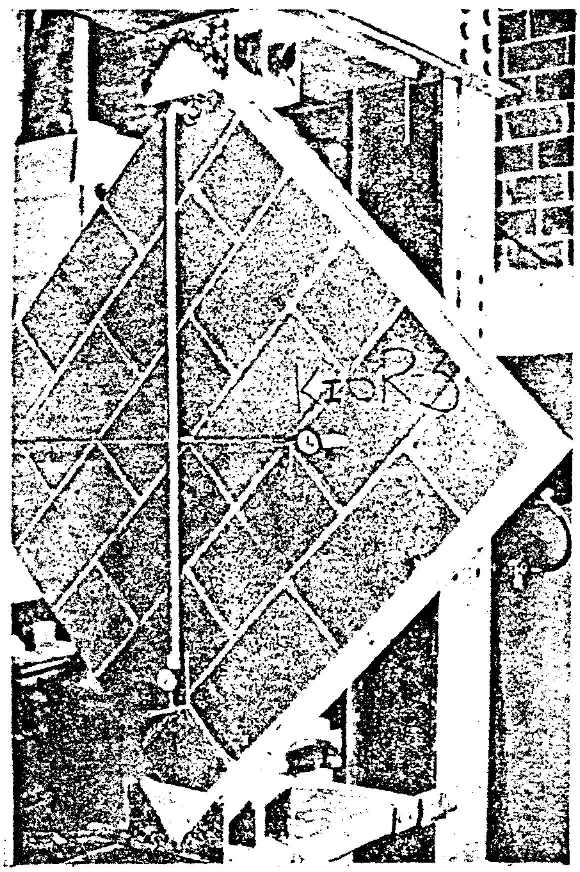


Figure 21: Racking Test Illustrating Instrumentation for recording vertical shortening and horizontal extension. Gages were applied both sides.

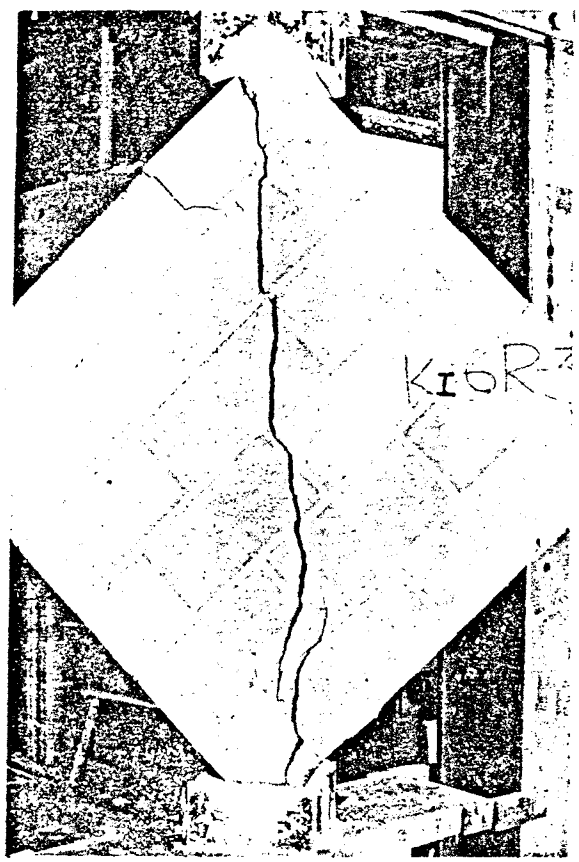


Figure 22: Racking Test at failure Specimen contains Korfil Inserts & is Reinforced with 1 #6 at 24" on center.

Figure 23: Racking Test at failure. Specimen conventionally constructed (without Korfil Inserts) and Reinforced with 1 #4 at 24" on Center.

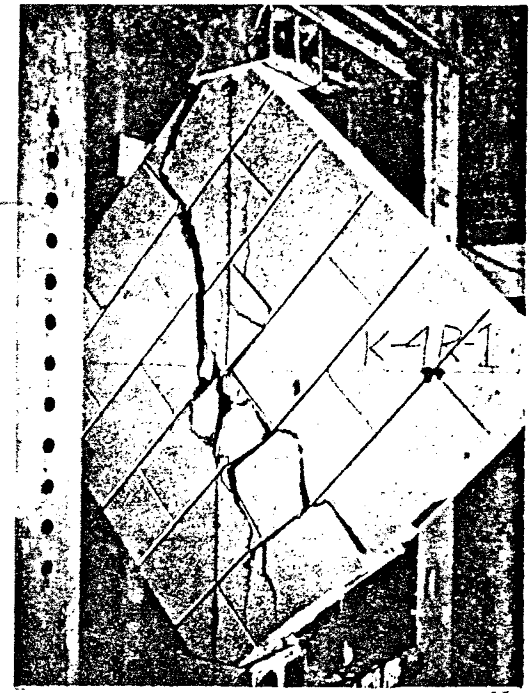


Figure 24: Racking Test continued beyond initial failure. Specimen conventionally constructed (without Korfil Inserts) and Reinforced with 1 #4 at 24" on Center.

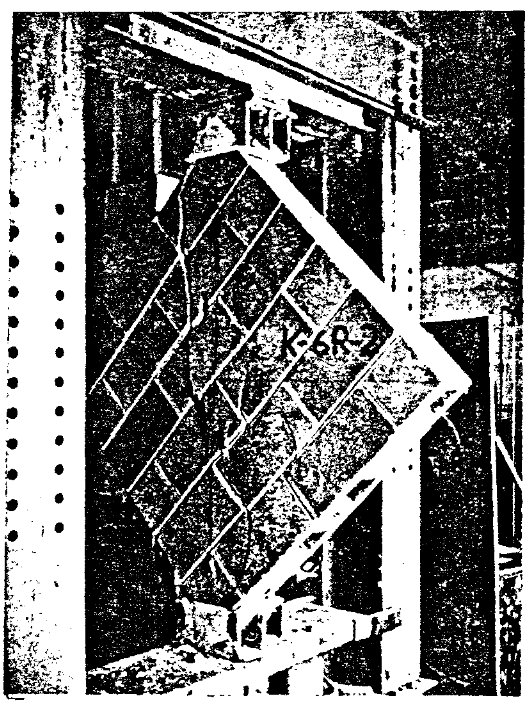


Figure 25: Racking Test at failure Specimen conventionally constructed (without Korfil Inserts) and Reinforced with 1 #6 at 24" on center.

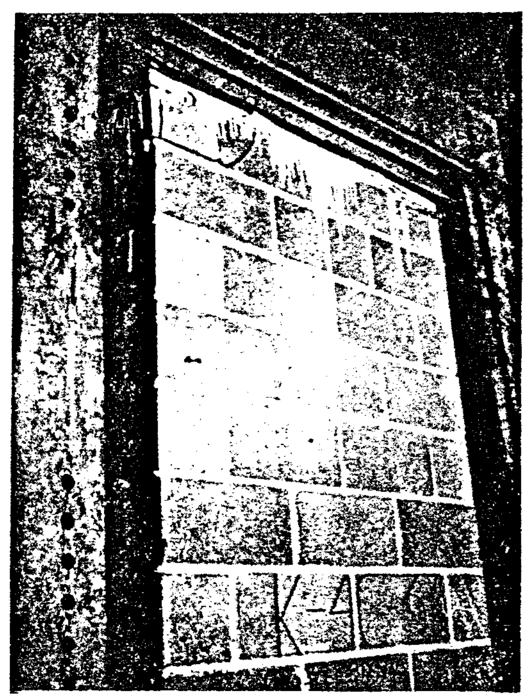


Figure 26: Compression Test showing premature failure in top course as referenced in Table VII. Specimen contains Korfil Inserts and is Reinforced with 1 #4 at 24" on Center.