April 2, 1997

Refer to: HNG-14

Mr. Kaddo Kothmann
President
Road Systems, Inc.
P.O. Box 2163
Big Spring, Texas 79721

Dear Mr. Kothmann:

Your March 4 letter to Mr. Gerald L. Eller provided the Federal Highway Administration (FHWA) information on the design and the crash-test performance of a new w-beam guardrail terminal named the Sequential Kinking Terminal (SKT-350). Design and performance details were contained in a March 1997 report from Southwest Research Institute entitled "Full-Scale Crash Evaluation of a Sequential Kinking Terminal (SKT-350)".

The SKT-350 is 15.2 m long and can be installed parallel to the roadway or with a 50:1 flare. Its major components include a 3.81-m w-beam rail section (modified by punching three 102-mm x 12.6-mm long slots in the "valley" of the rail centered at 267 mm, 546 mm, and 825 mm from the upstream end of the rail), an impact head assembly, a guide tube and guide rail assembly, and a breakaway cable anchorage assembly. Details for each of these components are included in the enclosed drawings SKT-1 through SKT-5.

When the SKT-350 is struck head-on, the impact head is forced rearward, bending the w-beam rail against the deflector plate which, in conjunction with a "kinker" beam in the head, causes short segments of rail to kink sequentially, and bend away from the impacting vehicle. For hits at and downstream from post 3 (the beginning of the length of need), the cable attachment transmits the tensile forces in the rail to the anchorage system to contain and redirect the impacting vehicle.

NCHRP Report 350 requires up to seven crash tests to determine the adequacy of a traffic barrier terminal/crash cushion at test level 3 (TL-3). Enclosure 2 is a summary of the results of the tests actually run on the SKT-350. We have noted that tests 3-34 and 3-39 were not run. Test 3-34 is a 100 km/h, 15 degree impact with an 820-kg car at the "critical impact point" which is approximately mid-way between the end of the terminal and the beginning of the length of need, i.e., at post number 2 for the SKT-350. Test 3-39 is a 100 km/h, 20 degree impact with a 2000-kg pickup truck at the mid-point of the terminal in a reverse direction. You stated that both tests were run previously on the ET-2000 and/or BEST terminals and that, because of the similarity of the three designs at the impact points specified for tests 3-34 and 3-39, these tests would be redundant, and hence, unnecessary for certification of the SKT-350. After reviewing the earlier tests and the details of the SKT-350 design, we agree that tests 3-34 and 3-39 are not needed. However, we note that in the reverse direction tests (test 3-39) with both the ET-2000 and the BEST, the impact heads were dislodged from the w-beam rail and were propelled approximately 60 m downstream in a line that was essentially parallel to the barrier installation. Under some site

and roadway alignment conditions this head could become a hazard to other motorists. We assume that the SKT-350 head would act the same, and that users be advised accordingly. Based on our analysis of the information you provided, we conclude that the SKT-350 terminal meets the appropriate evaluation criteria contained in NCHRP Report 350 and may be considered acceptable for use on projects on the National Highway System (NHS) when selected by a State highway agency. In addition to the design tested, we also agree that the post/foundation tube combinations shown in Enclosure 3 are acceptable for use with the SKT-350 without additional testing.

Since your product is proprietary, its use on Federal-aid highway projects, except exempt, non-NHS projects, is subject to the conditions stated in Title 23, Code of Federal Regulations, Section 635.411. If you have any questions, please call Mr. Hatton at (202) 366-1329 or Mr. Richard Powers at (202) 399-1320.

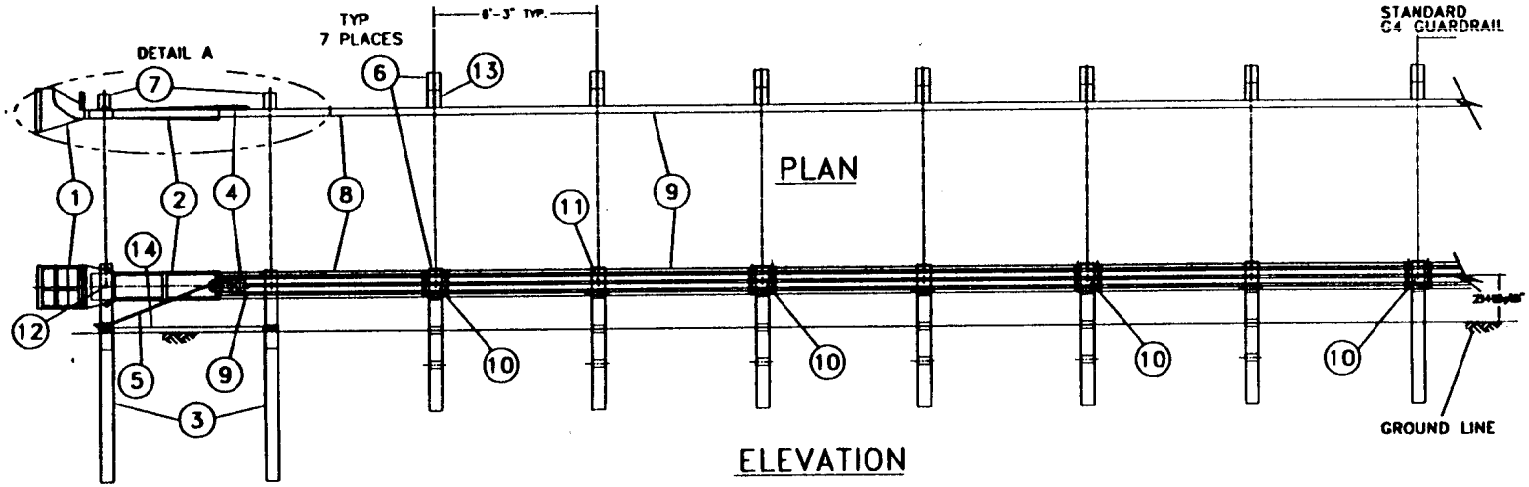
Sincerely yours,

(original James H. Hatton, Jr.)

for Dwight A. Horne, Chief
Federal-Aid and Design Division

3 Enclosures
Acceptance Letter CC-40

ITEM NO.	QTY	DESCRIPTION	DWG NO. AND PART NO.
1	1	IMPACT HEAD ASSY	SKT-1: B,C SKT-2: D,E,F,G
2	1	GUIDE RAIL AND GUIDE TUBE ASSY	SKT-3: H,I,J,K,L,M
3	2	FOUNDATION SLEEVE (B-4)	SKT-4
4	1	CABLE RELEASE BRACKET ASSY	SKT-5: N,O,P
5	1	BCT CABLE ANCHOR ASSEMBLY	-
6	6	PDE09 6" x 8" x 6'-0" CRT TIMBER POST (POSTS 3 THRU 8)	-
7	2	PDF01 5.5" x 7.5" x 42.5" BCT TIMBER POST (POSTS 1 & 2)	-
8	1	W-BEAM TERMINAL RAIL SECTION (12'-6")	SKT-1: A
9	3	2-SPACE OR 4 SPACE W-BEAM GUARDRAIL (12'-6" SECTION)	-
10	32	FBB01 GUARDRAIL SPLICE BOLT & RECESSED NUT	-
11	7	FBB04 GUARDRAIL BOLT AND RECESSED NUT (POSTS 2 THRU 8)	-
12	1ea	¾ ø ALL THREAD BOLT w/WASHER & NUT (POST 1)	-
13	6	PDB01 W-BEAM TIMBER BLOCKOUT (POSTS 3 THRU 8)	-
14	1	GROUND LINE STRUT ASSY	SKT-5: Q, R

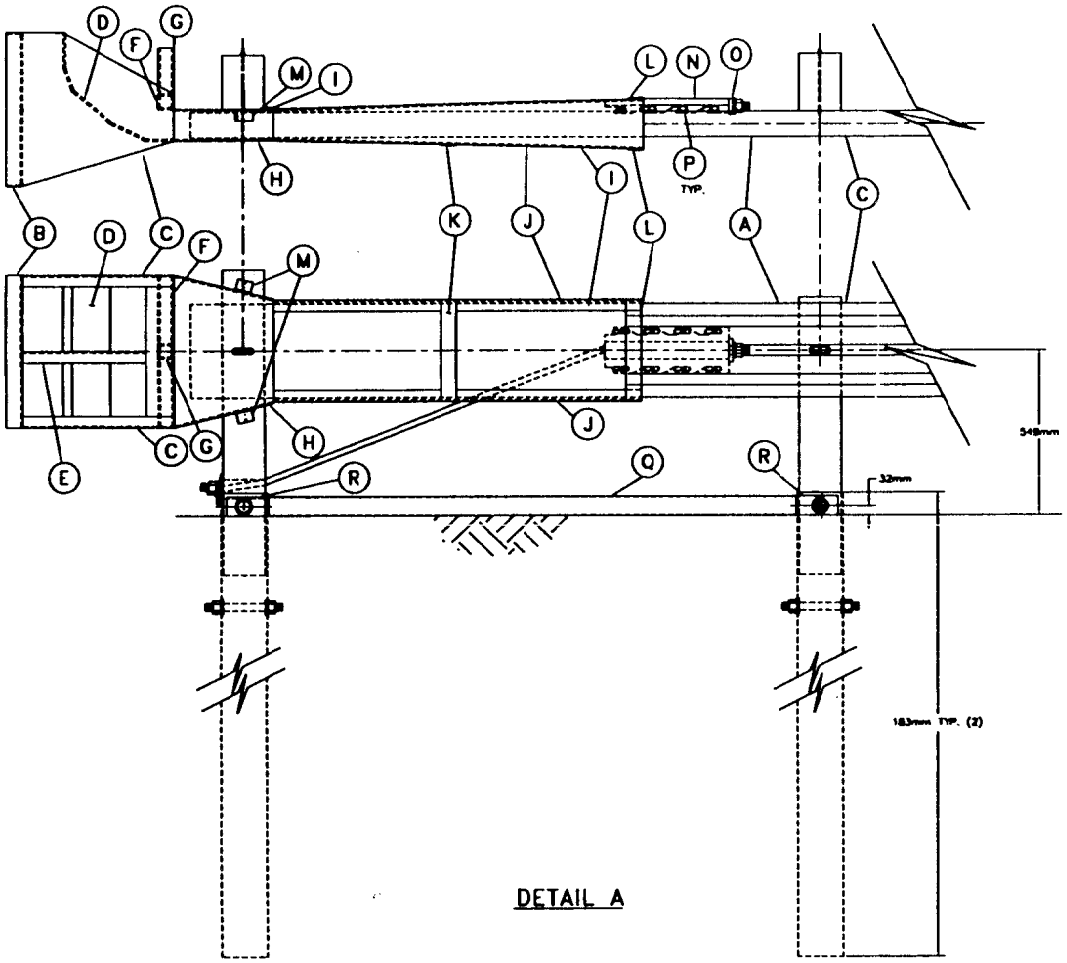


ELEVATION

SEQUENTIAL KINKING TERMINAL
(SKT-350) ASSEMBLY

DRAWN BY	DATE	DWG NO.	PG
LS	11/22/96	ASSY	1 2

REVISION DATE



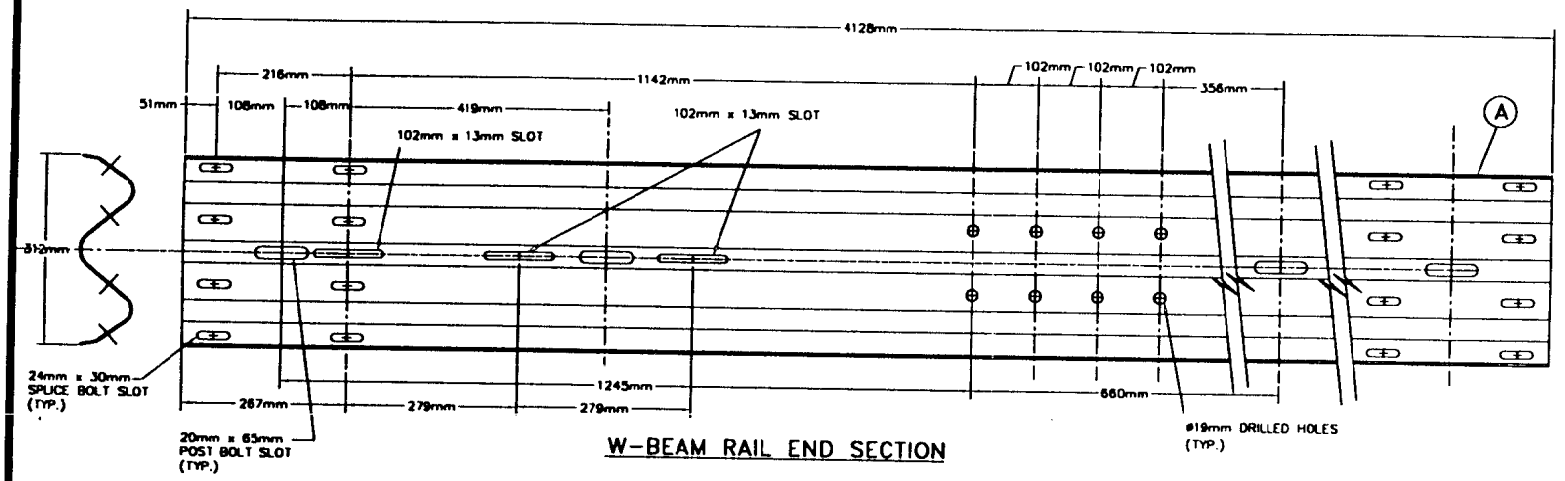
DETAIL A

ITEM NO.	DWG NO.	QTY	DESCRIPTION
A	SKT-1	1	W-BEAM TERMINAL RAIL SECTION (REF)
B	SKT-1	1	FRONT IMPACT PLATE
C	SKT-1	2	TOP AND BOTTOM PLATES
D	SKT-2	1	DEFLECTOR PLATE
E	SKT-2	1	GUSSET PLATE
F	SKT-2	1	KINKER BEAM
G	SKT-2	1	POST BREAKER BEAM
H	SKT-3	1	GUIDE TUBE
I	SKT-3	1	GUIDE TUBE STRAP
J	SKT-3	2	GUIDE RAIL CHANNELS
K	SKT-3	1	CENTER GUIDE RAIL STRAP
L	SKT-3	2	END GUIDE RAIL STRAPS
M	SKT-3	2	POST ANGLES
N	SKT-5	1	CABLE RELEASE BRACKET
O	SKT-5	1	CABLE RELEASE PLATE
P	SKT-5	8	SLEEVED BOLTS
Q	SKT-5	1	GROUND STRUT
R	SKT-5	2	YOKES
	SKT-6	–	WELDING SPECIFICATIONS

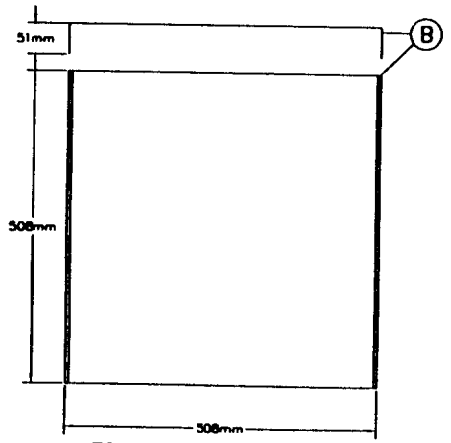
SEQUENTIAL KINKING TERMINAL (SKT-350) ASSEMBLY

DRAWN BY	DATE	DWG NO.	PG OF
LS	11/22/96	ASSY2	2 2
REVISION DATE			

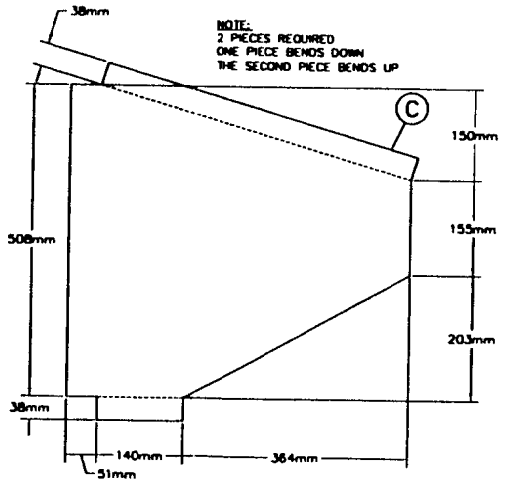
ITEM NO.	QTY	DESCRIPTION	MATERIAL
A	1	RAIL END SECTION	12 GA. W-BEAM
B	1	FRONT IMPACT PLATE	10 GA. 50 ksi PLATE
C	2	TOP AND BOTTOM PLATES	10 GA. 50 ksi PLATE



W-BEAM RAIL END SECTION



FRONT IMPACT PLATE



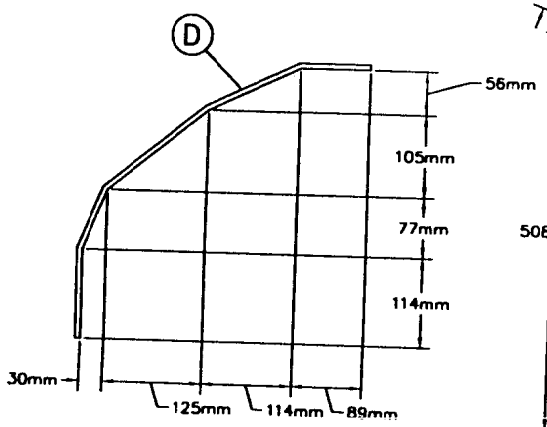
TOP AND BOTTOM PLATE

SEQUENTIAL KINKING TERMINAL
(SKT-350)
W-BEAM RAIL END SECTION
FRONT IMPACT PLATE
TOP AND BOTTOM PLATES

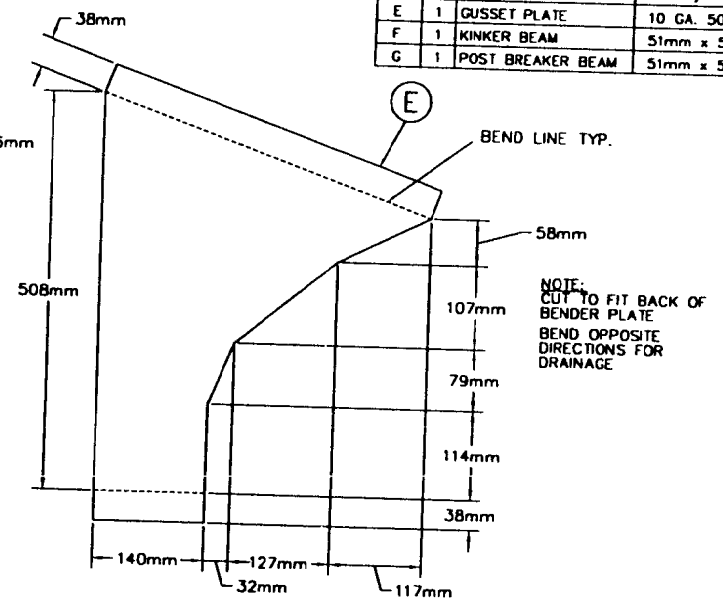
DRAWN BY	DATE	DWG NO.	SHEET NO. OF
LS	11/22/96	SKT-1	1 1

REVISION DATE

ITEM NO.	QTY	DESCRIPTION	MATERIAL
D	1	DEFLECTOR PLATE	A36 1/4" PLATE
E	1	GUSSET PLATE	10 GA. 50 ksi PLATE
F	1	KINKER BEAM	51mm x 51mm x ¼" A500 GRADE B
G	1	POST BREAKER BEAM	51mm x 51mm x ¼" A500 GRADE B

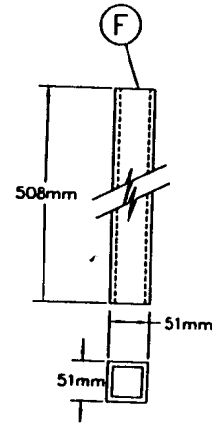


DEFLECTOR PLATE

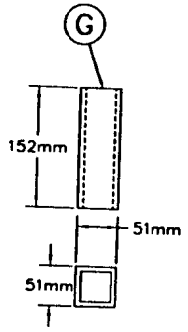


NOTE:
CUT TO FIT BACK OF BENDER PLATE
BEND OPPOSITE DIRECTIONS FOR DRAINAGE

GUSSET PLATE



KINKER BEAM



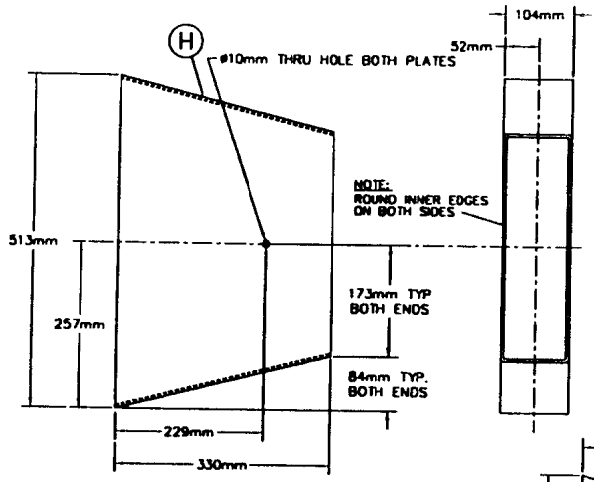
POST BREAKER BEAM

SEQUENTIAL KINKING TERMINAL
(SKT-350)
DEFLECTOR PLATE
GUSSET PLATE
KINKER BEAM
POST BREAKER BEAM

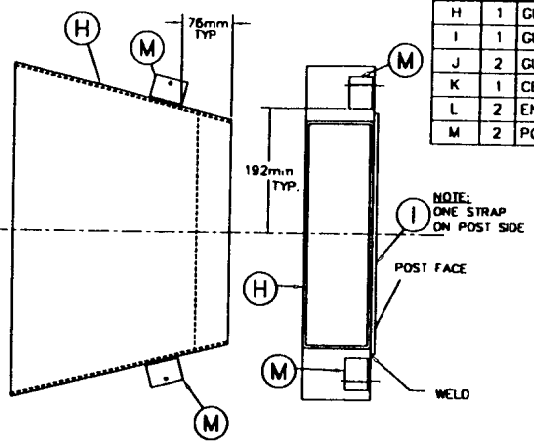
DRAWN BY	DATE	DWG NO.	PG OF
LS	11/22/98	SKT-2	1 1

REVISION DATE

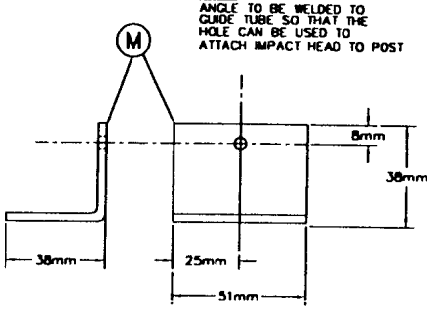
ITEM NO.	QTY	DESCRIPTION	MATERIAL
H	1	GUIDE TUBE	10 GA. 50 ksi PLATE
I	1	GUIDE TUBE STRAP	6mm 50 ksi PLATE
J	2	GUIDE RAIL CHANNELS	10 GA. 50 ksi PLATE
K	1	CENTER GUIDE RAIL STRAP	10 GA. 50 ksi PLATE
L	2	END GUIDE RAIL STRAPS	12.7mm 50 ksi PLATE
M	2	POST ANGLES	A36 3mm PLATE



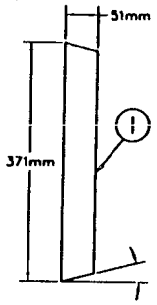
GUIDE TUBE



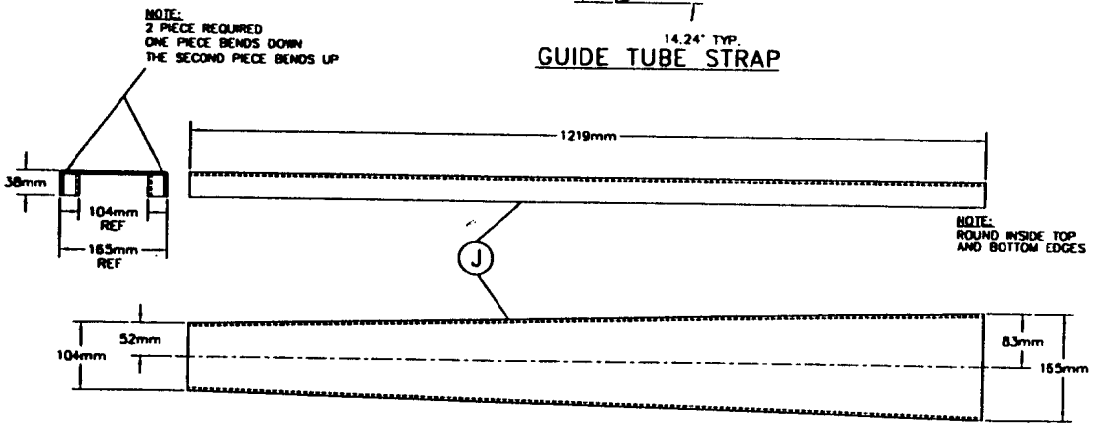
GUIDE TUBE,
POST ANGLE AND
GUIDE TUBE STRAP ASSEMBLY



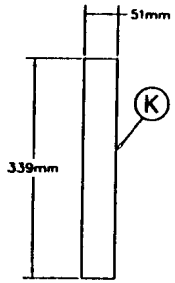
POST ANGLE



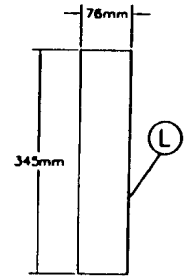
GUIDE TUBE STRAP



GUIDE RAIL CHANNEL



CENTER GUIDE
RAIL STRAP



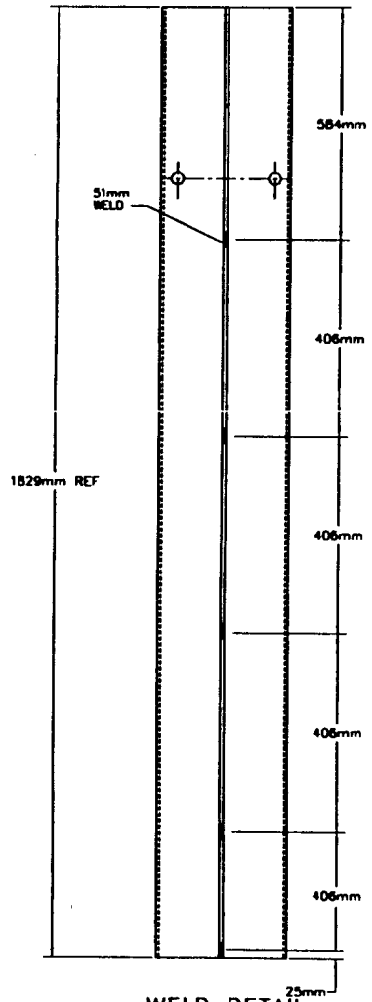
END GUIDE
RAIL STRAP

SEQUENTIAL KINKING TERMINAL
(SKT-350)
GUIDE TUBE
GUIDE TUBE STRAP
GUIDE RAIL CHANNELS
CENTER GUIDE RAIL STRAP
END GUIDE RAIL STRAPS
POST ANGLES

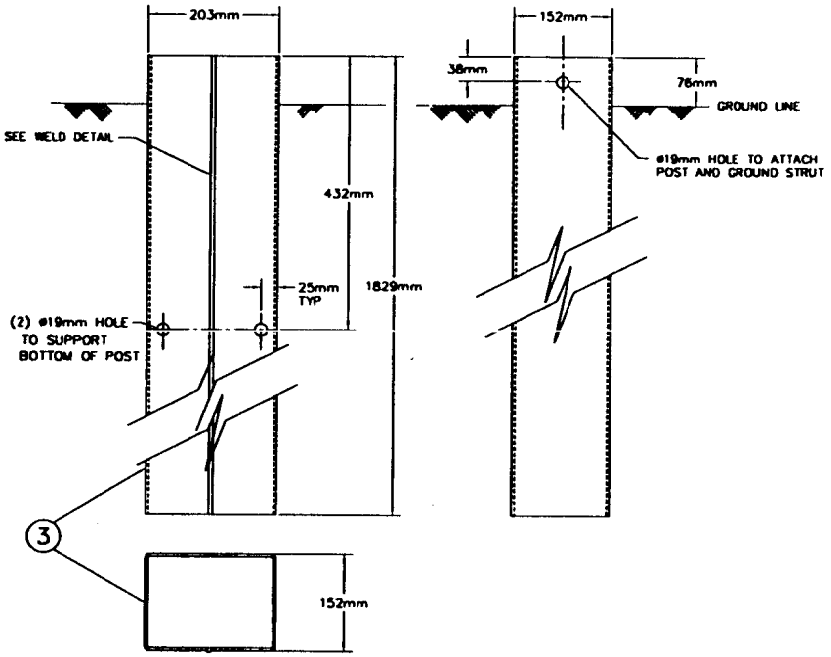
DRAWN BY	DATE	DWG NO.	PG OF
LS	11/22/96	SKT-3	1 1

REVISION DATE

ITEM NO.	QTY	DESCRIPTION	MATERIAL
3	2	FOUNDATION SLEEVE	50 ksi 3mm PLATE



WELD DETAIL
NOT TO SCALE



FOUNDATION SLEEVE

SEQUENTIAL KINKING TERMINAL
(SKT-350)

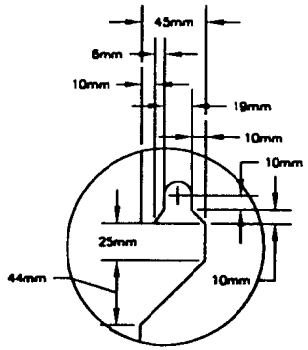
FOUNDATION SLEEVE

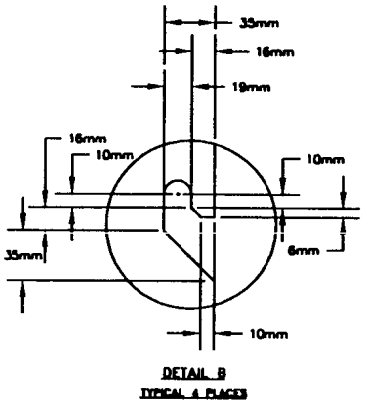
DRAWN BY	DATE	DWG NO.	PG OF
LS	11/22/96	SKT-4	1 1

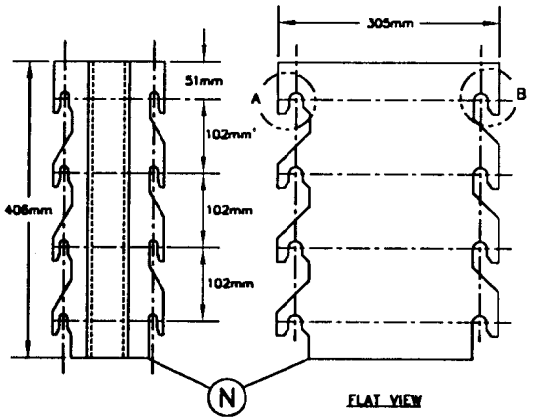
REVISION DATE

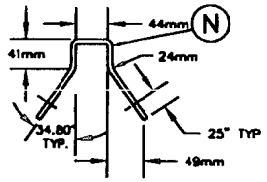
Sheet 6 of 7

ITEM NO.	QTY	DESCRIPTION	MATERIAL
N	1	CABLE RELEASE BRACKET	A36 3mm PLATE
O	1	CABLE RELEASE PLATE	A36 13mm PLATE
P	8	QUICK RELEASE BOLTS	A325
Q	1	GROUND STRUT	54mm x 54mm x 14 GA TUBING
R	2	YOKES	A36 5mm PLATE

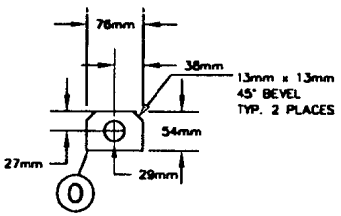






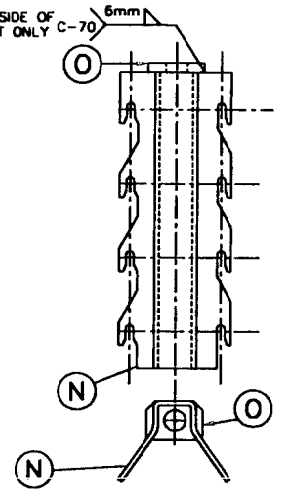


CABLE RELEASE BRACKET

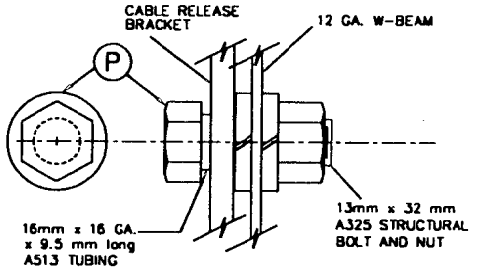


CABLE RELEASE PLATE

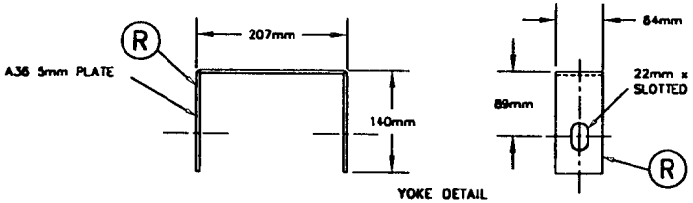
NOTE: WELD INSIDE OF BRACKET ONLY C-70



CABLE RELEASE ASSEMBLY



QUICK RELEASE BOLT



GROUND STRUT ASSEMBLY

SEQUENTIAL KINKING TERMINAL
(SKT-350)
CABLE RELEASE BRACKET
CABLE RELEASE PLATE
SLEEVED BOLT
GROUND STRUT
YOKES

DRAWN BY	DATE	DWG NO.	PG OF
LS	11/22/96	SKT-5	1 1

REVISION DATE

TABLE 1. SUMMARY OF CRASH TEST RESULTS

Test No.	Test Designation and Description	Actual Impact Conditions		Occupant Risk				Comments	Assessment
		Speed (km/h)	Angle (Deg.)	OIV (m/s)		RA (g's)			
				Long.	Lat.	Long.	Lat.		
SBD-1	Test 3-35 - Pickup truck redirection.	99.8 (62.0 mph)	20.0	5.7	1.7	-4.2	8.4	Maximum deflection = 0.8 m (31.5 in.). Length of contact = 7.6 m (24.9 ft). Posts 3 through 8 fractured.	**PASS**
SBD-2	Test 3-31 - Pickup truck end-on.	100.1 (62.2 mph)	0	4.3	2.0	-21.4	-16.3	Deformed bumper blocked exit of kinked rail and limited kinking to approx. 1.3 m (4 ft). Posts 1 through 7 broken off. Test judged unsatisfactory due to excessive long. ridedown acceleration.	**FAIL**
SBD-3	Test 3-31 - Pickup truck end-on.	100.1 (62.2 mph)	0	5.9	1.5	-7.6	5.4	Repeat of test SBD-2 with modified impact head. Posts 1 through 9 broken off. Approx. 15 m (50 ft) of rail fed through impact head.	**PASS**
SBD-4	Test 3-30 - Small car end-on.	98.5 (61.2 mph)	0	6.4	3.6	-5.6	3.9	Actual point of impact on front of vehicle was offset 584 mm (23 in.) instead of the nominal 381 mm (15 in.). Posts 1 through 4 broken off and approx. 4.5 m (15 ft) of the rail fed through impact head prior to the vehicle exiting. Vehicle yawed clockwise a total of 360 degrees.	**PASS**
SBD-5	Test 3-32 - Small car end-on at an angle.	100.1 (62.2 mph)	15.0	7.4	1.5	-9.6	-3.1	Posts 1 through 3 broken off with approx. 2.5 m (8 ft) of rail fed through impact head. Vehicle bent rail at post 4 and exited behind guardrail.	**PASS**
SBD-6	Test 3-33 - Pickup truck end-on at an angle.	100.1 (62.2 mph)	15.0	5.1	1.8	-13.9	13.3	Posts 1 through 3 broken off with approx. 1.5 m (5 ft) of rail fed through impact head. Vehicle bent rail at post 4 and exited behind guardrail.	**PASS**

TABLE 2. PROPOSED SKT-350 POST OPTIONS

SKT-350 Design Options	No. Of New 1.9 m (6 ft) Long, 3.2 mm (1/8 in.) Thick Foundation Tubes	No. of PTE05 Foundation Tubes with PLS03 Soil Plates	No. of CRT Posts
A	2	0	6
B	2	2	4
C	2	6	0
D	0	4	4
C	0	8	0