SLSF LOOP HANDLING SYSTEM

Volume IV

Analysis Verifications and
Supporting Appendices**MASTER**

by

H. Ahmed, R. A. Malek, A. Rafer, D. Ma,
F. D'Souza, and J. W. Leonard

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ARGONNE NATIONAL LABORATORY, ARGONNE, ILLINOIS**Prepared for the U. S. DEPARTMENT OF ENERGY
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ABSTRACT

SLSF loop handling system was analyzed for deadweight and postulated dynamic loading conditions, identified in Chapters II and III in Volume I of this report, using a linear elastic static equivalent method of stress analysis. Stress analysis of the loop handling machine is presented in Volume I of this report. Chapter VII in Volume I of this report is a contribution by EG & G Co., who performed the work under ANL supervision. Stress analysis of SLSF-LHS cradle structure is performed in Volume II and Volume III of this report; Volume II consists of computer modeling of LHM-Cradle-transporter system and Volume III consists of stress computations of Cradle and critical attachments per AISC Code guidelines. HFEF is credited with in-depth review of initial phase of work in Volume III of this report. A summary of results with conclusions and recommendations is presented in Chapter XV in volume III of this report. Volume IV of this report contains some relevant backup appendices for the report.

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APPENDIX A

SLSF LOOP HANDLING SYSTEM
FUNCTIONAL DESIGN REQUIREMENTS DOCUMENTA.1 SCOPE

A.1.1 This FDR Documents the design/performance requirements for the SLSF Loop Handling System (LHS). The system includes all the equipment necessary to provide locomotion capability for the SLSF In-Pile Loop at, and between, interfacing facilities at the Idaho Nuclear Engineering Laboratory (INEL).

A.1.2 Included in the engineering process for the handling system, is preparation of the documentation for approval of the system by the Manager, ERDA-ID, prior to use.

A.2 APPLICABLE DOCUMENTS

The following documents, of the exact issue shown, form a part of this document to the extent specified herein.

A.2.1 Argonne National Laboratory (ANL) Documents

A.2.1.1 System Design Description of the Sodium Loop Safety Facility In-Pile Loop System, R1000-1001-SA.

A.2.1.2 SLSF In-Pile Loop Dimensional Control Drawing, ANL Drawing No. R1020-0002-DR.

A.2.1.3 SLSF Quality Assurance Plan, ANL R1000-11000-SA.

A.2.1.4 ANL/HFEF-001 Conceptual Design for the Handling and Remote Disassembly of the SLSF Loop at the HFEF, May 1972.

A.2.2 Aerojet Nuclear Company (ANC) Documents

A.2.2.1 ANC, "FEFPL In-Pile Loop, Interface Locations", Drawing No. 402987.

A.2.2.2 ANC, "FEFPL In-Pile Loop, Interface A VC Block Leveling Pad and LHM", Drawing No. 402966.

A.2.2.3 ANC, "ETR Crane Modifications from 30 to 50 Tons", Drawing No. 1375-MTR-642-M1.

A.2.2.4 Phillips Petroleum Company, "ETR Reactor Building First Floor Plan", Drawing No. ETR-D-1584.

A.2.3 Government Documents

A.2.3.1 USAEC Manual 0500-1, Annex "L", Safe Transport of Radioactive and Fissile Materials.

A.2.3.2 RDT F 8-6T, "Requirements for Hoisting and Rigging of Special Components and Equipment", August, 1972.

A.2.3.3 RDT F 7-2T and Amendment 2, "Preparation for Sealing, Packaging, Packing and Marking of Components for Shipment and Storage", September 1972.

A.2.4 Non-Government Documents

A.2.4.1 ASTM D-635

A.2.4.2 National Electric Code 1971 (NFPA No. 70)

A.3 FUNCTIONS AND DESIGN REQUIREMENTS

A.3.1 General Functions

The loop handling system is a transfer-transport system of equipment which provides the capability to (1) handle the SLSF in-pile loop at various facilities within the INEL, and (2) transport the SLSF in-pile loop between these facilities (Reference A.2.1.1 and A.2.1.2). Two major subsystems are envisioned as the primary components of the handling system, the loop handling machine (LHM) and the transporter.

A.3.2 Specific Functions

A.3.2.1 Transfer of non-irradiated loops from the FS&R facility to the ETR for irradiation (Reference A.2.2.1 and A.2.2.2).

A.3.2.2 Transfer of irradiated loops from the ETR to interim storage during the ETR mid cycle refueling period and back to the ETR on completion of refueling.

A.3.2.3 Transfer of irradiated loops from the ETR to the HFEF/N for examination.

A.3.3 Design Requirements

A.3.3.1 SLSF Project Requirements for Loop Handling System

A.3.3.1.1 The handling system shall be capable of transferring and transporting, collectively or individually, a completely assembled in-pile loop, the primary vessel of the SLSF in-pile loop, and the test train for the SLSF in-pile loop.

A.3.3.1.2 Maximum design load of the loop hoisting equipment shall be 10,000 pounds. This is the maximum projected weight of SLSF loops.

A.3.3.1.3 The inside diameter of the LHM shall be 20 inches.

A.3.3.1.4 Maximum length of an SLSF loop (top flange to bottom of secondary tube) is 27 feet. The LHM shall accommodate this length without exceeding an overall length of 30 feet.

A.3.3.1.5 Maximum weight of the LHM and loop shall be 45 tons.

A.3.3.1.6 Maximum weight of the loop handling machine and loop, with ancillary equipment detached, shall be 40 tons.

A.3.3.1.7 Maximum weight of the LHM, loop and transporter shall be 100 tons.

A.3.3.1.8 The handling system shall provide power to the loop pump, (15 kw -- 0.50 PF) as required, to maintain the loop sodium at 450°F.

A.3.3.1.9 The requirement for providing power to the loop shall cover the vertical transfer of the loop between the LHM and ETR interfacing stations, as well as any residence period of the loop within the LHM.

A.3.3.1.10 The handling system shall provide instrumentation connections to the test train thermocouples (12) for monitoring loop temperatures. This requirement shall cover the vertical transfer of the loop between the LHM and the ETR interfacing stations as well as any residence period of the loop within the LHM.

A.3.3.1.11 The loop handling system shall be designed to handle loops in the 6 x 6, south-western section of test channel M-7 of the ETR, and in all other 6 x 6, 6 x 9, and 9 x 9 test channels.

A.3.3.1.12 The loop handling system shall be designed so that with a source resulting from a 1.8 MW fission power experiment for two ETR cycles in the test section, the loop can be removed from the reactor with: normal handling procedures within 48 hours after shutdown if no fuel is dispersed; within 4 days after shutdown if 20% of the fuel is uniformly dispersed; and within 10 days after shutdown if 100% of the fuel is uniformly dispersed.

A.3.3.2 Design/Performance Requirements

A.3.3.2.1 The loop handling system shall be designed in accordance with the specific requirements of AEC Manual 0500-1, Annex "L", Safe Transport of Radio-active and Fissile Materials.

φ¹ A.3.3.2.2 LHM equipment required for hoisting the loop during vertical transfers shall be designed in accordance with RDT F 8-6T, "Requirements for Hoisting and Rigging of Special Components and Equipment," August 1972. In addition, the design shall be such that any single component failure will not result in the load being dropped.

A.3.3.2.3 The LHS shall provide radiation protection such that radiation exposures are within the limits of AECM-0524, as invoked by Annex "L" in A.3.3.2.1 above.

A.3.3.2.4 The handling machine grapple drive shall be provided with instrumentation for continuously indicating the force applied to the grapple chains, with provisions for stopping grapple motion if pre-established force limits are reached.

A.3.3.2.5 The LHM grapple drive system shall be provided with position indicating equipment to monitor the elevation position of the grapple.

A.3.3.2.6 The LHM grapple drive system shall be powered by a stepless, variable speed, DC motor with an integral brake. The gearing ratio of the drive train shall be such that the maximum hoisting speed shall not exceed 10 ft/min. When lowering the loop, the rate of descent shall not exceed 5 ft/min. The 5 ft/min rate shall be achieved through automatic control which can be bypassed by a key switch and appropriate administrative controls.

A.3.3.2.7 The LHM shall provide support for the loop in both the vertical and near horizontal (approximately 10°) positions.

A.3.3.2.8 The LHS shall be designed with mechanical and/or electrical interlocks to control the sequential operations of equipment. These interlocks shall be coordinated with all interfacing systems and will be for operations that are critical for safe operation.

A.3.3.2.9 The LHS shall provide cooling, as required, to maintain the integrity of the transfer system.

A.3.3.2.10 The LHS and associated control equipment shall be designed to withstand the forces which might be imposed by wind, ice, and other natural elements.

A.3.3.3 Interface Requirements

A.3.3.3.1 All structural materials and components, within the control and scope of the LHS that come in contact with the primary water of the ETR and the argon of the HFEF/N main cell, shall be designed to assure compatibility with the ETR water and the HFEF/N cell atmosphere.

A.3.3.3.2 The LHM shall be compatible with the HFEF/N per item A.2.1.4.

A.3.3.3.3 The LHM shall be equipped to accept argon service prior to and during loop handling in the HFEF/N main cell. When mated with the HFEF/N, the LHM shall be sufficiently leak tight to limit an in-leakage to less than 0.01 CFM at 1.0 inch water pressure.

A.3.3.3.4 The LHM shall be compatible with the ETR crane per item A.2.2.3.

A.3.3.3.5 The LHS shall be compatible with the ETR space and load limitations per item A.2.2.4.

A.3.3.3.6 The LHS shall be designed to comply with the rules and regulations of the State of Idaho, Department of Highways.

A.3.3.4 Design Features

A.3.3.4.1 The LHM design shall be such that up to 10 tons of additional shielding can be placed on the machine without exceeding the load capacity of interfacing cranes.

A.3.3.4.2 All LHS mechanisms shall be automated for remote operation and shall have provisions for manual override in the event the prime mover fails.

A.3.3.5 Duty Cycles

A.3.3.5.1 The handling system shall be designed for 600 duty cycles. One duty cycle is defined as the steps necessary to insert the loop into the machine, transport the machine to a discharge location, discharge the loop, and secure the handling system.

A.3.3.5.2 The hoist subsystem of the handling system shall be designed for 1200 duty cycles. One cycle is defined as extending the lifting chains to their full extension and then returning them to the fully retracted position.

A.3.3.5.3 All other auxiliary system shall be designed for 3000 duty cycles.

A.3.3.6 Environment

A.3.3.6.1 For operation within a facility, ETR or HFEF/N, the LHS shall be designed for a temperature range of 50 to 100°F and a relative humidity of 90%.

A.3.3.6.2 During transport, the LHS shall be designed to withstand the effects of a -45 to 140°F temperature range and up to relative humidity of 100%.

A.3.3.7 Maintenance

A.3.3.7.1 The LHS shall be designed for interchangeability of parts where fit and Function are identical.

A.3.3.7.2 The LHS shall be designed for contact maintenance. This will require that the configuration of component equipment and subsystems be such that decontamination is facilitated.

A.3.3.8 Electrical

A.3.3.8.1 All wiring shall be fire-retardant and self-extinguishing in accordance with ASTM D 635.

A.3.3.8.2 All wiring and cable shall be designed to meet the requirements of the National Electrical Code, NFPA No. 70.

A.4 QUALITY ASSURANCE PROVISIONS

A.4.1 Quality Assurance Program

Quality Assurance shall be in accordance with ANL Quality Assurance Plan R1000-1000-SA (A.2.1.2).

A.4.2 Inspection and Testing

Inspection and testing shall be performed to the extent specified in the procurement specifications for each component or subassembly

A.5 PREPARATION FOR SHIPMENT

A.5.1 Components to be wetted by reactor coolant or HFEF/N argon gas shall be packaged for shipment and stored in accordance with RDT Standard F 7-2T and the ordering data as required for each component or part. Other components shall be packaged such that damage or degradation is precluded during shipment and storage of that part.

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TECHNICAL DOCUMENTATION LIST (contd)

DOCUMENT NUMBER	DOCUMENT TITLE	LAST REV.	DRAWING NUMBER
0601-DB	Shaft Sprocket Counter	5/25/77	
0602-DC	Pad	5/25/77	
0603-DC	Pad	5/25/77	
0604-DC	Brake Housing Locating Fix.	5/25/77	
0605-DB	Socket	11/16/77	
0606-DE	Test Stand for Gear Drive	5/25/77	
0607-DB	Coupling-Shafts Alignment	5/25/77	
1005-SE	Depleted Uranium Gamma Ray Shielding Segments	3/01/72	
1006-SE-00	Spec. for Main Body Assy FEFP Loop Handling Machine	12/29/75	
1007-SE-00	Loop Handling Machine System	11/05/73	
1011-SE	Trailer for the LHM	1/02/74	
1012-SE	Transporter Cradle Assembly	5/16/74	
1014-SE	Specs for Shield Valve Assy	5/20/74	
1015-SE	LHM Grapple	8/27/76	
1016-SE	LHM Grapple Drive Assy	2/07/73	
1017-SE	LHM Loop Supports	6/12/74	
1023-SE	FEFP LHS Functional Design Requirements Document	1/19/77	
1025-SP	Test Procedure for LHM Control Equip-FEFP LHM 173306	3/14/74	
1025-SP	Test Procedure LHM 173305	6/20/74	
1026-SE	50Kw Diesel Generator for LHM System	3/14/74	
1027-SP	Test Proc for LHM Power Dist. Panel	5/09/75	
1028-SP	Test Proc. for LHM Voltage Control Unit	5/09/75	
1029-SP	Test Proc. for Loop Handling Machine Remote Control Panel	5/09/75	
1030-SP	Test Procedure for LHM Transptr and LHM Cables	5/09/75	
1031-SC	Transporter Control Console for the FEFP Loop	8/05/74	

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DOCUMENT NUMBER	DOCUMENT TITLE	LAST REV.	DRAWING NUMBER
0002-DE	FEFP Loop Handling Machine & Transporter	5/20/75	RA-E 3815
0002-PL	Parts List for 0002-DE	5/19/75	RA-PL 3815
0003-DX	FEFP Loop Handling Machine Assy	2/25/74	RA-X-3815A
0003-PL	Parts List for 0003-DX	5/07/74	RA-PL-3815A
0004-DE	Main Body Assy	12/26/75	RA-E-3815A1
0004-PL	Parts List for 0004-DE	12/26/75	RA-PL-3815A1
0005-DE	Grapple Drive Assy	2/19/75	RA-E-3815A2
0005-PL	Parts List for 0005-DE	2/17/75	RA-PL-3815A2
0006-DE	Shield Valve Assembly	1/02/74	RA-E-3815A6
0006-PL	Parts List for 0006-DE	8/23/74	RA-PL-3815A6
0007-DB	Wiring Diagram Drive Test Panel	2/07/73	RA-B-3887
0008-DD	Operator Torque Setting	1/08/73	RA-D-3888
0009-DE	Dome Assembly (2 Sheets)	6/00/74	RA-E-3815A3
0009-PL	Parts List for 0009-DE	6/00/74	RA-PL-3815A3
0010-DE	Grapple Assy (4 Sheets)	12/09/74	RA-E-3815A4
0010-PL	Parts List for 0010-DE	9/07/76	RA-PL-3815A4
0011-DE	Loop Support - Upper Assy	9/04/75	RA-E-3815A5
0011-PL	Parts List for 0011-DE	9/05/75	RA-PL-3815A5
0012-DE	Loop Support - Lower Assy	10/25/73	RA-E-3815A8
0012-PL	Parts List for 0012-DE	10/09/73	RA-PL-3815A8
0013-DE	Liner Assy		RA-E-3815A7
0013-PL	Parts List for 0013-DE		RA-PL-3815A7
0014-DE	Gear Drive Assy	5/04/76	RA-E-3815A2A
0014-PL	Parts List for 0014-DE	5/04/76	RA-PL-3815A2A
0015-DE	Motor Drive Assy	8/10/73	RA-E-3815A2B
0015-PL	Parts List for 0015-DE	9/18/73	RA-PL-3815A2B
0016-DD	Loop Location Counter Assy	7/30/73	RA-DD-3815A2C
0016-PL	Parts List for 0016-DD	7/02/73	RA-PL-3815A2C
0017-DD	Flow Diagram for FEFP Loop Handling Machine		RA-D-3894
0018-DD	Flow Diagram for FEFP Trans.		RA-D-3895
0019-DE	Limiterorque Setting Fixture Assy	0/08/73	RA-E

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0019-PL	Parts List for 0019-DE	1/08/73	RA-PL-3897
0020-DE	LHM Counter Balance Assy	10/00/75	RA-E-3815A9
0020-PL	Parts List for 0020-DE	10/00/75	RA-PL-3815A9
0026-DD	FEFPL Project Transporter and Loop Handling Machine	8/05/76	RA-D-3815A10-5
0022-DD	FEFPL Project LHM Upper Support Operators	8/31/76	RA-D-3815A10-1
0023-DD	FEFPL Project LHM Lower Support Operators Schematic	8/31/76	RA-D-3815A10-2
0024-DD	FEFPL Project LHM Bottom Door Operator Schematic	1/05/74	RA-D-3815A10-3
0025-DD	FEFPL Project Transporter & Loop Handling Machine Cable	5/10/74	RA-D-3815A10-4
0021-DD	FEFPL Project Loop Handling Machine Elevation & Details	8/31/76	RA-D-3815A10
0027-DD	FEFPL Project Loop Handling Machine Console Assy	8/31/76	RA-D-3815A10-6
0028-DD	FEFPL Project LHM Control Panel Assy	8/31/76	RA-D-3815A10-7
0029-DD	FEFPL Project Loop Handling Machine Upper & Lower Supports Wiring Diagram	7/09/76	RA-D-3815A10-8
0030-DD	FEFPL Project Loop Handling Machine LHM Console Wiring	8/31/76	RA-D-3815A10-9
0031-DD	FEFPL Project LHM Bottom Door Operator & LHM Control Panel	8/31/76	RA-D-3815A10-10
0032-DD	FEFPL Project LHM Hoist Schematic Diagram	7/09/76	RA-D-3815A10-11
0033-DD	FEFPL Project LHM Power Distribution Panel Assy	11/23/74	RA-D-3815A10-12
0034-DD	FEFPL Project Transporter & Loop Handling Machine Cable	8/31/76	RA-D-3815A10-13
0035-DD	FEFPL Project LHM Connector Wiring Details	8/31/76	RA-D-3815A10-14
0036-DD	FEFPL Project Power Distrib. Panel Schematic Diagram	11/23/74	RA-D-3815A10-15
0037-DE	FEFPL Transporter	1/21/75	RA-E-3815B
0037-PL	Parts List for 0037-DE	12/00/75	RA-PL-3815B

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DOCUMENT NUMBER	DOCUMENT TITLE	LAST REV.	DRAWING NUMBER
0040-DE	FEFPL Elevating Assy	12/11/73	RA-E-3815B3
0040-PL	Parts List for 0040-DE	7/24/74	RA-PL-3915B3
0041-DE	FEFPL Cradle Elevating HYD. System	12/11/73	RA-E-3815B4
0041-PL	Parts List for 0041-DE	2/09/76	RA-PL-3915B4
0042-DE	Trunnion Assy	9/25/75	RA-PL-3815B3A
0043-DE	Cradle Assy	7/28/75	RA-E-3815B3B
0043-PL	Parts List for 0043-DE	12/11/73	RA-PL-3815B3B
0044-DE	Vertical Lock Assy	12/11/73	RA-E-3815B3A1
0044-PL	Parts List for 0044-DE	12/11/73	RA-PL-3815B3A1
0045-DE	LHM Vertical Hold Down Assy	12/11/73	RA-E-3815B3B1
0045-PL	Parts List for 0045-DE	12/11/73	RA-PL-3815B3B1
0046-DE	Base Plate Assy	12/11/73	RA-E-3815B3B2
0046-PL	Parts List for 0046-DE	12/11/73	RA-PL-3815B3B2
0047-DD	Vertical Positioner	12/11/73	RA-D-3815B3B2C
0047-PL	Parts List for 0047-DD	12/11/73	RA-PL-3815B3B2C
0048-DD	Horizontal Positioner	12/11/73	RA-D-3815B3B2A
0048-PL	Parts List for 0048-DD	12/11/73	RA-PL-3815B3B2A
0049-DE	Horizontal LHM Hold-down Center	12/11/73	RA-E-3815B3B2B
0049-PL	Parts List for 0049-DE	12/11/73	RA-PL-3815B3B2B
0050-DE	Horizontal LHM Down Left	12/11/73	RA-E-3815B3B2D
0050-PL	Parts List for 0050-DE	12/11/73	RA-PL-3815B3B2D
0051-DE	Horizontal LHM Hold-down Right	12/11/73	RA-E-3815B3B2E
0051-PL	Parts List for 0051-DE	12/11/73	RA-PL-3815B3B2E
0052-DE	Cradle Horizontal Hold Down	12/11/73	RA-E-3815B2A
0052-PL	Parts List for 0052-DE	12/11/73	RA-PL-3815B2A
0054-DD	FEFPL Cradle Elev. Hyd. Pro.	12/11/75	RA-C-3815B4A
0042-PL	Parts List for 0042-DE	12/11/73	RA-PL-3815B3A
0055-DD	Transporter Cradle Control Console	12/11/73	RA-D-3815B4B
0055-PL	Parts List for 0055-DD	11/28/73	RA-PL-3815B4B
0056-DC	Transporter Control Console Remote Control Cable 1	12/11/73	RA-C-3815B4B1

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DOCUMENT NUMBER	DOCUMENT TITLE	LAST REV.	DRAWING NUMBER
0056-PL	Parts List for 0056-DC	11/28/73	
0057-DC	Transporter Control Console Remote Cable 2 Wiring	12/11/73	RA-C-3815B4B2
0057-PL	Parts List for 0057-DC	11/28/73	RA-PL-3815B4B2
0059-DD	FEFPL Project Alip Power & Control Schematic Design	11/23/74	RA-D-3815A10-16
0060-DD	FEFPL Project Voltage Control Unit Console Wiring Diagram	2/13/76	RA-D-3815A10-17
0061-DD	FEFPL Proj Voltage Contr. Unit Console Drilling Plan	11/23/74	RA-D-3815A10-18
0062-DD	FEFPL Project Alip Power & Control Remote Control Wiring	11/23/74	RA-D-3815A10-19
0063-DD	FEFPL Project Alip Power & Control Remote Drilling Plan	11/23/74	RA-D-3815A10-20
0065-DE	Dummy Grapple Assy	8/31/73	
0065-PL	Parts List for 0065-PL	8/31/73	
0066-DE	FEFPL Transporter Cradle Schematic Diagram	7/09/76	
0067-DE	FEFPL Transported Cradle Wiring Diagram	7/09/76	
0069-PL	FEFPL Transporter Cradle Conduit System	5/11/74	
0069-DE	FEFPL Transporter Cradle Conduit System	12/11/73	
0070-DE	FEFPL Transporter Cradle Conduit System	12/11/73	
0071-DE	LHM Stand Requirements	11/14/73	
0072-DE	Chain Breaking Fixture Assy	1/29/74	
0072-PL	Parts List for 0072-DE	1/29/74	
0073-DE	Loop Handling Machine Spreader Bar Sub-assy	3/14/74	
0060-PL	Parts List for 0060-DD	2/16/76	
0062-PL	Parts List for 0062-DD	11/23/74	
0075-DD	FEFPL Project LHM Hoist Motor Control Interconnecting Wiring Diagrams	11/07/74	
0076-DD	FEFPL Project Special Adjustable Speed Motor Drive System	1/28/74	

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0079-DE	Grapple Drive Brake Assy	9/04/75	
0079-PL	Parts List for 0079-DE	4/03/75	
0080-DC	Long LHM Thermocouple Jumper Cable	6/04/75	
0080-PL	Parts List for 0080-DC	6/05/75	
0081-DE	LHM Removable Shielding Assy		
0082-DE	Lower Loop Support Assy Manual Drive		
0082-PL	Parts List for 0082-DE		
0083-DE	LHM Removable Shielding Assy Lower Main Body		
0083-PL	Parts List for 0083-DE		
0084-DE	Gear Drive Assy Layout	11/16/77	
0085-DD	Grapple Drive Brake Assy Layout Proposal 1		
0086-DD	Grapple Drive Brake Assy Layout Proposal 2		
0084-PL	Parts List for 0084-DE	5/25/77	
0100-DE	Shielding	7/07/72	RA-E-3815A1-3
0101-DB	Shield	5/24/72	RA-B-3815A6-4
0102-DD	Sleeve	11/01/74	RA-D-3815A1-1
0103-DE	Upper Half	11/04/75	RA-E-3815A1-2
0104-DB	Cover	8/24/72	RA-B-3815A1-4
0105-DB	Gasket	8/14/72	RA-B-3815A1-5
0106-DE	Lower Half	12/26/75	RA-E-3815A1-6
0107-DE	Body	11/19/73	RA-E-3815A6-1
0108-DE	Cover	5/07/74	RA-E-3815A6-2
0109-DD	Shield Enclosure	2/07/73	RA-D-3815A6-3
0110-DB	Body Rail	2/07/73	RA-B-3815A6-5
0111-DB	Shield Rail	11/08/73	RA-B-3815A6-6
0112-DB	Lead Screw	4/04/73	RA-B-3815A6-7
0113-DA	Screw Support	2/07/73	RA-A-3815A6-8
0114-DC	Screw Seal Block	2/07/73	RA-C-3815A6-9
0115-DA	Lead Nut Spacer	2/07/73	RA-A-3815A6-10
0116-DB	Lead Nut Retainer	2/07/73	RA-B-3815A6-11

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DOCUMENT NUMBER	DOCUMENT TITLE	LAST REV.	DRAWING NUMBER
0117-DA	Lead Nut	2/07/73	RA-A-3815A6-12
0118-DA	Pinion	4/04/73	RA-A-3815A6-13
0119-DA	Stem Nut	4/04/73	RA-A-3815A6-14
0120-DB	Valve Control Base	4/26/74	RA-B-3815A6-15
0121-DB	Valve Control Mount	4/04/73	RA-B-3815A6-16
0122-DB	Drive Shaft	4/04/73	RA-B-3815A6-17
0123-DA	Gear	4/04/73	RA-A-3815A6-18
0124-DB	Gear Cover	4/04/73	RA-B-3815A6-19
0125-DA	Retainer Bushing	2/07/73	RA-A-3815A6-20
0126-DA	Spacer	2/07/73	RA-A-3815A6-21
0127-DA	Plunger	2/07/73	RA-A-3815A6-22
0128-DC	Gasket	2/07/73	RA-C-3815A6-23
0129-DA	Lock Pin	2/07/73	RA-A-3815A6-24
0130-DC	Drip Pan	2/07/73	RA-C-3815A6-25
0131-DC	Guide Ring	12/27/73	RA-C-3825A6-26
0132-DB	Linear Ball Retainer	5/07/74	RA-B-3815A6-28
0133-DA	Knob	2/07/73	RA-A-3815A6-29
0134-DA	Lock Pin Bushing	2/07/73	RA-A-3815A6-30
0135-DA	Spring	2/07/73	RA-A-3815A6-31
0136-DC	Bottom Seal Plate	2/07/73	RA-C-3815A6-63
0137-DD	Torque Spring Bracket	1/27/75	RA-C-3815A2-1
0138-DB	Torque Spring Storage Drum	3/11/75	RA-B-3815A2-2
0139-DB	Storage Drum Shaft	2/17/75	RA-B-3815A2-3
0140-DB	Torque Spring Motor	3/13/75	RA-B-3815A2-4
0141-DB	Chain Reel Shaft	2/17/75	RA-B-3815A2-5
0142-DB	Torque Spring Drum	3/13/75	RA-B-3815A2-6
0143-DC	Chain Storage Reel	2/07/73	RA-C-3815A2-7
0144-DC	Gear Drive Box Cover	2/07/73	RA-C-3815A2-8
0145-DC	Gear Drive Box Cover Gasket	2/07/73	RA-C-3815A2-9
0146-DE	Gear Drive Box	5/16/75	RA-E-3815A2-10
0147-DD	Drive Chain Cover	2/07/73	RA-D-3815A2-11
0148-DC	Protective Cover-Bellows	2/07/73	RA-C-3815A2-12
0149-DC	Chain Enclosure - Bellows	2/07/73	RA-C-3815A2-13

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DOCUMENT NUMBER	DOCUMENT TITLE	LAST REV.	DRAWING NUMBER
0150-DC	Sprocket Pulley Block	2/07/73	RA-C-3815A2-14
0151-DB	Sprocket Pulley Shaft	2/07/73	RA-B-3815A2-15
0152-DB	Pulley Block Bearing Retainer	2/07/73	RA-B-3815A2-16
0153-DB	Sprocket Spacer No. 1	2/07/73	RA-B-3815A2-17
0154-DB	Sprocket Spacer No. 2	2/07/73	RA-B-3815A2-18
0155-DB	Pulley Block Anchor Rod	2/07/73	RA-B-3815A2-19
0156-DB	Load Cell Cover Plate	2/07/73	RA-B-3815A2-20
0157-DB	Input Shaft Collar	2/07/73	RA-B-3815A2-21
0158-DB	Collar Gasket	2/07/73	RA-B-3815A2-22
0159-DB	Sprocket Pullet	2/07/73	RA-B-3815A2-23
0160-DB	Pin - Chain	2/07/73	RA-B-3815A2-24
0161-DB	Sprocket	2/07/73	RA-B-3815A2A-1
0162-DB	Pad	2/07/73	RA-B-3815A2A-2
0163-DB	Shaft	2/07/73	RA-B-3815A2A-3
0164-DC	Bracket	2/07/73	RA-C-3815A2A-4
0165-DA	Collar	2/07/73	RA-A-3815A2A-5
0166-DB	Pad	2/07/73	RA-B-3815A2A-6
0167-DB	Sprocket	2/07/73	RA-B-3815A2A-7
0168-DB	Shaft	2/07/73	RA-B-3815A2A-8
0169-DC	Shaft	2/07/73	RA-B-3815A2A-9
0170-DA	Spacer	2/07/73	RA-A-3815A2A-10
0171-DA	Spacer	2/07/73	RA-A-3815A2A-11
0172-DB	Retainer	2/07/73	RA-B-3815A2A-12
0173-DA	Retainer	2/07/73	RA-A-3815A2A-13
0174-DE	Mounting Plate	2/07/73	RA-E-3815A2A-14
0175-DB	Gear	2/07/73	RA-B-3815A2A-15
0176-DB	Pillow Block	2/07/73	RA-B-3815A2A-16
0178-DB	Pillow Block	2/07/73	RA-B-3815A2A-18
0179-DB	Sprocket	2/07/73	RA-B-3815A2A-19
0180-DB	Gear	2/07/73	RA-B-3815A2A-20
0181-DC	Shaft	2/-7/73	RA-C-3815A2A-21
0182-DC	Pillow Block	2/07/73	RA-C-3815A2A-22
0183-DC	Sprocket	7/27/73	RA-A-3815A2A-23

TECHNICAL DOCUMENTATION LIST (contd)

<u>DOCUMENT NUMBER</u>	<u>DOCUMENT TITLE</u>	<u>LAST REV.</u>	<u>DRAWING NUMBER</u>
0184-DA	Shaft	2/07/73	RA-A-3815A2A-24
0185-DB	Motor Bracket Gusset	2/07/73	RA-B-3815A2B-1
0186-DA	Structural Angle	2/07/73	RA-A-3815A2B-2
0187-DE	Mounting and Tension Plate	9/18/73	RA-E-3815A2B-3
0188-DC	Right Angle Drive Bracket	2/07/73	RA-C-3815A2B-4
0189-DB	Sprocket	6/01/77	RA-B-3815A2B-5
0190-DB	Counter	2/07/73	RA-C-3815A2C-1
0191-DC	Mounting Plate	2/07/73	RA-C-3815A2C-2
0192-DB	Coupling	2/07/73	RA-B-3815A2C-3
0193-DB	Speed Increaser Output Plate	2/07/73	RA-B-3815A2C-4
0194-DB	Encoder Mounting Plate	7/02/73	RA-B-3815A2C-5
0195-DB	Shim Washer No. 1	2/07/73	RA-B-3815A2C-6
0196-DB	Encoder	7/27/73	RA-B-3815A2C-7
0197-DB	Encoder Gear	7/27/73	RA-B-3815A2C-8
0198-DB	Bevel Gear Shaft	2/07/73	RA-B-3915A2C-9
0199-DB	Transfer Shaft	2/07/72	RA-B-3815A2C-10
0200-DB	Transfer Shaft Gear	7/27/73	RA-B-3815A2C-11
0201-DB	Support Spaced Rod	2/07/72	RA-B-3815A2C-12
0202-DB	Side Cover	2/07/72	RA-B-3815A2C-13
0203-DB	Transfer Shaft Miter Gear	2/07/72	RA-B-3815A2C-14
0204-DB	Trust Washer No. 1	2/07/73	RA-B-3815A2C-15
0205-DB	Transfer Bearing Plate	7/02/73	RA-B-3815A2C-16
0206-DB	Sprocket	6/01/77	RA-B-3815A2C-17
0207-DA	Sprocket Shaft	2/07/73	RA-A-3815A2C-18
0208-DB	Sprocket Shaft Miter Gear	2/07/73	RA-B-3815A2C-19
0209-DB	Sprocket Shaft Spur Gear	2/07/73	RA-B-3815A2C-20
0210-DB	Bevel Gear Shaft Spur Gear	2/07/73	RA-B-3815A2C-21
0211-DB	Bevel Gear	2/07/73	RA-B-3815A2C-22
0212-DB	Bevel Gear Pinion	2/07/73	RA-B-3815A2C-23
0213-DB	Shim Washer No. 2	2/07/73	RA-B-3815A2C-24
0214-DA	Bevel Gear Pinion Shaft	2/07/73	RA-A-3815A2C-25
0215-DB	Speed Increaser Side	2/07/73	RA-B-3815A2C-26
0216-DC	Speed Increaser Bearing Plate	2/07/73	RA-C-3815A2C-27

TECHNICAL DOCUMENTATION LIST (contd)

DOCUMENT NUMBER	DOCUMENT TITLE	LAST REV.	DRAWING NUMBER
0218-DE	Dome Plate	8/31/73	RA-E-3815A3-1
0219-DE	Cover	8/28/72	RA-E-3815A1-3
0220-DD	Gasket	8/28/72	RA-D-3815A1-10
0221-DB	Sprocket Shaft	10/22/73	RA-B-3815A3-4
0222-DB	Guide Pin	2/03/75	RA-B-3815A3-5
0224-DB	Flange, Pump Connector	6/00/74	RA-B-3815A3-7
0225-DB	Flange, Thermocouple Conn.	6/00/74	RA-B-3815A3-8
0232-DB	Limit Switch Bracket	8/31/73	RA-B-3815A3-15
0233-DC	Connector Plate	6/14/74	RA-C-3815A3-16
0234-DA	Cable Clamp	8/31/73	RA-A-3815A3-17
0235-DB	Sprocket	8/31/73	RA-B-3815A3-18
0238-DB	Auxiliary Flange, Pump Conn.	11/11/74	RA-B-3815A3-21
0241-DB	Shackle	8/31/73	RA-B-3815A4-1
0242-DD	Finger Actuator Driver	6/17/74	RA-D-3815A4-2
0243-DB	Worm Gear Jack Screw	6/17/74	RA-B-3815A4-3
0244-DD	Body-Lower	6/17/74	RA-D-3815A4-4
0245-DE	Body-Middle	6/17/74	RA-E-3815A4-5
0246-DC	Finger Actuator	6/17/74	RA-C-3815A4-6
0247-DC	Shim	6/17/74	RA-C-3815A4-7
0248-DD	Finger Lock	6/17/74	RA-D-3815A4-8
0249-DC	Table	6/17/74	RA-C-3815A4-9
0250-DD	Body-Upper	6/17/74	RA-D-3815A4-11
0251-DB	Gear	6/17/74	RA-B-3815A4-12
0252-DB	Shaft	6/17/74	RA-B-3815A4-13
0254-DC	Finger	8/09/76	RA-C-3815A4-15
0255-DB	Retainer-Finger	6/17/74	RA-B-3815A4-16
0256-DB	Release-Finger	6/17/74	RA-B-3815A4-17
0257-DB	Pivot-Finger	6/17/74	RA-B-3815A4-18
0258-DB	Knob	9/07/76	RA-B-3815A4-19
0259-DB	Pin-Locating	6/17/74	RA-B-3815A4-20
0267-DA	Key	2/07/73	RA-A-3815A5-4
0268-DC	Saddle	2/07/73	RA-C-3815A5-3
0269-DA	Bearing Retainer	2/07/73	RA-A-3815A5-5

TECHNICAL DOCUMENTATION LIST (contd)

DOCUMENT NUMBER	DOCUMENT TITLE	LAST REV.	DRAWING NUMBER
0270-DD	Actuator Spacer	2/07/73	RA-D-3815A5-1
0271-DD	Rod	2/07/73	RA-D-3815A5-2
0272-DB	Nose Piece	10/04/73	RA-B-3815A8-1
0273-DD	Pin-Solid	10/25/73	RA-D-3815A8-2
0274-DB	End Plate	10/25/73	RA-B-3815A8-3
0275-DD	Seal Sleeve	5/01/73	RA-D-3815A8-4
0276-DD	Actuator Mounting Plate	2/07/73	RA-D-3815A8-5
0277-DE	Liner Weldment		RA-E-3815A7-1
0278-DB	Latch		RA-B-3815A7-2
0279-DA	Spring		RA-A-3815A7-3
0280-DA	Pin		RA-A-3815A7-4
0283-DB	Adapter	1/08/73	RA-B-3897-2
0284-DD	Frame	1/08/73	RA-D-3897-3
0285-DB	Base Load Cell	1/08/73	RA-B-3897-4
0286-DB	Retainer	8/14/72	RA-B-3815A1-B
0287-DE	Yoke	10/00/75	RA-E-3815A9-1
0288-DD	Right Counterweight	10/00/75	RA-D-3815A9-2
0289-DD	Left Counterweight	10/00/75	RA-D-3815A9-3
0293-DD	Frame	9/02/75	RA-D-3815B3A-1
0294-DB	Shaft	5/11/74	RA-B-3815B3A-2
0295-DC	Brace	7/00/75	RA-C-3815B3A-3
0296-DC	Block, Mounting	7/00/75	RA-C-3815B3A-4
0297-DB	Plate, Backup	5/11/74	RA-B-3815B3A-5
0298-DB	Shim, Vertical Lock	7/00/75	RA-B-3815B3A-6
0301-DC	Shaft	5/13/74	RA-C-3815B3A1-1
0302-DD	Body	9/02/75	RA-D-3815B3A1-2
0303-DE	Cradle Frame	7/00/75	RA-E-3815B3B-1
0305-DD	Saddle	9/02/75	RA-D-3815B3B-2
0307-DC	Restrainer	7/00/75	RA-C-3915B3B-4
0308-DC	Spacer	9/02/75	RA-C-3815B3B-5
0309-DB	Spacer-Restrainer	7/00/75	RA-B-3815B3B-15
0310-DD	Saddle	9/02/75	RA-D-3815B3B-6
0311-DC	Spacer	9/02/75	RA-C-3815B3B-7

TECHNICAL DOCUMENTATION LIST (contd)

DOCUMENT NUMBER	DOCUMENT TITLE	LAST REV.	DRAWING NUMBER
0312-DD	Saddle	9/02/75	RA-D-3815B3B-8
0313-DC	Spacer	9/02/75	RA-C-3815B3B-9
0314-DB	Keeper	5/11/74	RA-B-3815B3B-10
0315-DD	Lift Cylinder Bracket	8/27/75	RA-D-3815B3B-11
0316-DB	Cylinder Pin	11/04/75	RA-B-3815B3B-12
0317-DC	Spacer	9/02/75	RA-C-3815B3B-13
0318-DD	Saddle	9/02/75	RA-D-3815B3B-14
0319-DD	Slide	7/00/75	RA-D-3815B3B2D-1
0321-DD	Bracket, Mounting	5/11/74	RA-D-3815B3B2D-3
0322-DD	Body	8/22/75	RA-D-3815B3B2D-4
0323-DB	Stud	7/00/75	RA-B-3815B3B2D-5
0324-DB	Stud	7/00/75	RA-B-3815B3B2D-6
0325-DE	Base Plate	7/00/75	RA-E3815B3B2-1
0326-DD	Radial Locating Guide	7/00/75	RA-D-3815B3B2-2
0327-DB	Locator Bar	5/11/74	RA-B-3815B3B2-3
0328-DB	Stop Bar	5/11/74	RA-B-3815B3B2-4
0329-DD	Cover, Bumper	7/00/75	RA-D-3815B3B2A-1
0330-DB	Bar, Retaining	5/11/74	RA-B-3815B3B2A-2
0331-DD	Bracket	8/27/75	RA-D-3815B3B2A-3
0332-DD	Cover, Bumper	7/00/75	RA-D-3815B3B2C-1
0333-DD	Bracket	7/00/75	RA-D-3815B3B2C-3
0334-DC	Hold-Down Bar	7/00/75	RA-C-3815B3B1-1
0335-DB	Tightening Bar	5/13/74	RA-B-3815B3B1-2
0336-DB	Spring Plunger Mount	7/00/75	RA-B-3815B3B1-3
0337-DB	Spring Plunger Mount Spacer	7/00/75	RA-B-3815B3B1-4
0338-DB	Brace	5/13/74	RA-B-3815B3B1-5
0339-DB	Roll Spring	9/02/75	RA-B-3815B3B1-6
0340-DC	Spring Drum, Small	5/13/74	RA-C-3815B3B1-7
0341-DC	Rotation Stop Lever	5/13/74	RA-C-3815B3B1-8
0344-DB	Spacer Washer	5/13/74	RA-B-3815B3B1-11
0346-DD	Connecting Block	8/30/75	RA-B-3815B3B1-13
0347-DB	Spring Shaft Mount-Left	7/00/75	RA-B-3815B3B1-14
0348-DB	Spring Drum Shaft	7/00/75	RA-B-3815B3B1-15

TECHNICAL DOCUMENTATION LIST (contd)

DOCUMENT NUMBER	DOCUMENT TITLE	LAST REV.	DRAWING NUMBER
0349-DB	Spring Shaft Mount-Right	7/00/75	RA-C-3815B3B1-16
0352-DB	Pawl Mount Cover	7/00/75	RA-B-3815B3B1-19
0353-DB	Pawl Mount	7/00/75	RA-B-3815B3B1-20
0354-DB	Pawl Spring	12/11/73	RA-B-3815B3B1-21
0355-DB	Pawl	5/13/74	RA-B-3815B3B1-22
0357-DB	Spacer, Collar	5/13/74	RA-B-3815B3B1-24
0358-DC	Spring Drum, Large	5/13/74	RA-C-3815B3B1-25
0359-DB	Roller, Lock Ring	5/13/74	RA-B-3815B3B1-26
0360-DC	Rotation Lock Ring	5/13/74	RA-C-3815B3B1-27
0361-DD	Cam Shaft	8/27/75	RA-D-3815B3B1-28
0362-DE	Frame	7/00/75	RA-E-3815B2A-1
0363-DC	Slide, Locking	5/11/74	RA-C-3815B2A-2
0364-DD	Cover	5/11/74	RA-D-3815B2A-3
0365-DB	Shim	5/11/74	RA-B-3815B2A-4
0366-DD	Bracket, Cylinder	7/00/75	RA-D-3815B2A-5
0367-DB	Pad, Bumper	8/02/74	RA-B-3815B2A-6
0368-DB	Pad, Wear	7/00/75	RA-B-3815B2A-7
0370-DD	Body	9/27/75	RA-D-3815B3B2D-4
0372-DD	Body	9/27/75	RA-D-3815B3B2E-4
0378-DB	Spacer	5/11/74	RA-B-3815B3-13
0379-DC	Transmittal Shaft	5/11/74	RA-C-3815B3-1
0380-DC	Shaft Trunion	7/00/75	RA-C-3815B3-2
0381-DB	Thrust Bearing	5/11/74	RA-B-3815B3-3
0382-DC	Cap	5/11/74	RA-C-3815B3-4
0383-DB	Bearing Retainer	7/00/75	RA-B-3815B3-5
0384-DD	Cam	5/11/74	RA-D-3815B3-6
0385-DB	Cam Support Bushing	5/11/74	RA-B-3815B3-7
0386-DB	Shim, Mounting Block	7/00/75	RA-B-3815B3-8
0387-DB	Keeper	7/00/75	RA-B-3815B3-9
0388-DB	Shaft Mounting Block	10/21/75	RA-B-3815B3-10
0389-DC	Block, Mounting	7/00/75	RA-C-3815B3-11
0390-DD	Cylinder, Elevating	12/26/75	RA-D-3815B3-12
0391-DC	Cross-Over Junction	7/00/75	RA-C-3815B4-1

TECHNICAL DOCUMENTATION LIST (contd.)

DOCUMENT NUMBER	DOCUMENT TITLE	LAST REV.	DRAWING NUMBER
0392-DB	Deceleration Valve Spacer	5/11/74	RA-B-3815B4-2
0393-DB	Limit Switch U-Bracket	5/11/74	RA-B-3815B4-3
0394-DB	Limit Switch Trip Bracket	5/11/74	RA-B-3815B4-4
0396-DB	Limit Switch Spacer	5/11/74	RA-B-3815B4-6
0397-DB	Limit Switch Trip Plate & Guide	5/11/74	RA-B-3815B4-7
0398-DB	Limit Switch Mounting Plate	7/00/75	RA-B-3815B4-8
0399-DB	Cross Over Pipe Bracket	5/11/74	RA-B-3815B4-9
0400-DB	Bracket Spacer	5/11/74	RA-B-3815B4-10
0401-DB	Limit Switch Angle Bracket	7/00/75	RA-B-3815B4-11
0402-DB	Limit Switch Support Plate	7/00/75	RA-B-3815B4-12
0403-DB	Limit Switch Trip	7/00/75	RA-B-3815B4-13
0405-DB	Limit Switch Slotted Lever	5/11/74	RA-B-3815B4-15
0406-DB	Limit Switch Mounting Plate 1	5/11/74	RA-B-3815B4-16
0407-DB	Limit Switch Mounting Plate 2	5/11/74	RA-B-3815B4-17
0408-DB	Limit Switch Mounting Plate 3	7/00/75	RA-B-3815B4-18
0409-DC	Disc Springs Guide	3/13/75	RA-C-3815A2-25
0410-DB	Disc Springs Cover	2/07/73	RA-B-3815A2-26
0411-DB	Compression Spring	8/16/73	RA-B-3815A2-27
0412-DA	Spacer	10/22/73	RA-A-3815A3-3
0413-DA	Spacer	10/22/73	RA-A-3815A3-12
0414-DB	Spacer for Shock Pad	5/11/74	RA-B-3815B2A-8
0415-DB	Impact Shock Pad	12/11/73	RA-B-3815B2A-9
0416-DB	Bolt Short and Long	3/27/74	RA-B-3815A-1
0417-DC	Bearing Retainer	5/11/74	
0418-DC	Bearing Spacer	7/00/75	
0419-DD	Main Frame Assy	7/17/73	
0424-DD	Cross Section Bed of Trlr.	7/17/73	
0435-DD	Guide-Rail	9/02/75	
0436-DC	Cross-Over Junction	5/11/74	
0437-DD	Body-Upper	8/31/73	
0438-DD	Body-Lower	8/31/73	
0440-DC	Cross Over Junction	5/11/74	
0441-DC	Cross Over Junction	5/11/74	

TECHNICAL DOCUMENTATION LIST (contd)

DOCUMENT NUMBER	DOCUMENT TITLE	LAST REV.	DRAWING NUMBER
0444-DC	Spacer Retainer	7/00/75	
0445-DC	Spacer Retainer	7/00/75	
0446-DC	Spacer Retainer	7/00/75	
0447-DC	Body	1/29/74	
0448-DC	Clamp	1/29/74	
0449-DC	Adapter	1/29/74	
0450-DB	Shaft Stop	9/02/75	
0451-DB	Switch Trip Level	5/13/74	
0452-DB	Connector Rod	12/11/73	
0453-DC	Shaft Support	5/13/74	
0454-DC	Flo-Tork Adapter Plate	5/13/74	
0455-DC	Insert Round	3/01/74	
0456-DC	Insert Square	3/01/74	
0457-DD	Adapter Ring	6/17/74	
0458-DE	Middle Body Adapter	6/00/76	
0459-DD	Guide Ring	12/01/77	
0460-DE	Connector Ring	6/00/76	
0472-DB	Spacer Sprocket	3/15/74	
0477-DC	Plate Floating	11/19/74	
0478-DA	Locator Pin	6/17/74	
0480-DB	Post-Locating	6/17/74	
0485-DA	Clip Cable	6/17/74	
0488-DC	Support Connector	1/21/75	
0489-DD	Loop Support Test Fixture	8/01/74	NL40630-D
0490-DB	Gear Stud	6/17/74	
0491-DB	Stud Spring	6/17/74	
0492-DB	Plate Connector Hold-Down	11/11/74	
0493-DC	Support Cable Reel	6/29/74	
0494-DC	Gripper Cable	11/11/74	
0495-DD	Layout, Truck, Dolly & Trlr.	12/14/76	60384 Smith Co.
0496-DD	Layout, Jeep Dolly	12/14/76	D20115 Smith Co.
0497-DD	Bridge Layout	12/14/76	D20115A Smith Co.
0498-DD	Bridge to Deck Connection	12/14/76	D20115B Smith Co.

TECHNICAL DOCUMENTATION LIST (contd)

<u>DOCUMENT NUMBER</u>	<u>DOCUMENT TITLE</u>	<u>LAST REV.</u>	<u>DRAWING NUMBER</u>
0499-DD	Structural Details	12/14/76	D20115C Smith Co.
0500-DD	Deck Details	12/14/76	C20115D Smith Co.
0501-DD	G. Neck Layout	12/14/76	C20115E Smith Co.
0502-DB	Plate Adaptor	11/12/74	
0503-DB	Screw-Extension	12/06/74	
0504-DA	Stop-Nut	12/06/74	
0505-DA	Washer	12/06/74	
0506-DA	Retaining Plate Ball Bearing	1/13/75	
0507-DB	Counter Balance Weight 1	2/07/75	
0508-DB	Counter Balance Weight 2	2/06/75	
0509-DB	Counter Balance Weight 3	2/06/75	
0510-DE	Loop Support Synch Fixture	2/14/75	
0511-DD	Storage Stand 1	10/20/74	40331-D
0512-DD	Storage Stand 2	5/20/74	40331-D
0513-DE	Lift Fixture Lower Body	1/27/75	70447-F
0514-DE	Lift Fixture LHM Upper Half	1/27/75	70203-F
0515-DE	Erection Stand LHM	3/28/74	71191-F
0516-DC	Brake Housing	5/20/75	
0517-DB	Cover	5/20/75	
0518-DC	Brake Shaft	5/29/75	
0519-DB	Adapter	5/20/75	
0520-DC	Mounting Plate	5/20/75	
0521-DB	Shaft	5/20/75	
0523-DC	Bearing Support	5/20/75	
0526-DB	Adaptor	6/05/75	
0527-DD	Drive Shaft	9/03/75	
0528-DD	Clutch Housing	7/28/75	
0529-DC	Spacer	7/20/75	
0530-DB	Key	7/29/75	
0531-DD	Gate Valve Shield		
0532-DE	Shielding Dish Hopper		
0533-DE	Shielding Lower		
0534-DE	Shielding Lower		

TECHNICAL DOCUMENTATION LIST (contd)

DOCUMENT NUMBER	DOCUMENT TITLE	LAST REV.	DRAWING NUMBER
0535-DC	Chain Shoe	5/04/76	
0536-DE	Plug & Screw Drive Housing		
0537-DC	Screw Actuator		
0538-DA	Nose Piece		
0539-DB	Nut		
0540-DA	Worm Gear (Rework)		
0541-DC	Bearing Mounting Plate		
0542-DB	Bearing Shaft		
0543-DB	Shaft-Drive		
0544-DB	Driver Nut		
0545-DA	Worm		
0546-DE	Shielding		
0547-DE	Support Ring		
0548-DE	Shielding-Lower Front		
0549-DE	Shielding Lower LH & RH		
0550-DE	Shielding Rear		
0551-DD	Shielding		
0552-DA	Retainer Ball Bearing		
0553-DD	Grapple Adaptor	6/01/76	
0554-DA	Locating Pin	6/01/76	
0555-DA	Captive Bolt	6/01/76	
0556-DB	Plate-Disconnecting		
0557-DC	Lifting Fixture	10/11/76	
0558-DD	Dummy Loop Flange	10/11/76	
0559-DE	Base Mounting	5/25/77	
0560-DD	Housing Bearing	5/25/77	
0561-DD	Housing Bearing	5/25/77	
0562-DC	Shaft A	5/25/77	
0563-DB	Sproket	5/25/77	
0564-DC	Gear 4	5/25/77	
0565-DB	Gear 3	5/25/77	
0566-DB	Shaft B	5/25/77	
0567-DB	Gear 11	5/25/77	

TECHNICAL DOCUMENTATION LIST (contd)

DOCUMENT NUMBER	DOCUMENT TITLE	LAST REV.	DRAWING NUMBER
0568-DC	Adaptor-Bearing	11/16/77	
0569-DC	Shaft H	5/25/77	
0570-DB	Sprocket	5/25/77	
0571-DA	Sprocket	11/16/77	
0572-DB	Retainer	11/16/77	
0573-DC	Shaft F	5/25/77	
0574-DB	Gear 9	5/25/77	
0575-DB	Gear 6	5/25/77	
0576-DB	Shaft D	5/25/77	
0577-DC	Shaft E	5/25/77	
0578-DB	Gear 7	5/25/77	
0579-DB	Gear 8	5/25/77	
0580-DD	Flange Adapter	5/25/77	
0581-DD	Housing Brake Gears	5/25/77	
0582-DB	Gear 2	5/25/77	
0583-DC	Shaft C Flex Coupling Output	5/25/77	
0584-DB	Gear 1	5/25/77	
0585-DC	Shaft Brake J	5/25/77	
0586-DD	Cover-Brake Gear Housing	5/25/77	
0587-DC	Housing Brake & Clutch	5/25/77	
0588-DC	Shaft-Brake	11/16/77	
0589-DD	Housing Brake	5/25/77	
0590-DB	Cover	5/25/77	
0591-DB	Sprocket	5/25/77	
0592-DC	Bracket Idler Sprocket	5/25/77	
0593-DB	Shaft Idler Sprocket	5/25/77	
0594-DB	Gear 10	5/25/77	
0595-DB	Seal O Ring	5/25/77	
0596-DA	Spacer	5/25/77	
0597-DA	Spacer	5/25/77	
0598-DB	Guide Chain	5/25/77	
0599-DB	Shaft G	5/25/77	
0600-DB	Seal Bearing	5/12/77	

TECHNICAL DOCUMENTATION LIST (contd)

DOCUMENT NUMBER	DOCUMENT TITLE	LAST REV.	DRAWING NUMBER
1032-SE	Assy Installation & Startup of the Hydraulic System for the LHM Cradle Transporter	9/06/74	
1033-SP	Test & Check Procedure for the Alip Power Control and the Related Power Dist. System of the FEFPL Project LHM	5/05/75	
1034-SP	LHM Console Modification in Shop Insp. and Test Procedure Unit ANL 173305	5/19/76	
1035-SP	LHM Console Mod in Shop Insp. & Test Procedure Unit ANL 173306	5/19/76	
1036-SP	LHM Console Mod. Field Check Out Unit ANL 173305		
1037-SP	LHM Console Mod. Field Check Out Unit ANL 173306	9/21/76	
1038-SP	LHM Limit Set Adjustment Procedure for Upper and Lower Support Limitorque Operations	5/19/76	
1039-SP	Test Procedure for LHM Cables Fab. During LHM Console Mod.	5/19/76	
1040-SF	Spec. for Gear Drive Assy	6/15/77	

APPENDIX B

Structural Steel Design Specifications
Pertinent to SLSF-LHS-Cradle Structure

Structural Steel Design Specifications:

List of Symbols

The symbols used in this specification and their definitions are listed below:

A_{st} Cross-sectional area of stiffener or pair of stiffeners
 A_w Area of girder web; largest area of the web within an unstiffened segment

C_b Bending coefficient dependent upon moment gradient; equal to

$$1.75 + 1.05\left(\frac{M_1}{M_2}\right) + 0.3\left(\frac{M_1}{M_2}\right)^2$$

C_c Column slenderness ratio dividing elastic and inelastic buckling; equal to

$$\sqrt{\frac{2\pi^2 E}{F_y}}$$

C_c^1 Modified column slenderness ratio, equal to

$$C_c^1 = \sqrt{\frac{2\pi^2 E}{Q_s Q_a F_y}}$$

C_m Coefficient applied to bending term in interaction formula and dependent upon column curvature caused by applied moments

C_v Ratio of "critical" web stress, according to the linear buckling theory, to the shear yield stress of web material; (see definition page)

D Factor depending upon type of transverse stiffeners

E Modulus of elasticity of steel (29,000 kips per square inch)

F_a Axial stress permitted in the absence of bending moment

F_{as} Axial compressive stress, permitted in the absence of bending moment, for bracing and other secondary members

F_b Bending stress permitted in the absence of axial force

F'_b Allowable bending stress in compression flange of plate girders as reduced because of large web depth-to-thickness ratio

F'_e Euler stress divided by factor of safety; equal to

$$\frac{12\pi^2 E}{23(KL_b/r_b)^2}$$

F_{sr} Stress range, (ultimate strength of the type of steel used)

F_t Allowable tensile stress

F_v Allowable shear stress

F_y Specified minimum yield stress of the type of steel being used (kips per square inch). As used in this specification, "yield stress" denotes either the specified minimum yield point (for those steels that have a yield point) or specified minimum yield strength (for those steels that do not have a yield point).

K Effective length factor

L Span length (feet)

M Moment (kip-feet)

M_1 Smaller moment at end of unbraced length of beam-column

M_2 Larger moment at end of unbraced length of beam-column

M_D Moment produced by dead load

M_L Moment produced by live load

N Length of bearing of applied load (inches)

P Applied load (kips)

Q_α Ratio of effective profile area of an axially loaded member to its total profile area

Q_s Axial stress reduction factor where width-thickness ratio of unstiffened elements exceeds limiting value given in

Section 1.9.1.2

R	Reaction or concentrated transverse load applied to beam or girder (kips)
Y	Ratio of yield stress of web steel to yield stress of stiffener steel
a	Clear distance between transverse stiffeners
b	Actual width of stiffened and unstiffened compression elements
b_e	Effective width of stiffened compression element
b_f	Flange width of rolled beam or plate girder
c	Distance from neutral axis to extreme fiber of beam
d	Depth of beam or girder. Also diameter of roller or rocker bearing
f	Axial compression load on member divided by effective area (kips per square inch)
f_a	Computed Axial stress
f_b	Computed bending stress
f_t	Computed tensile stress
f_v	Computed shear stress (total shear divided by web area)
f_{vs}	Shear between girder web and transverse stiffeners (kips per linear inch of single stiffener or pair of stiffeners)
h	Clear distance between flanges of a beam or girder
k	Coefficient relating linear buckling strength of a plate to its dimensions and condition of edge support. Also, distance from outer face of flange to web toe of fillet or rolled shape or equivalent distance on welded section
l	Actual unbraced length (inches)
r	Governing radius of gyration
r_T	Radium of gyration of a section comprising the compression flange, plus one-third of the compression web area, taken about an axis in the plane of the web

- t Girder, beam, or column web thickness
- t_f Flange thickness

Section 1 DEFINITIONS

1.1 Compact Beam Section:

In order for a beam to qualify as a compact section, the following requirements shall be satisfied:

- a. The flanges shall be continuously connected to the web or webs.
- b. The width-thickness ratio of unstiffened projecting elements of the compression flange, as defined in Section 3.1.1, shall not exceed $65 \sqrt{F_y}$.
- c. The width-thickness ratio of stiffened elements of the compression flange, as defined in Section 3.2.1, shall not exceed $190 / \sqrt{F_y}$.
- d. The depth-thickness ratio of the web or webs shall not exceed the value given by Formulas (1.1) or (1.2) as applicable.

$$\frac{d}{t} = \frac{640}{\sqrt{F_y}} \left(1 - 3.74 \frac{fa}{F_y} \right) \text{ when } \frac{fa}{F_y} \leq 0.16 \quad (1-1)$$

$$\frac{d}{t} = \frac{257}{\sqrt{F_y}} \text{ when } \frac{fa}{F_y} > 0.16 \quad (1-2)$$

1.2 C_b . Bending coefficient dependent upon moment gradient:

$C_b = 1.75 + 1.05 (M_1/M_2) + 0.3 (M_1/M_2)^2$, but not more than 2.3, where

M_1 is the smaller and M_2 is the larger bending moment at the ends of the unbraced length, taken about the strong axis of the member, and where M_1/M_2 the ratio of end moments, is positive when M_1/M_2 have the same sign (reverse curvature bending) and negative when they are of opposite signs (single curvature bending). When the bending moment at any point within an unbraced

length is larger than that at both ends of this length, the value of C_b shall be taken as unity.

1.3 C_m . Coefficient applied to bending term in interaction formula:

C_m = a coefficient whose value shall be taken as follows:

1. For compression members in frames subject to joint translation (sidesway), $C_m = 0.85$.
2. For restrained compression members in frames braced against joint translation and not subject to transverse loading between their supports in the plane of bending,

$$C_m = 0.6 - 0.4 \frac{M_1}{M_2}, \text{ but not less than } 0.4,$$

where M_1/M_2 is the ratio of the smaller to larger moments at the ends of that portion of the member unbraced in the plane of bending under construction. M_1/M_2 is positive when the member is bent in reverse curvature and negative when it is bent in single curvature.

3. For compression members in frames braced against joint translation in the plane of loading and subjected to transverse loading between their supports, the value of C_m may be determined by rational analysis. However, in lieu of such analysis, the following values may be used: (a) for members whose ends are restrained, $C_m = 0.85$; (b) for members whose ends are unrestrained, $C_m = 1.0$.

- 1.4 C_v . Ratio of "critical" web stress to the shear yield stress of the web material

$$C_v = \frac{45,000k}{F_y(h/t)^2}, \text{ when } C_v \text{ is less than } 0.8$$

$$= \frac{190}{h/t} \sqrt{\frac{k}{F_y}}, \text{ when } C_v \text{ is more than } 0.8$$

$$k = 4.00 + \frac{5.34}{(a/h)^2}, \text{ when } a/h \text{ is less than } 1.0$$

$$= 5.34 + \frac{4.00}{(a/h)^2}, \text{ when } a/h \text{ is more than } 1.0$$

t = thickness of web, in inches

a = clear distance between transverse stiffeners, in inches

h = largest clear distance between flanges within an unstiffened segment, in inches

- 1.5 D - Factor depending upon type of transverse stiffeners:

$D = 1.0$ for stiffeners furnished in pairs

$= 1.8$ for single angle stiffeners

$= 2.4$ for single plate stiffeners

Section 2 STABILITY AND SLENDERNESS RATIOS

2.1 General

General stability shall be provided for the structure as a whole and for each compression element.

In determining the slenderness ratio of an axially loaded compression member, the length shall be taken as its effective length KL and r as the corresponding radius of gyration.

2.2 Sidesway Prevented

In frames where lateral stability is provided by adequate attachment to diagonal bracing, shear walls, an adjacent structure having adequate lateral stability, or to floor slabs or roof decks secured horizontally by walls or bracing systems parallel to the plane of the frame, and in trusses, the effective length factor, K , for the compression members shall be taken as unity, unless analysis shows that a smaller value may be used.

2.3 Sidesway Not Prevented

In frames where lateral stability is dependent upon the bending stiffness of rigidly connected beams and columns, the effective length KL of compression members shall be determined by a rational method and shall not be less than the actual unbraced length.

2.4 Maximum Ratios

The slenderness ratio, KL/r , of compression members shall not exceed 200.

The slenderness ratio, L/r , of tension members, other than rods, preferably should not exceed:

For main members 240

For bracing and other secondary members 300

Section 3 WIDTH-THICKNESS RATIOS

3.1 Unstiffened Elements Under Compression

3.1.1 Unstiffened (projecting) compression elements are those having one free edge parallel to the direction of compression stress. The width of unstiffened plates shall be taken from the free edge to the first row of fasteners or welds; the width of legs of angles, channel and zee flanges, and stems of tees shall be taken as the full nominal dimension; the width of flanges of I-shape members and tees shall be taken as one-half the full nominal width. The thickness of a sloping flange shall be measured half-way between a free edge and the corresponding face of the web.

3.1.2 Unstiffened elements subject to axial compression or compression due to bending shall be considered as fully effective when the ratio of width to thickness is not greater than the following:

Single-angle struts; double angle struts with separators . . . $76.0/\sqrt{F_y}$

Struts comprising double angles in contact; angles or
plates projecting from girders, columns or other
compression members; compression flanges of beams;

stiffeners on plate girders $95.0/\sqrt{F_y}$

Stems of tees $127.0/\sqrt{F_y}$

When the actual width-to-thickness ratio exceeds these values, the design stress shall be governed by the provisions of Section 3.3.

3.2 Stiffened Elements Under Compression

3.2.1 Stiffened compression elements are those having lateral support along both edges which are parallel to the direction of the compression stress. The width of such elements shall be taken as the distance between nearest lines of fasteners or welds.

3.2.2 Stiffened elements subject to axial compression, or to uniform compression due to bending as in the case of the flange of a flexural member, shall be considered as fully effective when the ratio of width to thickness is not greater than the following:

Flanges of square and rectangular box sections of

uniform thickness $238 / \sqrt{F_y}$

Unsupported width of cover plates perforated with a

succession of access holes $317 / \sqrt{F_y}$

All other uniformly compressed stiffened elements $253 / \sqrt{F_y}$

Except in the case of perforated cover plates, when the actual width-to-thickness ratio exceeds these values, the design shall be governed by the provisions of Section 3.3.

3.3 Slender Compression Elements

3.3.1 General

Axially loaded members, and flexural members containing elements subject to compression and having a width-thickness ratio in excess of the applicable limit given to Section 3, shall be proportioned to meet the requirements of this Section.

3.3.2 Stress Reduction Factor -- Unstiffened Compression Elements

Except as hereinafter provided, stress on unstiffened compression elements whose width-thickness ratio exceeds the applicable limit given in Section 3.1.2, shall be subject to a reduction factor Q_s and shall be determined by Formulas (3.1) to (3.6), as applicable, where b is the width of the unstiffened element as defined in Section 3.1.1. When such elements comprise the compression flange of a flexural member, the maximum allowable bending stress shall not exceed $0.65 Q_s$, nor the applicable value as provided in Section 5.4.5. The allowable stress of axially loaded

compression members shall be modified by the appropriate reduction factor Q_s as provided in Section 3.3.5.

For single angles:

When $76.0/\sqrt{F_y} < b/t < 155/\sqrt{F_y}$:

$$Q_s = 1.340 - 0.00447(b/t) \sqrt{F_y} \quad (3.1)$$

When $b/t \geq 155/\sqrt{F_y}$:

$$Q_s = 15,550/[F_y(b/t)^2] \quad (3.2)$$

For angles or plates projecting from columns or other projecting elements of compression members, and for compression flanges of girders:

When $95.0/\sqrt{F_y} < (b/t) < 176/\sqrt{F_y}$:

$$Q_s = 1.415 - 0.00437 (b/t) \sqrt{F_y} \quad (3.3)$$

When $b/t \geq 176/\sqrt{F_y}$:

$$Q_s = 20,000/[F_y(b/t)^2] \quad (3.4)$$

For stems of tees:

When $127/\sqrt{F_y} < (b/t) < 176/\sqrt{F_y}$:

$$Q_s = 1.908 - 0.00715 (b/t) \sqrt{F_y} \quad (3.5)$$

When $b/t \geq 176/\sqrt{F_y}$:

$$Q_s = 20,000/[F_y(b/t)^2] \quad (3.6)$$

However, unstiffened elements of channels and tees, whose proportions exceed the limits of Section 3.1.2, shall conform to the limits given in Table 3.3.1.

TABLE 3.3.1
Limiting Proportions for Channels and Tees

Shape	Ratio of full flange width to profile depth	Ratio of flange thickness to web or stem thickness
Built-up or Rolled Channels	≤ 0.25	≤ 3.0
	≤ 0.50	≤ 2.0
Built-up Tees	≥ 0.50	≥ 1.25
Rolled Tees	≥ 0.50	≥ 1.10

3.3.3 Effective Width--Stiffened Compression Elements

When the width-thickness ratio of a uniformly compressed stiffened element (except perforated cover plates) exceeds the applicable limit given in Section 3.2.2, a reduced effective width, b_e/t need not be taken as less than the applicable value permitted in Section 3.2.2.

For the flanges of square and rectangular sections of uniform thickness:

$$b_e = \frac{253t}{\sqrt{f}} \left(1 - \frac{50.3}{(b/t)\sqrt{f}} \right) \leq b \quad (3.7)$$

For other uniformly compressed elements:

$$b_e = \frac{253t}{\sqrt{f}} \left(1 - \frac{44.3}{(b/t)\sqrt{f}} \right) \leq b \quad (3.8)$$

where

b = actual width of a stiffened compression element as defined in Section 3.2.1.

t = its thickness

f = computed compressive stress in the stiffened elements are based on the design properties as specified in Section 3.3.4. If unstiffened elements are included in the total cross-section, f for the stiffened element must be such that the maximum compressive stress in the unstiffened element does not exceed $F_a Q_s$ or $F_b Q_s$ as applicable.

When the allowable stresses are increased due to wind or seismic loading, in accordance with the provisions of Section 5.5, the effective width b_e shall be determined on the basis of 0.75 times the stress caused by wind or seismic loading acting alone, or in combination with the design dead and live loading.

3.3.4 Design Properties

Properties of sections shall be determined in accordance with conventional methods, using the full cross-section of the member except as follows:

In computing the moment of inertia and section modulus of flexural members, with respect to the axis of bending under consideration, the effective width of stiffened compression elements parallel to the axis of bending and having a width-thickness ratio in excess of the applicable limit given in Section 3.2.2, rather than the actual width, shall be used. The axis of bending shall be located accordingly, except that, for sections otherwise symmetrical, the properties may conservatively and more easily be computed using a corresponding effective area on the tension side of the neutral axis as well. That portion of the area which is neglected in arriving at the effective area shall be located at, and symmetrically about the center line of the stiffened element to which it applies.

The stress f_a due to axial loading and radius of gyration r shall be computed on the basis of actual cross-sectional area. However, the allowable axial stress F_a , as provided in Section 3.3.5, shall be subject to the form factor

$$Q_a = \frac{\text{effective area}}{\text{actual area}}$$

where the effective area is equal to the actual area less $\Sigma(b - b_e)t$.

3.3.5 Axially Loaded Compression Members

The allowable stress for axially loaded compression members, containing unstiffened or stiffened elements, shall not exceed:

$$F_a = \frac{Q_s Q_a \left[1 - \frac{(KL/r)^2}{2C'_e} \right] F_y}{\frac{5}{3} + \frac{3(KL/r)}{8C'_e} - \frac{(KL/r)^3}{8C'_e{}^3}} \quad (3.9)$$

when the largest effective slenderness ratio of any unbraced segment of the member is less than C'_e , nor the value given by Formula (5.2) or (5.3) when KL/r exceeds C'_e or l/r exceeds 120, as applicable.

3.3.6 Combined Axial and Flexural Stress

In applying the provisions of Section 2 to members subject to combined axial and flexural stress, and containing stiffened elements whose width-thickness ratio exceeds the applicable limit given in Section 3, the stresses F_a , f_{bx} and f_{by} shall be calculated on the basis of the section properties as provided in Sections 3.3.3 and 3.3.5, as applicable. The allowable bending stress, F_b , for members containing unstiffened elements whose width-thickness ratio exceeds the applicable limit given in Section 3, shall be smaller value, $0.60F_y Q_s$ or that provided in Section 5.4.5.

Section 4 PLATE GIRDERS AND ROLLED BEAMS

4.1 Proportions

Riveted and welded plate girders, cover-plated beams and rolled or welded beams, shall in general be proportioned by the moment of inertia of the gross section.

4.2 Web

"The ratio of the clear distance between flanges to the web thickness shall not exceed

$$\frac{14,000}{\sqrt{F_y(F_y + 16.5)}}$$

except that when transverse stiffeners are provided, spaced not more than 1 1/2 times the girder depth, the limiting ratio may be $2,000/\sqrt{F_y}$ where F_y is the yield stress of the compression flange."

4.3 Flanges

The thickness of outstanding parts of flanges shall conform to the requirements of Section 3.1.2.

Flanges of welded plate girders may be varied in thickness or width by splicing a series of plates, or by the use of cover plates.

4.4 Flange Development

Welds connecting flange to web, or cover plate to flange, shall be proportioned to resist the total horizontal shear resulting from the bending forces on the girder. The longitudinal distribution of these intermittent welds shall be in proportion to the intensity of the shear. But the longitudinal spacing shall not exceed the maximum permitted, respectively, for compression or tension member welds. Additionally, welds connecting

flange to web shall be proportioned to transmit to the web any loads applied directly to the flange unless provision is made to transmit such loads by direct bearing.

Partial length cover plates shall be extended beyond the theoretical cutoff point, and the extended portion shall be attached to the beam or girder by fillet welds adequately and the applicable stresses allowed to develop the cover plate's portion of the flexural stresses in the beam or girder at the theoretical cutoff point. In addition, for welded cover plates, the welds connecting the cover plate termination to the beam or girder in the length α' , defined below, shall be adequate, at the allowed stresses, to develop the cover plate's portion of the flexural stresses in the beam or girder at the distance α' from the end of the cover plate. The length α' , measured from the end of the cover plate, shall be:

1. A distance equal to the width of the cover plate when there is a continuous weld equal to or larger than $3/4$ of the plate thickness across the end of the plate and continued welds along both edges of the cover plate in the length α' .
2. A distance equal to $1\ 1/2$ times the width of the cover plate when there is a continuous weld smaller than $3/4$ of the plate thickness across the end of the plate and continued welds along both edges of the cover plate in the length α' .
3. A distance equal to 2 times the width of the cover plate when there is no weld across the end of the plate but continuous welds along both edges of the cover plate in the length α' .

4.5 Stiffeners

4.5.1 Bearing stiffeners shall be placed in pairs at unframed ends on the webs of plate girders, and where required at points of concentrated loads. Such stiffeners shall have a close bearing against the flange, or flanges, through which they receive their loads or reactions, and shall extend approximately to the edge of the flange plates or flange angles. They shall be designed as columns subject to the provisions of Section 5.1, assuming the column section to comprise the pair of stiffeners and a centrally located strip of the web whose width is equal to not more than 25 times its thickness at interior stiffeners or a width equal to not more than 12 times its thickness when the stiffeners are located at the end of the web. The effective length shall be taken as not less than 3/4 of the length of the stiffeners in computing the ratio l/r . Only that portion of the stiffener outside of the flange angle fillet or the flange-to-web welds shall be considered effective in bearing.

4.5.2 Except as hereinafter provided, the largest average web shear, f_v , in kips per square inch, computed for any condition of complete or partial loading, shall not exceed the value given by Formula (4.1).

$$F_v = \frac{F_y}{2.89} (C_v) \leq 0.4F_y \quad (4.1)$$

Alternatively, for girders other than hybrid girders and tapered beams, if intermediate stiffeners are provided and spaced to satisfy the provisions of Section 4.5.3 and $C_v \leq 1$, the allowable shear given by Formula (4.2) may be used in lieu of the value given by Formula (4.1).

$$F_v = \frac{F_y}{2.89} \left[C_v + \frac{1 - C_v}{1.15 \sqrt{1 + (\alpha/h)^2}} \right] \leq 0.45F_y \quad (4.2)$$

4.5.3 Subject to the limitations of Section 4.2, intermediate stiffeners are not required when the ratio h/t is less than 260, and the maximum web shear stress f_v is less than that permitted by Formula (4.1).

The spacing of intermediate stiffeners, where stiffeners are required, shall be such that the web shear stress will not exceed the value for F_v given by Formulas (4.1) or (4.2), as applicable, and the ratio a/h shall not exceed $\frac{260}{h/t}^2$, not 3.0.

In girders designed on the basis of tension field action, the spacing between stiffeners at end panels, at panels containing large holes, and panels adjacent thereto, shall be such that f_v does not exceed the value given by Formula (4.1).

4.5.4 The moment of inertia of a pair of intermediate stiffeners or a single intermediate stiffener, with reference to an axis in the plane of the web, shall not be less than $(h/50)^4$.

The gross area, in square inches, of intermediate stiffeners spaced as required for Formula (4.2) (total area, when stiffeners are furnished in pairs) shall be not less than that computed by Formula (4.3).

$$A_{st} = \frac{1 - C_v}{2} \left[\frac{a}{h} - \frac{(a/h)^2}{\sqrt{1 + (a/h)^2}} \right] YDht \quad (4.3)$$

When the greatest shear stress f_v in a panel is less than that permitted by Formula (4.2) this gross area requirement may be reduced in like proportion.

Intermediate stiffeners required by Formula (4.2) shall be connected for a total shear transfer, in kips per linear inch of single stiffener or pair of stiffeners, not less than that computed by the formula

$$f_{vs} = h \sqrt{\left(\frac{F_y}{340}\right)^3} \quad (4.4)$$

where F_y = yield stress of web steel.

This shear transfer may be reduced in the same proportion that the largest computed shear stress f_v in the adjacent panels is less than that permitted by Formula (4.2). However, welds in intermediate stiffeners which are required to transmit to the web an applied concentrated load or reaction shall be proportioned for not less than the applied load or reaction.

Intermediate stiffeners may be stopped short of the tension flange a distance not to exceed 4 times the web thickness, provided bearing is not needed to transmit a concentrated load or reaction. When single stiffeners are used they shall be attached to the compression flange, it consists of a rectangular plate, to resist any uplift tendency due to torsion in the plate. When lateral bracing is attached to a stiffener or a pair of stiffeners, these, in turn, shall be connected to the compression flange to transmit 1 percent of the total flange stress, unless the flange is composed only of angles.

The clear distance between intermittent welds shall not be more than 16 times the web thickness nor more than 10 inches.

4.6 Reduction in Flange Stress

When the web depth-thickness ratio exceeds $760/\sqrt{F_b}$, the maximum stress in the compression flange shall not exceed

$$F'_b \leq F_b \left[1.0 - 0.0005 \left(\frac{A_w}{A_f} \left(\frac{h}{t} - \frac{760}{\sqrt{F_b}} \right) \right) \right] \quad (4.5)$$

4.7 Combined Shear and Tension Stress

Plate girder webs, which depend upon tension field action as provided in Formula (4.7), shall be so proportioned that bending tensile stress, due to moment in the plane of the girder web, shall not exceed $0.6F_y$ nor

$$\left(0.825 - 0.375 \frac{f_v}{F_v} \right) F_y \quad (4.6)$$

4.8 Splices

Groove welded splices in plate girders and beams shall develop the full strength of the smaller spliced section. Other types of splices in cross-sections of plate girders and in beams shall develop the strength required by the stresses, at the point of splice.

4.9 Horizontal Forces

The flanges of plate girders supporting cranes or other moving loads shall be proportioned to resist the horizontal forces produced by such loads.

4.10 Web Crippling

4.10.1 Webs of beams and welded plate girders shall be so proportioned that the compressive stress at the web toe of the fillets, resulting from concentrated loads not supported by bearing stiffeners, shall not exceed the value of $0.75F_y$; otherwise, bearing stiffeners shall be provided. The governing formulas shall be:

For interior loads,

$$\frac{R}{t(N + 2k)} \leq 0.75F_y \quad (4.7)$$

For end reactions,

$$\frac{R}{t(N + k)} \leq 0.75F_y \quad (4.8)$$

4.10.2 Webs of plate girders shall also be so proportioned or stiffened that the sum of the compression stresses resulting from concentrated and distributed loads, bearing directly on or through a flange plate, upon the compression edge of the web plate, and not supported directly by bearing stiffeners, shall not exceed

$$\left[5.5 + \frac{4}{(\alpha/h)^2} \right] \frac{10,000}{(h/t)^2} \text{ kips per square inch} \quad (4.9)$$

when the flange is restrained against rotation, nor

$$\left[2 + \frac{4}{(\alpha/h)^2} \right] \frac{10,000}{(h/t)^2} \text{ kips per square inch} \quad (4.10)$$

when the flange is not so restrained.

These stresses shall be computed as follows:

Concentrated loads shall be divided by the product of the web thickness and the girder depth or the length of panel in which the load is placed, whichever is the lesser panel dimension.

Distributed loads, in kips per linear inch of length, shall be divided by the web thickness.

4.11 Rotational Restraint at Points of Support

Beams and girders shall be restrained against rotation, about their longitudinal axis, at points of support.

Section 5 ALLOWABLE STRESSES FOR WORKING STRESS DESIGN

In this section, the allowable stresses for structural steel construction are presented for different types of straining actions. The allowable stresses and design formulas are following the AISC specifications and recommendations unless otherwise mentioned. This section should be supplemented by the AISC manual for steel construction and commentary on AISC specifications.

General: Except as provided in sections, all components of the structure shall be so proportioned that the stress, in kips per square inch, shall not exceed the following values.

5.1 Tension

On the net section

$$F_t = 0.60F_y \text{ or } 0.5F_{at}, \text{ whichever is smaller}$$

5.2 Shear

On the gross section: $F_v = 0.40F_y$

5.3 Compression

5.3.1 On the gross section of axially loaded compression members whose cross-sections meet the provisions of Section 4 when KL/r , the largest effective slenderness ratio of any unbraced segment is less than C_c :

$$F_a = \frac{\left[1 - \frac{(KL/r)^2}{2C_c^2} F_y \right]}{\frac{5}{3} + \frac{3(KL/r)}{8C_c} - \frac{(KL/r)^3}{8C_c^3}} \quad (5.1)$$

5.3.2 On the gross section of axially loaded compression members when KL/r exceeds C_c :

$$F_a = \frac{12\pi^2 E}{23(KL/r)^2} \quad (5.2)$$

5.3.3 On the gross section of axially loaded bracing and secondary members, when l/r exceeds 120 (for which $K = 1.0$):

$$F_{as} = \frac{F_a \text{ (by Formula (5.1) or (5.2))}}{1.6 - \frac{l}{200r}} \quad (5.3)$$

5.3.4 On the gross area of plate girder stiffeners:

$$F_a = 0.60F_y$$

5.3.5 Beam web crippling at the critical section:

$$F_a = 0.75F_y$$

5.4 Bending

5.4.1 Tension and compression on extreme fibers of compact built-up members symmetrical about, and loaded in, the plane of their minor axis, and meeting the requirements for lateral torsional buckling listed below.

$$F_b = 0.66F_y$$

In order to qualify under this section, a member must meet the following requirements:

1. The laterally unsupported length of the compression flange of members other than box members shall not exceed the value

$$76.0b_f/\sqrt{F_v} \text{ nor } \frac{20,000}{(d/A_f)F_v}.$$

2. The laterally unsupported length of the compression flange of a box-shaped member of rectangular cross section whose depth is not more than 6 times the width, and whose flange thickness is not more than 2 times the web thickness, shall not exceed the value

$$\left(1950 + 1200 \frac{M_1}{M_2}\right) \frac{b}{F_v}$$

except that it need not be less than $1200 (b/F_v)$.

5.4.2 Members who meet the requirements of Section 1.4.1, except that $b_f/2t_f$ exceeds $65/\sqrt{F_y}$ but is less than $95.0/\sqrt{F_y}$, may be designed on the basis of an allowable bending stress

$$F_b = F_y \left[0.79 - 0.002 \left(\frac{b_f}{2t_f} \right) \sqrt{F_y} \right] \quad (5.4)$$

5.4.3 Tension and compression on extreme fibers of box-type flexural members whose compression flange or web width-thickness ratio does not meet the requirements of Section 5.4.1 but does conform to the requirements of Section 3

$$F_b = 0.60F_y$$

Lateral torsional buckling need not be investigated for a box section whose depth is less than 6 times its width. Lateral support requirements for box sections of larger depth to width ratios must be determined by special analysis.

5.4 Tension on extreme fibers of flexural members not covered in Section 5.4.1, 5.4.2 or 5.4.3

$$F_y = 0.60F_y$$

5.5 Compression on extreme fibers of flexural members included under Section 5.4.4, and meeting the requirements of Section 3, having an axis symmetry in, and loaded in, the plane of their web, and compression on extreme fibers of channels bent about their major axis: the larger value computed by Formulas (5.5), (5.6) and (5.7) as applicable (unless a higher value can be justified on the basis of a more precise analysis), but not more than $0.60F_y$.

When

$$\sqrt{\frac{102 \times 10^3 C_b}{F_y}} \leq \frac{l}{r_T} \leq \sqrt{\frac{510 \times 10^3 C_b}{F_y}}$$

$$F_b = \left[\frac{2}{3} - \frac{F(l/r_T)^2}{1,530 \times 10^3 C_b} \right] F_y \quad (5.5)$$

When

$$l/r_T \geq \sqrt{\frac{510 \times 10^3 C_b}{F_y}}$$

$$F_b = \frac{170 \times 10^3 C_b}{(l/r_T)^2} \quad (5.6)$$

Or, when the compression flange is solid and approximately rectangular in cross-section and its area is not less than that of the tension flange ,

$$F_b = \frac{12 \times 10^3 C_b}{L_d/A_f} \quad (5.7)$$

When computing F_{bx} and F_{by} to be used in Formula (6.1a), C_b may be computed by the formula given above for frames subject to joint translation, and it shall be taken as unity for frames braced against joint translation. C_b may conservatively be taken as unity for cantilever beams.

5.4.6 Compression on extreme fibers of flexural members and meeting the requirements of Section 3 but not included in Section 5.4.5:

$$F_b = 0.60F_y$$

provided that sections bent about their major axis are braced laterally in the region of compression stress at intervals not exceeding $76.0b_f \sqrt{F_y}$.

5.5 Note that the above allowable stresses may be increased by one third above the values otherwise provided above when produced by wind or seismic loading acting alone or in combination with the design dead and live loads, provided the required section computed on this basis is not less than that required for the design dead and live load and impact (if any), computed without the one third stress increase and provided that stresses are not otherwise required to be calculated on the basis of reduction factors applied to design loads in combinations.

Section 6 COMBINED STRESSES

6.1 Axial Compression and Bending

Members subjected to both axial compression and bending stresses shall be proportioned to satisfy the following requirements:

$$\frac{f_a}{F_a} + \frac{C_{mx} f_{bx}}{1 - \frac{f_a}{F'_{ex}} F_{bx}} + \frac{C_{my} f_{by}}{1 - \frac{f_a}{F'_{ey}} F_{by}} \leq 1.0 \quad (6.1a)$$

$$\frac{f_a}{0.60F_y} + \frac{f_{bx}}{F_{bx}} + \frac{f_{by}}{F_{by}} \leq 1.0 \quad (6.1b)$$

When $\frac{f_a}{F_a} \leq 0.15$, Formula (6.2) may be used in lieu of Formulas (6.1a) and (6.1b)

$$\frac{f_a}{F_a} + \frac{f_{bx}}{F_{bx}} + \frac{f_{by}}{F_{by}} \leq 1.0 \quad (6.2)$$

In Formulas (6.1a), (6.1b), and (6.2) the subscripts x and y , combined with subscripts b , m , and e , indicate the axis of bending about which a particular stress or design property applies. As in the case of F_a , F_b and $0.6F_y$, $F'e$ may be increased one-third in accordance with Section 5.5.

6.2 Axial Tension and Bending

Members subject to both axial tension and bending stresses shall be proportioned at all points along their length to satisfy the requirements of Formula (6.16) where f_b is the computed bending tensile stress. However, the computed bending compressive stress, taken alone, shall not exceed the applicable value according to Section 5.4.

APPENDIX C
CRADLE AND TRAILER CROSSBEAM
SECTION PROPERTIES

Section Properties of Cradle Model

Each of the interconnected beam elements that form the model of the cradle may be subjected to end loads and moments. In the most general case, the loads have a normal (to the section) and two tangential (shear) components. To describe the resistance of the beam to these loads requires, for the normal load, a cross-sectional area, (called the axial area in the computer program) and for the tangential loads, modified, or shear, areas that measure the shearing rigidity of the beam.

In "Mechanics of Materials" by Timoshenko and Gere the shearing rigidity of a beam is defined as GA/f_s in which

$$f_s = \frac{A}{I^2} \int_A \frac{Q^2}{b^2} dA$$

Table 11-4 on page 372 gives the following values of f_s for some common sections.

SECTION	f_s
Rectangle	Rectangle	$\frac{6}{5}$
Circle	$\frac{10}{9}$
Thin Tube	2
I or Box Section
		$\frac{A}{A_{web}}$

The end moment has also three components, two bending moments and a torsional moment. For resistance to the bending moments, two moments of inertia, or second moments, of the section are required. For the torsional moment, the torsional stiffness is measured by the polar moment of inertia for circular sections only. For solid cross-sections of other shape, the torsional stiffness is difficult to calculate and results may or may not be available in handbooks or textbooks. For thin strips and thin hollow sections, the membrane analogy provides the most commonly-used method. Because many of the beam sections in the cradle are either thin strips or thin hollow sections, the membrane analogy formulas will be introduced. It should be noted that although the stiffness properties of these non-circular sections are not polar moments of inertia, they will be listed as J in order to conform to the computer program. In addition, because torsional shear stress depends on J/r , a dimension that is equivalent to r , and appears as $C(1)$ in the computer program, will be determined. For thin strips, either straight or curved, of length b and thickness t

$$J = \frac{bt^3}{3} \quad , \quad r = \text{CTORS} = t$$

For thin hollow sections

$$A_T = L_1 \times L_2$$

$$L = 2[L_1 + L_2]$$

$$J = \frac{4A_T^2}{\frac{L_1}{t_1} + \frac{L_2}{t_2} + \frac{L_1}{t_3} + \frac{L_2}{t_4}}$$

For constant thickness t , $J = \frac{4A_T^2}{L}$

$$r = \frac{J}{2A_{T \min}} = \text{CTORS}$$

For constant thickness t , $r = \frac{2A_T}{L} = \text{CTORS}$

Section 1

This is the upper half of the LHM cask including beams 10, 13, 29, 36, 60, 61, 511 - 519 It is assumed that the uranium shield, because it is not fastened to the flanges, does not contribute to the stiffness of the cask.

For the outer shell, with an outside diameter of 27.0 ins. and a wall thickness of 3/4 in,

$$\text{Area} = \frac{\pi}{4}(27^2 - 25.5^2) = 61.85 \text{ in}^2$$

$$J = \frac{\pi}{32}(27^4 - 25.5^4) = 10663 \text{ in}^4$$

For the inner shell, with an outside diameter of 20.25 in. and a wall thickness of 1/8 in.,

$$\text{Area} = \frac{\pi}{4}(20.25^2 - 20.0^2) = 7.9 \text{ in}^2$$

$$J = \frac{\pi}{32}(20.25^4 - 20.0^4) = 800 \text{ in}^4$$

For the combined section

$$\text{Axial area} = A(1) = 61.85 + 7.9 = 69.75 \text{ in}^2$$

$$\text{Shear areas } A(2) = A(3) = 69.75/2 = 34.88 \text{ in}^2$$

$$J(1) = 10663 + 800 = 11463 \text{ in}^4$$

$$I(2) = I(3) = 11463/2 = 5732 \text{ in}^4$$

Stress output not required on this member

Section 2

This is the lower half of the LHM cask including beams 77, 92, 525-528

It is assumed that the uranium shield, because it is not fastened to the flanges, does not contribute to the stiffness of the cask.

For the outer shell, with an outside diameter of 29.75 in. and a wall thickness of 1/2 in.,

$$\text{Area} = \frac{\pi}{4} (29.75^2 - 28.75^2) = 45.94 \text{ in}^2$$

$$J = \frac{\pi}{32} (29.75^4 - 28.75^4) = 9830 \text{ in}^4$$

For the inner shell, with an outside diameter of 20.25 in and a wall thickness of 1/8 in.,

$$\text{Area} = \frac{\pi}{4} (20.25^2 - 20.0^2) = 7.9 \text{ in}^2$$

$$J = \frac{\pi}{32} (20.25^4 - 20.0^4) = 800 \text{ in}^4$$

For the combined section:

$$\text{Axial area } A(1) = 45.94 + 7.9 = 55.84 \text{ in}^2$$

$$\text{Shear areas } A(2) = A(3) = 55.84/2 = 27.92 \text{ in}^2$$

$$J(1) = 9830 + 800 = 10,630 \text{ in}^4$$

$$I(2) = I(3) = 10,630/2 = 5315 \text{ in}^4$$

Stress output not required on this member.

Section 4Beams 3 and 4. Outboard portions of cross beam No. 1

All Thicknesses = 0.25 in

1. Cross Sectional Area

$$A = 2(18.250)(.250) + 2(12.5)(.250)$$

$$A = 15.375 \text{ in}^2 = A(1)$$

2. Neutral Axis

$$A_1 = (18.250)(.250)$$

$$y_1 = \frac{18.250}{2}$$

$$A_1 = 4.5625 \text{ in}^2$$

$$y_1 = 9.125 \text{ in}$$

$$A_2 = (12.5)(.250)$$

$$y_2 = .375 \text{ in}$$

$$A_2 = 3.125 \text{ in}^2$$

$$A_3 = (12.5)(.250)$$

$$y_3 = 16.125 \text{ in}$$

$$A_3 = 3.125 \text{ in}^2$$

$$\bar{Y} = \frac{2(4.5625)(9.125) + (3.125)(.375) + (3.125)(16.125)}{15.375}$$

$$\bar{Y} = 8.7693 \text{ in}$$

3. Moment of Inertia

$$I_{22} = \frac{2(.250)(12.5)^3}{12} + \frac{2(18.250)(.250)^3}{12} + 2(18.250)(.250)(6.375)^2$$

$$I_{22} = 81.3802 + .0475 + 370.8457$$

$$I_{22} = 452.2734 \text{ in}^4 = I(2), \quad H3 = 6.5 \times 2 = 13.0 \text{ in.}$$

$$I_{33} = \frac{2(.250)(18.250)^3}{12} + 2(.250)(18.250)(.356)^2$$

$$+ \frac{2(12.5)(.250)^3}{12} + (12.5)(.250)(7.356)^2$$

$$+ (12.5)(.250)(8.394)^2$$

$$I_{33} = 253.2663 + 1.1565 + .0326 + 169.0961 + 220.1851$$

$$I_{33} = 643.7366 \text{ in}^4 = I(3), \quad H2 = 9.481 \times 2 = 18.962$$

$$J = \frac{4A^2t}{L}$$

$$L = 2(12.75 + 15.75) = 57 \text{ in.}$$

$$A = 12.75 \times 15.75 = 200.8 \text{ in}^2$$

$$A^2 = 40325 \text{ in}^4, \quad t = 0.25 \text{ in.}$$

$$J = \frac{4 \times 40325 \times 0.25}{57} = 707.4 \text{ in}^4 = J(1)$$

$$r = \frac{2A}{L} = \frac{2 \times 200.8}{57} = 7.046 \text{ in.} = \text{CTORS}$$

4. Shearing rigidity = A/f_s

$$\text{For box section } f_s = A/A_{\text{WEB}}$$

$$\therefore \frac{A}{f_s} = \frac{A}{A} A_{\text{WEB}} = A_{\text{WEB}}$$

$$\text{For axis 22, } A_{\text{WEB}} = 12.5 \times 0.5 = 6.25 \text{ in}^2 = A(2)$$

$$\text{For axis 33, } A_{\text{WEB}} = 15.5 \times 0.5 = 7.75 \text{ in}^2 = A(3)$$

Section 5 is a compression only member. "T-bar" is a tension only member -
See Section 74. Section 5 for beams 5 and 6. Saddle support at Cross Beam
No. 1.

$$40^\circ = 0.698 \text{ radians.}$$

$$\begin{aligned} \text{Saddle area} &= 13.5 \times 0.698 \times 15.4 \\ &= 145.1 \text{ in.}^2 \end{aligned}$$

$$A(1) = 0.1451 \text{ D } 03$$

$$A(2) = A(3) = 0.0, J(1) = I(2) = I(3) = 0.1000 \text{ D } 01$$

No stress output required for this member.

Section 6Beam 9 Inboard portions of crossbeam No. 1

All thicknesses = 0.25 in.

1. Cross Sectional Area

$$A = 2(9.25 \times 0.25) + (12.5 \times 0.25) \times 2$$

$$A = 4.625 + 6.25$$

$$A = 10.875 \text{ in}^2 = A(1)$$

2. Neutral Axis

$$A_1 = 4.625$$

$$y_1 = 4.625 \text{ in}$$

$$A_2 = 3.125$$

$$y_2 = 0.375 \text{ in}$$

$$A_3 = 3.125$$

$$y_3 = 9.125 \text{ in}$$

$$\bar{y} = \frac{(4.625)(4.625) + (3.125)(0.375) + 3.125 \times 9.125}{10.875}$$

$$\bar{y} = \frac{21.39 + 1.17 + 28.52}{10.875}$$

$$\bar{y} = 4.70 \text{ in}$$

3. Moment of Inertia

$$I_{22} = \frac{2(0.25)(12.5)^3}{12} + 2 \frac{(9.25)(0.25)^3}{12} + 2(9.25 \times 0.25)(6.375)^2$$

$$I_{22} = 81.38 + 0.02 + 187.96$$

$$I_{22} = 269.36 \text{ in}^4 = I(2), \quad H3 = 6.5 \times 2 = 13.0 \text{ in.}$$

$$I_{33} = 2 \frac{(0.25)(9.25)^3}{12} + 2(9.25 \times 0.25)(0.075)^2 + \frac{2 \times 12.5 (0.25)^3}{12} \\ + (12.5 \times 0.25) [(4.325)^2 + (4.425)^2]$$

$$I_{33} = 32.98 + 0.026 + 0.032 + 119.64$$

$$I_{33} = 152.68 \text{ in}^4 = I(3), \quad H2 = 4.70 \times 2 = 9.4 \text{ in.}$$

$$J = \frac{4A^2 t}{L}$$

$$L = 2(12.75 + 8.75) = 43 \text{ in}$$

$$A = 12.75 \times 8.75 = 111.6 \text{ in}^2$$

$$A^2 = 12446 \text{ in}^4, \quad t = 0.25 \text{ in.}$$

$$J = \frac{4 \times 12446 \times 0.25}{43} = 289.4 \text{ in}^4 = J(1)$$

$$r = \frac{2A}{L} = \frac{2 \times 111.6}{43} = 5.191 \text{ in.} = \text{CTORS}$$

4. Shearing rigidity = A/f_s

$$f_s = A/A_{WEB}, \frac{A}{f_s} = \frac{A}{A} A_{WEB} = A_{WEB}$$

$$\text{For axis 22, } A_{WEB} = 12.5 \times 0.5 = 6.25 \text{ in}^2 = A(2)$$

$$\text{For axis 33, } A_{WEB} = 8.5 \times 0.5 = 4.25 \text{ in}^2 = A(3)$$

Section 7 Beams 11, 12, 34, 35

Upper Portion of Cradle Side Beams

1. Cross Sectional Area

$$A = 2(11.0)(.375) + 2(7)(.500)$$

$$A = 15.250 \text{ in}^2 = A(1)$$

2. Neutral Axis

$$\bar{x} = 3.5 \text{ in}$$

$$\bar{y} = 6.0 \text{ in}$$

3. Moment of Inertia

$$I_{22} = \frac{2(.500)(7)^3}{12} + \frac{2(11)(.375)^3}{12} + 2(11)(.375)(2.9375)^2$$

$$I_{22} = 28.583 + .097 + 71.19$$

$$I_{22} = 99.87 \text{ in}^4 = I(2), \quad H3 = 7.0 \text{ in.}$$

$$I_{33} = \frac{2(.375)(11)^3}{12} + \frac{2(7)(.500)^3}{12} + 2(7)(.500)(5.750)^2$$

$$I_{33} = 83.188 + .146 + 231.438$$

$$I_{33} = 314.771 \text{ in}^4 = I(3), \quad H2 = 12.0 \text{ in.}$$

$$J = \frac{4A^2}{\frac{L_1}{t_1} + \frac{L_2}{t_2}}$$

$$L_1 = 2 \times 11.5 = 23 \text{ in.}, t_1 = 0.375 \text{ in.}, \frac{L_1}{t_1} = 61.33$$

$$L_2 = 2 \times 5.875 = 11.75 \text{ in.}, t_2 = 0.5 \text{ in.}, \frac{L_2}{t_2} = 23.5$$

$$A = 11.5 \times 5.875 = 67.56 \text{ in}^2$$

$$A^2 = 4564 \text{ in}^4$$

$$J = \frac{4 \times 4564}{61.33 + 23.5} = 215.2 \text{ in}^4 = J(1)$$

$$r = \text{CTORS} = \frac{J}{2At_{\min}} = \frac{215.2}{2 \times 67.56 \times 0.375} = 4.25 \text{ in}$$

4. Shearing rigidity = A/f_s

$$f_s = \frac{A}{A_{\text{WEB}}}, \frac{A}{f_s} = \frac{A}{A} A_{\text{WEB}} = A_{\text{WEB}}$$

$$\text{For axis 22, } A_{\text{WEB}} = 2 \times 5.5 \times 0.5 = 5.5 \text{ in}^2 = A(2)$$

$$\text{For axis 33, } A_{\text{WEB}} = 2 \times 11 \times 0.375 = 8.25 \text{ in}^2 = A(3)$$

Section 8, Beams 14 and 15 Cradle Horizontal Hold-Down

$$\begin{aligned} \text{Axial area } A(1) &= 5.75 \times 15.75 - 15 \times 4.625 \\ &= 31.19 \text{ in}^2 \end{aligned}$$

$$\text{Shear area } A(2) = 15 \times 1.125 = 16.88 \text{ in}^2$$

$$\text{Shear area } A(3) = 4.625 \times 0.75 = 3.47 \text{ in}^2$$

$$\bar{y} = \frac{15.75 (0.375 \times 0.1875 + 0.75 \times 4.375) + 4.625 \times 0.75 \times 2.688}{31.19}$$

$$= 3.648 \text{ in}, \bar{x} = 7.875 \text{ in}$$

$$\begin{aligned} I_{22} &= \frac{1}{12} [1.125 \times 15^3 + 2 \times 5.75 \times 0.375^3] + 2 \times 5.75 \times 0.375 \times 7.688^2 \\ &= 571.3 \text{ in}^4 = I(2) \end{aligned}$$

$$H3 = 15.75 \text{ in.}$$

$$\begin{aligned} I_{33} &= \frac{1}{12} [15(0.75^3 + 0.375^3) + 0.75 \times 5.75^3] + 15(0.75 \times 1.725^2 + 0.375 \times 3.462^2) \\ &\quad + 5.75 \times 0.75 \times 0.775^2 \\ &= 115.9 \text{ in}^4 = I(3), H2 = 3.65 \times 2 = 7.30 \text{ in} \end{aligned}$$

$$J = \frac{4A^2}{2 \frac{L_1}{t_1} + \frac{L_2}{t_2} + \frac{L_2}{t_1}}$$

$$L_1 = 5.188 \text{ in}, L_2 = 15.375 \text{ in}$$

$$t_1 = 0.375 \text{ in}, t_2 = 0.75 \text{ in}$$

$$A = 5.188 \times 15.375 = 79.76 \text{ in}^2$$

$$\frac{2L_1}{t_1} = \frac{5.188 \times 2}{0.375} = 27.67$$

$$\frac{L_2}{t_2} = \frac{15.375}{0.75} = 20.5$$

$$\frac{L_2}{t_1} = \frac{15.375}{0.375} = 41.0$$

$$J = \frac{4 \times 79.76^2}{89.17} = 285 \text{ in}^4 = J(1)$$

$$r = \frac{J}{2At_{\min}} = \frac{285}{2 \times 79.76 \times 0.375} = 4.76 \text{ in} = \text{CTORS}$$

Section 9 for beam 23, Section 20 for beam 67, Section 75 for beam 22,
Section 76 for beam 66.

These sections model the holddown mechanism at crossbeam Nos. 2 & 4. The holddown mechanism consists of a strap 0.5 x 3.75 in. around the LHM cask. The members can effectively transmit axial load only. Small values for the inertias and torsional constant will be coded into the finite element program; however, the boundary conditions imposed upon the member will prevent moments or shears from occurring.

$$A(1) = 0.5(3.75) = 1.875 \text{ in}^2$$

$$A(2) = A(3) = 0.0$$

$$I_{22} = I_{33} = L = 1.0 \text{ in}^4$$

Section 10 for beam 24Saddle support at Cross Beam No. 2.

For Section 10,

$$\begin{aligned}\text{Saddle area} &= 13.5 \times 0.524 \times 18.4 \\ &= 130.2 \text{ in.}^2\end{aligned}$$

$$A(1) = 0.1302 \text{ D } 03$$

$$A(2) = A(3) = 0.0, J(1) = I(2) = I(3) = 0.1000 \text{ D } 01$$

Section 10 is a compression-only member.

Section 11, All of Cross Beam No. 2

1. Cross Sectional Area

$$A = 2(15)(.250) + 2(18.750)(.250)$$

$$A = 16.875 \text{ in}^2 = A(1)$$

2. Neutral Axis

$$A_1 = (18.750)(.250)$$

$$y_1 = \frac{18.750}{2}$$

$$A_1 = 4.6875 \text{ in}^2$$

$$y_1 = 9.375 \text{ in}$$

$$A_2 = (15)(.250)$$

$$y_2 = .375 \text{ in}$$

$$A_2 = 3.750 \text{ in}^2$$

$$A_3 = (15)(.250)$$

$$y_3 = 12.625 \text{ in}$$

$$A_3 = 3.750 \text{ in}^2$$

$$\bar{y} = \frac{2(4.6875)(9.375) + (3.750)(.375) + (3.750)(12.625)}{2(4.6875) + 2(3.750)}$$

$$\bar{y} = 8.097 \text{ in}$$

3. Moment of Inertia

$$I_{33} = \frac{2(15)(.250)^3}{12} + (15 \times .250)(7.722)^2 + (15 \times .250)(4.528)^2 \\ + \frac{2(.250)(18.750)^3}{12} + 2(.250 \times 18.750)(1.278)^2$$

$$I_{33} = .0391 + 223.6098 + 76.8854 + 274.6582 + 15.3120$$

$$I_{33} = 590.5045 \text{ in}^4 = I(3), H2 = 10.653 \times 2 = 21.306$$

$$I_{22} = \frac{2(18.750)(.250)^3}{12} + 2(18.750)(.250)(7.625)^2 \\ + \frac{2(.250)(15)^3}{12}$$

$$I_{22} = .0488 + 545.0684 + 140.625$$

$$I_{22} = 685.7422 \text{ in}^4 = I(2), H3 = 15.5 \text{ in.}$$

The protruding 6 in. pieces will have no appreciable effect on the stiffness of the section.

$$J = \frac{4A^2t}{L}$$

$$L = 2(15.25 + 12.25) = 55 \text{ in}$$

$$A = 15.25 \times 12.25 = 186.8 \text{ in}^2$$

$$A^2 = 34899 \text{ in}^4, t = 0.25 \text{ in}$$

$$J = \frac{4 \times 34899 \times 0.25}{55} = 634.5 \text{ in}^4 = J(1)$$

$$r = \frac{2A}{L} = \frac{2 \times 186.8}{55} = 6.79 \text{ in} = \text{CTORS}$$

4. Shearing rigidity = A_{WEB}

For axis 22, $A_{WEB} = 15 \times 0.5 = 7.5 \text{ in}^2 = A(2)$

For axis 33, $A_{WEB} = 12 \times 0.5 = 6 \text{ in}^2 = A(3)$

Section 12Beams 30 and 31

These beams simulate the lifting lugs as they are loaded by the beams carrying the counterweights.

$$\begin{aligned}\text{Axial area } A(1) &= 16 \times 64 - 14.75 \times 62.75 \\ &= 98.5 \text{ in}^2\end{aligned}$$

$$\begin{aligned}\text{Shear area } A(2) &= A_{\text{WEB}} = 14.75 \times 2 \times 0.625 \\ &= 18.44 \text{ in}^2\end{aligned}$$

$$\begin{aligned}\text{Shear area } A(3) &= A_{\text{WEB}} = 62.75 \times 2 \times 0.625 \\ &= 78.44 \text{ in}^2\end{aligned}$$

$$\begin{aligned}I_{22} &= \frac{1}{12} [64 \times 16^3 - 62.75 \times 14.75^3] \\ &= 5065 \text{ in}^4 = I(2)\end{aligned}$$

$$\begin{aligned}I_{33} &= \frac{1}{12} [16 \times 64^3 - 14.75 \times 62.75^3] \\ &= 45820 \text{ in}^4 = I(3)\end{aligned}$$

$$J = \frac{4A^2t}{L}$$

$$L = 2(63.375 + 15.375) = 157.5 \text{ in.}$$

$$A = 63.375 \times 15.375 = 974.4 \text{ in}^2$$

$$A^2 = 949437 \text{ in}^4$$

$$J = \frac{4 \times 949437 \times 0.625}{157.5} = 15070 \text{ in}^4 = J(1)$$

No stress output required for this member.

Section 13Beams 32 and 33

These beams are at right angles to the cask center line and extend from the lifting lugs to the counter weights.

$$\text{Axial area } A(1) = 7.33 + 0.3125 \times 10.75 \\ = 10.69 \text{ in}^2$$

$$\text{Shear area } A(3) = A_{\text{WEB}} = 2(2.89 - 0.526) 0.436 \\ = 2.06 \text{ in}^2$$

$$\text{Shear area } A(2) = A_{\text{WEB}} = (10 - 2 \times 0.436)(0.526 + 0.3125) \\ = 7.65 \text{ in}^2$$

$$\bar{x} = \frac{10.75 \times 0.315 \times 0.1563 + 2 \times 2.364 \times 0.436 \times 1.4945}{10.69}$$

$$+ \frac{10 \times 0.526 \times 2.9395}{10.69}$$

$$= 1.78 \text{ in}$$

$$\bar{y} = 5.375 \text{ in.}$$

$$\begin{aligned}
 I_{33} &= \frac{1}{12} [10.75 \times 0.3125^3 + 10 \times 0.526^3 + 2 \times 0.436 \times 2.364^3] \\
 &\quad + 10.75 \times 0.3125 \times 1.624^2 + 10 \times 0.526 \times 1.159^2 + 2 \times 0.436 \\
 &\quad \times 2.364 \times 0.2855^2 \\
 &= 17.20 \text{ in}^4 = I(2), \quad H2 = 1.78 \times 2 = 3.56 \text{ in.}
 \end{aligned}$$

$$\begin{aligned}
 I_{22} &= 90.7 + \frac{1}{12} \times 0.3125 \times 10.75^3 \\
 &= 123.05 \text{ in}^4 = I(3), \quad H3 = 10.75
 \end{aligned}$$

TORSIONAL PROPERTIES

$$A = 9.564 \times 2.784 = 26.63 \text{ in}^2$$

$$A^2 = 708.95 \text{ in}^4$$

$$L_1 = 9.564, \quad t_1 = 0.526, \quad \frac{L_1}{t_1} = 18.18$$

$$L_2 = 2 \times 2.784 = 5.568, \quad t_2 = 0.436$$

$$\frac{L_2}{t_2} = 12.77, \quad t_3 = 0.3125, \quad \frac{L_1}{t_3} = 30.60$$

$$J = \frac{4A^2}{\frac{L_1}{t_1} + \frac{L_2}{t_2} + \frac{L_1}{t_3}} = \frac{4 \times 708.95}{61.55} = 46.07 \text{ in}^4 = J(1)$$

$$r = \frac{J}{2At_{\min}} = \frac{46.07}{2 \times 26.63 \times 0.3125}$$

No stress output required for this member.

For Section 15,

$$\begin{aligned}\text{Saddle area} &= 13.5 \times 0.942 \times 15 \\ &= 190.8 \text{ in.}^2\end{aligned}$$

$$A(1) = 0.1908 \text{ D } 03$$

$$A(2) = A(3) = 0.0, J(1) = I(2) = I(3) = 0.1000 \text{ D } 01$$

$$C(1) = -1.000, C(2) = C(3) = 1.000$$

Section 16, Beams 44 and 45. Inboard portions of Crossbeam No. 3.

All Thicknesses = 0.25 in.

1. Cross Sectional Area

$$A = 2(14)(.250) + (13)(.250) + (13.750)(.250)$$

$$A = 13.6875 \text{ in}^2 = A(1)$$

2. Neutral Axis

$$A_1 = 2(14.250)(.250)$$

$$y_1 = .250 + \frac{14.250}{2}$$

$$A_1 = 7.125 \text{ in}^2$$

$$y_1 = 7.375 \text{ in}$$

$$A_2 = (12.5)(.250)$$

$$y_2 = 14.375 \text{ in}$$

$$A_2 = 3.125 \text{ in}^2$$

$$A_3 = (13.750)(.250)$$

$$y_3 = .125 \text{ in}$$

$$A_3 = 3.4375 \text{ in}^2$$

$$\bar{y} = \frac{(7.125)(7.375) + (3.125)(14.375) + (3.4375)(.125)}{13.6875}$$

$$\bar{y} = 7.1524 \text{ in}$$

3. Moment of Inertia

$$I_{22} = \frac{2(.250)(13)^3}{12} + \frac{2(14)(.250)^3}{12} + 2(14)(.250)(6.375)^2 \\ + \frac{2(.250)(.375)^3}{12} + 2(.250)(.375)(6.6875)^2$$

$$I_{22} = 91.5417 + .0365 + 284.4844 + .0022 + 8.3855$$

$$I_{22} = 384.4502 \text{ in}^4 = I(2), \quad H3 = 13.75 \text{ in.}$$

$$I_{33} = \frac{2(.250)(14)^3}{12} + 2(.250)(14)(.0976)^2 + \frac{(13)(.250)^3}{12} \\ + (13)(.250)(7.2226)^2 + \frac{(13.750)(.250)^3}{12} + (13.750)(.250)(7.0274)^2$$

$$I_{33} = 114.3333 + .066 + .0169 + 169.539 + .0179 + 169.759$$

$$I_{33} = 453.7318 \text{ in}^4 = I(3), \quad H2 = 7.348 \times 2 = 14.696 \text{ in.}$$

$$J = \frac{4A^2t}{L}$$

$$L = 2(12.75 + 14.25) = 54 \text{ in}$$

$$A = 12.75 \times 14.25 = 181.7 \text{ in}^2$$

$$A^2 = 33011 \text{ in}^4, \quad t = 0.25 \text{ in}$$

$$J = \frac{4 \times 33011 \times 0.25}{54} = 611.3 \text{ in}^4 = J(1)$$

$$r = \frac{2A}{L} = \frac{2 \times 181.7}{54} = 6.73 \text{ in} = \text{CTORS}$$

4. Shearing rigidity = A_{WEB}

$$\text{For axis 22, } A_{\text{WEB}} = 12.5 \times 0.5 = 6.25 \text{ in}^2 = A(2)$$

$$\text{For axis 33, } A_{\text{WEB}} = 14 \times 0.5 = 7 \text{ in}^2 = A(3)$$

Section 18, Beams 54 and 55 between crossbeam No. 3 and attachment to Elevating Cylinder.

All Thicknesses 0.5 in.

$$A (1) = 12.125 \times 13 - 11.125 \times 12 = 24.125 \text{ in}^2$$

$$A (2) = A_{\text{web}} = 1 \times 11.125 = 11.125 \text{ in}^2$$

$$A (3) = A_{\text{web}} = 1 \times 12 = 12 \text{ in}^2$$

$$I_{22} = \frac{1}{12} \left[13 \times 12.125^3 - 12 \times 11.125^3 \right] = 554.2 \text{ in}^4 = I(2)$$

$$I_{33} = \frac{1}{12} \left[12.125 \times 13^3 - 11.125 \times 12^3 \right] = 617.8 \text{ in}^4 = I(3)$$

$$H2 = 13.0 \text{ in.}, H3 = 12.125 \text{ in.}$$

$$J = \frac{4A^2t}{L}$$

$$L = 2(11.625 + 12.5) = 48.75 \text{ in.}$$

$$A = 11.625 \times 12.5 = 145.3 \text{ in}^2$$

$$A^2 = 21116 \text{ in}^4$$

$$J = \frac{4 \times 21116 \times 0.5}{48.25} = 875.3 = J(1)$$

$$r = \frac{2A}{L} = \frac{2 \times 145.3}{48.25} = 6.02 \text{ in} = \text{CTORS}$$

Section 19, Beams 56, 57, 58 and 59. Side Beams between Crossbeams No.3 and No. 4.

1. Cross Sectional Area

$$A = 2(7)(.500) + 2(11)(.375) + (13)(.375)$$

$$A = 20.125 \text{ in}^2 = A(1)$$

2. Neutral Axis

$$A_1 = (13)(.375)$$

$$x_1 = .1875 \text{ in}$$

$$A_1 = 4.875 \text{ in}^2$$

$$A_2 = (11)(.375)$$

$$x_2 = .9375 \text{ in}$$

$$A_2 = 4.125 \text{ in}^2$$

$$A_3 = (11)(.375)$$

$$x_3 = 6.8125 \text{ in}$$

$$A_3 = 4.125 \text{ in}^2$$

$$A_4 = 2(7)(.5)$$

$$x_4 = 3.875 \text{ in}$$

$$A_4 = 7.0 \text{ in}^2$$

$$\bar{x} = \frac{(4.875)(.1875) + (4.125)(.9375) + (4.125)(6.8125) + (7)(3.875)}{20.125}$$

$$\bar{x} = 2.9818 \text{ in}$$

$$\bar{y} = 6.500 \text{ in}$$

3. Moment of Inertia

$$\begin{aligned} I_{22} &= \frac{2(.500)(7)^3}{12} + 2(.500)(7)(.8932)^2 + \frac{2(11)(.375)^3}{12} \\ &\quad + (11)(.375)(3.8307)^2 + (11)(.375)(2.0443)^2 + \frac{(13)(.375)^3}{12} \\ &\quad + (13)(.375)(2.7943)^2 \end{aligned}$$

$$\begin{aligned} I_{22} &= 28.5833 + 5.5846 + .0967 + 60.5313 + 17.2390 \\ &\quad + .0571 + 38.0645 \end{aligned}$$

$$I_{22} = 150.1567 \text{ in}^4 = I(2), \quad H3 = 4.39 \times 2 = 8.78 \text{ in.}$$

$$\begin{aligned} I_{33} &= \frac{2(.375)(11)^3}{12} + \frac{(.375)(13)^3}{12} + \frac{2(7)(.500)^3}{12} \\ &\quad + 2(7)(.500)(5.750)^2 \end{aligned}$$

$$I_{33} = 83.1875 + 68.6563 + .1458 + 231.4375$$

$$I_{33} = 383.4271 \text{ in}^4 = I(3), \quad H2 = 13.0 \text{ in.}$$

$$J = \frac{4A^2}{\frac{I_1}{t_1} + \frac{I_2}{t_2} + \frac{I_3}{t_3}}$$

Assume right side is 0.75 in. thick with centerline cc

$$L_1 = 11.5 \text{ in.}, \quad t_1 = 0.375 \text{ in.}, \quad \frac{L_1}{t_1} = 30.66$$

$$L_2 = 2 \times 6.25 = 12.5 \text{ in.}, \quad t_2 = 0.5 \text{ in.}, \quad \frac{L_2}{t_2} = 25.0$$

$$t_3 = 0.75 \text{ in.}, \quad \frac{L_1}{t_3} = 15.33$$

$$A = 11.5 \times 6.25 = 71.875 \text{ in}^2$$

$$A^2 = 5166 \text{ in}^4, \quad t_{\min} = 0.375 \text{ in}$$

$$J = \frac{4 \times 5166}{30.66 + 25 + 15.33} = 291.1 \text{ in}^4 = J(1)$$

$$r = \frac{J}{2At_{\min}} = \frac{291.1}{2 \times 71.88 \times 0.375} = 5.40 \text{ in} = \text{CTORS}$$

4. Shearing rigidity = A_{WEB}

$$\text{For axis 22, } A_{\text{WEB}} = 5.75 \times 1 = 5.75 \text{ in}^2 = A(2)$$

$$\text{For axis 33, } A_{\text{WEB}} = 11(0.375 + 0.75) = 12.375 \text{ in}^2 = A(3)$$

Section 21 for beam 68. This is a compression-only member.

Saddle support at Cross Beam No. 4.

$28^\circ = 0.489$ radians, $64^\circ = 1.117$ radians.

For Section 21,

$$\begin{aligned}\text{Saddle area} &= 14.875 \times 1.117 \times 17.6 \\ &= 292.4 \text{ in.}^2\end{aligned}$$

$$A(1) = 0.2924 \text{ D } 03$$

$$A(2) = A(3) = 0.0, J(1) = I(2) = I(3) = 0.1000 \text{ D } 01$$

No stress output required for this member.

Section 22, Beams 69 and 70. Inboard portions of Crossbeam No. 4.

2

All Thicknesses = 0.250 in

1. Cross Sectional Area

$$A = 2(16)(.250) + 2(15)(.250)$$

$$A = 15.5 \text{ in}^2 = A(1)$$

2. Neutral Axis

$$A_1 = (16)(.250)$$

$$y_1 = \frac{16}{2}$$

$$A_1 = 4.0 \text{ in}^2$$

$$y_1 = 8.0 \text{ in}$$

$$A_2 = (15)(.250)$$

$$y_2 = .375 \text{ in}$$

$$A_2 = 3.750 \text{ in}^2$$

$$A_3 = (15)(.250)$$

$$y_3 = 12.875 \text{ in}$$

$$A_3 = 3.750 \text{ in}^2$$

$$\bar{y} = \frac{2(4.0)(8.0) + (3.750)(.375) + (3.750)(12.875)}{2(4) + 2(3.750)}$$

$$\bar{y} = 7.335 \text{ in}$$

3. Moment of Inertia

$$I_{22} = \frac{2(.250)(15)^3}{12} + \frac{2(16)(.250)^3}{12} + 2(16)(.250)(7.625)^2$$

$$I_{22} = 140.625 + .0417 + 465.125$$

$$I_{22} = 605.7917 \text{ in}^4 = I(2), H3 = 15.5 \text{ in.}$$

$$I_{33} = \frac{2(.250)(16)^3}{12} + 2(.250)(16)(.665)^2 + \frac{2(15)(.250)^3}{12}$$

$$+ (15)(.250)(5.540)^2 + (15)(.250)(6.960)^2$$

$$I_{33} = 170.6667 + 3.5378 + .0391 + 115.0935 + 181.656$$

$$I_{33} = 470.9931 \text{ in}^4 = I(3), H2 = 8.665 \times 2 = 17.330 \text{ in}$$

$$J = \frac{4A^2t}{L}$$

$$L = 2(15.25 + 12.5) = 55.5 \text{ in}$$

$$A = 15.25 \times 12.5 = 190.6 \text{ in}^2$$

$$A^2 = 36338 \text{ in}^4 \quad t = 0.25 \text{ in}$$

$$J = \frac{4 \times 36338 \times 0.25}{55.5} = 654.7 \text{ in}^4 = J(1)$$

$$r = \frac{2A}{L} = \frac{2 \times 190.6}{55.5} = 6.87 \text{ in.} = \text{CTORS}$$

4. Shearing rigidity = A_{WEB}

$$\text{For axis 22, } A_{\text{WEB}} = 15 \times 0.5 = 7.5 \text{ in}^2 = A(2)$$

$$\text{For axis 33, } A_{\text{WEB}} = 12.25 \times 0.5 = 6.13 \text{ in}^2 = A(3)$$

Section 23, Side beams 71 and 72 just behind Crossbeam No. 4.

1. Cross Sectional Area

$$A = 13 \times (0.5 + 0.375) + 2 \times 11 \times 0.375 + 2 \times 7 \times 0.5$$

$$= 26.63 \text{ in}^2 = A(1)$$

2. Neutral Axis

$$\bar{y} = 6.5 \text{ in.}, \bar{x} = 4 \text{ in (estimated for simplicity)}$$

3. Moments of Inertia

$$I_{33} = \frac{1}{12} [0.875 \times 13^3 + 0.75 \times 11^3 + 2 \times 7 \times 0.5^3] + 2 \times 7 \times 0.5 \times 5.75^2$$

$$= 474.9 \text{ in}^4 = I(3), H2 = 13 \text{ in.}$$

$$I_{22} = \frac{1}{12} [1 \times 7^3 + 13 \times 0.5^3 + 13 \times 0.375^3 + 2 \times 11 \times 0.375^3] + 13$$

$$\times 0.5 \times 3.625^2 + 13 \times 0.375 \times 3.813^2 + 11 \times 0.375 \times 3.063^2$$

$$+ 11 \times 0.375 \times 2.938^2 + 2 \times 7 \times 0.5 \times 0.0625^2$$

$$= 259.5 \text{ in}^4 = I(2), H2 = 8 \text{ in}$$

$$J = \frac{4A^2}{\frac{L_1}{t_1} + \frac{L_2}{t_2} + \frac{L_1}{t_3}}$$

$$\begin{aligned}
 L_1 &= 11.5 \text{ in.}, t_1 = 0.875 \text{ in.}, \frac{L_1}{t_1} = 13.14 \\
 L_2 &= 2 \times 6.625 = 13.25 \text{ in.}, t_2 = 0.5, \frac{L_2}{t_2} = 26.5 \\
 t_3 &= 0.75 \text{ in.}, \frac{L_1}{t_3} = 15.33
 \end{aligned}$$

$$A = 11.5 \times 6.625 = 76.19 \text{ in}^2$$

$$A^2 = 5804 \text{ in}^4$$

$$J = \frac{4 \times 5804}{13.14 + 26.5 + 15.33} = 422.3 \text{ in}^4 = J(1)$$

$$r = \frac{J}{2At_{\min}} = \frac{422.3}{2 \times 76.19 \times 0.5} = 5.54 \text{ in} = \text{CTORS}$$

4. Shearing rigidity = A_{WEB}

$$\text{For 22 axis, } A_{\text{WEB}} = 5.8125 \times 2 \times 0.5 = 5.813 \text{ in}^2 = A(2)$$

$$\text{For 33 axis, } A_{\text{WEB}} = 11 \times (0.875 + 0.75) = 17.88 \text{ in}^2 = A(3)$$

Section 24, Main beam for cradle pivot support. Beams 75, 76, 90, 91.

$$\begin{aligned} \text{Axial area, } A(1) &= 2 \times 24 \times 0.375 + 3 \times 5.5 \times 0.5 \\ &= 26.25 \text{ in.}^2 \end{aligned}$$

$$\text{Shear area, } A(2) = \text{Area}_{\text{web}} = 3 \times 5.5 \times 0.5 = 8.25 \text{ in.}^2$$

$$\text{Shear area, } A(3) = \text{Area}_{\text{web}} = 2 \times 23 \times 0.375 = 17.25 \text{ in.}^2$$

$$\begin{aligned} I_{22} &= \frac{1}{12} \left[1.5 \times 5.5^3 + 2 \times 24 \times 0.375^3 \right] + 2 \times 24 \times 0.375 \times 2.9375^2 \\ &= 176.3 \text{ in.}^4 = I(2), \quad H3 = 6.25 \text{ in.} \end{aligned}$$

$$\begin{aligned} I_{33} &= \frac{1}{12} \left[2 \times 0.375 \times 24^3 + 3 \times 5.5 \times 0.5^3 \right] + 2 \times 5.5 \times 0.5 \times 11.75^2 \\ &= 1623.2 \text{ in.}^4 = I(3), \quad H2 = 24.0 \text{ in.} \end{aligned}$$

From symmetry, the central 1/2 in. horizontal section carries no torque and may be neglected.

$$J = \frac{4A^2}{\frac{L_1}{t_1} + \frac{L_2}{t_2}}$$

$$L_1 = 2 \times 23.5 = 47 \text{ in.}, t_1 = 0.375 \text{ in.}, \frac{L_1}{t_1} = 125.3$$

$$L_2 = 2 \times 5.875 = 11.75 \text{ in.}, t_2 = 0.5 \text{ in.}, \frac{L_2}{t_2} = 23.5$$

$$A = 23.5 \times 5.875 = 138.1 \text{ in.}^2$$

$$A^2 = 19061 \text{ in.}^4$$

$$J = \frac{4 \times 19061}{125.3 + 23.5} = 512.4 \text{ in.}^4 = J(1)$$

$$r = \frac{J}{2At_{\min}} = \frac{512.4}{2 \times 138.1 \times 0.375} = 4.95 \text{ in.} = \text{CTORS}$$

$$\begin{aligned}
 I_{22} &= \frac{1}{12} [1.5 \times 5.5^3 + 2 \times 24 \times 0.375^3] + 2 \times 24 \times 0.375 \times 2.9375^2 \\
 &= 176.33 \text{ in}^4 = I(3), H3 = 6.25 \text{ in.}
 \end{aligned}$$

Torsional Properties

$$\tau_1 = \frac{h_1}{t_1}, \tau_2 = \frac{h_1}{t_2}, \tau_3 = \frac{h_2}{t_2}, \tau_4 = \frac{h_2}{t_1}, \tau_5 = \frac{h_1 - h_2}{t_1} \quad (1)$$

$$\tau_1 L_1 + \tau_2 L_2 + \tau_5 L_1 + \tau_2 L_2 = 2G\theta A_1 \quad (2)$$

$$\tau_3 L_3 + \tau_4 L_1 + \tau_3 L_3 - \tau_5 L_1 = 2G\theta A_2 \quad (3)$$

Substituting from (1) in (2) we get

$$2h_1 \left[\frac{L_1}{t_1} + \frac{L_2}{t_2} \right] - h_2 \frac{L_1}{t_1} = 2G\theta A_1 \quad (4)$$

Substituting from (1) in (3) we get

$$- \frac{h_1}{t_1} L_1 + 2h_2 \left[\frac{L_1}{t_1} + \frac{L_3}{t_2} \right] = 2G\theta A_2 \quad (5)$$

Solving (4) and (5) simultaneously yields

$$h_2 = \frac{G\theta (2A_1 + 16.25A_2)}{612.7}$$

$$A_1 = 5.875 \times 13.5 = 79.31 \text{ in.}^2$$

$$A_2 = 5.875 \times 10 = 58.75 \text{ in.}^2$$

$$h_2 = 1.82 G\theta, h_1 = 1.88 G\theta$$

$$T = 2 [A_1 h_1 + A_2 h_2]$$

$$= 2 [79.31 \times 1.88 + 58.75 \times 1.82] \text{ G}\theta$$

$$= 512.1 \text{ G}\theta,$$

$$J = 512.1 \text{ in.}^4$$

$$\tau_{\max} = \frac{h_1}{t_2} = \frac{1.88 \text{ G}\theta}{0.375} = 5.01 \text{ G}\theta$$

$$r = 5.01 \text{ in.} = \text{CTORS}$$

Section 26, Crossbeams 84 and 85. This is outboard section of crossbeams No. 5. The 32 in. dimension is an average of a tapered section.

All Thicknesses = .250 in

1. Cross Sectional Area

$$32 \times 15.5 - 31.5 \times 15$$

$$496 - 472.5 = 23.5 \text{ in}^2 = A(1)$$

2. Neutral Axis

$$\bar{x} = \frac{15.5}{2} = 7.75 \text{ in}$$

$$\bar{y} = \frac{32}{2} = 16 \text{ in}$$

3. Moment of Inertia

$$I_{22} = \frac{1}{12} [32 \times 15.5^3 - 31.5 \times 15^3] = 1071 \text{ in}^4 = I(2)$$

$$I_{33} = \frac{1}{12} [15.5 \times 32^3 - 15 \times 31.5^3] = 3256 \text{ in}^4 = I(3)$$

$$H2 = 32 \text{ in}, H3 = 15.5 \text{ in}$$

$$J = \frac{4A^2t}{L}$$

$$L = 2(15.25 + 31.75) = 94 \text{ in}$$

$$A = 15.25 \times 31.75 = 484.2 \text{ in}^2$$

$$A^2 = 234438 \text{ in}^4, \quad t = 0.25 \text{ in}$$

$$J = \frac{4 \times 234438 \times 0.25}{94} = 2494 \text{ in}^4 = J(1)$$

$$r = \frac{2A}{L} = \frac{2 \times 484.2}{94} = 10.3 \text{ in} = \text{CTORS}$$

4. Shearing rigidity = A_{WEB}

$$\text{For axis 22, } A_{\text{WEB}} = 15 \times 0.5 = 7.5 \text{ in}^2 = A(2)$$

$$\text{For axis 33, } A_{\text{WEB}} = 31.5 \times 0.5 = 15.75 \text{ in}^2 = A(3)$$

Section 27Beams 88 and 89. Inboard portions of crossbeam No. 5

All Thicknesses = 0.25 in.

1. Cross Sectional Area

$$A = 15.5 \times 13 - 15 \times 12.5$$

$$= 201.5 - 187.5 = 14 \text{ in}^2 = A(1)$$

2. Neutral Axis

$$\bar{y} = 6.5 \text{ in}$$

$$\bar{x} = 7.75 \text{ in}$$

3. Moments of Inertia

$$I_{22} = \frac{1}{12} (13 \times 15.5^3 - 12.5 \times 15^3) = 518.4 \text{ in}^4 = I(2)$$

$$H2 = 13. \text{ in}$$

$$I_{33} = \frac{1}{12} (15.5 \times 13^3 - 15 \times 12.5^3) = 396.4 \text{ in}^4 = I(3)$$

$$H3 = 15.5 \text{ in}$$

$$J = \frac{4A^2 t}{L}$$

$$L = 2(15.25 + 12.75) = 56 \text{ in}$$

$$A = 15.25 \times 12.75 = 194.4 \text{ in}^2$$

$$A^2 = 37791 \text{ in}^4 \quad t = 0.25 \text{ in}$$

$$J = \frac{4 \times 37791 \times 0.25}{56} = 674.8 \text{ in}^4 = J(1)$$

$$r = \frac{2A}{L} = \frac{2 \times 194.4}{56} = 6.94 \text{ in} = \text{CTORS}$$

4. Shearing rigidity = A_{WEB}

$$\text{For axis 22, } A_{\text{WEB}} = 15 \times 0.5 = 7.5 \text{ in}^2 = A(2)$$

$$\text{For axis 33, } A_{\text{WEB}} = 12.5 \times 0.5 = 6.25 \text{ in}^2 = A(3)$$

Section 28, Beams 95 and 96. From base plate to cradle side beams at lower end of cradle.

$$\begin{aligned}\text{Axial area } A(1) &= 12 \times 6.25 + (12 \times 6.25 - 11 \times 5.5) \\ &= 75 + 14.5 = 89.5 \text{ in.}^2\end{aligned}$$

$$\begin{aligned}\text{Shear area } A(2) &= A(3) = 5/6 \times 12.5 \times 6.25 \\ &= 65.1 \text{ in.}^2 + (\text{neglect hollow portion})\end{aligned}$$

$$\bar{y} = \frac{75 \times 6 + 14.5 \times 18}{89.5} = 7.94 \text{ in.}$$

$$\begin{aligned}I_{22} &= \frac{1}{12} \left[12 \times 6.25^3 + 2 \times 0.5 \times 5.5^3 + 2 \times 12 \times 0.375^3 \right] \\ &\quad + 2 \times 12 \times 0.375 \times 2.9375^2 \\ &= 335.8 \text{ in.}^4 = I(2), H3 = 6.25 \text{ in.}\end{aligned}$$

$$\begin{aligned}
 I_{33} &= \frac{1}{12} [6.25 \times 12^3 + 6.25 \times 12^3 - 5.5 \times 11^3] \\
 &\quad + 1.94^2 \times 75 + 10.06^2 \times 14.5 \\
 &= 2939.7 \text{ in}^4 = I(3), H2 = 16.1 \times 2 = 32.2 \text{ in.}
 \end{aligned}$$

TORSIONAL PROPERTIES

To obtain the torsional properties, it is assumed that the section consists of a 12 x 6.25 in. hollow portion and a 12 x 6.25 in. solid portion that are not connected but act together to resist the applied torque. The angle of twist per unit length (θ) will be the same for both portions.

For solid rectangular section $b = 12 \text{ in.}$, $c = 6.25 \text{ in.}$,
 $b/c = 1.92 \text{ in.}$, $T_s = \text{solid torque}$

$$G\theta = \frac{T_s}{Bbc^3}$$

From Theory of Elasticity, $B = 0.225$

$$G\theta = \frac{T_s}{0.225 \times 12 \times 244} = \frac{T_s}{659.2}$$

For hollow section, $T_h = \text{hollow torque.}$

$$L_1 = 2 \times 5.875 = 11.75 \text{ in.}, t_1 = 0.5 \text{ in.}$$

$$L_2 = 2 \times 11.5 = 23 \text{ in.}, t_2 = 0.375 \text{ in.}$$

$$\frac{L_1}{t_1} + \frac{L_2}{t_2} = \frac{11.75}{0.5} + \frac{23}{0.375} = 84.83$$

$$A = 5.875 \times 11.5 = 67.56 \text{ in.}^2$$

$$A^2 = 4564 \text{ in.}^4$$

$$G\theta = \frac{T_h}{4A^2} \left[\frac{L_1}{t_1} + \frac{L_2}{t_2} \right]$$

$$G\theta = \frac{T_h}{4 \times 4564} \times 84.83 = \frac{T_h}{215.2}$$

$$T = T_s + T_h = G\theta (659.2 + 215.2)$$

$$T = 874.4G\theta$$

STRESSES

For solid rectangular section

$$\tau = \frac{T_s}{\sqrt{bc}^2}$$

From Theory of Elasticity $\alpha = 0.244$

$$\tau_s = \frac{T_s}{0.244 \times 12 \times 39.1} = \frac{T_s}{114.5}$$

$$T_s = \frac{659.2}{874.4} T = 0.754T$$

$$\tau_s = \frac{0.754T}{114.5} = \frac{T}{151.8}$$

For hollow section

$$\tau_h = \frac{T_h}{2At} = \frac{T_h}{2 \times 67.56 \times 0.375} = \frac{T_h}{50.67}$$

$$T_h = 0.246T$$

$$\tau_h = \frac{0.246T}{50.67} = \frac{T}{206.0}$$

SUMMARIZING

$$J = 874.4 \text{ in.}^4$$

$$r = \frac{874.4}{151.8} = 5.76 \text{ in.} = \text{CTORS}$$

Section 29, Beams 100 and 101 in base plate.

$$\text{Axial area, } A(1) = 72(1.25 + 0.625) + 4.125 \times 2 = 143.25 \text{ in}^2$$

$$\text{Shear area, } A(2) = 70 \times (1.25 + 0.625) = 131.25 \text{ in}^2$$

$$\text{Shear area, } A(3) = 2 \times 4.125 = 8.25 \text{ in}^2$$

$$\bar{y} = \frac{(72 \times 1.25) 5.75 + (72 \times 0.625) 0.312 + 2 \times 4.125 \times 2.687}{143.25}$$

$$= 3.86 \text{ in, } \bar{x} = 36 \text{ in}$$

$$I_{22} = \frac{1}{12}[(1.25 + 0.625) 72^3 + 4 \times 4.125 \times 0.5^3] + 0.5 \times 4.125(2 \times 35.75^2 + 2 \times 11.75^2)$$

$$= 64,161 \text{ in}^4 = I(2), H2 = 3.86 \times 2 = 7.72 \text{ in.}$$

$$I_{33} = \frac{1}{12}[72(1.25^3 + 0.625^3) + 2 \times 4.125^3] + (72 \times 1.25) 1.515^2 + (72 \times 0.625) 3.548^2$$

$$+ 2 \times 4.125 \times 1.173^2$$

$$= 809.3 \text{ in}^4 = I(3), H3 = 72.0 \text{ in.}$$

For torsion, neglect central ribs,

$$L_1 = 5.0625 \text{ in}, t_1 = 0.5 \text{ in}, \frac{L_1}{t_1} = 10.125$$

$$L_2 = 71.5 \text{ in}, t_2 = 1.25 \text{ in}, \frac{L_2}{t_2} = 57.20$$

$$\frac{L_2}{t_3} = \frac{71.5}{0.625} = 114.4$$

$$\frac{2L_1}{t_1} + \frac{L_2}{t_2} + \frac{L_2}{t_3} = 2 \times 10.125 + 57.20 + 114.4$$

$$= 191.85$$

$$A = 5.0625 \times 71.5 = 361.96 \text{ in}^2$$

$$A^2 = 131021 \text{ in}^4$$

$$J(1) = \frac{4 \times 131021}{191.85} = 2732 \text{ in}^4$$

No stress output required for this member.

Section 30, Beams 102 and 103 - Trunnion Pins

1. Cross Sectional Area

$$A = (3.14)(2.5)^2$$

$$A = 19.6350 \text{ in}^2 = A(1)$$

2. Neutral Axis

$$\bar{y} = 2.5 \text{ in}$$

$$\bar{x} = 2.5 \text{ in}$$

3. Moment of Inertia

$$I = \frac{\pi 5^4}{64}$$

$$I = 30.6796 \text{ in}^4 = I(2) = I(3), H2 = H3 = 5.0 \text{ in}$$

$$J = \frac{\pi r^4}{2}$$

$$J = \frac{\pi (2.5)^4}{2}$$

$$J = 61.359 \text{ in}^4 = J(1), \text{ CTORS}$$

4. Shearing rigidity A/f_s

For circular section, form factor

$$f_s = \frac{10}{9}$$

$$\frac{A}{f_s} = \frac{19.635 \times 9}{10} = 17.67 \text{ in}^2 = A(2) = A(3)$$

Section 31

$$\text{Axial area } A(1) = 3 \times 6 - 2.5 \times 5.5$$

$$= 4.25 \text{ in}^2$$

$$I_{22} = \frac{1}{12} [3 \times 6^3 - 2.5 \times 5.5^3]$$

$$= 19.34 \text{ in}^4 = I(2), H_2 = 3 \text{ in.}$$

$$I_{33} = \frac{1}{12} [6 \times 3^3 - 5.5 \times 2.5^3]$$

$$= 6.338 \text{ in}^4 = I(3), H_3 = 6.0 \text{ in.}$$

$$J = \frac{4A^2t}{L}$$

$$L = 2 [5.75 + 2.75] = 17 \text{ in.}$$

$$A = 5.75 \times 2.75 = 15.81 \text{ in}^2$$

$$A^2 = 250.0 \text{ in}^4$$

$$J = \frac{4 \times 250 \times 0.25}{17} = 14.71 \text{ in}^4 = J(1)$$

$$\text{Shear area } A(2) = 2 \times 5.75 \times 0.25$$

$$= 2.875 \text{ in}^2$$

$$\text{Shear area } A(3) = 2 \times 2.5 \times 0.25$$

$$= 1.25 \text{ in}^2$$

$$r = \frac{J}{2At_{\min}} = \frac{14.71}{2 \times 15.81 \times 0.25}$$

$$= 1.86 \text{ in.} = \text{CTORS}$$

Section 32, 12 in. wide flange I beam.

From tables:

$$\text{Axial area } A(1) = 10.59 \text{ in}^2$$

$$I_{22} = 23.74 \text{ in}^4 = I(2), H_2 = 12.24 \text{ in.}$$

$$I_{33} = 280.8 \text{ in}^4 = I(3), H_3 = 6.565 \text{ in.}$$

$$J = \sum \frac{bt^3}{3}$$

$$= \frac{2 \times 6.565 \times 0.54^3 + 11.16 \times 0.305^3}{3}$$

$$= 0.792 \text{ in}^4 = J(1), r = t_{\max} = 0.540 = \text{CTORS}$$

$$\text{Shear area } A(2) = 2 \times 6.565 \times 0.54 = 7.090 \text{ in}^2$$

$$\text{Shear area } A(3) = 11.16 \times 0.305 = 3.404 \text{ in}^2$$

Section 33

$$\begin{aligned} \text{Axial area } A(1) &= 2 \times 10 \times 0.375 + (6 \times 3 - 5.5 \times 2.5) \\ &= 7.5 + 4.25 \\ &= 11.75 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} \bar{y} &= \frac{7.5 \times 5 + 4.25 \times 1.5}{11.75} = \frac{43.875}{11.75} \\ &= 3.734 \text{ in.} \end{aligned}$$

$$\begin{aligned} I_{22} &= \frac{1}{12} \left[2 \times 10 \times 0.375^3 + 3 \times 6^3 - 2.5 \times 5.5^3 \right] \\ &\quad + 2 \times 10 \times 0.375 \times 3.1875^2 \\ &= 95.63 \text{ in}^4 = I(2), H3 = 3.375 \times 2 = 6.75 \end{aligned}$$

$$\begin{aligned} I_{33} &= \frac{1}{12} \left[0.75 \times 10^3 + 6 \times 3^3 - 5.5 \times 2.5^3 \right] \\ &\quad + 2 \times 10 \times 0.375 \times 1.266^2 + 4.25 \times 2.234^2 \\ &= 102.07 \text{ in}^4 = I(3), H2 = 6.266 \times 2 = 12.532 \end{aligned}$$

For lower enclosed section

$$G\theta = \frac{T_B}{4A^2} \left[\frac{L_1}{t_1} + \frac{L_2}{t_2} \right]$$

$$L_1 = 2 \times 2.75 = 5.50 \text{ in.}, t_1 = 0.625 \text{ in.}, \frac{L_1}{t_1} = 8.8$$

$$L_2 = 2 \times 5.525 = 13.25 \text{ in.}, t_2 = 0.25 \text{ in.}, \frac{L_2}{t_2} = 53$$

$$A = 2.75 \times 6.625 = 18.219 \text{ in}^2$$

$$A^2 = 331.9 \text{ in}^4$$

$$G\theta = \frac{T_B \times 61.8}{4 \times 331.9} = \frac{T_B}{21.48}$$

For thin strips.

$$G\theta = \frac{T_s 3}{b t^3}$$

$$b = 2 \times 7 = 14 \text{ in.}, t^3 = 0.375^3 = 0.05273 \text{ in}^3$$

$$G\theta = \frac{T_s \times 3}{14 \times 0.05273} = \frac{T_c}{0.0246}$$

$$T_B + T_C = G\theta (21.48 + 0.0246) = 21.73 G\theta$$

$$J = 21.73 \text{ in}^4 = J(1), r = \frac{21.73}{2 \times 18.219 \times 0.25} = 2.385 \text{ in.} = \text{CTORS}$$

$$\text{Shear area } A(2) = 6 \times 0.5 = 3 \text{ in}^2$$

$$\text{Shear area } A(3) = 10 \times 0.75 = 7.5 \text{ in}^2$$

Section 34, 72, 73

$$\text{Axial area } A(1) = 4^2 - 3.25^2$$

$$5.4375 \text{ in}^2$$

$$\text{Shear area } A(2) = 3.25 \times 0.75 = 2.4375 \text{ in}^2$$

$$\text{Shear area } A(3) = 2.4375 \text{ in}^2$$

$$I_{22} = I_{33} = \frac{1}{12} [4 \times 4^3 - 3.25 \times 3.25^3]$$

$$= 12.04 \text{ in}^4, H_2 = H_3 = 4 \text{ in.}$$

$$J = \frac{4A^2t}{L}$$

$$L = 4 \times 3.625 = 14.5$$

$$A = 3.625^2 = 13.14 \text{ in}^2$$

$$A^2 = 172.7 \text{ in}^4$$

$$J = \frac{4 \times 172.7 \times 0.375}{14.5} = 17.86 \text{ in}^4$$

$$r = \frac{17.86}{2 \times 13.14 \times 0.375} = 1.812 \text{ in.} = \text{CTORS}$$

$$I_{33} = \frac{(7.5)(\frac{3}{8})^3}{12} + (7.5 \times \frac{3}{8})(1.2375)^2 + 2 \frac{(\frac{3}{8})(4.25)^3}{12} \\ + 2(4.25 \times \frac{3}{8})(1.085)^2$$

$$I_{33} = 0.03 + 4.31 + 4.80 + 3.77$$

$$I_{33} = 12.91 \text{ in}^4, \quad H3 = 7.5 \text{ in}$$

Open Section

$$J = \frac{\Sigma ab^3}{3}$$

$$\Sigma ab^3 = 2(4.25)(\frac{3}{8})^3 + (7.5)(\frac{3}{8})^3$$

$$\Sigma ab^3 = 0.843 \text{ in}^3$$

$$b_{\max} = 0.375$$

$$J = \frac{0.843}{3}$$

$$J = 0.281 \text{ in}^4, \quad \text{CTORS} = t_{\min} - 0.375 \text{ in.}$$

5. Shear Areas

$$6 \times 0.375 = 2.25 \text{ in}^2 = A(2)$$

$$2 \times 4.25 \times 0.375 = 3.18 \text{ in}^2 = A(3)$$

Section 36

$$\begin{aligned}\text{Axial area } A(1) &= 16 \times 0.375 + 6 \times 0.75 + 4.75 \times 0.375 \\ &= 6 + 4.5 + 1.781 \\ &= 12.281 \text{ in}^2\end{aligned}$$

$$\begin{aligned}\bar{x} &= \frac{6 \times 0.1875 + 4.5 \times 3.375 + 1.781 \times 6.5625}{12.281} \\ &= 2.27 \text{ in.}\end{aligned}$$

$$\begin{aligned}\bar{y} &= \frac{6 \times 8 + 4.5 \times 0.375 + 1.781 \times 2.375}{12.281} \\ &= 4.390 \text{ in.}\end{aligned}$$

$$\begin{aligned}I_{22} &= \frac{1}{12} \left[16 \times 0.375^3 + 0.75 \times 6^3 + 4.75 \times 0.375^3 \right] \\ &\quad + 6 \times 2.083^2 + 4.5 \times 1.105^2 + 1.781 \times 4.293^2 \\ &= 77.943 \text{ in}^4 = I(2), \quad H_3 = 4.48 \times 2 = 8.96 \text{ in.}\end{aligned}$$

$$\begin{aligned}I_{33} &= \frac{1}{12} \left[0.375 \times 16^3 + 6 \times 0.75^3 + 0.375 \times 4.75^3 \right] \\ &\quad + 6 \times 3.61^2 + 4.5 \times 4.015^2 + 1.781 \times 2.015^2 \\ &= 286.77 \text{ in}^4 = I(3), \quad H_2 = 11.61 \times 2 = 23.22 \text{ in.}\end{aligned}$$

$$J = \frac{\sum bt^3}{3}$$

$$= \frac{20.75 \times 0.375^3 + 6 \times 0.75^3}{3}$$

$$= 1.208 \text{ in}^4 = J(1), r = t = 0.75 \text{ in.} = \text{CTORS}$$

$$\text{Shear area } A(2) = 6 \times 0.75 = 4.5 \text{ in}^2$$

$$\text{Shear area } A(3) = 0.375 \times 20.75 = 7.781 \text{ in}^2$$

Section 74 for beam 545

This is a tension-only member used to model the "T" bar in slot hold
down mechanism at cross beam No. 1. See Fig. V. 3.1.3-1 for general arrange-
ment

rail is 11.0 in. long
(in the X1 direction of
the model)

the member is effectively capable of axial load only. Small values for the inertias and torsional constant will be coded into the finite element program; however, the boundary conditions imposed upon the member will prevent moments or shears from occurring.

$$A (1) = 1.25 (11.0) = 13.75 \text{ in}^2$$

$$A (2) = A(3) = 0.0$$

$$I_{22} = I_{33} = J = 1.0 \text{ in}^4$$

Section 9 for beam 23.Section 20 for beam 67

Transverse inertia case only.

In the travel case where a transverse (X2) inertia force is applied, the above beam sections must become bearing (compression-only) members in order for the load to have a path to the crossbeam. These members model the bearing surface of the LHM cask on the crossbeam saddle support.

Section 9:

Radius of cask = 13.5 in.

an approximate bearing surface subtends an arc of $24.98^\circ - 0.436$ radians

length of the saddle = 18.4 in

bearing area = $0.436 (13.5) 18.4 = 108.3 \text{ in}^2$

$$A = 108.3 \text{ in}^2$$

$$I_{22} = I_{33} = J = 0.0 \text{ in}^4$$

$$A (2) = A (3) = 0.0 \text{ in}^2$$

No stress output required for this member.

Section 20:

Radius of Cask = 14.87 in

an approximate bearing surface subtends an arc of $28^\circ - 0.489$ radians

length of saddle = 17.6 in.

bearing area = $0.489 (14.87) 17.6 = 128.0 \text{ in}^2$

$$A = 128.0 \text{ in}^2$$

$$I_{22} = I_{33} = J = 0.0 \text{ in}^4$$

$$A (2) = A (3) = 0.0 \text{ in}^2$$

No stress output required for this member

Section No. 58

p 1-50 AISC Manual of Steel Construction (7th ED)

$$A(1) = 6.09 \text{ in}^2$$

$$A(2) = \frac{5}{6}(2)(2.942)(0.501)$$

$$A(2) = 2.457 \text{ in}^2$$

$$A(3) = [12 - 2(0.501)] (0.282)$$

$$A(3) = 3.10 \text{ in}^2$$

$$I_{22} = 3.9 \text{ in}^4$$

$$I_{33} = 128.1 \text{ in}^4$$

$$J = 0.371 \text{ in}^4$$

$$CTORS = 0.507$$

$$H3 = 2.3 \times 2 = 4.6$$

$$H2 = 12.0$$

$$t_f = 0.501"$$

$$t_w = 0.282"$$

$$b_f = 2.942"$$

$$d = 12.0"$$

Section 38 and 60L 4X4X $\frac{1}{4}$

p 1-56 AISC

$$A (1) = 194 \text{ in}^2$$

$$A (2) = A (3) = 5/6(4)(0.25)$$

$$A (2) = A (3) = 0.833 \text{ in}^2$$

$$I_{22} = 3.0 \text{ in}^4 \quad \text{CTORS} = 0.25$$

$$I_{33} = 3.0 \text{ in}^4 \quad H2 = (2.91)2$$

$$= 5.82$$

$$J = 0.0404 \text{ in}^4 \quad H3 = (2.91)2$$

$$= 5.82$$

Section 39

S18 X 54.7

S18X54.7

p 1-46 AISC

$$A (1) = 16.10 \text{ in}^2 \quad t_f = 0.691"$$

$$A (2) = 2 (5/6) (0.691) (6.001)"$$

$$t_w = 0.461"$$

$$A (2) = 6.911 \text{ in}^2 \quad b_f = 6.001"$$

$$A (3) = [18 - 2 (0.691)] (0.461)$$

$$d = 18.00"$$

$$I_{22} = 42.0 \text{ in}^4$$

$$I_{33} = 889.9 \text{ in}^4$$

$$J = 2.37 \text{ in}^4$$

$$\text{CTORS} = 0.63$$

$$H3 = 6.001$$

$$H2 = 18.00$$

Section 40

Square Tube - 3 1/2 X 3 1/2 X 1/4 p 1 - 103 AISC

$$A (2) = [3.5 - 2(0.25)] (2) (0.25)$$

$$A (2) = 0.5 \text{ in}^2$$

$$A (3) = 1.5 \text{ in}^2$$

$$A = 3.25 \times 3.25 = 10.6525 \text{ in}^2$$

$$L = 4(3.25) = 13.0 \text{ in}$$

$$J = \frac{4 (10.6525)^2 (0.25)}{13.0} = 8.58 \text{ in}^4$$

$$r = \frac{2(10.6525)}{13.0} = 1.6388$$

$$A (1) = 3.09 \text{ in}^2$$

$$A (2) = 1.5 \text{ in}^2$$

$$A (3) = 1.5 \text{ in}^2$$

$$I_{22} = 5.29 \text{ in}^4$$

$$I_{33} = 5.29 \text{ in}^4$$

$$J = 8.58 \text{ in}^4$$

$$CTORS = 1.639$$

$$H2 = 3.5$$

$$H3=3.5$$

Section 41

$$C 10 \times 25 + PL \frac{1}{4} \times 9 \frac{3}{4}$$

p 1 - 50 AISC

Neutral Axis:

A	dz	A(.012)	$\bar{d}z = \frac{11.57}{9.788} = 1.182$
7.35	0.617	4.535	
$\frac{2.4375}{9.7875}$	2.886	$\frac{7.035}{11.570}$	

A	I (2)	I (3)	t_f	t_w	b_f	d
7.35	3.36	91.2	0.436"	0.526"	2.886"	10.0"
2.44	0.013	19.31				

$$I_{22} = 3.36 + 7.35 (1.182 - 0.617)^2 + 0.013 + 2.44 (1.704)^2$$

$$I_{22} = 12.804 \text{ in}^4$$

$$I_{33} = 91.2 + 19.31 = 110.51 \text{ in}^4$$

Torsional Constant

$$0.436 \quad 10 - 0.436 = 9.564$$

$$2.886 - \frac{.526}{2} - \frac{.25}{2} = 2.498$$

$$A = 9.564 \times 2.498 = 23.891 \text{ in}^2 = \text{ENCLOSED AREA}$$

$$J = \frac{4A^2}{\frac{L_1}{t_1} + \frac{L_2}{t_2} + \frac{L_3}{t_3} + \frac{L_4}{t_4}}$$

$$J = \frac{4(23.891)^2}{\frac{9.564}{0.526} + \frac{9.564}{0.25} + \frac{(2)(2.498)}{0.436}} = 33.625 \text{ in}^4$$

$$r = \frac{J}{2At_{\min}} = \frac{33.625}{2(23.891)(.25)} = 2.815$$

$$A (2) = 2(2.886 - 0.526 - 0.25)(0.436)$$

$$A (2) = 1.840 \text{ in}^2$$

$$A (3) = 10 - 2(0.436)(0.526) + 9.75(0.25)$$

$$A (3) = 7.239 \text{ in}^2$$

SUMMARY

$$A (1) = 9.7875 \text{ in}^2$$

$$A (2) = 1.840 \text{ in}^2$$

$$A (3) = 7.239 \text{ in}^2$$

$$I_{22} = 12.804 \text{ in}^4$$

$$I_{33} = 110.51 \text{ in}^4$$

$$J = 33.625 \text{ in}^4$$

$$CTORS = 2.815$$

$$H3 = 2(1.704 + \frac{.25}{2}) = 3.658$$

$$H2 = 10.0$$

Section 42 and 46

W 10 X 15

p 1-40 AISC

W 10 X 15

$$A (1) = 4.40 \text{ in}^2 \quad t_f = 0.269''$$

$$A (2) = 2 (5/6) (4.0 \times 0.269) \quad t_w = 0.230''$$

$$A (2) = 1.7933 \text{ in}^2 \quad b_f = 4.0''$$

$$A (3) = [10 - 2 (0.269)] (0.23) \quad d = 10.0''$$

$$A (3) = 2.176 \text{ in}^2$$

$$I_{22} = 2.79 \text{ in}^4 \quad \text{CTORS} = 0.269$$

$$I_{33} = 68.8 \text{ in}^4 \quad H2 = 10.0$$

$$J = 0.104 \text{ in}^4 \quad H3 = 4.0$$

Section 43

C 8 X 11.5

p 1-50 AISC

$$A (1) = 3.35 \text{ in}^2 \quad t_f = 0.39''$$

$$A (2) = 2 (5/6) (2.26) (0.39) \quad t_w = 0.220''$$

$$A (2) = 1.469 \text{ in}^2 \quad b_f = 2.26''$$

$$A (3) = [8. - 2(0.39)] (0.22) \quad d = 8.0''$$

$$A (3) = 1.588 \text{ in}^2$$

$$I_{22} = 1.3 \text{ in}^4$$

$$I_{33} = 32.3 \text{ in}^4$$

$$J = 0.131 \text{ in}^4$$

$$\text{CTORS} = 0.39$$

$$H2 = 8.0$$

$$H3 = 1.68 (2) = 3.36$$

Section 44, 62, 63, 65, and 66

p 1-38 AISC

W 12 X 27

$$A (1) = 7.97 \text{ in}^2$$

$$t_f = 0.4''$$

$$A (2) = 2 (5/6) (6.497 \times 0.4)$$

$$t_w = 0.237''$$

$$A (2) = 4.331 \text{ in}^2$$

$$b_f = 6.497$$

$$A (3) = [11.96 - 2(0.4)] (0.237) d = 11.95''$$

$$A (3) = 2.645 \text{ in}^2$$

$$I_{22} = 16.6 \text{ in}^4$$

$$CTORS = 0.4$$

$$I_{33} = 204.1 \text{ in}^4$$

$$H2 = 11.96$$

$$J = 0.351 \text{ in}^4$$

$$H3 = 6.497$$

Section 45 and 59

S 18 X 54.7	p 1-46 AISC
W 24 X 100	p 1-30 AISC
S 18 X 54.7	W 24 X 100
$t_f = 0.681"$	$t_f = 0.775"$
$t_w = 0.461"$	$t_w = 0.468"$
$b_f = 6.001"$	$b_f = 12.0"$
$d = 18.0"$	$d = 24.0"$
$I_{22} = 21.2 \text{ in}^4$	$I_{22} = 203.5 \text{ in}^4$
$I_{33} = 795.5 \text{ in}^4$	$I_{33} = 2987.3 \text{ in}^4$

Neutral Axis:

	A	d_{33}	d_{22}	Ad_{33}	Ad_{22}
S18	15.94	9.0	0.0	143.46	0.0
W24	<u>29.43</u>	<u>16.0</u>	<u>5.125</u>	<u>470.88</u>	<u>150.829</u>
	45.37			614.34	150.829

$$J_{33} = \frac{614.34}{45.37} = 13.541"$$

$$J_{22} = \frac{150.829}{45.37} = 3.324"$$

$$J_{22} = 21.2 + 15.94 (3.324)^2 + 203.5 + 29.43 (1.801)^2 = 496.28 \text{ in}^4$$

$$J_{33} = 795.5 + 15.94 (13.541 - 9.0)^2 + 2987.3 + 29.43 (14.459 - 12.0)^2 = 4289.45 \text{ in}^4$$

$$A (2) = 5/6 \left[(12) (0.775 + (5.125 + 6.0) (0.775)) + 2 (6.001) (0.691) \right]$$

$$A (3) = \left[24 - 2 (0.775) \right] (0.468) + \left[18 - 2 (0.691) \right] (0.461)$$

$$A (3) = 18.167 \text{ in}^2$$

J: TREAT AS BOX SECTION, NEGLECT FLANGES

$$18 - 4 = 14", 14 - \frac{0.775}{2} - \frac{0.691}{2} = 13.267"$$

$$A = 13.267 \times 5.125 = 67.993 \text{ in}^2$$

ENCLOSED AREA

$$J = \frac{4A^2}{\frac{L_1}{t_1} + \frac{L_2}{t_2} + \frac{L_3}{t_3} + \frac{L_4}{t_4}}$$

$$J = \frac{4 (67.993)^2}{\frac{13.267}{0.468} + \frac{13.267}{0.461} + \frac{5.125}{0.691} + \frac{5.125}{0.775}}$$

$$J = 259.88 \text{ in}^4$$

Compare w/ ΣJ of S18 & W 24

$$\Sigma J = 2.37 + 4.87 = 7.24 \text{ in}^4$$

$$A (1) = 45.37 \text{ in}^2$$

$$A (2) = 21.846 \text{ in}^2$$

$$A (3) = 18.167 \text{ in}^2$$

$$I_{22} = 496.28 \text{ in}^4$$

$$I_{33} = 4289.45 \text{ in}^4$$

$$J = 259.88 \text{ in}^4$$

$$CTORS = 14.58$$

$$H3 = 7.81 (2) = 15.62$$

$$H2 = 14.47 (2) = 28.94$$

Section 47

C 10 X 15.3

p 1-50 AISC

$$A (1) = 4.47 \text{ in}^2$$

$$t_f = 0.436''$$

$$\text{C 10 X 15.3 } A (2) = 2 (5/6) (2.6) (0.436)$$

$$t_w = 0.240''$$

$$A (2) = 1.889 \text{ in}^2$$

$$b_f = 2.60''$$

$$A (3) = [10 - 2 (0.436)] (0.24)$$

$$A (3) = 2.191 \text{ in}^2$$

$$I_{22} = 1.8 \text{ in}^4$$

$$\text{CTORS} = 0.24 \text{ in}$$

$$I_{33} = 47.3 \text{ in}^4$$

$$H3 = 1.966 (2)$$

$$J = 0.211 \text{ in}^4$$

$$H3 = 3.932 \text{ in}$$

$$d = 10.0''$$

$$H2 = 10.0 \text{ in}$$

Section 49

W 14 X 34

W 14 X 34

p 1-36 AISC

$$A (1) = 10.0 \text{ in}^2$$

$$t_f = 0.453''$$

$$A (2) = 2 (5/6) (6.75) (0.453)$$

$$t_w =$$

$$A (2) = 5.096 \text{ in}^2$$

$$b_f = 6.75''$$

$$A (3) [14.0 - 2 (0.453)] (0.287)$$

$$d = 14.0''$$

$$A (3) = 3.758 \text{ in}^2$$

$$I_{22} = 21.3 \text{ in}^4$$

$$\text{CTORS} = 0.453 \text{ in}$$

$$I_{33} = 339.2 \text{ in}^4$$

$$H2 = 14.0 \text{ in}$$

$$J = 0.567 \text{ in}^4$$

$$H3 = 6.75 \text{ in}$$

Section 50

W 24 X 100

W 24 X 100

p 1-30 AISC

$$A (1) = 29.43 \text{ in}^2$$

$$t_f = 0.775''$$

$$A (2) = 5/6 [(12) 0.775] (2)$$

$$A (2) = 15.5 \text{ in}^2$$

$$A (3) = [24 - 2(0.775)] 0.468$$

$$A (3) = 10.507 \text{ in}^2$$

$$I_{22} = 203.5 \text{ in}^4$$

$$I_{33} = 2987.3 \text{ in}^4$$

$$J = 4.87 \text{ in}^4$$

$$t_w = 0.468''$$

$$d = 24.0''$$

$$CTORS = 0.775 \text{ in}$$

$$H2 = 24.0 \text{ in}$$

$$H3 = 12.0 \text{ in}$$

Section 51

L 2 X 2 X 1/4

p 1-57 AISC

$$A (1) 0.94 \text{ in}^2$$

$$L2 X 2 X \frac{1}{4} \quad A (2) = 2 (0.25) 5/6 = 0.417 \text{ in}^2$$

$$A (3) = 0.417 \text{ in}^2$$

$$I_{22} = 0.348 \text{ in}^4$$

$$I_{33} = 0.348 \text{ in}^4$$

$$J = 0.0195 \text{ in}^4$$

$$CTORS = 0.25 \text{ in}$$

$$H2 = H3 = (1.41) 2 = 2.82 \text{ in}$$

Section 52 and 64 **W 12 X 40**

W 12 X 40

p 1-38 AISC

$$A (1) = 11.77 \text{ in}^2$$

$$t_f = 0.516"$$

$$A (2) = 5/6 \left[2 (8) (0.516) \right], \quad t_{w..} = 0.294"$$

$$A (2) = 6.88 \text{ in}^2$$

$$b_f = 8.0"$$

$$A (3) = \left[11.94 - 2 (0.516) \right] (0.294)$$

$$A (3) = 3.207 \text{ in}^2$$

$$I_{22} = 44.1 \text{ in}^4$$

$$CTORS = 0.516$$

$$I_{33} = 310.1 \text{ in}^4$$

$$H2 = 11.94$$

$$J = 0.956 \text{ in}^4$$

$$H3 = 8.0$$

$$d = 11.94 \text{ in.}$$

Section 53

$$2 - \frac{7}{8} \times 10 + 1 - \frac{5}{8} \times 6 \frac{1}{8}$$

$$A (1) = 2 \left(\frac{7}{8} \right) (10) + \frac{5}{8} (6.125)$$

$$A (2) = 21.328 \text{ in}^2$$

$$A (2) = \frac{5}{6} (2) (0.875) (10)$$

$$A (2) = 14.583 \text{ in}^2$$

$$A (3) = \left(\frac{5}{8} \right) (6.125)$$

$$A (3) = 3.828 \text{ in}^2$$

$$I_{22} = 2 \left(\frac{1}{12} \right) \left(\frac{7}{8} \right) (10)^3 + \frac{1}{12} (6.125) \left(\frac{5}{8} \right)^3$$

$$I_{22} = 145.958 \text{ in}^4$$

$$I_{33} = \frac{1}{12} (10) \left(\frac{7}{8} \right)^3 (2) + \frac{1}{12} \left(\frac{5}{8} \right) (6.125)^3 + (2) \left(\frac{7}{8} \right) (10) \left(\frac{6.125}{2} + \frac{7}{8} \times \frac{1}{2} \right)^2$$

$$I_{33} = 227.459 \text{ in}^4$$

$$J = \frac{1}{3} \left[2(10) \left(\frac{7}{8} \right)^3 + (6.125) \left(\frac{5}{8} \right)^3 \right]$$

$$J = 4.965 \text{ in}^4$$

$$CTORS = 0.875 \text{ in}$$

$$H2 = 6.125 + 2 (.875) = 7.875 \text{ in}$$

$$H3 = 10.0 \text{ in}$$

Section 55

C10 X 25

C 10 X 25

p 1-50 AISC

$$A (1) = 7.33 \text{ in}^2$$

$$t_f = 0.436''$$

$$A (2) = 5/6 \left[(2.886)(0.436)(2) \right]$$

$$t_w = 0.526''$$

$$A (2) = 2.097 \text{ in}^2$$

$$b_f = 2.886''$$

$$A (3) = \left[10.0 - 2 (0.436) \right] (0.526)$$

$$A (3) = 4.801 \text{ in}^2$$

$$I_{22} = 3.4 \text{ in}^4$$

$$CTORS = 0.526 \text{ in}$$

$$I_{33} = 90.7 \text{ in}^4$$

$$H3 = 2.266 (2)$$

$$J = 0.69 \text{ in}^4$$

$$H3 = 4.532 \text{ in}$$

$$d = 10.00''$$

$$H2 = 10.0$$

Section 56, 68, 69

C6 X 8.2

C 6 X 8.2

p 1-50 AISC

$$A (1) = 2.39 \text{ in}^2$$

$$t_f = 0.343''$$

$$A (2) = 2 (5/6) (1.92) (0.343)$$

$$t_w = 0.20''$$

$$A (2) = 1.098 \text{ in}^2$$

$$b_f = 1.92''$$

$$A (3) = \left[6.0 - 2 (0.343) \right] (0.2)$$

$$A (3) = 1.063 \text{ in}^2$$

$$I_{22} = 0.70 \text{ in}^4$$

$$CTORS = 0.343 \text{ in}$$

$$I_{33} = 13.0 \text{ in}^4$$

$$H3 = 1.40 (2)$$

$$J = 0.075 \text{ in}^4$$

$$H2 = 6.0 \text{ in}$$

$$d = 6.0''$$

Section 57

S12'X 40.8

S 12 X 40.8

p 1-46 AISC

$$A (1) = 12.01 \text{ in}^2$$

$$t_f = 0.659''$$

$$A (2) = (5/6) (2) (5.252) (0.659)$$

$$t_w = 0.462''$$

$$A (2) = 5.768 \text{ in}^2$$

$$b_f = 5.252''$$

$$A (3) = 12 - 2 (0.659) (0.462)$$

$$d = 12.00''$$

$$A (3) = 4.935 \text{ in}$$

$$I_{22} = 13.6 \text{ in}^4$$

$$I_{33} = 272.0 \text{ in}^4$$

$$J = 1.76 \text{ in}^4$$

$$CTORS = 0.659 \text{ in}$$

$$H_2 = 12.0 \text{ in}$$

$$H_3 = 5.252 \text{ in}$$

Section 67, 70, 71

Neutral Axis:

$$\Sigma M_{11} = \frac{3/8 (4) (2.5) + 1/2 (7) (.25)}{(3/8) (4) + 1/2 (7)} = 0.925"$$

$$A (2) = 5/6 (7) (1/2) = 2.9167 \text{ in}^2$$

$$A (1) = (3/8) (4) + 1/2 (7) = 5.0 \text{ in}^2$$

$$A (3) = 5/6 (4) (3/8) = 1.25 \text{ in}^2$$

$$I_{22} = 1/12 (4) (3/8)^3 + 1/12 (1/2) (7)^3$$

$$I_{22} = \underline{14.309 \text{ in}^4}$$

$$I_{33} = 1/12 (3/8) (4)^3 + 7 (1/2)^3 + (3/8) (4) (2.5 - 0.925)^2 + 7 (1/2) (0.925 - .25)^2$$

$$I_{33} = \underline{7.3885 \text{ in}^4}$$

$$J = \Sigma 1/3 bt^3 = 1/3 (4) (3/8)^3 + 2 (3.5 - 3/16) (1/2)^3 = 0.3464 \text{ in}^4$$

$$H2 = \underline{3.575} (2) = 7.150 \text{ in}$$

$$H3 = 3.5 (2) = 7.0 \text{ in}$$

$$CTORS = 0.5" \text{ in}$$

Section 54, Beam No. 426, 428, 430

$$A_1 = 30 \times .375 = 11.25 \text{ in}^2; A_2 = 12 \times .375 = 4.5 \text{ in}^2; A_{\text{tot}} = 15.75 \text{ in}^2$$

Location of Center of Gravity of Areas (c of g)

$$\Sigma M_{a_{\text{axis}}} = 3.4415(4.5) = \bar{b} (11.25 + 4.5) \quad \bar{b} = 0.9833"$$

$$\Sigma M_{b_{\text{axis}}} = (34.9145)(4.5) + 11.25(15) = \bar{a} (11.25 + 4.5) \quad \bar{a} = 20.6899"$$

$$14.225 + 1.72125 = 15.9463$$

Calculation of Moments of Inertia for inclined leg

$$I_{\xi} = 1/12 (.375) (12)^3 + (4.5)(13.0624)^2$$

$$I_{\xi} = 821.818 \text{ in}^4$$

$$I_{\eta} = 1/12 (12) (.375)^3 + 4.5 (6.1455)^2$$

$$I_{\eta} = 170.005 \text{ in}^4$$

$$I_{\eta\xi} = I_{\eta\xi} + d_{\xi}d_{\eta}A, (I_{\eta\xi} \rightarrow 0)$$

$$I_{\eta\xi} = (13.0624) (-6.1455) (4.5)$$

$$I_{\eta\xi} = -361.2374 \text{ in}^4$$

$$I_3 = \frac{I_{\eta} + I_{\xi}}{2} + \frac{I_{\eta} - I_{\xi}}{2} \cos 2\theta - I_{\eta\xi} \sin 2\theta$$

$$I_2 = \frac{I_{\eta} + I_{\xi}}{2} - \frac{I_{\eta} - I_{\xi}}{2} \cos 2\theta + I_{\eta\xi} \sin 2\theta \quad \theta = -35^\circ \text{ or } 325^\circ$$

$$I_3 = \frac{170.005 + 821.818}{2} + \frac{(170.005 - 821.818)}{2} \cos (-70) - (-361.2374) \sin -70$$

$$I_3 = 44.993 \text{ in}^4$$

$$I_2 = \frac{170.005 + 821.818}{2} - \frac{170.005 - 821.818}{2} \cos (-70) + (-361.2374) \sin (-70)$$

$$I_2 = 946.83 \text{ in}^4$$

$$I_{23} = I_{\eta} - I_{\xi} \sin 2\theta + I_{\eta\xi} \cos 2\theta$$

$$= \frac{(170.005 - 821.818)}{2} \sin (-70) + (-361.2374) \cos (-70)$$

$$= 182.701 \text{ in}^4$$

Add in Contribution from Horizontal Leg to get total moment of inertia

$$I_2^{\text{TOT}} = 946.83 + 1/12 (.375) (30)^3 + (11.25) (5.6899)^2$$

$$I_2^{\text{TOT}} = 2154.80 \text{ in}^4$$

$$I_3^{\text{TOT}} = 44.993 + 1/12 (30) (.375)^3 + 11.25 (0.9833)^2$$

$$I_3^{\text{TOT}} = 56.002 \text{ in}^4$$

$$I_{23} = 182.701 + 11.25 (-5.6899) (-0.9833)$$

$$I_{23} = 245.643 \text{ in}^4$$

Calculation of Principal Axes of Inertia
(i.e. Those where I_{xy} (or I_{23}) = 0)

$$I_{\max} = \frac{I_3 + I_2}{2} + 1/2 \sqrt{(I_3 - I_2)^2 + 4 I_{32}^2}$$

$$I_{\min} = \frac{I_3 + I_2}{2} - 1/2 \sqrt{(I_3 - I_2)^2 + 4 I_{32}^2}$$

X = Angle of Inclination to Principal Axes

$$\tan 2x = \frac{2 I_{32}}{I_2 - I_3}$$

$$I_{\max} = \frac{56.002 + 2154.8}{2} + 1/2 \sqrt{(56.002 - 2154.8)^2 + 4 (245.643)^2}$$

$$I_{\max} = 2183.167 \text{ in}^4$$

$$I_{\min} = \frac{56.002 + 2154.8}{2} - 1/2 \sqrt{(56.002 - 2154.8)^2 + 4 (245.643)^2}$$

$$I_{\min} = 27.635 \text{ in}^4$$

$$\tan 2x = \frac{2(245.643)}{(2154.8 - 56.002)}$$

$$x = 6.59^\circ$$

$$T = \Sigma 1/3 \text{ bt}^3 = 1/3 (1375) (30 + 12) = 0.7383 \text{ in}^4$$

$$I_{22} = 2183.167 \text{ in}^4$$

$$T = 0.7383 \text{ in}^4$$

$$I_{33} = 27.635 \text{ in}^4$$

$$A = 15.75 \text{ in}^2$$

$$A (2) = 30 (.375) 5/6 = 9.375, \text{ SF2} = 0.8333$$

$$A (3) = 0.0$$

$$\text{CTORS} = 0.375$$

$$H2 = 3.2833 + 4.5963 = 7.8796$$

$$H3 = 20.3876$$

Beam No. 426, 428, 430

Location of JC Node For 54

Since Member 414 is estimated and the two sets of offsets are so close, use same offsets.

$$X\ 1\ \text{offset} = -2.565$$

$$X\ 2\ \text{offset} = 0.0$$

$$X\ 3\ \text{offset} = -9.645$$

421	509.75	-29.0	33.625
	-2.565	0.0	-9.645
	<u>-49.015</u>	<u>0.0</u>	<u>+70.0</u>
70	458.17	-29.0	93.98

Section Properties of Legs

Bending Properties:

$$\begin{aligned} d_{out} &= 4 \frac{1}{2}'' \\ d_{in} &= 4 \end{aligned}$$

$$\begin{aligned} I_2 = I_3 &= \frac{\pi (d_{out}^4 - d_{in}^4)}{64} = \frac{\pi (4.5^4 - 4^4)}{64} \\ &= 7.562 \text{ in}^4 \end{aligned}$$

$$J = \frac{4A_i^2}{\frac{ds}{t}} = \frac{4A_i^2 t}{S} = \frac{4 \left(\frac{4.25}{2}\right)^2 \pi (.25)}{4.25 \pi}$$

S = Circumference

$$J = \frac{(4.25)^3 \pi (1/4)}{16} = \frac{4.25^3 \pi}{16} = 15.07 \text{ in}^4$$

—Section cannot transmit torsion; torsion will be released and any J quantity may be used.

Axial Properties:

The trailer legs are operated by hydraulic pressure. Effectively, the trailer legs may be replaced by a column of oil. The compressibility of the oil may then be used to calculate an effective axial area for the trailer legs.

Let B - Bulk Modulus

Let Ref. 1 = Elements of Physics, 4th Ed; Shortley and Williams

Ref. 2 = Physics, Part I and II, Halliday and Resnick

From Ref. 1 p. 232

$$B = -V \frac{dp}{dv} \text{ or } -V \frac{\Delta P}{\Delta V} \quad (\text{Force/Length}^2)$$

Let $k_e = \frac{F}{\Delta h}$ = Effective Spring Constant

$$B = \frac{-hA (FA)}{\Delta hA} = -hA \left(\frac{F}{\Delta h} \right)$$

$$\frac{-B}{hA} = k_e = \frac{F}{\Delta h}$$

Estimate:

h = height of column of oil - ht from base of main trailer beam to ground

$$h = 36"$$

A = cross sectional area of column estimate 3/4" diameter tube

$$A = \frac{.75^2}{4} \pi = 0.4418 \text{ in}^2$$

From Standard Handbook for Mechanical Engineers 7th ed. by Baumeister & Marks.

p 3-52 Table 3 $B = 2.25 \times 10^5 \text{ psi}$

p 6-9 $B = 5510^6 \text{ to } 80 \times 10^6 \text{ ATM @ } 70^\circ\text{F}$
 $= 3.7 \times 10^6 \text{ to } 5.4 \times 10^6 \text{ psi}$

Conservatively Use $B = 2.25 \times 10^5$ psi

Use $k_e = 15000.0$ lb/in.

Since the axial stiffness of a beam is determined by AE/l , an effective area is as follows:

$$A = \frac{kel}{E} = \frac{15000 (36)}{29000000.0} = 0.1862 \text{ in}^2$$

$$A = 0.1862 \text{ in}^2$$

Summary of Section Properties to be used

$$A = 0.1862 \text{ in}^2$$

$$I_2 = I_3 = 7.562 \text{ in}^4$$

$$J = 15.07 \text{ in}^4$$

CTORS

$$\begin{aligned} \text{Estimate wieght of leg} &= 0.28356 \times \frac{\pi}{4} (4.5^2 - 4.0^2) \times 36 \\ &= 34.07 \text{ lbs} \end{aligned}$$

+ misc. parts (say) 70 #/leg

Section 79

Roller bearing @ cradle pivot support provides positive attachment for horizontal actions

Approximate as a 3" ϕ Rod.

$$A (1) = \pi r^2 = \pi (3/2)^2 = 7.069 \text{ in}^2$$

$$A (2) = A (3) = .9 A (1) = 6.36 \text{ in}^2$$

$$I_{22} = I_{33} = \frac{\pi d^4}{64} = \frac{\pi (3)^4}{64} = 3.98 \text{ in}^4$$

$$J = 2(3.98) = 7.95 \text{ in}^4$$

$$H2 = H3 = 3.0"$$

$$CTORS = 1.5"$$

10" Inclination

Z Offset

$$ZA = 8.657"$$

$$XA = 0.0$$

$$YZ$$

$$XB.4BZB=0.0$$

Index of Parameters

A (1) = Cross Sectional Area

A (2) = Shear area corresponding to bending about the 2-2 axis, i.e. shear force in the 3-3 direction

A (3) = Shear area corresponding to bending about the 3-3 axis

I (2) = I_{22} = Moment of Inertia of the cross sectional area about the 2-2 axis.

I (3) = I_{33} = Moment of inertia of the cross sectional area about the 3-3 axis.

J = Torsional Constant

H2 and H3 - Cross sectional depths for use in stress calculations.

CTORS = Used in torsional stress computations

$$\sigma_{TORS} = \frac{(TORQUE) (CTORS)}{J}$$

For thin rectangular section

$$\sigma = \frac{Tt}{4} \text{ where } t = \text{thickness}$$

therefore CTORS = t (maximum thickness used for open sections of variable thicknesses)

For closed sections

$$\sigma = \frac{T}{2At} = \frac{T}{J} \cdot \frac{J}{2At}$$

where A is the enclosed area as defined earlier.

$$\text{Thus } CT_{\phi RS} = \frac{J}{2At} = r \text{ defined earlier}$$

t_f = Thickness of flange

t_w = Thickness of web

b_f = width of flange

d = Depth of section

All references to AISC are to the American Institute of Steel Construction Manual of Steel Construction Seventh edition.

<u>Section No.</u>	<u>XA</u>	<u>YA</u>	<u>ZA</u>	<u>XB</u>	<u>YB</u>	<u>ZB</u>
38	_____	_____	7.91	_____	_____	14.91
39	_____	_____	_____	_____	_____	_____
40	_____	_____	_____	_____	_____	_____
41	_____	_____	-7.5	_____	_____	-7.5
42	_____	_____	4.0	_____	_____	4.0
43	_____	_____	-5.0	_____	_____	-5.0
44	_____	_____	3.025	_____	_____	3.025
45	_____	-1.801	2.459	_____	-1.801	2.459
46	_____	_____	_____	_____	_____	_____
47	_____	_____	-7.0	_____	_____	-7.0
48	_____	_____	_____	_____	_____	_____
49	_____	_____	5.0	_____	_____	5.0
50	_____	_____	_____	_____	_____	_____
51	_____	_____	11.41	_____	_____	11.41
52	_____	_____	6.03	_____	_____	6.03
53	_____	_____	-8.063	_____	_____	-8.063
54	0.76	_____	-17.757	0.076	_____	-17.757
55	1.812	_____	-6.761	1.812	_____	-6.761
56	_____	_____	-9.423	_____	_____	-7.114
57	_____	_____	_____	_____	_____	_____
58	_____	_____	3.0	_____	_____	3.0
59	_____	1.801	2.459	_____	1.801	2.459
60	_____	_____	10.91	_____	_____	10.91
61	_____	_____	_____	_____	_____	_____
62	1.558	_____	-5.815	1.558	_____	-5.815
63	1.558	_____	-5.815	1.558	_____	-5.815
64	_____	_____	-6.453	_____	_____	-6.453
65	_____	_____	-6.443	_____	_____	-4.164
66	_____	_____	-4.159	_____	_____	_____
67	_____	_____	-11.498	_____	_____	-9.219
68	_____	_____	-7.144	_____	_____	-4.617
69	_____	_____	-4.617	_____	_____	-2.985
70	_____	_____	-9.219	_____	_____	-6.692
71	_____	_____	-6.692	_____	_____	-5.06

Section

No.	A (1)	A (2)	A (3)	J	I (2)	I (3)	CTORS	H2	H3
1	69.75	34.88	34.88	11463.0	5732.0	5732.0			
2	55.84	27.92	27.92	10630.0	5315.0	5315.0			
3	IN F	IN I T E L Y	R I G I D	707.4	452.27	643.74	7.05	18.97	13.0
4	15.38	6.25	7.75	1.0	1.0	1.0			
5	145.1	0.0	0.0	289.4	269.36	152.68	5.19	9.4	13.0
6	10.88	6.25	4.25	215.2	99.87	314.77	4.25	12.0	7.0
7	15.25	5.50	8.25	285.0	571.3	115.9	4.76	7.3	15.75
8	31.19	16.88	3.47	1.0	1.0	1.0			
9	108.3	0.0	0.0	1.0	1.0	1.0			
10	130.2	0.0	0.0	1.0	1.0	1.0			
11	16.88	7.5	6.0	634.5	685.74	590.51	6.79	21.31	15.5
12	98.5	18.44	78.44	15070.0	5065.0	45820.0			
13	10.69	2.06	7.65	46.07	17.20	123.05			
14	45.97	0.0	0.0	1.0	1.0	1.0			
15	190.8	0.0	0.0	1.0	1.0	1.0			
16	13.69	6.25	7.0	611.3	384.45	453.73	6.73	14.70	13.75
17	8.49	0.0	0.0	1.0	1.0	1.0			
18	24.13	11.125	12.0	875.3	554.2	617.8	6.02	13.0	12.13
19	20.13	5.75	12.38	291.1	150.16	383.43	5.40	13.0	8.78
20	128.0	0.0	0.0	1.0	1.0	1.0			
21	292.4	0.0	0.0	1.0	1.0	1.0			
22	15.5	7.5	6.13	654.7	605.80	470.99	6.87	17.33	15.5
23	26.63	5.62	17.88	422.3	259.5	474.9	5.54	13.0	8.0
24	26.25	8.25	17.25	512.4	176.3	1623.2	4.95	24.0	6.25
25	26.25	16.88	8.25	512.1	1990.52	176.33	5.01	6.25	32.28
26	23.5	7.5	15.75	2494.0	1071.0	3256.0	10.30	32.0	15.5
27	14.0	7.5	6.25	674.8	518.4	396.4	6.94	13.0	15.5
28	89.5	65.1	65.1	874.4	335.8	2939.7	5.76	32.2	6.25
29	143.25	131.25	8.25	2732.0	64161.0	809.3			
30	19.64	17.67	17.67	61.36	30.68	30.68	2.5	5.0	5.0
31	4.25	2.88	1.25	14.71	19.34	6.338	1.86	3.0	6.0
32	10.59	7.09	3.41	0.80	23.74	280.80	0.540	12.24	6.57
33	11.75	3.0	7.5	21.73	95.63	102.07	2.385	12.53	6.75
34	5.44	2.44	2.44	17.86	12.04	12.04	1.812	4.0	4.0
35	6.0	2.25	3.18	0.29	45.61	12.91	0.38	6.4	7.5
36	12.29	4.5	7.79	1.21	77.94	286.77	0.75	23.22	8.96

Section

No.	A (1)	A (2)	A (3)	J	I (2)	I (3)	CTORS	H 2	H 3
37									
38	1.94	8.83	0.83	0.04	3.0	3.0	0.25	5.82	5.82
39	16.10	6.91	7.66	2.37	42.0	889.9	0.63	18.0	6.00
40	3.09	1.50	1.50	8.58	5.29	5.29	1.64	3.5	3.5
41	9.79	1.84	7.24	33.63	12.81	110.51	2.82	10.0	3.66
42	4.40	1.79	2.17	0.11	2.79	68.8	0.27	10.0	4.0
43	3.36	1.47	1.59	0.13	1.30	32.3	0.39	8.0	3.36
44	7.97	4.33	2.65	0.35	16.6	204.1	0.4	11.96	6.50
45	45.37	21.85	18.17	259.88	496.28	4289.45	14.58	28.94	15.62
46	4.40	1.79	2.17	0.11	2.79	68.8	0.27	10.0	4.0
47	4.47	1.89	2.19	0.21	1.8	47.3	0.24	10.0	3.93
48	S E C T I O N N O : 4 8 N O T U S E D								
49	10.0	5.10	3.76	0.57	21.3	339.2	0.45	14.0	6.75
50	29.43	15.5	10.51	4.87	203.5	2987.3	0.78	24.0	12.0
51	0.94	0.42	0.42	0.02	0.35	0.35	0.25	2.82	2.82
52	11.77	6.88	3.21	0.96	44.1	310.1	0.52	11.94	8.0
53	21.33	14.58	3.83	4.97	145.96	227.46	0.88	7.88	10.0
54	15.75	9.38	0.0	0.74	2183.0	28.0	0.38	15.76	40.78
55	7.33	2.10	4.80	0.69	3.40	90.7	0.53	10.0	4.53
56	2.39	1.10	1.06	0.08	0.70	13.0	0.34	6.0	2.8
57	12.01	5.77	4.94	1.76	13.6	272.0	0.66	12.0	5.25
58	6.09	2.46	3.10	0.38	3.9	128.1	0.51	12.0	4.6
59	45.37	21.85	18.17	259.88	496.28	4289.45	14.58	28.94	15.62
60	1.94	0.83	0.83	0.04	3.0	3.0	0.25	5.82	5.82
61	0.02	0.0	0.0	0.0	7.56	7.56	0.0	4.50	4.50
62	7.97	4.33	2.65	0.35	16.6	204.1	0.40	11.96	6.5
63	7.97	4.33	2.65	0.35	16.6	204.1	0.40	11.96	6.5
64	11.77	6.88	3.21	0.96	44.1	310.0	0.52	11.94	8.0
65	7.97	4.33	2.65	0.35	16.6	204.1	0.4	11.96	6.5
66	7.97	4.33	2.65	0.35	16.6	204.1	0.4	11.96	6.5
67	5.0	2.92	1.25	0.35	14.31	7.39	0.5	7.15	7.0
68	2.39	1.10	1.06	0.08	0.70	13.0	0.34	6.0	2.8
69	2.39	1.10	1.06	0.08	0.70	13.0	0.34	6.0	2.8
70	5.0	2.92	1.25	0.35	14.31	7.39	0.5	7.15	7.0
71	5.0	2.92	1.25	0.35	14.31	7.39	0.5	7.15	7.0
72	5.44	2.44	2.44	17.86	12.04	12.04	1.81	4.0	4.0

<u>Section</u> <u>No.</u>	<u>A (1)</u>	<u>A (2)</u>	<u>A (3)</u>	<u>J</u>	<u>I (2)</u>	<u>I (3)</u>	<u>CTORS</u>	<u>H2</u>	<u>H3</u>
73	5.44	2.44	2.44	17.86	12.04	12.04	1.81	4.0	4.0
74	7.07	6.36	6.36	7.95	3.98	3.98	1.5	3.0	3.0

CRADLE BEAM END OFFSET

Section No.	XA	YA	ZA	XB	YB	ZB
72	0.0	0.0	0.0	0.0	5.69	-1.234
73	0.0	0.0	0.0	0.0	-5.69	-1.234

CRADLE HORIZONTAL BEARING GUIDE-END OFFSET

Cradle Inclination	Section No.	XA	YA	ZA	XB	YB	ZB
10	79	0.0	0.0	8.657	0.0	0.0	0.0
46.5	79	-0.811	0.0	-9.421	0.0	0.0	0.0
90	79	0.781	0.0	1.472	0.0	0.0	0.0

APPENDIX D

STIFFNESS CHARACTERISTICS OF PNEUMATIC TIRES

APPENDIX D

STIFFNESS CHARACTERISTICS OF PNEUMATIC TIRES

A. Frank D'Souza

Pneumatic tires are functional parts of many vehicles. The tire is employed to carry the load, absorb road shocks, transmit tractive force, steer, and brake the vehicle. In order to effectively design such systems, it is necessary to know the mechanical properties of the component parts, including the tires. The aim of this short note is to discuss the stiffness characteristics of pneumatic tires in the three (3) mutually orthogonal directions shown in Figure 1.

Fig. 1. Coordinate System

The stiffness k_z in the vertical direction z is important for the load carrying capacity of the tire and for isolation of road induced shock and

vibrations. The stiffness k_y , in the lateral direction y , is important for the determination of the lateral force when the tire rotates at a slip angle. The stiffness k_x in the longitudinal direction plays a role in the generation of tractive and braking forces. These three stiffnesses of a pneumatic tire are discussed separately in the following. The spring rates considered here in any one of the three directions are part of the rigid body or lowest order vibration mode in that direction. The flexural modes are not included.

Vertical Stiffness

The lowest natural frequency of the vertical vibrations of a vehicle is determined mainly by the sprung mass and the stiffness of the suspension springs. For an automobile, this frequency ranges from about 1 to 3 Hz. The second resonant frequency is determined by the unsprung mass and the vertical tire stiffness, and for an automobile it lies between 8 and 20 Hz. The correct determination of the tire stiffness in the vertical direction is therefore very important.

Rasmussen and Cortese¹ of General Motors Corporation have measured the vertical spring rate of automobile tires by the resonance method, where the natural frequency is measured and the spring rate is calculated. It is an indirect method and yields a derived value of the spring rate. In his discussion of Reference 1, Tarpinian of Uniroyal, Inc. gives the spring rates of three tires employed by Rasmussen and Cortese under the same conditions (*i.e.* rolling at 11 m.p.h. with 1104 lbs load). However, Tarpinian determined the spring rates by two static methods, namely, the slope of the steady state load-deflection curve, and the change in load for a change in static deflection. For all three tires, the values obtained by the resonance method were higher

than those obtained by Tarpinian. The static stiffness of a pneumatic tire is different from its dynamic stiffness. This difference is due to the viscoelasticity of the tire material and is explained later.

Clark² has derived a simple expression for calculating the vertical stiffness of aircraft tires from simple geometric considerations of the contact patch.

His equation for the stiffness is given by

$$k_z = \pi p_0 \sqrt{dw} \text{ and } P = k_z \delta \quad (1)$$

where p_0 is the inflation pressure, d the tire diameter and w is the section width as shown in Figure 2. Here P is load and δ is the vertical deflection.

Fig. 2. Cross Section of Aircraft Tire

It should be noted that aircraft tires are molded without the heavy shoulder structure used in automotive and truck tires. Their cross-sectional

shape is closer to a circle which is the assumption in the derivation of Equation (1). Clark has compared the results of Eq. (1) with the extensive experimental data on aircraft tires reported by Horne of NASA. Figure 3 shows only one such comparison for a 15.50-20, 14 ply aircraft tire. For the particular tire, $d = 44$ in., $w = 12$ in. and $H = 11$ in. It is observed that when a tire is loaded vertically and afterwards unloaded, a hysteresis loop is obtained in the load-deflection curve. This finding has been confirmed by the experimental results of van Eldik Thieme³ for automotive tires and he has shown that the loop area decreases and the vertical stiffness increases with increasing speed.

The tire stiffness is composed of a part originating from the structural rigidity of the tire, and a part dependent on the inflation pressure. Under the rated conditions, the latter part is predominant. It has been found³ that the structural rigidity of the aircraft tires may supply 3 to 8 percent of the total stiffness, whereas for automotive tires, this percentage is about 15 percent. The steady state load-vertical deflection curve may be approximated by a straight line. Only for relatively low values of vertical load, a noticeable deviation from linearity takes place. The slope of Eq. (1) in Fig. 3 appears to be very close to the experimental value and for this reason, Eq. (1) may be useful for aircraft tires but its validity for truck tires is unproven.

Tielking, Francher and Wild⁴ give the experimental results of truck tire tests using a flat bed tire testing machine. Figure 4 shows their data as load versus change in rolling height for three truck tires. The rolling velocity of the tires is sufficiently low (1.44 m.p.h.) that the vertical load-deflection data for a standing tire shown by a dashed line in Fig. 4

Fig. 3. Vertical Load-Deflection Experiments vs. Predictions of Eq. (1) For Tire: 15.50-20, 14 ply²

for the 12.00-20/G tire is almost parallel to that of the slow rolling tire. Since the hysteresis loop is not shown, it appears that separate data were not taken when the tires were loaded and then unloaded. The vertical load-deflection data are quite linear and the slope of the straight lines yields the vertical stiffness k_z .

The values that they give are $k_z = 5850$ lbs./in. for the 11.00-22/G tire and $k_z = 5420$ lbs./in. for the 15-22.5/H tire. For the 12.00-20/G tire, we calculate k_z as 5360 lbs./in.

Fig. 4. Vertical Load Versus Change in Low-Speed Rolling Height of Tires⁴

We now discuss the reasons why the stiffness of a pneumatic tire under dynamic conditions differs from its static stiffness. Overton, Mills and

Ashley⁵ based on a suggestion of Gehman represent the dynamic behavior of pneumatic tires by the use of a viscoelastic model as shown in Fig. 5 where m is the unsprung mass.

Fig. 5. Viscoelastic Tire Model

Drawing a free body diagram of the mass and balancing forces we get:

$$mD^2z + k_1z + CD(z-x) = P \quad (2)$$

where D is the differential operator d/dt . For the spring k_2 and damper C , equating the forces we obtain,

$$CD(z-x) = k_2x$$

or solving for x , it follows that

$$x = \frac{CD}{CD+k_2} z \quad (3)$$

Now substituting for x from Eq. (3) in Eq. (2) and simplifying the expression, the transfer function is given by,

$$z = \frac{(CD+k_2)}{mCD^3 + mk_2D^2 + c(k_1+k_2)D + k_1k_2} \quad (4)$$

In steady state, setting $D = 0$ in Eq. (4) the static equation between P and z is given by $P = k_1z$. In the dynamic case, factoring a quadratic term from the cubic denominator of Eq. (4), we can determine the natural frequency associated with the quadratic and indirectly the dynamic stiffness which is different from the static stiffness k_1 . Overton *et al.* have identified the values of k_1 , k_2 and c from experimental frequency response for two automobile tires. Although there is no doubt that rubber is viscoelastic, its behavior can be matched by a suitable model such as that of Fig. 5. But the model is entirely formal since the model elements cannot be identified with specific features of molecular structure.

In order to determine the frequency up to which the static tire stiffness is valid, we let $D = j\omega$ in the transfer function of Eq. (4), and plot the log of its magnitude versus frequency on a semilog paper (Bode diagram) and determine the frequency up to which the frequency response is flat.

Lateral Stiffness

The lateral stiffness k_y of a non-rolling tire is important for the relaxation properties and side force of a rolling tire. In a static test, the lateral stiffness is determined by loading a tire upon a flat surface with a normal load. The surface is then moved sideways. Clark² has obtained an

analytic expression for lateral stiffness by assuming an idealized model of a beam on elastic foundation. His expression is given by,

$$S = \sqrt{2} \delta_s \rho_o \eta w \sqrt{\frac{d}{H}} \quad (5)$$

where S is the steady side force, d is the tire diameter, w the section width, H the section height as shown in Fig. 6, ρ_o the inflation pressure, δ_s the static side deflection and η a correction factor which Clark chooses as 0.75 based on experimental results. Clark has compared the results predicted by Eq. (5) with the experimental results of Horne. Figure 7 shows only one such comparison for a 15.50-20, 14 ply aircraft tire. Again, it is seen that the experimental results exhibit hysteresis and the predictions of Eq. (5) are within the hysteresis loops for normal inflation pressures.

Fig. 6. Idealized Section of Aircraft Tire

Tielking, Fancher and Wild⁴ have also obtained the lateral static stiffness of the three truck tires mentioned earlier. Figure 8 shows their experimental data. Their results are shown in the table below.

(a) INITIAL INFLATION PRESSURE, 105 POUNDS PER SQUARE in.

(b) INITIAL INFLATION PRESSURE, 85 POUNDS PER SQUARE in.

Fig. 7. Side Load-Deflection Experiments vs. Predictions of Eq. (5) For Tire 15.50-20, 14 ply²

(c) INITIAL INFLATION PRESSURE,
65 POUND PER SQUARE in.

Fig. 7. (CONCLUDED)

Table I

Tire Size	Rated Load	Inflation Pressure	k_z	k_y
11.00-22/G	6140 lbs.	90 psi	5850 lbs/in	1910 lbs/in
12.00-20/G	6140 lbs.	80 psi	5360	1900
15-22.5/H	8640 lbs.	90 psi	5420	2860

As mentioned earlier the value of k_z for the 12.00-20/G tire has been estimated by the writer. Again, it appears from the absence of the hysteresis in Fig. 8 that Tielking *et al.* does not show data for loading and unloading.

Longitudinal Stiffness

The longitudinal stiffness k_x of a tire contributes to the generation of breaking and tractive forces. Dodge, Orne and Clark⁶ have developed an

Fig. 8. (a) Lateral Spring Rate k_y vs. Tire Load⁴

Fig. 8. (b) Lateral Spring Rate k_y vs. Inflation Pressure For Tires Shown⁴

analytical equation for predicting this stiffness. The pneumatic tire is idealized as an elastic bar supported by an elastic shear foundation. The elastic bar portion of the model represents the ability of the sidewall to withstand shear forces. Their result is expressed as:

$$k_x = \left| -2A_s E q \tanh(q \pi a) \right| \quad (6)$$

where A_s is the cross-sectional area of the bar at any location, E the effective extension modulus of the tread region in the circumferential direction, "a" the outside tire radius and $q = \sqrt{k_s/A_s E}$. Here k_s , the spring rate per unit length of the shear foundation, is defined by $k_s = \frac{2Gh}{A}$ where G is the effective shear modulus of the sidewall, h the sidewall thickness and A is the length along the sidewall from the rim to the point of intersection of the tread and carcass. The symbols are shown in Fig. 9.

The tire is orthotropic and hence, the shear modulus G of the carcass and the effective stiffness $A_s E$ of the tread region in the circumferential direction must be computed for a given tire. Dodge *et al*,⁶ use average values of these properties throughout the cross section which they obtained after lengthy computations. They also give an approximate method for evaluating $A_s E$ and G but the approximations require considerable information about the tire structural properties such as cord half-angle, extension modulus of an individual ply in the direction normal to the cord, the shear modulus of an individual ply in the direction normal to the cord, the shear modulus of an individual ply, etc. Hence, Eq. (6) would be of interest only to a tire designer.

In order to check the validity of Eq. (6), Dodge *et al*,⁶ tested five (5) automobile tires. The geometric and structural properties of the tires tested

Table II
SUMMARY OF GEOMETRIC, ELASTIC, AND STRUCTURAL PROPERTIES OF FIVE AUTOMOTIVE TIRES

Item (Ref. 5, Table I)	Tire 1	Tire 2	Tire 3	Tire 4	Tire 5
	Bias-Ply 8.00x14	Bias-Ply 7.50x14	Bias-Ply 5.90x15	Radial-Ply 7.50x14	Radial-Ply 155 mm x15
a - outside radius of tire	12.525	13.94	12.875	13.44	12.25
L - half circumference	39.35	43.79	40.45	42.22	38.48
ET - extension modulus, tread rubber	670.	560.	481.	690.	490.
A - length, mean meridional section	4.6408	5.8404	4.9217	5.7238	4.5529
h - effective thickness for K_s	0.164	0.110	0.160	0.250	0.280
G - effective shear modulus for K_s	28440.	47164.	43876.	269. (G_{xy})	144. (G_{xy})
A_sE - effective spring rate, circumferential	779.	747.	760.	11906.	23027.
K_s - spring rate, shear foundation	2010.	1747.	2852.	18.98	23.50
BETAC - cord half angle, crown	0.6458	0.6283	0.6109	0.3142	0.2356
ROC - radial location, crown	12.120	13.38	12.355	12.92	11.70
ROB - radial location, rim	7.078	7.20	7.515	7.06	7.59
R - idealized radius, sidewall	3.22	3.03	2.84	3.13	2.17
y_c - y-coordinate, center for R	1.935	2.490	2.092	2.454	1.939
x_c - x-coordinate, center for R	-0.057	0.465	-0.146	0.405	0.704
R_i - idealized radius, crown region	3.40	2.62	2.76	3.54	4.88
ERUB - extension modulus, carcass rubber	438.	310.	370.	625.	300.
GRUB - shear modulus, carcass rubber	146.	103.	123.	208.	100.
MURUB - Poisson ratio, carcass rubber	0.500	0.500	0.500	0.500	0.500
GCORD - shear modulus, cord	705.	705.	705.	705.	705.
AESUBC - spring rate, cord	200.	623.	317.	350.	307.
DIAMC - effective diameter, cord	0.025	0.040	0.026	0.025	0.023
MUC - Poisson ratio, cord	0.700	0.700	0.700	0.700	0.700
TPLY - effective ply thickness	0.041	0.055	0.040	0.040	0.040
NCORD - cord count, crown	26.	19.	24.	18.	20.
ALPSTR - normal angle, intersection	0.7746	0.6085	0.6665	0.6427	0.5775
ALPHR - normal angle, rim	2.2148	2.5331	2.3973	2.4714	2.6792
BW - tread width	4.36	4.40	3.20	4.60	3.68

Table III
SUMMARY OF EXPERIMENTAL AND CALCULATED VALUES OF K_x

Tire	k_x - lb/in.	
	Experimental	Calculated
1	2530	2503
2	2300	2286
3	2780	2944
4	1340	1469
5	1265	950

Fig. 9. Meridional Cross-Section of Tire

are given in Table II and a comparison between experimental and calculated values is shown in Table III. Both of these tables have been extracted from Ref. 6. It is seen that Eq. (6) yields a good estimate of the longitudinal stiffness but it is not directly useful for our purpose.

In the absence of experimental data for the longitudinal stiffness of truck tires, here we estimate this property in the following manner. The experimental results given by van Eldik Thieme³ for two automobile tires are shown below.

<u>Tire</u>	<u>Inflation Pressure</u>	<u>Normal Load</u>	<u>k_z</u>	<u>k_y</u>	<u>k_x</u>	<u>k_ψ</u>
Bias ply, 175 S14	21 psi	737 lbs	1118 $\frac{\text{lbs}}{\text{in}}$	671 $\frac{\text{lbs}}{\text{in}}$	2515 $\frac{\text{lbs}}{\text{in}}$	25,118 $\frac{\text{lb.in}}{\text{rad}}$
Radial ply SR14	27	737 lbs	950	503	1509	21,654

Here, k_ψ is the torsional stiffness discussed later. The results shown here have been converted from the units of kgf and meters to lbs. and inches. For the bias ply tire, the ratio $k_x/k_y = 3.75$ and $k_x/k_z = 2.25$. If these ratios were to remain the same for the 12.00-12/G truck tire, then from Table 1 and the first ratio, we get $k_x = 7125$ lbs/in and from the second ratio $k_x = 12,060$ lbs/in. The average of these two values is 9593 lbs/in. Hence, $k_x = 9,600$ lbs/in may be employed as a crude estimate.

Torsional Stiffness

The torsional stiffness k_ψ of a nonrolling tire about its vertical axis (i.e. axis perpendicular to the ground plane and passing through the wheel centerline) is of value for the assessment of the steering torque required at zero or nearly zero forward speed. By idealizing a tire as a string on an elastic foundation, Clark² has obtained the following equation for an aircraft tire.

$$k_\psi = \eta \left(\frac{\sqrt{2}}{\pi} \right) d P \sqrt{\frac{w}{H}} \quad (7)$$

where P is the tire vertical load, d the tire diameter, w the section width and H is the section height as shown in Fig. 2. Here η is a correction factor which Clark chooses as 0.75. It should be noted that this stiffness is independent of the inflation pressure. Clark has also compared the

predictions of Eq. (7) with the experimental results of Horne. Only one such comparison is shown in Fig. 10 for a 15.50-20, 14 ply aircraft tire. It can be seen that the torsional deflection curves show even more hysteresis than do the vertical and side load-deflection curves. It is difficult to assign any specific torsional spring rate to a given set of conditions. In some cases, the predictions of Eq. (7) are within the hysteresis loop. For an inflation pressure of 85 psi. and vertical load of 10,000 lbs, the slope predicted by Eq. (7) is 162,338 lbs.in/radian.

Conclusions and Recommendations

It can be concluded that the dynamic stiffness of a pneumatic tire is quite different from its static stiffness due to the viscoelastic nature of the tire material. Experimental data shows that when a tire is loaded statically and then unloaded, the load-deflection curve shows a hysteresis loop. Hence, the static tire stiffnesses are only approximations. For a truck tire with a G load rating, the experimental values of the static stiffnesses are 5360 lbs/in in the vertical direction and 1950 lbs/in in the lateral direction. These values may be compared with the predictions of Eqs. (1) and (5), respectively, which are approximations for aircraft tires. Concerning the longitudinal stiffness, experimental data exist for automobile tires. A simple analytical expression is also not available and a rough estimate of the value of the longitudinal stiffness is 9600 lbs/in. Experimental data for the torsional stiffness of truck tires are not available and Eq. (7) may be employed to obtain an approximate value.

(a) INITIAL INFLATION PRESSURE, 105 POUNDS PER SQUARE in.

(b) INITIAL INFLATION PRESSURE, 85 POUNDS PER SQUARE in.

Fig. 10. Torsional Moment vs. Torsion Angle²

References

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APPENDIX E

VERIFICATION OF COMPUTER OUTPUT

E.1 VERIFICATION OF COMPUTER OUTPUT

This section is devoted to checking the structural analysis of the SLSF cradle. A STARDYN computer analysis was done for both stationary and traveling conditions. For the stationary condition, 3 positions for the cradle, namely 10° , 46° , 90° inclinations were considered. For each position, a normal and an emergency load case was analyzed. In the former, both supporting cylinders were assumed active, while in the latter, one of the two cylinders was assumed to be disengaged. In addition, several travel load cases were also analyzed. All load cases analyzed are numbered according to their definitions in Chapter IX (Volume II of this report).

As mentioned above, this section is only concerned with checking the computer output for all the above mentioned cases. The checking procedure is independent from the computer analysis. The overall equilibrium of the total system is investigated by taking sections across the whole LHM and cradle structures at designated points along the longitudinal axis of the structure. The sum of all internal forces, in all members cut by a given section, can be obtained by invoking equilibrium conditions for the portion of the structure to the left of the section. It must be realized that this procedure is not intended to check the stresses in the individual members nor to verify the modeling technique. However, since the computer analysis program is based on a displacement method, the independent check used should verify whether the assumed model and loading were properly input and analyzed.

E.2 REMARKS ON THE COMPUTATIONS AND FIGURES

1. All figures show the bending moments about the major axis on the compression side.
2. All values of bending moments shown in the figures are in pound-inch units and are scaled down by a factor of 10^3 .
3. For Load Cases 1, 2, 3 and 4, the X_5 Force in the equilibrium check tables at the various sections is the moment about the point of the intersection of the X_1 axis and a plane parallel to the X_2 - X_3 plane passing through the node at which the equilibrium check is investigated.
4. For Load Cases 5 and 6, the X_5 force in the equilibrium check table is the moment about an axis parallel to the X_2 global axis through the node at which the equilibrium check is investigated.

E.3 LOAD CASE 1E.3.1 Section to the left of node (102)

$$x_1 = 230.3284" \quad x_2 = 0 \quad x_3 = 0$$

Applied Loads:

NODE	F_{x_1}	F_{x_3}	F_{x_5}
101		-854.0	36185.18
84		-1211.25	-577 + 46043.97
85		-3024.53	-4765.9 + 94123.37
86		-3057.30	4093.57 + 31012.23
Sub Total		-8147.08	206115
Correction*	+126.4	-716.7	1249.4
Total	+126.4	-8863.8	207364

Internal Forces:

MEMBER	F_{x_1}	F_{x_3}	F_{x_5}
513	-126.0	8860.0	-207140

$$* \begin{cases} \text{Load Correction} = (143.5) \left(\frac{240.472 - 230.3284}{2} \right) = 727.8 \\ \text{Moment Correction} = \frac{(143.5)}{\cos 10^\circ} \frac{(240.472 - 230.3284)^2}{12} = 1249.4 \end{cases}$$

E.3.2 Section to the left of node (111)

$$x_1 = 181.0881 \quad x_2 = 0 \quad x_3 = 0$$

Applied Loads:

NODE	F_{x_1}	$F_{x_3} \cdot 10^2$	$F_{x_5} \cdot 10^4$
Previous		-81.4708	20.61152 40.11647
102		-41.7972	-2.49871 20.581067
87		-69.425	2.61442 1.91433
103,104		-1.0811 x 2	1.147276
487,488		-0.122073 x 2	0.13039
105,106		-.26594 x 2	.2840702
107,108		-.388014 x 2	.3821
489,490		-.86184	.4244
109,110		-.161895 x 2	.174952
Sub Total		-197.595	85.6535
Correction*	34.3	-1.948	+.00923
Total	34.3	-199.543	85.6627

Internal Forces:

MEMBER	F_{x_1}	F_{x_2}	$F_{x_3} \cdot 10^2$	$F_{x_5} \cdot 10^4$
514	-165	0	203	-87.4 - 0.4431
11	65.4	51.5	-1.53	.805 + 0.034 + 0.058
12	65.4	-51.5	-1.53	.805 + 0.034 + 0.058
Total	-34.2	0	199.94	-86.05

$$\begin{aligned} \star \left\{ \begin{aligned} \text{Load Correction} &= 143.5(183.8455 - 181.0881)/2 = 197.8 \\ \text{Moment Correction} &= 143.5(183.8455 - 181.0881)^2/12 = 92.3 \end{aligned} \right. \end{aligned}$$

E.3.3 Section to the left of node 123

$$x_1 = 132.8325 \quad x_2 = 0 \quad x_3 = 0$$

Applied Loads:

NODE	F_{x_1}	$F_{x_3} \cdot 10^2$	$F_{x_5} \cdot 10^4$
Previous		-197.595	85.6535 95.3506
111		-6.3043	-.01357 3.042173
88		-10.8343	-.112031 4.75868
89		-14.9455	-.006133 4.98956
90		-26.6633	-.798995 6.827138
112,113		-2.14052 x 2	2.229386
114,115		-.442212 x 2	.469786
116,117		-.442212 x 2	.485144
118,119		-.274185 x 2	.289377
120,121, } 491,492 }		-.74634 x 2	.7203
122		-.8058	.3888
Sub Total		-265.237	204.34
Correction*	+319.02	-18.093	.8243
Total		-283.329	205.165

Internal Forces:

MEMBER	F_{x_1}	F_{x_2}	$F_{x_3} \cdot 10^2$	$F_{x_5} \cdot 10^4$
517	-990	0	308	-219 - 1.8161
34	335	-801	-12.5	7.08 - 0.1079 + 0.4776
35	335	801	-12.5	7.08 - 0.1079 + 0.4776
Total	-320	0	283	-205.9248

$$* \begin{cases} \text{Load Correction} = 143.5(158.4375 - 132.8325)/2 = 1837.2 \\ \text{Moment Correction} = \frac{143.5}{\cos 10^\circ}(158.4375 - 132.8325)^2/12 = .8243 \end{cases}$$

E.3.4 Section to the left of node 147

$$x_1 = 45.43079 \quad x_2 = 0 \quad x_3 = 0$$

Applied Loads:

NODE	F_{x_1}	$F_{x_3} \cdot 10^2$	$F_{x_5} \cdot 10^4$
Previous		-265.237	204.34 231.8217
123		-20.5205	.788141 + 17.9353
131		-21.0195	-.16123 + 17.8332
91		-45.618	-.19521 + 33.3119
92		-26.9317	.357433 + 14.9985
93		-61.0653	-.105743 + 32.5044
146		-10.619	.008366 + 4.62752
94		-11.141	.00867 + 4.30641
95		-28.6437	-.18072 + 9.88709
96		-20.4	.00456 + 4.36959
97		-16.0945	.00409 + 1.59292
124,125		-1.5559 x 2	2.83864
126,127		-.59516 x 2	1.08583
130,498		-.637	0.55674
132,133		-6.05337 x 2	10.27151
134,135		-32.3815 x 2	60.74414
138,139		-60212 x 2	.81652
142,143		-.59516 x 2	.88186
144,145		-2.53232 x 2	3.752205
Sub Total		-616.578	659.7114
Correction*	+119.27	-6.76435	.11505
Total	+119.27	-623.342	659.8262

$$* \begin{cases} \text{Load Correction} = 138.8(55.32811 - 45.43079)/2 = 686.87 \\ \text{Moment Correction} = \frac{138.8(55.32811 - 45.43079)^2/12}{\cos 10^\circ} = 1150.514 \end{cases}$$

Internal Forces:

MEMBER	F_{x_1}	F_{x_2}	$F_{x_3} \cdot 10^2$	$F_{x_5} \cdot 10^4$
524	8340		118	-219 + 2.4465
58,59	-20400 x 2	± 933	-125 x 2	-104 x 2 + 76.4275 +9.5508
46,47	16200 x 2	± 8.26	378 x 2	-163.296 - 363.403
Total	-60**	0	624	-659.35

**This value is not accurate since it is resulting from the difference of two large numbers that are given on the output to 3 significant digits only.

Figure E.3-1 Bending Moments along the LHM

Figure E.3-2 Bending Moments along the Cradle Main Beam

Figure E.3-3 Bending Moments along Crossbeam #1

Figure E.3-4 Bending Moments along Crossbeam #2

Figure E.3-5 Bending Moments along Crossbeam #3

Figure E.3-6 Bending Moments along Crossbeam #4

Figure E.3-7 Bending Moments along Crossbeam #5

E.4 LOAD CASE 2E.4.1 Section to the left of node 111

$$x_1 = 181.0881" \quad x_2 = 0 \quad x_3 = 0"$$

NODE	x_1	x_2	x_3	$x_5(E4)$
Previous			-8147.08	20.61152 40.11647
102			-4179.72	-2.4987 +20.581
87			-6942.50	2.6144 1.9143
103,104			-108.107 x 2	1.14727
105,106			-26.59 x 2	0.28407
107+485			-38.89	0.1915
108+486			-38.89	0.1915
109,110			-16.1895 x 2	-0.05459
487,488			-12.2073 x 2	0.13039
489,490			-86.184	0.4244
Sub Total			-19759.5	85.6535
Correction*	+84.3		-194.8	.0092
Total	34.3		-19954.3	85.6627

Internal Forces:

MEMBER	F_{x_1}	F_{x_2}	F_{x_3}	$F_{x_5} \cdot 10^4$
514	79.1	-758	18900	-80.4000 + 0.2124
11	381.0	439	117	287 + 0.1977
12	-494.0	318	962	-8.3 - .2563 - .4122
Total	-33.9	-1	19979	-86.088

$$* \begin{cases} \text{Load Correction} = 143.5 \frac{(183.8455 - 181.0881)}{2} = 197.8 \\ \text{Moment Correction} = 92.3 \end{cases}$$

E.4.2 Section to the left of node 123

$x_1 = 132.8325$

$x_2 = 0$

$x_3 = 0$

Applied Loads:

NODE	F_{x_1}	$F_{x_3} \cdot 10^2$	$F_{x_5} \cdot 10^4$
Previous		-197.595	85.6535 95.3506
111		-6.304	-.01357 3.0422
88		-10.834	-.11203 4.75869
89		-14.9455	.061333 4.98956
90		-26.6633	-.79899 6.82714
112,113		-2.1405 x 2	2.22939
114,115		-.442212 x 2	.46979
116,117		-.442212 x 2	.485144
118,119		-.274185 x 2	.28938
120,121 + 491,492		-.74589 x 2	.71987
122+493		-.80525	.38858
Sub Total		-265.237	204.348
Correction*	319.0195	-18.0925	.82433
Total	319.0195	-283.329	205.165

$$* \left\{ \begin{array}{l} \text{Load Correction} = 143.5(158.4375 - 132.8325)/2 = 1837.16 \\ \text{Moment Correction} = \frac{143.5}{\cos 10^\circ} (158.4375 - 132.8325)^2/12 = 8243.3 \end{array} \right.$$

Internal Forces:

MEMBER	F_{x_1}	F_{x_2}	$F_{x_3} \cdot 10^2$	$F_{x_5} \cdot 10^4$
517	-1370	-758	330	-223 - 2.5132
34	335	-428	44.3	-8.03 + 0.1079 - 1.6925
35	720	1190	-91.1	26 + 0.239 + 3.4805
Total	-315	4	283.2	-205.405

E.4.3 Section to the left of node 147

$x_1 = 45.43079$

$x_2 = 0$

$x_3 = 0$

Applied loads:

NODE	x_1	x_2	$x_3(E2)$	$x_5(E4)$
Previous			-265.237	204.34 231.8217
123			-20.5205	.78814 17.93527
124,125			-1.55593 x 2	2.8387
126,127			-.59516 x 2	1.08583
128,129			-.31616 x 2	.57956
130+498			-.6326	.5529
131			-21.0195	-.161623 17.8332
132,133			-6.05337 x 2	10.27151
134,135			-32.3815 x 2	60.74414
138			-.602117	.40826
139			0	.40826
142,143			-.59516 x 2	.88186
144,145			-2.53232 x 2	3.75221
146			-10.619	.083661 4.62752
91			-45.618	-.19521 33.3119
92			-26.9317	.357433 14.99851
93			-61.0653	-.105743 32.5044
94			-11.141	.00867 4.30641
95			-28.6437	-.18072 9.88709

Applied loads(contd):

NODE	x_1	x_2	$x_3(E2)$	$x_5(E4)$
96			-20.4	.045564 4.36959
97			-16.0945	.048792 + 1.5929
Sub Total			-616.578	659.7114
Correction*	119.3		-67.64	.11505
Total	119.3		-623.342	659.8262

$$* \begin{cases} \text{Load Correction} = 138.8(55.32811 - 45.43079)/2 = 686.87 \\ \text{Moment Correction} = \frac{138.8}{\cos 10^\circ}(55.32811 - 45.43079)^2/12 = 1150.5 \end{cases}$$

Internal Forces:

MEMBER	F_{x_1}	F_{x_2}	$F_{x_3} \cdot 10^2$	$F_{x_5} \cdot 10^4$
524	8430	-758	113	-219 + 2.4465
58	-31800	-431	-279	28.3 + 59.5716 + 10.659
59	-9140	1410	33.2	-30.8 + 17.122 - 1.2683
46	32400	-220	756	-163.296 - 363.403
Total	-110	1	623.2	-659.64

E.4.5 Section to the left of node 159

$$X_1 = 32.62829$$

$$X_2 = 0$$

$$X_3 = 0$$

Applied loads:

NODE	F_{x_1}	$F_{x_3} \cdot 10^2$	$F_{x_5} \cdot 10^4$
Previous		-616.578	659.7114 78.9374
147		-15.9967	-.077456 2.04798
148,149		-2.83816 x 2	.94356
152,153		-.214924 x 2	.00753
154+499		-.80215	.1027
500+502 501+503		-.68763 x 2	.17607
Sub Total		-640.858	741.849
Correction*	154.3	-8.75	.1925
Total	154.3	-649.608	742.0416

$$* \begin{cases} \text{Load Correction} = 138.8(45.43079 - 32.62829)/2 = 888.5 \\ \text{Moment Correction} = \frac{138.8}{\cos 10^\circ} (45.43079 - 32.62829)^2/12 = 1925 \end{cases}$$

Internal Forces:

MEMBER	F_{x_1}	F_{x_2}	$F_{x_3} \cdot 10^2$	$F_{x_5} \cdot 10^4$
77	15900	-758	-296	-176 + 1.075
71	-33500	-775	-38.6	-1.15 + 75.107 - 1.661
72	-15000	1750	228	-58.9 + 33.63 + 9.814
46	32400	-220	756	0 - 163.296 - 460.19
Total	200**	-3**	649.4	-741.572

**These values are not quite accurate due to limited accuracy available on the output.

Figure E.4-1 Bending Moments along Cradle Left Main Beam

Figure E.4-2 Bending Moments along Cradle Right Main Beam

Figure E.4-3 Bending Moments along Crossbeam #1

Figure E.4-4 Bending Moments along Crossbeam #2

Figure E.4-5 Bending Moments along Crossbeam #3

Figure E.4-6 Bending Moments along Crossbeam #4

Figure E.4-7 Bending Moments along Crossbeam #5

E.5 LOAD CASE 3

E.5.1 Section to the left of node 123

$$X_1 = 95.86639$$

$$X_2 = 0$$

$$X_3 = 0$$

Applied Loads:

NODE	X_1 -Coord.	F_{x_1}	$F_{x_3} \cdot 10^2$	$F_{x_5} \cdot 10^3$
84	190.584		-12.1125	-.4033 + 114.7267
85	185.7655		-30.245	-3.3312 + 271.9026
86	171.1036		-30.573	2.8613 + 230.0227
87	131.5232		-69.425	18.274 + 247.5474
88	126.5670		-10.8343	-.7831 + 33.2632
89	119.2016		-14.9455	.4287 + 34.8756
90	113.7636		-26.6633	-8.2419 + 47.7798
101	193.63		-8.540	83.4901
102	164.0135		-41.7972	-17.4653 + 284.836
103+104	179.9717		-1.0811 x 2	18.1847
105+106	181.4225		-.2659 x 2	4.5506
485+107 486+108	181.4225		-.3880 x 2	6.6395
109,110	184.0338		-.1619 x 2	2.8548
111	129.5958		-6.3043	-0.0948 + 21.264
112,113	145.554		-2.1405	21.2714
114,115	149.9062		-.4422 x 2	4.7794
116,117	157.16		-.4422 x 2	5.421
118,119	148.4555		-.2742 x 2	2.8838
491+121 492+120	148.4555		-.7462 x 2	7.848
122+493	148.455		-.8058	4.238
487,488	181.4225		-.1221 x 2	2.0888
489,490	184.0338		-.86185	7.599
Sub Total			-265.24	1449.2
Correction*	931.5	931.5	-.0884	5.56 + 87.34
Total	931.5	931.5	-274.07	1542.1

Applied Loads(contd):

$$* \begin{cases} \text{Load Correction} = \frac{143.5}{2}(113.7636 - 95.8664) = 1284.1 \\ \text{Moment Correction} = \frac{143.5}{12 \cos 46.5} [113.7636 - 95.8664]^2 = 5564.54 \end{cases}$$

Internal Forces:

MEMBER	F_{x_1}	$F_{x_3} \cdot 10^2$	$F_{x_5} \cdot 10^3$
517	-2860	279.0	-1530 - 268.15
34,35	966×2	-2.6×2	$47 \times 2 + 151.88 + 8.298$
	928	273.8	-1543.97

E.5.2 Section to the left of node 147

$x_1 = 34.7749$

$x_2 = 0$

$x_3 = 0$

Applied Loads:

NODE	x_1 -coord.	F_{x_1}	$F_{x_3} \cdot 10^2$	$F_{x_5} \cdot 10^4$
Previous	95.86639		-265.24	144.92 + 162.04
91	85.8164		-45.618	-0.1364 + 23.284
92	73.7014		-26.9318	0.2498 + 10.489
93	71.9805		-61.065	-0.0739 + 22.7197
94	61.7928		-11.141	0.00606 + 3.010
95	58.9018		-28.644	-.1263 + 6.911
96	49.7466		-20.4	0.0318 + 3.054
97	41.6929		-16.095	0.0286 + 1.113
123	95.8664		-20.521	0.5509 + 12.536
124,125	111.8246		-1.556 x 2	2.3977
126,127	111.8246		-0.5952 x 2	0.9171
128,129	113.6381		-0.3162 x 2	0.4987
130+498	113.6381		-0.6323	0.4987
131	94.0767		-21.0195	-0.113 + 12.465
132,133	94.0767		-6.053 x 2	7.1795
134,135	131.477		-32.3815 x 2	62.627
138,139	93.6443		-1.374 x 2	1.6177
140,141	97.6711		0	0
142,143	99.8473		-0.5952 x 2	0.7746
144,145	99.8473		-2.532 x 2	3.2957
146	65.2346		-10.619	0.0585 + 3.2345
Sub Total		0	-614.063	484.075
Correction		348.3	-3.305	0.0804 + 1.0234
Total		348.3	-617.368	485.15

Applied Loads:Correction between node 97 and 147

$$\text{Load correction} = \frac{138.8}{2} (41.6929 - 34.7749) = 480.1$$

$$X_1\text{-component} = 348.3 \quad X_3\text{-component} = 330.5$$

$$\text{Moment correction} = \frac{138.8}{12 \cos 46.5} [41.6929 - 34.7749] = 804.2$$

Internal Forces:

MEMBER	F_{x_1}	F_{x_2}	$F_{x_3} \cdot 10^2$	$F_{x_5} \cdot 10^4$
524	23700	0	367	-182 + 69.634
58,59	-12000 x 2	±1190	-220 x 2	-0.846 x 2 - 34.17 + 70.216
46,47	-44 x 2	±1.55	348 x 2	-0.444 - 408.727
Total	-388*	0	623*	-487.182*

*These values are not quite accurate because of limited output accuracy.

Figure E.5-1 Bending Moments along LHM

Figure E.5-2 Bending Moments along Cradle Main Beam

Figure E.5-3 Bending Moments along Crossbeam #1

Figure E.5-4 Bending Moments along Crossbeam #2

Figure E.5-4 Bending Moments along Crossbeam #3

Figure E.5-6 Bending Moments along Crossbeam #4

Figure E.5-7 Bending Moments along Crossbeam #5

E.6 LOAD CASE 4E.6.1 Section to the left of node 123

$$X_1 = 95.86639$$

$$X_2 = 0$$

$$X_3 = 0$$

Applied Loads:

NODE	X_1 -coord.	F_{X_1}	$F_{X_3} \cdot 10^2$	$F_{X_5} \cdot 10^3$
84	190.584		-12.1125	-.4033 + 114.7267
85	185.7655		-30.245	-3.3312 + 271.9026
86	171.1036		-30.573	2.8613 + 230.0227
87	131.5232		-69.425	18.274 + 247.5474
88	126.5670		-10.8343	-.7831 + 33.2632
89	119.2016		-14.9455	0.4287 + 34.8756
90	113.7636		-26.6633	-8.2419 + 47.7798
101	193.63		-8.540	83.4901
102	164.0135		-41.7972	-17.4653 + 284.836
103+104	179.9717		-1.0811 x 2	18.1847
105+106	181.4225		-.2659 x 2	4.5506
485+107 486+108	181.4225		-.3880 x 2	6.6395
109,110	184.0338		-.1619 x 2	2.8548
111	129.5958		-6.3043	-0.0948 + 21.264
112,113	145.554		-2.1405	21.2714
114,115	149.9062		-.4422 x 2	4.7794
116,117	157.16		-.4422 x 2	5.421
118,119	148.4555		-.2742 x 2	2.8838
491+121 492+120	148.4555		-.7462 x 2	7.848
122+493	148.455		-.8058	4.238
487,488	181.4225		-.1221 x 2	2.0888
489,490	184.0338		-.86185	7.599
Sub Total	0	0	-265.24	1449.2
Correction*	931.5	931.5	-0.884	5.56 + 87.34
Total	931.5	931.5	-274.07	1542.1

Applied Loads(contd):

$$* \begin{cases} \text{Load correction} = \frac{143.5}{2} (113.7636 - 95.8664) = 1284.1 \\ \text{Moment correction} = \frac{143.5}{12 \cos 46.5} [113.7636 - 95.8664]^2 = 5564.54 \end{cases}$$

Internal Forces:

MEMBER	F_{x_1}	F_{x_2}	$F_{x_3} \cdot 10^2$	$F_{x_5} \cdot 10^3$
517	-4000	-610	290	-1560 - 375.033
34	-1210	-624	29.7	-50.4 - 95.124 - 47.396
35	4280	1230	-45.7	173 + 336.47 + 72.929
Total	-930	0	274	-1546

E.6.2 Section to the left of node 147

$x_1 = 34.7749$

$x_2 = 0$

$x_3 = 0$

Applied Loads

NODE	x_1 -coord.	F_{x_1}	$F_{x_3} \cdot 10^2$	$F_{x_5} \cdot 10^4$
Previous	95.86639	0	-265.24	144.92 + 162.04
91	85.8164		-45.618	-0.1364 + 23.284
92	73.7014		-26.9318	0.2498 + 10.489
93	71.9805		-61.065	-0.0739 + 22.7197
94	61.7928		-11.141	0.00606 + 3.010
95	58.9018		-28.644	-.1263 + 6.911
96	49.7466		-20.4	0.0318 + 3.054
97	41.6929		-16.095	0.0286 + 1.113
123	95.8664		-20.521	0.5509 + 12.536
124,125	111.8246		-1.556 x 2	2.3977
126,127	111.8246		-0.5952 x 2	0.9171
128,129	113.6381		-0.3162 x 2	0.4987
130+498	113.6381	0	-0.6323	0.4987
131	94.0767		-21.0195	-0.113 + 12.465
132,133	94.0767		-6.053 x 2	7.1795
134,135	131.477		-32.3815 x 2	62.627
138,139	93.6443		-1.374 x 2	1.6177
140,141	97.6711		0	0
142,143	99.8473		-0.5952 x 2	0.7746
144,145	99.8473		-2.532 x 2	3.2957
146	65.2346		-10.619	0.0585 + 3.2345
Sub Total		0	-614.063	484.075
Correction		348.3	-3.305	0.0804 + 1.0234
Total		348.3	-617.368	485.15

Load correction: x_1 -comp = 348.3, x_3 -comp = -330.5

Moment correction = 804.2

Internal Forces:

MEMBER	F_{x_1}	F_{x_2}	$F_{x_3} \cdot 10^2$	$F_{x_5} \cdot 10^4$
524	23900	-610	364	-181 + 70.222
58	-16500	-864	-400	18.3 - 23.492 + 63.833
59	-7920	1500	-38.1	-20.8 - 11.276 + 6.080
46	87.7	-28.2	695	-0.442 - 408.139
47	0	0	0	0
Total	-432.3*	-2.2	620.9	-486.714*

*These values are not quite accurate because of limited output accuracy.

Figure E.6-1 Bending Moments along LHM

Figure E-6-2 Bending Moments along Cradle Left Main Beam

Figure E.6-3 Bending Moments along Cradle Right Main Beam

Figure E.6-4 Bending Moments along Crossbeam #1

Figure E.6-5 Bending Moments along Crossbeam #2

Figure E.6-6 Bending Moments along Crossbeam #3

Figure E.6-7 Bending Moments along Crossbeam #4

Figure E.6-8 Bending Moments along Crossbeam #5

E.7 LOAD CASE 5E.7.1 Section to the left of node 102

$x_1 = 5.0$

$x_2 = 0$

$x_3 = 233.0$

Applied Loads:

NODE	F_{x_1}	$F_{x_3} \cdot 10^2$	F_{x_5}
101		-8.54	0
84		-12.1125	0
85		-30.245	0
86		-30.573	0
Total		-81.4708	

Internal Forces:

MEMBER	$F_{x_3} \cdot 10^2$	F_{x_5}
513	81.5	0

E.7.2 Section to the left of node 111

$x_1 = 5.0$

$x_2 = 0$

$x_3 = 183$

Applied Forces:

NODE	F_{x_1}	$F_{x_3} \cdot 10^2$	$F_{x_5} \cdot 10^2$
Previous		-81.4708	0
102		-41.7972	0
87		-69.425	0
103,104		-1.0811 x 2	47.5671
105,106		-0.2659 x 2	12.7653
107,108		-0.388 x 2	18.624
109,110		-0.1619 x 2	8.937
485,486		0	0
487,488		-0.1221 x 2	5.859
489	-135.8	-0.3238	8.936
490	135.8	-0.5381	14.85
Total	0	-197.59	117.54

Internal Forces:

MEMBER	F_{x_1}	$F_{x_3} \cdot 10^2$	$F_{x_5} \cdot 10^2$
514	-136	193	-82.8
11,12	67.9 x 2	2.18 x 2	30.6 x 2 - 95.92
Total	0	197.36	-117.52

E.7.3 Section to the left of node 147

$x_1 = 5.0$

$x_2 = 0$

$x_3 = 45.25$

Applied Loads:

NODE	F_{x_1}	$F_{x_3} \cdot 10^2$	$F_{x_5} \cdot 10^3$
Previous		-197.590	11.754
88		-10.834	0
89		-14.946	0
90		-26.663	-4.399
91		-45.618	0
92		-26.932	0
93		-61.065	0
94		-11.141	0
95		-28.644	0
96		-20.40	0
97		-16.095	0
111		-6.304	0
112,113		-2.141 x 2	9.418
114,115		-0.442 x 2	2.476
116,117		-0.442 x 2	3.361
118,119		-0.274 x 2	1.426
120+492 121+491		0.7462 x 2	2.116
122+493	± 150.35	.8058	2.064
123		-20.521	0
124,125		-1.556 x 2	6.846
126,127		-0.595 x 2	2.619
128,129		-0.362 x 2	1.549
130+498	± 4768	-0.633	1.550
131		-21.020	0
132,133		-6.053 x 2	0
134,135		-32.382 x 2	333.918
138,139		-2.111 x 2	8.023

Applied Loads:

NODE	F_{x_1}	$F_{x_3} \cdot 10^2$	$F_{x_5} \cdot 10^3$
140,141		0	0
142,143		-0.595×2	2.619
144,145		-2.532×2	11.142
146		-10.619	0
494,495		0	0
496,497		0	0
Total	0	-618.958	396.48

Internal Forces:

MEMBER	F_{x_1}	F_{x_2}	$F_{x_3} \cdot 10^2$	$F_{x_5} \cdot 10^3$
524	4780		591.0	87
58,59	2060×2	± 655	-88.7×2	$50.1 \times 2 + 390.28$
46,47	-4450×2	± 0.42	103×2	$851.29 - 1823.1$
Total	0	0	619.6	-394.34

Figure E.7-1 Bending Moments along Cradle Main Beam

Figure E.7-2 Bending Moments along Crossbeam #1

Figure E.7-3 Bending Moments along Crossbeam #2

Figure E.7-4 Bending Moments along Crossbeam #3

Figure E.7-5 Bending Moments along Crossbeam #4

Figure E.7-6 Bending Moments along Crossbeam #5

E.8 LOAD CASE 6E.8.1 Section to the left of node 111

$x_1 = 5.0$

$x_2 = 0$

$x_3 = 183$

Applied Forces:

NODE	F_{x_1}	$F_{x_3} \cdot 10^2$	$F_{x_5} \cdot 10^2$
Previous		-81.4708	0
102		-41.7972	0
87		-69.425	0
103,104		-1.0811 x 2	47.5671
105,106		-0.2659 x 2	12.7653
107,108		-0.388 x 2	18.624
109,110		-0.1619 x 2	8.937
485,486		0	0
487,488		-0.1221 x 2	5.859
489	-135.8	-0.3238	8.936
490	135.8	-0.5381	14.85
Total	0	-197.59	117.54

Internal Forces:

MEMBER	F_{x_1}	F_{x_2}	$F_{x_3} \cdot 10^2$	$F_{x_5} \cdot 10^2$
514	21.7	-94.1	193.0	-40.8
11	33.1	88.8	2.63	45.6 - 57.86
12	54.8	5.3	1.73	-63.1 - 38.06
Total	0	0	197.36	-117.5

E.8.2 Section to the left of node 147

$x_1 = 5.0$

$x_2 = 0$

$x_3 = 45.25$

Applied Loads:

NODE	F_{x_1}	$F_{x_3} \cdot 10^2$	$F_{x_5} \cdot 10^3$
Previous		-197.59	11.754
88		-10.834	0
89		-14.946	0
90		-26.663	-4.399
91		-45.618	0
92		-26.932	0
93		-61.065	0
94		-11.141	0
95		-28.644	0
96		-20.40	0
97		-16.095	0
111		-6.304	0
112,113		-2.141 x 2	9.418
114,115		-0.442 x 2	2.476
116,117		-0.442 x 2	3.361
118,119		-0.274 x 2	1.426
120+492		-0.746 x 2	2.116
121+491			
122+493	± 150.35	0.8058	2.06
123		-20.521	0
124,125		-1.556 x 2	6.846
126,127		-0.595 x 2	2.619
128,129		-0.362 x 2	1.549
130+498	± 4768	-0.633	1.550
131		-21.020	0
132,133		-6.053 x 2	0
134,135		-32.382 x 2	333.918
138,139		-2.111 x 2	8.023
140,141		0	0

Applied Loads:

NODE	F_{x_1}	$F_{x_3} \cdot 10^2$	$F_{x_5} \cdot 10^3$
142,143		-0.595×2	2.619
144,145		-2.532×2	11.142
146		-10.619	0
494,495		0	0
496,497		0	0
Total	0	-618.96	396.48

Internal Forces:

MEMBER	F_{x_1}	F_{x_2}	$F_{x_3} \cdot 10^2$	$F_{x_5} \cdot 10^3$
524	3800	-94.1	591.0	4.05
58	3380	-512	-128.0	79.9 + 281.6
59	193	609	-15.8	12.8 + 34.76
46,47	-7373	-2.3	17.1	704.94 - 151.34
Total	0	0	618.2	-395.30

Figure E.8-1 Bending Moments along Cradle Left Main Beam

Figure E.8-2 Bending Moments along Cradle Right Main Beam

Figure E.8-3 Bending Moments along Crossbeam #1

Figure E.8-4 Bending Moments along Crossbeam #2

Figure E.8-5 Bending Moments along Crossbeam #3

Figure E.8-6 Bending Moments along Crossbeam #4

Figure E.8-7 Bending Moments along Crossbeam #5

E.9 LOAD CASE 7E.9.1 Section to the left of node 123

$X_1 = 132.8325$

$X_2 = 0$

$X_3 = 18.3448$

Applied Loads:

NODE	F_{x_1}	F_{x_3}	F_{x_5}
84		-1209.23	-577.056 + 163862
85		-3014.39	-4765.90 + 387698
86		-3054.80	+4093.57 + 328817
87		-6936.96	+26144.2 + 353875
88		-1083.43	-1120.31 + 47586.8
89		-1488.49	+613.328 + 49693
90		-4865.57	-7989.95 + 124583
101		-847.760	118574
102		-4179.72	-24987.1 + 407506
103+104		-108.107 x 2	21906
106+106		-26.5944 x 2	5407.1
485+107 486+108		-38.93 x 2	7915.7
109,110		-16.1895 x 2	3312
111		-630.429	-135.667 + 30422
112,113		-214.052 x 2	22294
114,115		-44.2212 x 2	4697.9
503,504 116,117	-6073.46 x 2	+34400 x 2	+351215 - 3773969
118,119		-27.4185 x 2	2894
491,121 492,120		-74.6206 x 2	7875.5
122+493		-80.5807	4252
487,488		-12.2073 x 2	2482.1
489,490		-86.19117	8816.4
Sub Total	-12147	+40197.8	-1327009
Correction	319	-1809.3	+8243
Total	-11828	+38388.5	1318766

Internal Forces:

MEMBER		F_{x_1}	F_{x_2}	F_{x_3}	$F_{x_5} \cdot 10^3$
123	517	8200	0	-19100	927
(125,124)	34,35	1810×2	± 62.2	-9630×2	$199 \times 2 \begin{matrix} -78.43 \\ +73.577 \end{matrix}$
Total		+11820	0	-38360	1320.147

E.9.2 Section to the left of node 147

$x_1 = 34.7749$

$x_2 = 0$

$x_3 = 0$

Applied Loads:

NODE	F_{x_1}	F_{x_3}	F_{x_5}
Previous	-12147	+40197.8	-1327009-187200-3513356
91		-4554.52	-1952.10 + 332587
92		-2681.95	+3574.33 + 149360
93		-6078.16	-1057.43 + 323534
94		-1105.08	+86.6762 + 42715
95		-2857.43	-1807.20 + 98631
96		-2037.23	+455.638 + 43637
97		-1604.54	+408.792 + 15881
123		-2052.05	+7881.41 + 179353
124,125		-155.593 x 2	28387
126,127		-59.5157 x 2	10858
128,129		-31.6159 x 2	5796
130+498		-63.2664	5798.7
131		-2101.95	-1616.23 + 178332
132,133		-605.337 x 2	102715
134,135		-3238.15 x 2	607441
138,139		-60.2117 x 2	8165
140,141			
142,143		-59.5157 x 2	8818.6
144,145		-253.232 x 2	37522
146		-1061.90	+836.614 + 46275
Sub Total	-12147	5073.4	-2794949
Correction	+119	-676.4	+1151
Total	12028	4397	-2793798

Internal Forces:

MEMBER		F_{x_1}	F_{x_2}	F_{x_3}	$F_{x_5} \cdot 10^3$
147	524	8400	0	13600	767
(148,149)	58,59	8810×2	± 619	7330×2	$75 \times 2 - 381.751 - 56.0$
(136,137)	46,47	-7000×2	± 14.7	-16300×2	$0 + 746.67 + 1567.056$
Total		12020	0	-4340	2792970

Figure E.9-1 Bending Moments along the Cradle Main Beam

Figure E.9-2 Bending Moments along Crossbeam #1

Figure E.9-3 Bending Moments along Crossbeam #2

Figure E.9-4 Bending Moments along Crossbeam #3

Figure E.9-5 Bending Moments along Crossbeam #4

Figure E.9-6 Bending Moments along Crossbeam #5

E.10 LOAD CASE 8E.10.1 Section to the left of node 123

$$X_1 = 132.8325$$

$$X_x = 0$$

$$X_3 = 18.3448$$

Applied Loads:

NODE	F_{X_1}	F_{X_3}	F_{X_5}
84	-1209.23		+101.751 - 28893
85	-3014.39		-340.356 - 68362
86	-3054.80		-721.806 - 57979
87	-6936.96		-4609.93 - 62398
88	-1083.43		+197.542 - 8391
89	-1488.49		-108.146 - 8762
90	-2661.57		-3058.22 - 12017
101	-847.760		-20908
102	-4179.72		+4405.91 - 71854
103+104	-108.107 x 2		+967.47
105+106	-26.5944 x 2		+342.76
485+107 486+108	-38.9316 x 2		+501.77
109,110	-16.1895 x 2		+323.45
111	-630.429		+23.9218 - 5364.2
112,113	-214.052 x 2		+5632.6
114,115	-44.2212 x 2		1686
116,117	-44.2212 x 2		+2557
118,119	-27.4185 x 2		937.5
491+121 492+120	-74.6297 x 2		2551.8
122+493	-80.5807		1377.6
487,488	-12.2073 x 2		157.3
489,490	-86.1844		860.9
Sub Total	-26486		-329791
Correction		+319	-1431
Total	-26486	319	-331222

$$\text{Load Correction} = [143.5 (158.4375 - 132.8325)/2] \sin 10^\circ = 319$$

$$\text{Moment Correction} = \frac{(143.5) \sin 10^\circ}{\cos 10^\circ} (158.4375 - 132.8325)^2 / 12 = 1431$$

Internal Forces:

MEMBER	F_{x_1}	F_{x_2}	F_{x_3}	$F_{x_5} \cdot 10^3$
517	24600	0	3160	254
34,35	963×2	± 186	-1740×2	$52.9 \times 2 - 41.728$ $+13.294$
Total	26526		-320	331.366

E.10.2 Section to the left of node 147

$$x_1 = 45.43079$$

$$x_2 = 0$$

$$x_3 = 2.9335$$

Applied Loads:

NODE	F_{x_1}	F_{x_3}	F_{x_5}
Previous	-26486		-329791 - 408183
91	-4554.52		+344.208 - 58644
92	-2681.95		-630.252 - 26336
93	-6078.16		+186.453 - 57048
94	-1105.08		-15.2834 - 7532
95	-2857.43		+318.659 - 17391
96	-2037.23		-80.3412 - 7694
97	-1604.54		-72.0811 - 2800
123	-2052.05		-1389.71 - 31625
124,125	-155.593 x 2		+1946.3
126,127	-59.5157 x 2		+744.5
128,129	-31.6159 x 2		+551.2
130+498	-63.26636		+551.46
131	-2102.95		+284.985 - 31445
132,133	-605.337 x 2		-18111
134,135	-3238.15 x 2		+231960
138,139	-60.2117 x 2		+883.6
140,141			
142,143	-59.5157 x 2		1104
144,145	-253.232 x 2		+4698
146	-1061.90		-147.518 - 8159.6
Sub Total	61610		-763570
Correction		119.3	-120
Total	61610	119.3	-763690

$$\text{Load Correction} = (138.8)(\sin 10)(55.32811 - 45.4308)/2 = 119.3$$

$$\text{Moment Correction} = \frac{(138.8)(\sin 10)}{\cos 10} (55.32811 - 45.4308)^2/12 = 120$$

Internal Forces:

MEMBER	F_{x_1}	F_{x_2}	F_{x_3}	$F_{x_5} \cdot 10^3$
524	58400		3360	363
58,59	3190×2	± 39.7	1940×2	$15.8 \times 2 - 138228$ -14823
46,47	-1580×2	± 3.16	-3680×2	$0 + 168534 + 353789$
Total	61620	0	-120	763873

Figure E.10-1 Bending Moments along the Cradle Main Beam

Figure E.10-2 Bending Moments along Crossbeam #1

Figure E.10-3 Bending Moments along Crossbeam #2

Figure E.10-4 Bending Moments along Crossbeam #3

Figure E.10-5 Bending Moments along Crossbeam #4

Figure E.10-6 Bending Moments along Crossbeam #5

E.11 LOAD CASE 11E.11.1 Section to the left of node 102

$$x_1 = 230.3284''$$

$$x_2 = 0$$

$$x_3 = 0$$

Applied Loads:

NODE	F_{x_1}	F_{x_3}	F_{x_5}
101		-897.760	38039.35
84		-1255.01	-577 + 47707.46
85		-3024.53	-4765.9 + 94123.37
86		-3057.30	4093.57 + 31012.23
Sub Total		-8234.6	209603
Correction*	+126.4	-716.7	1249.4
Total	+126.4	-8951.3	210852

Internal Forces:

MEMBER	F_{x_1}	F_{x_3}	F_{x_5}
513	-126.0	8950	-211000

$$* \begin{cases} \text{Load Correction} = (143.5) \left(\frac{240.472 - 230.3284}{2} \right) = 727.8 \\ \text{Moment Correction} = \frac{(143.5)}{\cos 10^\circ} \left(\frac{(240.472 - 230.3284)^2}{12} \right) = 1249.4 \end{cases}$$

E.11.2 Section to the left of node 111

$x_1 = 181.0881$

$x_2 = 0$

$x_3 = 0$

Applied Loads:

NODE	F_{x_1}	$F_{x_3} \cdot 10^2$	$F_{x_5} \cdot 10^4$
Previous		-82.346	20.9603 40.547
102		-41.2563	-2.49871 20.3147
87		-69.425	2.61442 1.91433
103,104		-1.0811 x 2	1.147276
487,488		-0.122073 x 2	0.13039
105,106		-.26594 x 2	.2840702
107,108		-.388014 x 2	.3821
489,490		-0.34	.1674
109,110		-.161895 x 2	.174952
Sub Total		-197.407	85.909
Correction*	34.3	-1.948	+.00923
Total	34.3	-199.355	85.919

Internal Forces:

MEMBER	F_{x_1}	F_{x_2}	$F_{x_3} \cdot 10^2$	$F_{x_5} \cdot 10^4$
514	-164	0	202	-87.6 - 0.4431
11	64.9	51.5	-1.5	0.790 + 0.034 + 0.058
12	64.9	-51.5	-1.5	0.790 + 0.034 + 0.058
Total	-34.2	0	200	-86.28

$$* \begin{cases} \text{Load Correction} = 143.5(183.8455 - 181.0881)/2 = 197.8 \\ \text{Moment Correction} = 143.5(183.8455 - 181.0881)^2/12 = 92.3 \end{cases}$$

E.11.3 Section to the left of node 123

$x_1 = 132.8325$

$x_2 = 0$

$x_3 = 0$

Applied Loads:

NODE	F_{x_1}	$F_{x_3} \cdot 10^2$	$F_{x_5} \cdot 10^4$
Previous		-197.407	85.909 95.260
111		-6.16600	-.01357 2.975
88		-10.8343	-.112031 4.75868
89		-14.9455	-.006133 4.98956
90		-26.6633	-.798995 6.827138
112,113		-2.14052 x 2	2.229386
114,115		-.442212 x 2	.469786
116,117		-.442212 x 2	.485144
118,119		-.274185 x 2	.289377
120,121 491,492		-.74634 x 2	.7203
122		-.8058	.3888
Sub Total		-264.911	204.35
Correction*	+319.02	-18.093	.8243
Total		-283.000	205.175

$$* \begin{cases} \text{Load Correction} = 143.5(158.4375 - 132.8325)/2 = 1837.2 \\ \text{Moment Correction} = \frac{143.5}{\cos 10} (158.4375 - 132.8325)^2/12 = 8243 \end{cases}$$

Internal Forces:

MEMBER	F_{x_1}	F_{x_2}	$F_{x_3} \cdot 10^2$	$F_{x_5} \cdot 10^4$
517	-991	0	308	-219 - 1.8179
34	336	-801	-12.5	7.07 - 0.1082 + 0.4776
35	336	801	-12.5	7.07 - 0.1082 + 0.4776
Total	-319	0	283	-205.9472

E.11.4 Section to the left of node 147

$x_1 = 45.43079$

$x_2 = 0$

$x_3 = 0$

Applied Loads:

NODE	F_{x_1}	$F_{x_3} \cdot 10^2$	$F_{x_5} \cdot 10^4$
Previous		-264.911	204.35 231.537
123		-20.5205	.788141 + 17.9353
131		-21.0195	-.161623 + 17.8332
91		-45.618	-.195210 + 33.3119
92		-26.9317	.357433 + 14.9985
93		-61.0653	-.105743 + 32.5044
146		-10.619	.008366 + 4.62752
94		-11.141	.008670 + 4.30641
95		-28.6437	-.180720 + 9.88709
96		-20.4	.004560 + 4.36959
97		-16.0945	.004090 + 1.59292
124,125		-1.5559 x 2	2.83864
126,127		-.59516 x 2	1.08583
130,498		-.637	0.55674
132,133		-6.05337 x 2	10.27151
134,135		-32.38150 x 2	60.74414
138,139		-60212 x 2	.81652
142,143		-.59516 x 2	.88186
144,145		-2.53232 x 2	3.752205
Sub Total		-616.252	659.436
Correction*	+119.27	-6.76435	.11505
Total	+119.27	-623.016	659.551

$$* \begin{cases} \text{Load Correction} = 138.8(55.32811 - 45.43079)/2 = 686.87 \\ \text{Moment Correction} = \frac{138.8}{\cos 10^\circ} (55.32811 - 45.43079)^2/12 = 1150.514 \end{cases}$$

Internal Forces:

MEMBER	F_{x_1}	F_{x_2}	$F_{x_3} \cdot 10^2$	$F_{x_5} \cdot 10^4$
524	8330		118	-220 + 2.4435
58,59	-20400 x 2	± 933	-125 x 2	-104 x 2 + 76.4275 + 9.5508
46,47	16200 x 2	± 8.26	378 x 2	-163.296 - 363.403
Total	-70	0	624	-660.35

Figure E.11-1 Bending Moments along the Cradle Main Beam

Figure E.11-2 Bending Moments along Crossbeam #1

Figure E.11-3 Bending Moments along Crossbeam #2

Figure E.11-4 Bending Moments along Crossbeam #3

Figure E.11-5 Bending Moments along Crossbeam #4

Figure E.11-6 Bending Moments along Crossbeam #5

E.12 LOAD CASE 12E.12.1 Section to the left of node 111

$x_1 = 181.0881''$

$x_2 = 0$

$x_3 = 0''$

NODE	x_1	x_2	x_3	$x_5 \cdot 10^4$
Previous			-8234.6	20.9603 40.547
102			-4125.63	-2.4987 +20.581
87			-6942.50	2.6144 1.9143
103,104			-108.107 x 2	1.14727
105,106			-26.59 x 2	0.28407
107+485			-38.89	0.1915
108+486			-38.89	0.1915
109,110			-16.1895 x 2	-0.05459
487,488			-12.2073 x 2	0.13039
489,490			-34	0.1674
Sub Total			-19740.7	85.909
Correction*	+34.3		-194.8	.0092
Total	34.3		-19935.5	85.919

Internal Forces:

MEMBER	F_{x_1}	F_{x_2}	F_{x_3}	$F_{x_5} \cdot 10^4$
514	79.9	-757	18800	-80.6000 + 0.2145
11	380.0	439	120	285 + 0.197
12	-494.0	318	964	-8.3 - .2563 - .4122
Total	-34.1	0	19984	-84.285

$$* \begin{cases} \text{Load Correction} = 143.5 \frac{(183.8455 - 181.0881)}{2} = 197.8 \\ \text{Moment Correction} = 92.3 \end{cases}$$

E.12.2 Section to the left of node 123

$X_1 = 132.8325$

$X_2 = 0$

$X_3 = 0$

Applied Loads:

NODE	F_{x_1}	$F_{x_3} \cdot 10^2$	$F_{x_5} \cdot 10^4$
Previous		-197.407	85.909 95.2599
111		-6.166	-.01357 3.0422
88		-10.834	-.11203 4.75869
89		-14.9455	.061333 4.98956
90		-26.6633	-.79899 6.82714
112,113		-2.1405 x 2	2.22939
114,115		-.442212 x 2	.46979
116,117		-.442212 x 2	.485144
118,119		-.274185 x 2	.28938
120,121 +		-.74589 x 2	.71987
491,492			
122+493		-.80525	.38858
Sub Total		-264.911	204.513
Correction*	319.0195	-18.0925	.82433
Total	319.0195	-283.0	205.330

$$* \begin{cases} \text{Load Correction} = 143.5 (158.4375 - 132.8325)/2 = 1837.16 \\ \text{Moment Correction} = \frac{143.5}{\cos 10^\circ} (158.4375 - 132.8325)^2/12 = 8243.3 \end{cases}$$

Internal Forces:

MEMBER	F_{x_1}	F_{x_2}	$F_{x_3} \cdot 10^2$	$F_{x_5} \cdot 10^4$
517	-1370	-757	330	-223 - 2.5132
34	335	-427	44.3	-8.04 + 0.1079 - 1.6925
35	719	1180	-90.9	25.9 + 0.239 + 3.4805
Total	-316	4	283.4	-205.505

E.12.3 Section to the left of node 147

$x_1 = 45.43079$

$x_2 = 0$

$x_3 = 0$

Applied Loads:

NODE	F_{x_1}	F_{x_2}	$F_{x_3} \cdot 10^2$	$F_{x_5} \cdot 10^4$
Previous			-264.911	204.513 231.5368
123			-20.5205	.78814 17.93527
124,125			-1.55593 x 2	2.8387
126,127			-.59516 x 2	1.08583
128,129			-.31633 x 2	.57987
130+498			-.6326	.5529
131			-21.0195	-.161623 17.8332
132,133			-6.05337 x 2	10.27151
134,135			-32.38150 x 2	60.74414
138			-.602117	.40826
139			0	.40826
142,143			-.59516 x 2	.88186
144,145			-2.53232 x 2	3.75221
146			-10.619	.083661 4.62752
91			-45.618	-.19521 33.3119
92			-26.9317	.357433 14.99851
93			-61.0653	-.105743 32.5044
94			-11.141	.00867 4.30641
95			-28.6437	-.18072 9.88709
96			-20.4	.045564 4.36959
97			-16.0945	.048792 + 1.5929
Sub Total			-616.252	659.5998
Correction*	119.3		-67.64	.11505
Total	119.3		-623.016	659.7146

$$* \begin{cases} \text{Load Correction} = 138.8(55.32811 - 45.43079)/2 = 686.87 \\ \text{Moment Correction} = \frac{138.8}{\cos 10^\circ} (55.32811 - 45.43079)^2/12 = 1150.5 \end{cases}$$

Internal Forces:

MEMBER	F_{x_1}	F_{x_2}	$F_{x_3} \cdot 10^2$	$F_{x_5} \cdot 10^4$
524	8420	-757	113	-219 + 2.4436
58	-31800	-431	-279	28.3 + 59.5716 + 10.659
59	-9130	1410	33.2	-30.8 + 17.103 - 1.2683
46	32400	-217	755	-163.296 - 363.403
Total	-110	4	622.2	-659.62

E.12.4 Section to the left of node 159

$X_1 = 32.62829$

$X_2 = 0$

$X_3 = 0$

Applied Loads:

NODE	F_{x_1}	$F_{x_3} \cdot 10^2$	$F_{x_5} \cdot 10^4$
Previous		-616.252	659.5998 78.8957
147		-15.9967	-.077456 2.04798
148,149		-2.83816 x 2	.94356
152,153		-.214924 x 2	.00753
154+499		-.80215	.1027
500+502 501+503		-.68763 x 2	.17607
Sub Total		-640.532	741.6957
Correction*	154.3	-8.75	.1925
Total	154.3	-649.282	741.8883

$$* \begin{cases} \text{Load Correction} = 138.8(45.43079 - 32.62829)/2 = 888.5 \\ \text{Moment Correction} = \frac{138.8}{\cos 10^\circ} (45.43079 - 32.62829)^2/12 = 1925 \end{cases}$$

Internal Forces:

MEMBER	F_{x_1}	F_{x_2}	$F_{x_3} \cdot 10^2$	$F_{x_5} \cdot 10^4$
77	15900	-758	-295	-176 + 1.075
71	-33500	-775	-38.6	-1.15 + 75.107 - 1.661
72	-15000	1750	228	-58.9 + 33.63 + 9.814
46	32400	217	755	0 - 163.296 - 459.58
Total	200**	0	649.4	-740.963

**These values are not quite accurate due to limited accuracy available on the output.

Figure E.12-1 Bending Moments along the Cradle Left Main Beam

Figure E.12-2 Bending Moments along the Cradle Right Main Beam

Figure E.12-3 Bending Moments along Crossbeam #1

Figure E.12-4 Bending Moments along Crossbeam #2

Figure E.12-5 Bending Moments along Crossbeam #3

Figure E.12-6 Bending Moments along Crossbeam #4

Figure E.12-7 Bending Moments along Crossbeam #5

E.13 LOAD CASE 13E.13.1 Section to the left of node 123

$x_1 = 95.86639$

$x_2 = 0$

$x_3 = 0$

Applied Loads:

NODE	x_1 -Coord.	F_{x_1}	$F_{x_3} \cdot 10^2$	$F_{x_5} \cdot 10^3$
84	190.584		-12.5501	-.4033 + 118.8715
85	185.7655		-30.245	-3.3312 + 271.9026
86	171.1036		-30.573	2.8613 + 230.0227
87	131.5232		-69.425	18.274 + 247.5474
88	126.5670		-10.8343	-.7831 + 33.2632
89	119.2016		-14.9455	.4287 + 34.8756
90	113.7636		-26.6633	-8.2419 + 47.7798
101	193.63		-8.978	87.772
102	164.0135		-41.2563	-17.4563 + 281.15
103+104	179.9717		-1.0811 x 2	18.1847
105+106	181.4225		-.2659 x 2	4.5506
485+107 486+108	181.4225		-.3880 x 2	6.6395
109,110	184.0338		-.1619 x 2	2.8548
111	129.5958		-6.166	-0.0948 + 20.798
112,113	145.554		-2.1405	21.2714
114,115	149.9062		-.4422 x 2	4.7794
116,117	157.16		-.4422 x 2	5.421
118,119	148.4555		-.2742 x 2	2.8838
491+121 492+120	148.4555		-.6770 x 2	7.120
122+493	148.455		-.8058	4.238
487,488	181.4225		-.1221 x 2	2.0888
489,490	184.0338		-.86185	7.599
Sub Total			-265.839	1452.75
Correction*	931.5	931.5	-.0884	5.56 + 87.34
Total	931.5	931.5	-274.669	1545.65

$$* \begin{cases} \text{Load Correction} = \frac{143.5}{2} (113.7636 - 95.8664) = 1284.1 \\ \text{Moment Correction} = \frac{143.5}{12 \cos 46.5} [113.7636 - 95.8664]^2 = 5564.54 \end{cases}$$

Internal Forces

MEMBER	F_{x_1}	$F_{x_3} \cdot 10^2$	$F_{x_5} \cdot 10^3$
517	-2860	279.0	-1530 - 268.15
34,35	964×2	-2.59×2	$46.8 \times 2 + 151.57 + 8.266$
	932	273.8	-1544.7

E.13.2 Section to the left of node 147

$x_1 = 34.7749$

$x_2 = 0$

$x_3 = 0$

Applied Loads

NODE	x_1 -Coord.	F_{x_1}	$F_{x_3} \cdot 10^2$	$F_{x_5} \cdot 10^4$
Previous	95.86639		-265.839	145.28 + 162.41
91	85.8164		-45.618	-0.1364 + 23.284
92	73.7014		-26.9318	0.2498 + 10.489
93	71.9805		-61.065	-0.0739 + 22.7197
94	61.7928		-11.141	0.00606 + 3.010
95	58.9018		-28.644	-.1263 + 6.911
96	49.7466		-20.4	0.0318 + 3.054
97	41.6929		-16.095	0.0286 + 1.113
123	95.8664		-20.521	0.5509 + 12.536
124,125	111.8246		-1.556 x 2	2.3977
126,127	111.8246		-0.5952 x 2	0.9171
128,129	113.6381		-0.3162 x 2	0.4987
130+498	113.6381		-0.6323	0.4987
131	94.0767		-21.0195	-0.113 + 12.465
132,133	94.0767		-6.053 x 2	7.1795
134,135	131.477		-32.3815 x 2	62.627
138,139	93.6443		-1.374 x 2	1.6177
140,141	97.6711		0	0
142,143	99.8473		-0.5952 x 2	0.7746
144,145	99.8473		-2.532 x 2	3.2957
146	65.2346		-10.619	0.0585 + 3.2345
Sub Total		0	-614.663	484.805
Correction		348.3	-3.305	-.0804 + 1.0234
Total		348.3	-617.968	485.88

Correction between node 97 and 147

$$\text{Load Correction} = \frac{138.8}{2} (41.6929 - 34.7749) = 480.1$$

$$x_1\text{-component} = 348.3 \quad x_3\text{-component} = 330.5$$

$$\text{Moment Correction} = \frac{138.8}{12 \cos 46.5} [41.6929 - 34.7749] = 804.2$$

Internal Forces

MEMBER	F_{x_1}	F_{x_2}	$F_{x_3} \cdot 10^2$	$F_{x_5} \cdot 10^4$
524	23600	0	366	-182 + 69.340
58,59	-12000 x 2	± 1190	-220 x 2	-0.900 x 2 - 34.17 + 70
46,47	-43.9 x 2	± 1.58	347 x 2	-0.443 - 407.552
Total	487*	0	620	-486.41

*These values are not quite accurate because of limited output accuracy.

Figure E.13-1 Bending Moments along the Cradle Main Beam

Figure E.13-2 Bending Moments along Crossbeam #1

Figure E.13-3 Bending Moments along Crossbeam #2

Figure E.13-4 Bending Moments along Crossbeam #3

Figure E.13-5 Bending Moments along Crossbeam #4

Figure E.13-6 Bending Moments along Crossbeam #5

E.14 LOAD CASE 14E.14.1 Section to the left of node 123

$x_1 = 95.86639$

$x_2 = 0$

$x_3 = 0$

Applied Loads:

NODE	x_1 -coord.	F_{x_1}	$F_{x_3} \cdot 10^2$	$F_{x_5} \cdot 10^3$
84	190.584		-12.5501	-.4033 + 118.8715
85	185.7655		-30.245	-3.3312 + 271.9026
86	171.1036		-30.573	2.8613 + 230.0227
87	131.5232		-69.425	18.2740 + 247.5474
88	126.5670		-10.8343	-.7831 + 33.2632
89	119.2016		-14.9455	0.4287 + 34.8756
90	113.7636		-26.6633	-8.2419 + 47.7798
101	193.63		-8.97760	87.768
102	164.0135		-41.2563	-17.4653 + 281.150
103+104	179.9717		-1.0811 x 2	18.1847
105+106	181.4225		-.2659 x 2	4.5506
485+107 486+108	181.4225		-.3880 x 2	6.6395
109,110	184.0338		-.1619 x 2	2.8548
111	129.5958		-6.166	-0.0948 + 20.796
112,113	145.554		-2.1405	21.2714
114,115	149.9062		-.4422 x 2	4.7794
116,117	157.16		-.4422 x 2	5.421
118,119	148.4555		-.2742 x 2	2.8838
491+121 492+120	148.4555		-.7462 x 2	7.848
122+493	148.455		-.8058	4.238
487,488	181.4225		-.1221 x 2	2.0888
489,490	184.0338		-.86185	7.599
Sub Total	0	0	-265.436	1453.47
Correction*	931.5	931.5	-0.884	5.56 + 87.34
Total	931.5	931.5	-274.266	1546.37

Applied Loads(contd):

$$* \begin{cases} \text{Load Correction} = \frac{143.5}{2} (113.7636 - 95.8664) = 1284.1 \\ \text{Moment Correction} = \frac{143.5}{12 \cos 46.5} [113.7636 - 95.8664]^2 = 5564.54 \end{cases}$$

Internal Forces:

MEMBER	F_{x_1}	F_{x_2}	$F_{x_3} \cdot 10^2$	$F_{x_5} \cdot 10^3$
517	-3990	-609	290	-1550 - 374.095
34	-1210	-623	29.6	-50.4 - 95.124 - 47.236
35	<u>4270</u>	<u>1230</u>	<u>-45.6</u>	<u>172 + 335.684 + 72.769</u>
Total	-930	2	274	-1536.4

E.14.2 Section to the left of node 147

$x_1 = 34.7749$

$x_2 = 0$

$x_3 = 0$

Applied Loads:

NODE	x_1 -coord.	F_{x_1}	$F_{x_3} \cdot 10^2$	$F_{x_5} \cdot 10^4$
Previous	95.86639		-265.436	145.347 + 162.16
91	85.8164		-45.618	-0.1364 + 23.284
92	73.7014		-26.9318	0.2498 + 10.489
93	71.9805		-61.065	-0.0739 + 22.7197
94	61.7928		-11.141	0.00606 + 3.010
95	58.9018		-28.644	-.1263 + 6.911
96	49.7466		-20.4	0.0318 + 3.054
97	41.6929		-16.095	0.0286 + 1.113
123	95.8664		-20.521	0.5509 + 12.536
124,125	111.8246		-1.556 x 2	2.3977
126,127	111.8246		-0.5952 x 2	0.9171
128,129	113.6381		-0.3162 x 2	0.4987
130+498	113.6381		-0.6323	0.4987
131	94.0767		-21.0195	-0.113 + 12.465
132,133	94.0767		-6.0530 x 2	7.1795
134,135	131.477		-32.3815 x 2	62.627
138,139	93.6443		-1.3740 x 2	1.6177
140,141	97.6711		0	0
142,143	99.8473		-0.5952 x 2	0.7746
144,145	99.8473		-2.5320 x 2	3.2957
146	65.2346		-10.619	0.0585 + 3.2345
Sub Total			-614.259	484.622
Correction*		348.3	-3.305	0.0804 + 1.0234
Total		348.3	-617.564	485.697

Load Correction: x_1 -comp = 348.3, x_3 -comp = -330.5

Moment Correction = 804.2

Internal Forces:

MEMBER	F_{x_1}	F_{x_2}	$F_{x_3} \cdot 10^2$	$F_{x_5} \cdot 10^4$
524	23900	-609	364	-181 + 70.222
58	-16400	-863	-399	18.3 - 23.350 + 63.673
59	-7910	1500	38	-20.8 - 11.262 + 6.064
46	87.6	-27.9	694	-0.441 - 407.55
47	0	0	0	0
Total	-322.4	-0.1	621.0*	-486.144

*These values are not quite accurate because of limited output accuracy.

Figure E.14-1 Bending Moments along the Cradle Left Main Beam

Figure E.14-2 Bending Moments along the Cradle Right Main Beam

Figure E.14-3 Bending Moments along Crossbeam #1

Figure E.14-4 Bending Moments along Crossbeam #2

Figure E.14.5 Bending Moments along Crossbeam #3

Figure E.14-6 Bending Moments along Crossbeam #4

Figure E.14-7 Bending Moments along Crossbeam #5

E.15 LOAD CASE 15E.15.1 Section to the left of node 102

$x_1 = 5.0$

$x_2 = 0$

$x_3 = 233.0$

Applied Loads:

NODE	F_{x_1}	$F_{x_3} \cdot 10^2$	F_{x_5}
101		-8.978	0
84		-12.5501	0
85		-30.245	0
86		-30.573	0
Total		-82.346	0

Internal Forces:

MEMBER	$F_{x_3} \cdot 10^2$	F_{x_5}
513	82.3	0

E.15.2 Section to the left of node 111

$x_1 = 5.0$

$x_2 = 0$

$x_3 = 183$

Applied Forces:

NODE	F_{x_1}	$F_{x_3} \cdot 10^2$	$F_{x_5} \cdot 10^2$
Previous		-82.346	0
102		-41.2563	0
87		-69.425	0
103,104		-1.0811 x 2	47.5671
105,106		-0.2659 x 2	12.7653
107,108		-0.3880 x 2	18.624
109,110		-0.1619 x 2	8.937
485,486		0	0
487,488		-0.1221 x 2	5.859
489	-33.86	-0.3238	8.936
490	33.86		
Total	0	197.38	102.69

Internal Forces:

MEMBER	F_{x_1}	$F_{x_3} \cdot 10^2$	$F_{x_5} \cdot 10^2$
514	-33.9	193	-16.9
11,12	16.9 x 2	2.18 x 2	5.1 x 2 - 95.92
Total	0	197.36	-102.62

E.15.3 Section to the left of node 147

$x_1 = 5.0$

$x_2 = 0$

$x_3 = 45.25$

Applied Loads:

NODE	F_{x_1}	$F_{x_3} \cdot 10^2$	$F_{x_5} \cdot 10^3$
Previous		197.38	10.269
88		-10.834	0
89		-14.946	0
90		-26.663	-4.339
91		-45.618	0
92		-26.932	0
93		-61.065	0
94		-11.141	0
95		-28.644	0
96		-20.40	0
97		-16.095	0
111		-6.166	0
112,113		-2.141 x 2	9.418
114,115		-0.442 x 2	2.476
116,117		-0.442 x 2	3.361
118,119		-0.274 x 2	1.426
120+492		-0.6771 x 2	1.92
121+491			
122+493	± 437.25	.8058	2.064
123		-20.521	0
124,125		-1.556 x 2	6.846
126,127		-0.595 x 2	2.619
128,129		-0.316 x 2	1.352
130+498	± 1177	-0.633	1.550
131		-21.020	0
132,133		-6.053 x 2	0
134,135		-32.382 x 2	333.918
138,139		-2.111 x 2	8.023
140,141		0	0

Applied Loads:

NODE	F_{x_1}	$F_{x_3} \cdot 10^2$	$F_{x_5} \cdot 10^3$
142,143		-0.595×2	2.619
144,145		-2.532×2	11.142
146		-10.619	0
494,495		0	0
496,497		0	0
Total	0	-618.518	394.6

Omt

Internal Forces:

MEMBER	F_{x_1}	F_{x_2}	$F_{x_3} \cdot 10^2$	$F_{x_5} \cdot 10^3$
524	1580		591.0	-171
58,59	1250×2	± 655	32.8×2	$39 \times 2 + 144.32$
46,47	2040×2	± 0.42	47.4×2	$390.25 - 838.98$
Total	0	0	620.2	397.41

Figure E.15-1 Bending Moments along the Cradle Main Beam

Figure E.15-2 Bending Moments along Crossbeam #1

Figure E.15-3 Bending Moments along Crossbeam #2

Figure E.15-4 Bending Moments along Crossbeam #3

Figure E.15-5 Bending Moments along Crossbeam #4

Figure E.15-6 Bending Moments along Crossbeam #5

E.16 LOAD CASE 16E.16.1 Section to the left of node 102Applied Loads

NODE	F_{x_1}	$F_{x_3} \cdot 10^2$	$F_{x_5} \cdot 10^2$
84		-12.550	0
85		-30.245	0
86		-30.573	0
101		-8.978	0
Total	0	-82.346	0

Internal Forces

MEMBER	F_{x_1}	F_{x_2}	$F_{x_3} \cdot 10^2$	$F_{x_5} \cdot 10^2$
513	0	0	82.3	0

E.16.2 Section to the left of node 111

$x_1 = 5.0$

$x_2 = 0$

$x_3 = 183$

Applied Forces

NODE	F_{x_1}	$F_{x_3} \cdot 10^2$	$F_{x_5} \cdot 10^2$
Previous		-82.346	0
102		-41.2563	0
87		-69.425	0
103,104		-1.0811×2	47.5671
105,106		-0.2659×2	12.7653
107,108		-0.388×2	18.624
109,110		-0.1619×2	8.937
485,486		0	0
487,488		-0.1221×2	5.859
489		-0.3238	8.936
490		0	0
Total		-197.38	102.69

Internal Forces

MEMBER	F_{x_1}	F_{x_2}	$F_{x_3} \cdot 10^2$	$F_{x_5} \cdot 10^2$
514	35.1	-58.8	193.0	17.6
11	4.67	62.4	2.45	17.1 - 53.9
12	-39.8	-3.6	1.91	-41.4 - 42.02
Total	0	0	197.45	-102.62

E.16.3 Section to the left of node 147

$x_1 = 5.0$

$x_2 = 0$

$x_3 = 45.25$

Applied Loads

NODE	F_{x_1}	$F_{x_3} \cdot 10^2$	$F_{x_5} \cdot 10^3$
Previous		-197.38	10.269
88		-10.834	0
89		-14.946	0
90		-26.663	-4.399
91		-45.618	0
92		-26.932	0
93		-61.065	0
94		-11.141	0
95		-28.644	0
96		-20.40	0
97		-16.095	0
111		-6.166	0
112,113		-2.141 x 2	9.418
114,115		-0.442 x 2	2.476
116,117		-0.442 x 2	3.361
118,119		-0.274 x 2	1.426
120+492		-0.677 x 2	1.92
121+491			
122+493	± 1605.7	-0.8058	2.06
123		-20.521	0
124,125		-1.556 x 2	6.846
126,127		-0.595 x 2	2.619
128,129		-0.3163 x 2	1.353
130+498	± 1285	-0.633	1.550
131		-21.020	0
132,133		-6.053 x 2	0
134,135		-32.382 x 2	333.918
138,139		-2.111 x 2	8.023
140,141		0	0

Applied Loads

NODE	F_{x_1}	$F_{x_3} \cdot 10^2$	$F_{x_5} \cdot 10^3$
142,143		-0.595×2	2.619
144,145		-2.532×2	11.142
146		-10.619	0
494,495		0	0
496,497		0	0
Total	0	618.43	394.6

Internal Forces

MEMBER	F_{x_1}	F_{x_2}	$F_{x_3} \cdot 10^2$	$F_{x_5} \cdot 10^3$
524	1580	-58.8	591.0	-173
58	2110	-313	-63.9	$57.2 + 140.6$
59	361	373	-3.09	$20.2 + 6.8$
46,47	-4060	-1.3	94	$388.34 - 831.92$
Total	-9	0	618.0	-391.78

Figure E.16-1 Bending Moments along the Cradle Left Main Beam

Figure E.16-2 Bending Moments along the Cradle Right Main Beam

Figure E.16-3 Bending Moments along Crossbeam #1

Figure E.16-4 Bending Moments along Crossbeam #2

Figure E.16-5 Bending Moments along Crossbeam #3

APPENDIX F
FINITE ELEMENT PROGRAM

APPENDIX F

FINITE ELEMENT PROGRAM

The finite element program chosen to solve the structural problem was the MRI/STARDYNE, version 3, FEB0178 issue. The program was run on a CDC 6600 Computer.

In modeling the structure, several program dependent techniques were used. These techniques may vary from program to program yet, conceptually accomplish the same end (when used correctly). What follows is a brief discussion of several of the more important modeling techniques as implemented by STARDYNE. It is hoped that this will help in providing a base for comparison with other finite element programs should the need arise.

F.1 Offsets and Rigid Beams

When the neutral axes of joining members were not coincident, it was necessary to account for this misalignment by using member end offsets or by joining the neutral axes together with rigid beams.

Beam offsets link the member's end to the node by means of rigid links however, actual node number and member numbers are not required to define this link (it is automatically accounted for). The offsets are defined at the start and end of a member as the distance, parallel to the global axes, from the incident node to the members end. In the cradle model, rigid links were used rather than offsets, because as the cradle inclination changed, the member end offset distances, parallel to the global axes, changed. Thus, each model would have required new offsets. In this case rigid beams were the more efficient approach.

The rigid beams used in this finite element program may be viewed as a means of coupling the degrees of freedom in the infinitely rigid system (all nodes connected to the infinitely rigid beams). Only the degrees of freedom from the highest node number of the infinitely rigid system remain a part of the structural model. The remaining nodes of the infinitely rigid system are not represented in the structure stiffness matrix (though all loads applied to them are correctly considered in the model).

Thus the rigid beam approach is the same as coupling the degrees of freedom at the nodes in question. This is precisely what occurs in a connection in which the members are offset. Artificially simulating rigid beams by using

arbitrarily large section properties can result in stiffness mis-match situations and corresponding matrix ill-conditioning problems. The coupling approach avoids this problem.

F.2 Tension-Only/Compression Only Members

In the cradle/LHM section of the structure, there are several connections and members which require one to specify particular members as tension-only or compression-only members. For example, the hold down straps are tension-only members while the LHM cask resting in the support saddles results in a compression only member. This member non-linearity indicates that some type of iterative solution is required.

The following is a brief outline of the manner in which the chosen finite element program (MRI/STARDYNE) treats the tension-only/compression-only problem.

First, at the points where a one way action is indicated (tension or compression), two nodes will be coded with identical coordinates. These points shall be called "BOP Points" (Bottom Out Points). A lack of connectivity between these points releases the structure so that the points may displace past one another under load.

Second, at each of the BOP Points, a set of self equilibrating forces, consistent with the type of force the joint can transmit, will be coded. These unit load cases will create influence coefficients which will be used to create a flexibility matrix, $[F]$, for the released structure.

Third, the actual loads will be applied to the released structure so that the relative displacements, $\{\delta\}$, of the two nodes at each BOP point may be obtained.

The first pass through the STARDYNE program yields the displacements necessary to create $[F]$ and $\{\delta\}$.

The second step of this procedure is to use a post processing program to take the displacement from the first pass and form the $[F]$ and $\{\delta\}$ matrices. This post process or then iteratively solves the system of equations.

$$[F] \cdot \{P\} + \{\delta\} = 0,$$

where the $\{P\}$ matrix contains the factors for each BOP case which will restore compatibility to the structure consistent with the BOP point capabilities.

For example, if BOP1 is a compression-only point and the δ vector indicates that the nodes comprising the point move in a compression manner, the system will be iterated until the displacements of the two nodes are the same, i.e. compatibility is restored, and the corresponding P is given some value. Conversely, if the points tend to move apart, tension is indicated and the P factor is zero for that BOP point. The net result of this post processor is to form a force vector (P times the BOP unit load cases) which will restore compatibility to the released structure under load.

With the above load vector plus the actual applied load vector, a second pass through the original STARDYNE geometry (this amounts to a restart with the saved stiffness matrix) is made yielding the final displacements, member end reactions and stresses. The released structure now has its compatibility restored.

Tables F-1, F-2 and F-3 are summaries of the BOP points for the various load cases. The degree of freedom portion of the table is included for the following reason. It is necessary to specify a degree of freedom which will yield an axial load only on the member. Consequently, an individual global coordinate system, which will yield axes parallel and normal to the member, needs to be specified for each BOP point and member in question. The degree of freedom column is a summary of the axis of an individual coordinate system chosen to yield a member axial load only.

Table F-1. Tension/Compression-Only Points
Load Cases 1-6 Inclusive

BOP NO.	NODE 1	NODE 2	DEGREE OF FREEDOM	TYPE OF LOAD
1	485	107	X1'	COMP
2	486	108	X1'	COMP
3	490	489	X3'	TENS
4	492	120	X3'	TENS
5	491	121	X3'	TENS
6	493	122	X3'	COMP
7	498	130	X3'	COMP
8	502	500	X3'	TENS
9	503	501	X3'	TENS
10	499	154	X3'	COMP

Table F-2. Tension/Compression Only Points
Load Cases 7-9 Inclusive

BOP NO.	NODE 1	NODE 2	DEGREE OF FREEDOM	TYPE OF LOAD
1	485	107	X1'	COMP
2	486	108	X1'	COMP
3	490	489	X3'	TENS
4	492	120	X3'	TENS
5	491	121	X3'	TENS
6	493	122	X3'	COMP
7	498	130	X3'	COMP
8	502	500	X3'	TENS
9	503	501	X3'	TENS
10	499	154	X3'	COMP
11	494	496	X1'	COMP
12	495	497	X1'	COMP
13	117	505	X3'	COMP
14	116	504	X3'	COMP

Table F-3. Tension/Compression Only Points
Load Case 10

BOP NO.	NODE 1	NODE 2	DEGREE OF FREEDOM	TYPE OF LOAD
1	485	107	X1'	COMP
2	486	108	X1'	COMP
3	490	489	X3'	TENS
4	492	120	X1'	COMP
5	491	121	X3'	TENS
6	493	122	X3'	COMP
7	498	130	X3'	COMP
8	502	500	X1'	COMP
9	503	501	X3'	TENS
10	499	154	X3'	COMP
11	494	496	X1'	COMP
12	495	497	X1'	COMP
13	117	505	X3'	COMP
14	116	504	X3'	COMP

APPENDIX G

MATRIX SOLUTION FOR TORSION OF CELLULAR CROSS-SECTIONS

by

J. W. Leonard

Appendix G

by

J.W. Leonard

On the following pages is given a method of analysis for the prediction of torsional shear stresses in thin-walled cellular members. The derivation given in Section 48 of Reference 1 is generalized for a member with an arbitrary number and arrangement of cells in the cross-section. A compact matrix representation is adopted which leads readily to a form for the solution which is amenable to conversion to a computer routine.

The analysis is based on the use of the membrane analogy for torsional stresses. It is assumed that all cells in the cross-section are closed, that there are no re-entrant corners, and that wall thicknesses are small compared to the dimensions of the cross section.

The derivations given in the succeeding section is followed by an illustration of the solution method. Finally, a listing of a FORTRAN program for use on TSO is given along with sample outputs.

DERIVATION

Consider the cellular cross-section shown in Figure 1 with N cells and M wall sections, hereafter called "links". Each link i ($i = 1, M$) is assumed to have a uniform wall thickness h_i over its length s_i . Each link is assigned a direction, as indicated by the arrow on the center line of the link. Links on the exterior of the cross-section should be assigned a direction corresponding to the direction of positive torque (typically counter-clockwise). Interior link directions may be assigned arbitrarily.

For each cell and link in the cross section let

$$u_j = \text{shear flow in cell } j; j = 1, M$$

$$a_j = \text{area of cell } j \text{ enclosed by link center lines;} \\ j = 1, M$$

$$r_i = s_i/h_i; i = 1, N$$

Now define the following matrices (order of matrices shown as parenthetical subscripts):

Figure 1. Representative Cellular Cross-Section

$$[U] = [u_j] \quad (M \times 1)$$

$$[A] = [a_j] \quad (M \times 1)$$

$$[B] = [b_{ji}] \quad (M \times N)$$

$$[C] = [b_{ij}/|b_{ij}|] \quad (M \times N)$$

where $b_{ji} = +r_i$ if link i is included in cell j in a counter-clockwise sense, $b_{ji} = -r_i$ if link i is included in cell j in a clockwise sense, or $b_{ji} = 0$ if link i is not included in cell j . For example, the matrices $[B]$ and $[C]$ for the cross-sections shown in Figure 2 are given in Tables 1 and 2.

Table 1. Sample C Matrix

		columns		
		1	2	3
rows	1	1	0	0
	2	1	0	0
	3	1	0	0
	4	1	0	0
	5	1	-1	0
	6	0	0	1
	7	0	1	0
	8	0	1	-1
	9	0	0	1
	10	0	1	0
	11	0	0	1

Figure 2. Sample Cellular Section

Table 2. Sample B Matrix

		columns										
		1	2	3	4	5	6	7	8	9	10	11
rows	1	r_1	r_2	r_3	r_4	r_5	0	0	0	0	0	0
	2	0	0	0	0	$-r_5$	0	r_7	r_8	0	r_{10}	0
	3	0	0	0	0	0	r_6	0	$-r_8$	r_9	0	r_{11}

According to the membrane analogy, one can determine the angle of twist θ from

$$(2G\theta) [A] = [K][U] \quad (1)$$

where G is the shear modulus and $[K]$ is a connectivity matrix which can be shown to be

$$[K] (M \times M) = [B][C] \quad (2)$$

If one assumes for the moment that the twist angle θ were known, the shear flow could be calculated from Eq. (1) as

$$[U] = (2G\theta) [K]^{-1}[A] \quad (3)$$

where the superscript (-1) denotes the inverse matrix.

Another relationship of the membrane analogy is that the torque M_t is given by

$$M_t = 2[A]^T [F] \quad (4)$$

where the superscript (T) denotes the transpose matrix. Substituting Eq. (3) into Eq. (4), one gets

$$\theta = M_t / GJ \quad (5)$$

where the scalar function J is given by

$$J = 4[A]^T [K]^{-1}[A] \quad (6)$$

Thus, from eqs. (3), (5) and (6) the shear flow is given by

$$[U] = \frac{2M_t}{J} [K]^{-1}[A] \quad (7)$$

The torsional shear stress in a link i is denoted by τ_i . In terms of the shear flow t_i in a link, the torsional shear stress is given by

$$\tau_i = t_i / h_i \quad (8)$$

The link shear flow t_i equals the difference between the shear flows in the loops in which the link is contained. Thus

$$[T](N \times 1) = [t_i] = [C][U] \quad (9)$$

The positive senses of t_i and τ_i coincide with the assumed positive directions of the link i . That is, a positive τ_i denotes a shear stress in the direction of the arrow on link i , and a negative τ_i denotes a shear stress in the direction opposite to the arrow.

ILLUSTRATION

An idealized cross section of a reinforced box beam is shown in Figure 3. Lengths and thicknesses of the six wall sections are given in Table 3. The areas and links comprising the three cells are given in Table 4.

Figure 3. Box Beam Cross-Section

Table 3. Link Properties

link	s(in)	h(in)	r
1	13.0	3/8	34.6667
2	6.0	1/2	12
3	11.5	3/8	30.6667
4	11.5	3/8	30.6667
5	6.0	1/2	12
6	13.0	1/2	26

Table 4. Cell Properties

cell	a(in ²)	links
1	8.625	1, -3
2	69.000	2, 3, 5, -4
3	8.625	4, 6

From Tables 3 and 4 it is possible to construct the matrices [A], [B], [C] as follows

$$[B] = \begin{bmatrix} 34.6667 & 0 & -30.6667 & 0 & 0 & 0 \\ 0 & 12 & 30.6667 & -30.6667 & 12 & 0 \\ 0 & 0 & 0 & 30.6667 & 0 & 26 \end{bmatrix}$$

$$[A] = \begin{bmatrix} 8.625 \\ 69. \\ 8.625 \end{bmatrix}$$

$$[C] = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ -1 & 1 & 0 \\ 0 & -1 & 1 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

Thus, the connectivity matrix [K] is given by

$$[K] = [B][C] = \begin{bmatrix} 65.3333 & 30.6667 & 0 \\ -30.6667 & 85.3333 & -30.6667 \\ 0 & 30.6667 & 56.6667 \end{bmatrix}$$

Inverting K and forming the product $J = 4[A]^T[K]^{-1}[A]$ one gets

$$[K]^{-1} = \begin{bmatrix} .01936 & .00864 & .00467 \\ .00864 & .01840 & .00996 \\ .00467 & .00996 & .02304 \end{bmatrix}$$

$$J = 454.3525 \text{ in}^4$$

From Eq. (7), the shear flows for an applied torque of 327,100 in-lbs. are

$$[U] = 2\left(\frac{Mt}{J}\right) [K]^{-1}[A] = \begin{bmatrix} 1156.78 \\ 2058.99 \\ 1333.59 \end{bmatrix}$$

Thus, the link shear flows are

$$T = [C][U] = \begin{bmatrix} 1156.78 \\ 2058.99 \\ 902.21 \\ -725.40 \\ 2058.99 \\ 1333.59 \end{bmatrix}$$

Finally, the torsional shear stresses are calculated from $\tau_i = t_i/h_i$ as shown below:

link	$t(\text{lbs/in})$	$h(\text{in})$	$\tau(\text{psi})$
1	1156.78	0.375	3085
2	2058.99	0.5	4118
3	902.21	0.375	2406
4	-725.40	0.375	-1934
5	2058.99	0.5	4118
6	1333.59	0.5	2667

The positive shears denote torsional stresses directed as the arrows in Figure 3. The negative shear τ_4 can be interpreted as a positive shear directed opposite to the arrow on link 4.

COMPUTER PROGRAM

On the following pages is a listing of a short FORTRAN program which can be accessed by TSO to calculate the torsional stresses in cellular members. Two sample outputs are given. The first sample output corresponds to the sample illustrative example considered in the previous section.

The second sample output corresponds to the box beam considered in Section 2.1 of Reference 2. The results of the second sample output were compared to those given in Reference 2: less than 2.1% discrepancy was observed for all stresses.

REFERENCES

1. Timoshenko, S.J., "Strength of Materials: Part II Advanced Theory and Problems," 3rd ed., Van Nostrand Reinhold Co., New York, 1958.
2. Ahmed, H.U., Section 2.1 of ANL/ENG/DE/3640, June 1976.

First Sample Output

TORSION OF A CELLULAR MEMBER

NO. OF LINKS = 6
 NO. OF CELLS = 3
 MAX NO. OF LINKS PER CELL = 4
 APPLIED TORQUE = 327100.000000

LIN K	LENGTH	WIDTH
1	13.00000	0.37500
2	6.00000	0.50000
3	11.50000	0.37500
4	11.50000	0.37500
5	6.00000	0.50000
6	13.00000	0.50000

CEL L	AREA	DIRECTED LINKS			
1	8.62500	1.	-3.	0.	0.
2	69.00000	2.	3.	5.	-4.
3	8.62500	4.	6.	0.	0.

RESULTS WITH J FACTOR = 454.37648083

LIN K	SHEAR FLOW	SHEAR STRESS
1	1156.560	3084.160
2	2059.039	4118.078
3	902.479	2406.611
4	-725.593	-1934.916
5	2059.039	4118.078
6	1333.446	2666.892

END OF PROBLEM

Second Sample Output

TORSION OF A CELLULAR MEMBER

NO. OF LINKS = 6
 NO. OF CELLS = 3
 MAX NO. OF LINKS PER CELL = 4
 APPLIED TORQUE = 327100.000000

LINK	LENGTH	WIDTH
1	13.00000	0.37500
2	6.62500	0.50000
3	11.50000	0.37500
4	11.50000	0.37500
5	6.62500	0.50000
6	13.00000	0.50000

CELL	AREA	DIRECTED LINKS			
1	8.62500	1.	-3.	0.	0.
2	67.56200	2.	3.	5.	-4.
3	9.34000	4.	6.	0.	0.

RESULTS WITH J FACTOR = 424.31206648

LINK	SHEAR FLOW	SHEAR STRESS
1	1179.607	3145.619
2	2079.447	4158.895
3	899.840	2399.574
4	-699.976	-1866.603
5	2079.447	4158.895
6	1379.471	2758.943

END OF PROBLEM

Listing of FORTRAN Programs

```

      IMPLICIT REAL*8 (A-H,O-Z)
      DIMENSION S(50),H(50),A(50),T(35),C(50,50),B(50,50),
1      ST(50,50)
200 READ(5,1,END=300)NLINK,NCELL,MAX,TORQ
1  FORMAT(3I5,F15.0)
   WRITE(6,10)NLINK,NCELL,MAX,TORQ
10  FORMAT(1X//////// TORSION OF A CELLULAR MEMBER//5X,
1    'NO. OF LINKS =',I5/5X,'NO. OF CELLS =',I5/
2    5X,'MAX NO. OF LINKS PER CELL =',I5/5X,
3    'APPLIED TORQUE =',F15.6//)
   IF(MAX.LE.35)GO TO 100
   WRITE(6,101)
101 FORMAT(' *****ERROR: MAX NO. LINKS PER CELL EXCEEDS 35 *****')
   CALL EXIT
100 DO 105 I=1,NCELL
   DO 105 J=1,NLINK
   B(I,J)=0.
105 C(J,I)=0.
   READ(5,3) (S(I),H(I),I=1,NLINK)
3  FORMAT(6F10.0)
   WRITE(6,11)
11  FORMAT(5X,'LINK',2X,'LENGTH',5X,'WIDTH')
   DO 4 I=1,NLINK
   WRITE(6,12) I,S(I),H(I)
12  FORMAT(3X,I5,F10.5,F10.5)
4  S(I)=S(I)/H(I)
   WRITE(6,13)
13  FORMAT(1X////////5X,'CELL',3X,'AREA',10X,'DIRECTED LINKS')
   DO 2 J=1,NCELL
   READ(5,3) A(J), (T(K),K=1,MAX)
   WRITE(6,14) J,A(J), (T(K),K=1,MAX)
14  FORMAT(3X,I5,F10.5,2X,8F5.0/(20X,8F5.0//))
   DO 5 K =1,MAX
   AIJ=DABS(T(K))
   IJ=AIJ
   IF(IJ.EQ.0)GO TO 2
   IF(IJ.LE.NLINK)GO TO 102
   WRITE(6,103)
103 FORMAT(' *****ERROR: LINK NO. IN LIST ',
1    'EXCEEDS NO. OF LINKS*****')
   CALL EXIT
102 C(IJ,J)=T(K)/AIJ
5  B(J,IJ)=C(IJ,J)*S(IJ)
2  CONTINUE
   CALL MULT(B,C,ST,NCELL,NLINK,NCELL)
   DO 6 J=1,NCELL
6  B(J,1)=A(J)
   CALL MATINV(ST,NCELL,B,1,DET,50)
   IF(DET.NE.0.0)GO TO 104
   WRITE(6,106)
106 FORMAT(' *****ERROR: SINGULAR COEFFICIENT MATRIX *****')
   GO TO 9
104  GJ=0.
   DO 42 I=1,NCELL

```

```

42   GJ=GJ+A(I)*B(I,1)
      GJ=4.*GJ
      DO 7 J=1,NCELL
7    B(J,1)=TORQ*2./GJ*B(J,1)
      CALL MULT(C,B,S,NLINK,NCELL,1)
      WRITE(6,15)GJ
15   FORMAT(1X///5X,'RESULTS WITH J FACTOR = ',F15.8//5X,
1     'LINK',2X,'SHEAR FLOW',2X,'SHEAR STRESS')
      DO 8 I=1,NLINK
      C(I,1)=S(I)/H(I)
8    WRITE(6,16)I,S(I),C(I,1)
16   FORMAT(3X,15,3X,F10.3,3X,F10.3)
9    WRITE(6,17)
17   FORMAT(1X///5X,'END OF PROBLEM'///)
      GO TO 200
300  STOP
      END

```

```

SUBROUTINE MULT(A,B,C,NA,NB,NC)
  IMPLICIT REAL*8 (A-H,O-Z)
  DIMENSION A(50,50),B(50,50),C(50,50)
  DO 1 I=1,NA
  DO 1 J=1,NC
    T=0.
  DO 2 K=1,NB
2    T=T+A(I,K)*B(K,J)
1    C(I,J)=T
  RETURN
  END

```

Appendix H

H.1 Computer Program of Chapter XII

This part contains the computer program of Chapter XII. The required input data is quite simple. For each loading case, one card only is needed. There are four parameters in each input card. Their sequences is ICASE, F_1 , AM_2 , AM_3 .

ICASE : loading case number

F_1 : axial force of cross beam (lb)

AM_2 : moment M_2 of cross beam (in - lb)

AM_3 : moment M_3 of cross beam (in - lb)

There is no specified field for each parameter. So far as the four parameters are in proper sequence with a comma immediately following each parameter. For example

Case 10, $F_1 = -9.750E03$, $M_2 = -9.120E05$, $M_3 = 1.915E05$

could be input as:

- - - 1 0 , - - 9 . 7 5 0 E 0 3 , - - 9 . 1 2 0 E 0 5 , - 1 . 9 1 5 E 0 5 - -

```

DOUBLE PRECISION A,B,DETERM
DIMENSION A(3,3),B(3,1)
DO 99 I=1,23
100 FORMAT (1H1,'INPUT 1ST NO. 1 FOR FIXED EDGE, CONSTANT LINE LOAD'
2  ,/,1X,'          2 FOR FIXED EDGE, MOMENT LOADING',/,
3  1X,'          3 FOR SIMPLY SUPPORTED, CONSTANT LINE LOAD'
4  ,/,1X,'          4 FOR SIMPLY SUPPORTED, MOMENT LOADING',/,
5  1X,'INPUT 2ND NO. FOR '
3  , 'LOADING PER UNIT LENGTH.',//)
READ (5,*) ICASE,F1,AM2,AM3
WRITE (6,111) ICASE,F1,AM2,AM3
111 FORMAT (1H1,14X,16('*'),/,15X,'* LOAD CASE ',I2,'*',/,15X,
1  16('*'),/,5X,'R1',10X,'M2 ',9X,'M3 ',/,1X,3(1PE10.3,2X))
N=3
H=1
NMAX=N
PI=3.1415926
AL=24.75
BL=11.5
POB=2.*PI/BL
PID=PI/BL
PSI=4.
H=0.375
E=30E+06
D=E*H**3/12./(1.-0.3**2)
DO 99 II=1,2
IF (II.EQ.2) GO TO 602
WRITE (6,601)
601 FORMAT(///,1X,'I. THREE INTERMITTENT WELDS. ')
U1=0.75
V1=2.75
U2=4.75
V2=6.75
U3=8.75
V3=10.75
GO TO 604
602 CONTINUE
U1=0.
V1=11.5
U2=0.
V2=0.
U3=0.
V3=0.
VB=BL
WRITE (6,603)
603 FORMAT(///,1X,'II. CONTINUOUS WELDS. ')
604 CONTINUE
IF (II.EQ.1) PF=(F1/2.-AM3/15.5)/((V1-U1)+(V2-U2)+(V3-U3))
IF (II.EQ.2) PF=(F1/2.-AM3/15.5)/(V1-U1)
PM=AM2/BL/15.5
WRITE (6,605)
605 FORMAT(///,1X,'A. FIXED - EDGE BOUNDARY CONDITION : ')
606 FORMAT(///,1X,'A.1 EFFECT OF FORCE R1 AND MOMENT M3 (P =',
1  F10.1,')')
607 FORMAT(///,1X,'A.2 EFFECT OF MOMENT M2 (P =',F10.1,')')
608 FORMAT(///,1X,'B.1 EFFECT OF FORCE R1 AND MOMENT M3 (P =',
1  F10.1,')')
609 FORMAT(///,1X,'B.2 EFFECT OF MOMENT M2 (P =',F10.1,')')
610 FORMAT(///,1X,'B. SIMPLY SUPPORTED EDGES :')

```

C
C *** FIXED EDGE; CONSTANT FORCE

C

```

1 CONTINUE
  WRITE (6,606) PF
  A(1,1)=2.*PI*AL*POB**3
  A(1,2)=PI*AL**2*POB**3
  A(1,3)=2./3.*PI*AL**3*POB**3-4.*PI*AL*POB
  A(2,1)=A(1,2)
  A(2,2)=2./3.*PI*AL**3*POB**3
  A(2,3)=PI*AL**4/2.*POB**3-2.*PI*AL**2*POB
  A(3,1)=A(1,3)
  A(3,2)=A(2,3)
  A(3,3)=2./5.*PI*AL**5*POB**3-8./3.*PI*AL**3*POB+12.*AL*BL
  B(1,1)=2.*PF/D*(V1-U1-(SIN(V1*POB)-SIN(U1*POB))/POB
1    +V2-U2-(SIN(V2*POB)-SIN(U2*POB))/POB
2    +V3-U3-(SIN(V3*POB)-SIN(U3*POB))/POB)
  B(2,1)=PSI*B(1,1)
  B(3,1)=PSI**2*B(1,1)

```

C

```

  WRITE (6,104) ((A(K,J),J=1,3),B(K,1)),K=1,3)
104 FORMAT(////,3(1X,3(E10.3,2X),5X,E10.3,/))

```

C

```

  CALL MATINV(A,N,B,M,DETERM,NMAX)
  WRITE (6,500) B
  WRITE (6,101)
101 FORMAT(////,1X,'MOMENTS AND STRESSES ALONG THE CLAMPED EDGE '
2    ,//,7X,'X',9X,'W',14X,'MY',13X,'SIGY',13X,'SIGX',/)
  W=0.
  DO 11 J=1,26
    X=J-1
    IF(J.EQ.26) X=24.75
    PAR=B(1,1)+B(2,1)*X+B(3,1)*X**2
    AMY=-D*POB**2*PAR
    SIGY=6.*AMY/H**2
    SIGX=0.3*SIGY
    WRITE(6,102) X,W,AMY,SIGY,SIGX
102 FORMAT(5X,F6.2,4X,F10.6,2X,2(F10.2,5X),8X,F10.2,8X,F10.2)
  11 CONTINUE
  WRITE(6,103)
103 FORMAT(////,1X,'MOMENTS AND STRESSES ALONG THE CENTER '
2    ,//,7X,'X',9X,'W',14X,'MY',13X,'SIGY',13X,'MX',13X,'SIGX'/)
  DO 12 J=1,26
    X=J-1
    IF(J.EQ.26) X=24.75
    PAR=B(1,1)+B(2,1)*X+B(3,1)*X**2
    W=2.*PAR
    AMY=-D*(4.*0.3*B(3,1)-POB**2*PAR)
    AMX=-D*(4.*B(3,1)-0.3*POB**2*PAR)
    SIGY=6.*AMY/H**2
    SIGX=6.*AMX/H**2
    WRITE(6,102) X,W,AMY,SIGY,AMX,SIGX
  12 CONTINUE

```

C

```

C *** FIXED EDGE;      MOMENT LOADING

```

C

```

2 CONTINUE
  WRITE (6,607) PM
  A(1,1)=36.5714*AL/BL
  A(1,2)=18.2857*AL**2/BL
  A(1,3)=12.1905*AL**3/BL-0.8218*AL*BL
  A(2,1)=A(1,2)
  A(2,2)=12.1905*AL**3/BL
  A(2,3)=9.14285*AL**4/BL-0.4109*AL**2*BL

```

```

A(3,1)=A(1,3)
A(3,2)=A(2,3)
A(3,3)=0.03694*AL*BL**3-0.5479*AL**3*BL
1      +7.3143*AL**5/BL
IF(II.EQ.1) S=(V2-U2)/2.
IF(II.EQ.1) U1=5.
IF(II.EQ.1) V1=3.
IF(II.EQ.1) B(1,1)=(S**3/3.-8.*S**5/(5.*BL**2)+16.*S**7/
1      (7.*BL**4)+U1**3/3.-V1**3/3.-8.*(U1**5
2      -V1**5)/(5.*BL**2)+16.*(U1**7-V1**7)/
3      (7.*BL**4))*4.*EM/BL/D
IF(II.EQ.2) B(1,1)=0.038095*PN*BL**2/
B(2,1)=PSI*B(1,1)
B(3,1)=B(1,1)*PSI**2

```

C

```

WRITE(6,104) ((A(K,J),J=1,3),B(K,1)),K=1,3)
CALL MATINV(A,N,B,M,DETERM,NMAX)
WRITE(6,500) B
DO 21 K=1,2
IF (K.EQ.1) WRITE(6,101)
IF (K.EQ.1) Y=BL/2.
IF (K.EQ.2) WRITE(6,201)
IF (K.EQ.2) Y=BL/SQRT(20.)
PAS=-48./BL**2*Y+320./BL**4*Y**3.
DO 21 J=1,26
X=J-1
IF(J.EQ.26) X=24.75
PAR=B(1,1)+B(2,1)*X+B(3,1)*X**2
AMY=-D*(2.*0.3*P(3,1)*(Y-8.*Y**3/BL**2+16.*Y**5/BL**4)+PAR*PAS)
AMX=-D*(2.*B(3,1)*(Y-8.*Y**3/BL**2+16.*Y**5/BL**4)+0.3*PAR*PAS)
SIGY=6.*AMY/H**2
SIGX=6.*AMX/H**2
WRITE(6,102) X,W,AMY,SIGY,AMX,SIGX
21 CONTINUE
201 FORMAT(///,1X,'MOMENTS AND STRESSES ALONG Y=BL/SQRT(20.)'
2      ,///,7X,'X',9X,'W',14X,'MY',13X,'SIGY',/)
500 FORMAT(///,7X,'A',11X,'B',11X,'C',/,3(2X,E10.3),/)
99 CONTINUE
STOP
END

```


H.2 Computer Program for Beam and Weld Stresses

This section of the appendix explains the details of the computer program adopted for the beam and weld analyses described in chapters X and XI. While those analyses consider only selected beams at one of two nodes and for a particular loading case, the computer program calculates the stresses for all beams at both nodes and for all loading cases. They are set up to determine stresses with proper consideration of their direction, at all points where the maximum value may occur and follow all necessary steps even if they seem unnecessary from the stand point of design or obviously insignificant and can be neglected as noted in the analysis. Also included herein are complete listings of the input data as interpreted by the computer for each set of analysis.

An outline of the content of this section is as follows:

H.2.1

Conformance to AISC code requirements. Analysis of beam element stresses and printout results of this computer program are described in chapter X.

H.2.1.1 Fortran program, AISCBM, for the LHM cradle structure beam stress calculations.

H.2.1.2 Explanation of the program AISCBM.

H.2.1.3 Input data listing for program AISCBM.

H.2.2

Cradle structure weld calculations for connecting welds (beam to beam joint). Sample manual calculations illustrating the computer program and the printout results of the program are included in chapter XI.

H.2.2.1 Fortran program, CONWLD, for connecting weld calculations.

H.2.2.2 Explanation of the program CONWLD.

H.2.2.3 Input data listing for program CONWLD.

H.2.3

Computer calculations of local welds (between plates of a built-up member) for longitudinal beams and cross beams as described in chapter XI will be added later to this appendix.

H.2.4

Computer calculations of the trunion block stresses will be added later to this appendix.

H.2.1.1 Computer Program AISCBM

```

C      AISCBM
C      THIS PROGRAM CALCULATES STRESSES IN THE BEAM MEMBERS OF
C      LHM CRADLE STRUCTURE TO CHECK CONFORMANCE TO AISC CODE
ISN 0002      DIMENSION NCASE(16),NBEAM(26),NMODE(52)
ISN 0003      DIMENSION P1(26,2,16),F2(26,2,16),F3(26,2,16),T1(26,2,16),
C      EM2(26,2,16),EMS(26,2,16)
ISN 0004      DIMENSION AGR(26),AM2(26),AM3(26),GI2(26),GI3(26),EI2(26),
C      EI3(26),YZJ(26),CT(26),CB(26),CL(26),CR(26),HDT(26),SR3(26),
C      C2(26),C3(26),QS(26),QA(26),ADH(26)
ISN 0005      DIMENSION SR2(26,16)
ISN 0006      WRITE(6,20)
ISN 0007      20  FORMAT(10X,'STRESS CALCULATION IN BEAM MEMBERS- LHM CRADLE',
C      ' STRUCTURE PER AISC CODE',//)
ISN 0008      WRITE(6,21)
ISN 0009      21  FORMAT(29X,'TABLE OF FORCES AND MOMENTS',/)
ISN 0010      WRITE(6,22)
ISN 0011      22  FORMAT(2X,'CASE BEAM NODE      AXIAL      SHEAR      SHEAR',
C      '      TORQUE      MOMENT      MOMENT')
ISN 0012      WRITE(6,23)
ISN 0013      23  FORMAT(3X,'NO      NO      NO      P1      F2      ',
C      'F3      T1      EM2      EMS')
ISN 0014      KK=0
ISN 0015      DO 30 I=1,26
ISN 0016      DO 30 J=1,2
ISN 0017      KK=KK+1
ISN 0018      DO 30 K=1,16
ISN 0019      READ(5,35)NCASE(K),NBEAM(I),NMODE(KK),P1(I,J,K),F2(I,J,K),
C      F3(I,J,K),T1(I,J,K),EM2(I,J,K),EMS(I,J,K)
ISN 0020      35  FORMAT(2I3,I4,6E10.3)
ISN 0021      30  WRITE(6,41)NCASE(K),NBEAM(I),NMODE(KK),P1(I,J,K),F2(I,J,K),
C      F3(I,J,K),T1(I,J,K),EM2(I,J,K),EMS(I,J,K)
ISN 0022      41  FORMAT(3I5,6E12.4)
ISN 0023      WRITE(6,50)
ISN 0024      50  FORMAT(1H1,30X,'TABLE OF BEAM SECTION PROPERTIES',////)
ISN 0025      WRITE(6,52)
ISN 0026      52  FORMAT(' BEAM  WEB AREA TOTAL      MOMENT OF INERTIA',11X,
C      'EXTREME FIBER DISTANCE  TORQUE RAD  REDUCTION  SHEAR',
C      ' SLENDER')
ISN 0027      WRITE(6,54)
ISN 0028      54  FORMAT(18X,'AREA',77X,'FACTOR      FACTOR      RATIO',/, ' NO',
C      ' AM2 AM3 GROSS ACTUAL/GROSS EFFECTIVE POLAR',
C      ' TOP BOT LFT RGT FROM2 FROM3',23X,'ALONG 3')
ISN 0029      WRITE(6,56)
ISN 0030      56  FORMAT(19X,'AGR      GI2      GI3      EI2      EI3      YZJ      CT',
C      ' CB      CL',
C      ' CR      C2      C3      QS      QA      H/T A/H SR3',/)
ISN 0031      DO 58 I=1,26
ISN 0032      58  READ(5,60)NBEAM(I),AM2(I),AM3(I),AGR(I),GI2(I),GI3(I),
C      EI2(I),EI3(I),YZJ(I),HDT(I),ADH(I)
ISN 0033      60  FORMAT(13,1X,3F6.2,5F7.1,F6.1,F5.2)
ISN 0034      DO 63 I=1,26
ISN 0035      63  READ(5,65)NBEAM(I),QS(I),QA(I),C2(I),C3(I),CT(I),CB(I),CL(I),
C      CR(I),SR3(I)

```

```

ISN 0036      65  FORMAT(I3,1X,2F5.2,6F6.2,F5.1)
ISN 0037      DO 70 I=1,25
ISN 0038      70  WRITE(6,71)NBEAM(I),AM2(I),AM3(I),ASR(I),GI2(I),GI3(I),EI2(I),
C             EIS(I),YZJ(I),CT(I),CB(I),CL(I),CR(I),C2(I),C3(I),QS(I),
C             GA(I),HDT(I),ADH(I),SR3(I)
ISN 0039      71  FORMAT(I4,1X,3F6.2,5F7.1,1X,4F6.2,1X,4F6.2,F6.1,F5.2,F6.1)
ISN 0040      WRITE(6,75)
ISN 0041      75  FORMAT(//,20X,'VALUE OF SLENDERNESS RATIO:  SR2 ABT 2-2',
C             ' FOR LOAD CASES 1-15',/)
ISN 0042      WRITE(6,77)
ISN 0043      77  FORMAT(' BEAM',/,2X,'NO      1      2      3      4      5      6',
C             '      7      8      9     10     11     12     13     14',
C             '      15     16',/)
ISN 0044      DO 79 I=1,26
ISN 0045      79  READ(5,80)NBEAM(I),(SR2(I,K),K=1,16)
ISN 0046      80  FORMAT(I3,2F5.1,F4.1,F5.1,F4.1,F5.1,7F4.1,3F5.1)
ISN 0047      DO 90 I=1,26
ISN 0048      90  WRITE(6,91)NBEAM(I),(SR2(I,K),K=1,16)
ISN 0049      91  FORMAT(I4,1X,16F6.1)
ISN 0050      WRITE(6,95)
ISN 0051      95  FORMAT('1')
ISN 0052      100 FORMAT(30X,'TABLE OF BEAM STRESSES: NORMAL AND SHEAR',/)
ISN 0053      102 FORMAT(21X,'VALUE OF NORMAL STRESSES      RATIO NORMAL      VALUE',
C             ' OF SHEAR STRESSES      RATIO MAX RATIO MIN.')
ISN 0054      104 FORMAT(49X,'OVER ALLOWABLE',33X,'SHEAR/ STRESS      SAFETY',
C             ' / ' LOAD BEAM NODE TOP-LFT TOP-RGT BOT-RGT BOT-LFT',16X,'22-',
C             'TOP 22-BOT 33-RGT 33-LFT ALLOW OVER      FACTOR')
ISN 0055      106 FORMAT(' CASE NO      NO      STL      STR      SSR      SBL      RTOT',
C             '1 RTOT2      V2T      V2B      V3R      V3L      RV      ALLOW',/)
ISN 0056      KK=0
ISN 0057      DO 160 I=1,26
ISN 0058      DO 160 J=1,2
ISN 0059      KK=KK+1
ISN 0060      DO 160 K=1,16
ISN 0061      IF(J.EQ.1)P1(I,J,K)=-P1(I,J,K)
ISN 0062      IF(J.EQ.1)SM2(I,J,K)=-SM2(I,J,K)
ISN 0063      IF(J.EQ.1)SM3(I,J,K)=-SM3(I,J,K)
ISN 0064      SP1=P1(I,J,K)/ASR(I)
ISN 0065      SM2T=SM2(I,J,K)*CT(I)/GI2(I)
ISN 0066      SM2B=-SM2(I,J,K)*CB(I)/GI2(I)
ISN 0067      SM3L=SM3(I,J,K)*CL(I)/GI3(I)
ISN 0068      SM3R=-SM3(I,J,K)*CR(I)/GI3(I)
ISN 0069      SM2T=SM2(I,J,K)*CT(I)/EI2(I)
ISN 0070      SM2B=-SM2(I,J,K)*CB(I)/EI2(I)
ISN 0071      SM3L=SM3(I,J,K)*CL(I)/EI3(I)
ISN 0072      SM3R=-SM3(I,J,K)*CR(I)/EI3(I)
ISN 0073      STL=SP1+SM2T+SM3L
ISN 0074      STR=SP1+SM2T+SM3R
ISN 0075      SBL=SP1+SM2B+SM3L
ISN 0076      SSR=SP1+SM2B+SM3R
ISN 0077      ASB=0.6*50000.
ISN 0078      IF(K.EQ.2.OR.K.EQ.4.OR.K.EQ.6.OR.K.EQ.12.OR.K.EQ.14.OR.K.EQ.16)
ISN 0079      C      ASB=1.33*0.6*50000.
ISN 0080      IF(K.EQ.7.OR.K.EQ.8.OR.K.EQ.9.OR.K.EQ.10)ASB=1.25*.6*50000.
ISN 0081      IF(SP1.GT.0.)GO TO 140

```

```

ISN 0037      112  CONTINUE
ISN 0038      SR=SR2(I,K)
ISN 0039      IF(SR3(I).GT.SR)SR=SR3(I)
ISN 0091      CC=107.0/SCRT(QS(I)*QA(I))
ISN 0092      IF(SR-CC)114,114,116
ISN 0093      114  FACT1=SR/CC
ISN 0094      FA=50.*QS(I)*QA(I)*(1.0-0.5*FACT1**2)/(1.667+(.375*FACT1)-
C              .125*FACT1**3)
ISN 0095      GO TO 117
ISN 0096      116  FA=149330./SR**2
ISN 0097      117  CONTINUE
ISN 0098      IF(FA.GT.30.0)FA=30.0
ISN 0100      IF(K.EQ.2.OR.K.EQ.4.OR.K.EQ.6.OR.K.EQ.12.OR.K.EQ.14.
C              .OR.K.EQ.16)FA=1.33*FA
ISN 0102      IF(K.EQ.7.OR.K.EQ.8.OR.K.EQ.9.OR.K.EQ.10)FA=1.25*FA
ISN 0104      SMIN=STL
ISN 0105      IF(STR.LT.SMIN)SMIN=STR
ISN 0107      IF(SBL.LT.SMIN)SMIN=SBL
ISN 0109      IF(SBR.LT.SMIN)SMIN=SBR
ISN 0111      SSM=SMIN-SP1
ISN 0112      RSAX=ABS(SP1/(FA*1000.))
ISN 0113      IF(RSAX-0.15)113,113,119
ISN 0114      113  CONTINUE
ISN 0115      RSM=ABS(SSM/ASS)
ISN 0116      RTOT1=RSAX+RSM
ISN 0117      GO TO 130
ISN 0118      119  FE2=1.493E05/(SR2(I,K))**2
ISN 0119      FE3=1.493E05/(SR3(I))**2
ISN 0120      FACT2=0.35/(1.0-ABS(SP1/FE2))
ISN 0121      FACT3=0.35/(1.0-ABS(SP1/FE3))
ISN 0122      RSM2T=ABS(SEM2T*FACT2/ASS)
ISN 0123      RSM2B=ABS(SEM2B*FACT2/ASS)
ISN 0124      RSM3L=ABS(SEM3L*FACT3/ASS)
ISN 0125      RSM3R=ABS(SEM3R*FACT3/ASS)
ISN 0126      IF(SMIN.EQ.STL)GO TO 121
ISN 0127      IF(SMIN.EQ.STR)GO TO 122
ISN 0128      IF(SMIN.EQ.SBL)GO TO 123
ISN 0129      IF(SMIN.EQ.SBR)GO TO 124
ISN 0130      121  RTOTA=RSAX+RSM2T+RSM3L
ISN 0131      GO TO 125
ISN 0132      122  RTOTA=RSAX+RSM2T+RSM3R
ISN 0133      GO TO 125
ISN 0134      123  RTOTA=RSAX+RSM2B+RSM3L
ISN 0135      GO TO 125
ISN 0136      124  RTOTA=RSAX+RSM2B+RSM3R
ISN 0137      125  RTOTB=ABS(SMIN/ASS)
ISN 0138      RTOT1=RTOTA
ISN 0139      IF(RTOTB.GT.RTOT1)RTOT1=RTOTB
ISN 0140      130  RTOT2=-.0
ISN 0141      GO TO 155
ISN 0142      140  CONTINUE
ISN 0143      SCONP=STL
ISN 0144      IF(STR.LT.SCONP)SCONP=STR
ISN 0145      IF(SBL.LT.SCONP)SCONP=SBL
ISN 0146      IF(SBR.LT.SCONP)SCONP=SBR
ISN 0147
ISN 0148
ISN 0149
ISN 0150
ISN 0151
ISN 0152
ISN 0153

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ISN 0155      RTOT2=ABS((SCCNP-SP1)/AS3)
ISN 0156      IF(STL.GT.0.)STL=SP1+SCN2T+SCN3L
ISN 0157      IF(STR.GT.0.)STR=SP1+SCN2T+SCN3R
ISN 0158      IF(SBL.GT.0.)SBL=SP1+SCN2B+SCN3L
ISN 0159      IF(SBR.GT.0.)SBR=SP1+SCN2B+SCN3R
ISN 0160      SMAX=STL
ISN 0161      IF(STR.GT.SMAX)SMAX=STR
ISN 0162      IF(SBL.GT.SMAX)SMAX=SBL
ISN 0163      IF(SBR.GT.SMAX)SMAX=SBR
ISN 0164      RTOT1=SMAX/AS3
ISN 0165      155 CONTINUE
ISN 0166      VF2=F2(I,J,K)/AH2(I)
ISN 0167      VF3=F3(I,J,K)/AH3(I)
ISN 0168      VT2B=T1(I,J,K)*C2(I)/YZJ(I)
ISN 0169      VT2T=-T1(I,J,K)*C2(I)/YZJ(I)
ISN 0170      VT3R=T1(I,J,K)*C3(I)/YZJ(I)
ISN 0171      VT3L=-T1(I,J,K)*C3(I)/YZJ(I)
ISN 0172      V2T=VF2+VT2T
ISN 0173      V2B=VF2+VT2B
ISN 0174      V3R=VF3+VT3R
ISN 0175      V3L=VF3+VT3L
ISN 0176      VMAX=ABS(V2T)
ISN 0177      IF(ABS(V2B).GT.VMAX)VMAX=ABS(V2B)
ISN 0178      IF(ABS(V3R).GT.VMAX)VMAX=ABS(V3R)
ISN 0179      IF(ABS(V3L).GT.VMAX)VMAX=ABS(V3L)
ISN 0180      IF(ADH(I)-1.0)157,157,158
ISN 0181      157 FACTK=4.0+(5.34/(ADH(I)))**2)
ISN 0182      GO TO 159
ISN 0183      158 FACTK=5.34+(4.0/(ADH(I)))**2)
ISN 0184      159 CONTINUE
ISN 0185      CV=26.9*SQRT(FACTK)/HDT(I)
ISN 0186      CV1=900.*FACTK/(HDT(I))**2
ISN 0187      IF(CV1.LE.0.8)CV=CV1
ISN 0188      ASHRN=17301.*CV
ISN 0189      IF(ASHRN.GT.20000.0)ASHRN=.4*50000.
ISN 0190      ASHR=ASHRN
ISN 0191      IF(K.EQ.2.OR.K.EQ.4.OR.K.EQ.6.OR.K.EQ.12.OR.K.EQ.14.OR.K.EQ.16)
ISN 0192      C ASHR=1.33*ASHRN
ISN 0193      IF(K.EQ.7.OR.K.EQ.8.OR.K.EQ.9.OR.K.EQ.10)ASHR=1.25*ASHRN
ISN 0194      RV=VMAX/ASHR
ISN 0195      RMAX=RTOT1
ISN 0196      IF(RTOT2.GT.RMAX)RMAX=RTOT2
ISN 0197      IF(RV.GT.RMAX)RMAX=RV
ISN 0198      SF=1.0/RMAX
ISN 0199      IF(K.EQ.1)WRITE(6,100)
ISN 0200      IF(K.EQ.1)WRITE(6,102)
ISN 0201      IF(K.EQ.1)WRITE(6,104)
ISN 0202      IF(K.EQ.1)WRITE(6,106)
ISN 0203      IF(K.EQ.10)GO TO 160
ISN 0204      WRITE(6,161)NCASE(K),NBEAM(I),NODE(KK),STL,STR,SBR,SBL,RTOT1,
ISN 0205      C RTOT2,V2T,V2B,V3R,V3L,RV,RMAX,SF
ISN 0206      161 FORMAT(I4,2I5,2X,4F8.0,F7.3,F6.3,1X,4F8.0,F7.3,F6.3,F11.1)
ISN 0207      IF(K.EQ.15)WRITE(6,165)
ISN 0208      165 FORMAT('1')
ISN 0209      160 CONTINUE
ISN 0210      WRITE(6,170)
ISN 0211      170 FORMAT(1H1,20X,'MODIFIED TABLE OF FORCES AND MOMENTS',/)
ISN 0212      KK=0
ISN 0213      DO 180 I=1,26
ISN 0214      DO 180 J=1,2
ISN 0215      KK=KK+1
ISN 0216      DO 180 K=1,16
ISN 0217      WRITE(6,181)NCASE(K),NBEAM(I),NODE(KK),P1(I,J,K),F2(I,J,K),
ISN 0218      C F3(I,J,K),T1(I,J,K),BM2(I,J,K),BM3(I,J,K)
ISN 0219      180 CONTINUE
ISN 0220      181 FORMAT(3I5,6E12.4)
ISN 0221      STOP
ISN 0222      END

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H.2.1.2 Explanation of Program AISCBM

<u>Lines</u>	<u>Explanation</u>
	Identification of program
ISN 0002	There are 26 beams, 2 nodes in each beam, 16 load cases
ISN 0003	Array of force P_1 , F_2 , & F_3 and T_1 , BM_2 , BM_3
ISN 0004	Array of various section properties
ISN 0005	Array of slenderness ratio abt. 2-2 axis
ISN 0006-0013	Heading for tabulation of forces and moments
ISN 0014-0022	Do loop to read and print forces and moments
ISN 0023-0030	Heading for tabulation of section properties
ISN 0031-0049	Do loops to read and print all sections properties
ISN 0050-0055	Heading for tabulation of stresses and safety factors
ISN 0056-0060	Do loop for required calculations
ISN 0061-0065	Change sign of reactions P_1 , BM_2 , and BM_3 , for "FROM" nodes to be consistant with "TO" nodes.
ISN 0067	$f_a = P_1 \div \text{Gross area for axial force stress}$
ISN 0068-0071	$F_b = M_c \div I$ bending stresses for each corner using gross section
ISN 0072-0075	$F_b = M_c \div I$ bending stresses for each corner of section using effective section

ISN 0076-0079	$f_a + f_b$ combined axial and bending, using effective section
ISN 0080	Allowable bending stress $F_b = 0.6 F_y$ for normal loading
ISN 0081	$F_b = 1.33 \times .6 F_y$ for accidental loading
ISN 0083	$F_b = 1.25 \times .6 F_y$ for travel loading
ISN 0085	For combined axial tension and bending go to 140 analysis
ISN 0087-0089	For axial compression: determine the greater of two slenderness ratios (SR2 & SR3)
ISN 0091	Evaluate $C'c$ using $E = 29000$; $F_y = 50$
ISN 0092	Compares $C'c$ with SR. If $C'c < SR$, go to 116
ISN 0093-0095	Evaluate F_a from EQ. 3.9 of Appendix B for $C'c > SR$
ISN 0096	Evaluate F_a from EQ. 1.5-2 of AISC Code for $C'c < SR$
ISN 0097-0098	Where calculated $F_a > 0.6 F_y$, use $F_a = 30 \text{ ksi}$
ISN 0100	For accidental loading, allowable F_a is increased 33%
ISN 0102	For travel loading, allowable F_a is increased 25%
ISN 0104-0109	Determines max. compression for combined stresses
ISN 0111	Determines total compressive bending stress (SBM)
ISN 0112	Calculate ratio axial stress over allowable, $RSAX = f_a \div F_a$
ISN 0113	Is $RSAX \leq .15$, go to 118 otherwise go to 119

ISN 0114-0115	Using EQ 6.2 of Appendix B for $RSAX \leq 0.15$
ISN 0116	Determine ratio $RTOT1 = f_a/F_a + f_b/F_b$ with $F_b = 0.6 F_y$ or as increased. Refer to section 6.1 of appendix B
ISN 0017	There is no need to check net tension stress because it will always be lower in absolute value than the maximum compression. $RTOT2 = 0.0$ will give an indication that the particular case is combined axial compression and bending
ISN 0118-0121	For $RSAX > 0.15$ use EQ. 6.1a or 6.1b of Appendix B. Evaluate F'_{ex} and F'_{ey} and factor $C_m/(1 - f_a/F'_e)$ for x (2) and y (3)
ISN 0122-0125	Calculate the ratio: bending stress over allowable stress per EQ. 6.1a
ISN 0126-0132	Determine where the maximum combined compressive stress is
ISN 0134-0140	Determine total ratio, $RTOTA$ (axial compression and bending) per EQ. 6.1a
ISN 0141	Evaluate total ratio, $RTOTB$ per EQ. 6.1b where all allowables are 30.0 ksi or as increased.
ISN 0142-0143	Determine the higher of total ratios per EQs. 6.1a or 6.1b ($RTOT1$)
ISN 0145	$RTOT2 = 0.0$ indicates combined axial compression and bending
ISN 0146	Proceed to shear stress calculations
ISN 0147-0153	For evaluation of combined axial tension and bending (from line 1310), determine maximum compression.
ISN 0155	Total ratio, $RTOT2$, compression stress over allowable stress using allowable of 30 ksi or as increased. Note that axial stress which is tension, is neglected. Refer to section 6.2 of appendix B.

ISN 0156-0162	Check if combined stresses in each corner are tension. If so, recalculate bending stresses using the gross cross section properties.
ISN 0164-0169	Determine maximum tension stress (axial plus bending)
ISN 0171	Calculate total ratio stress over allowable (RTOT1)
ISN 0172	Shear stress analysis
ISN 0173	$f_{v_2} = F_2 \div AW_2$ stress due to F_2
ISN 0174	$f_{v_3} = F_3 \div AW_3$ stress due to F_3
ISN 0175-0178	$f_T = T_1 \times \bar{r}/J$ stress due to torsion at all plates top, bottom, right and left.
ISN 0179-0182	Total shear stress at each plate
ISN 0183-0188	Determine max. shear stress
ISN 0190	Determine which of two equations 1.7 of Appendix B to use
ISN 0191-0192	Evaluate EQ 1.7 for $a/h < 1.0$
ISN 0193	Evaluate EQ 1.7 for $a/h > 1.0$
ISN 0194-0197	Evaluate C_v , EQs 1.4 and 1.5 of Appendix B. Determine which of two equations are applicable.
ISN 0199-0200	Evaluate allowable shear stress, EQ 4.1 of appendix B ($F_y = 50000$)
ISN 0202-0205	Set values of allowable shear (ASHR) for normal loading, accidental (x 1.33) loading and travel loading (x 1.25)
ISN 0207	Ratio, RV, of maximum shear stress over allowable

ISN 0208-0211	Determine which of the ratios $RTOT$ and $RTOT2$ from direct stresses and RV from shear stresses is highest. This maximum value is $RMAX$.
ISN 0213	Factor of safety is the reciprocal of maximum ratio
ISN 0214-0228	Printing of stress results and factor of safety
ISN 0228-0239	Re-printing of forces and moments to verify the change in the signs for "From" nodes from line 860-880

This program does not include the evaluation of the compactness or non-compactness of the beam sections which is already presented in the manual calculations of chapter X. The properties of each beam section used in this program (section H.2.1.3) are taken from the manual calculations.

TABLE H.2.1.3-1 FORCES AND MOMENTS INPUT LISTING

CASE NO	BEAM NO	NODE NO	AXIAL P1	SHEAR F2	SHEAR F3	TORQUE T1	MOMENT BM2	MOMENT BM3
1	3	105	0.5109E 02	-0.2947E 03	-0.1448E 02	0.2026E 02	0.6071E 03	0.1456E 03
2	3	105	-0.3184E 03	0.9008E 03	0.3432E 03	0.3199E 05	-0.9320E 04	0.2015E 05
3	3	105	0.6715E 02	-0.1973E 03	-0.6049E 02	0.8456E 02	0.6953E 03	0.1721E 03
4	3	105	-0.2303E 03	0.6199E 03	0.2252E 03	0.2345E 05	-0.7228E 04	0.1486E 05
5	3	105	0.4349E 02	-0.6790E 02	-0.8339E 02	0.1116E 03	0.4544E 03	-0.5092E 02
6	3	105	-0.5326E 01	0.5476E 02	-0.3872E 02	0.3445E 04	-0.8066E 03	0.1953E 04
7	3	105	0.2298E 03	0.5492E 04	-0.1448E 02	0.2032E 02	0.5146E 04	-0.3325E 05
8	3	105	-0.2226E 02	0.7715E 03	-0.8212E 02	0.1148E 03	-0.5996E 03	0.2950E 03
9	3	105	-0.4116E 02	0.3302E 04	0.8212E 02	-0.1148E 03	-0.3471E 03	-0.9333E 04
10	3	105	-0.9402E 04	-0.2212E 04	0.7971E 04	0.1575E 06	-0.2203E 06	0.1041E 06
11	3	105	0.5086E 02	-0.2917E 03	-0.1448E 02	0.2026E 02	0.6024E 03	0.1493E 03
12	3	105	-0.3181E 03	0.9023E 03	0.3429E 03	0.3194E 05	-0.9310E 04	0.2012E 05
13	3	105	0.6700E 02	-0.1959E 03	-0.6049E 02	0.8456E 02	0.6929E 03	0.1721E 03
14	3	105	-0.2300E 03	0.6195E 03	0.2247E 03	0.2341E 05	-0.7217E 04	0.1483E 05
15	3	105	0.3175E 02	-0.1693E 02	-0.8339E 02	0.1166E 03	0.3498E 03	-0.2019E 03
16	3	105	0.3599E 02	0.3982E 02	-0.5603E 02	0.1986E 04	-0.4037E 03	0.9514E 03
1	3	107	-0.5109E 02	0.2947E 03	0.1448E 02	-0.2026E 02	-0.4305E 03	-0.3741E 04
2	3	107	0.3184E 03	-0.9008E 03	-0.3432E 03	-0.3199E 05	0.5133E 04	-0.9165E 04
3	3	107	-0.6715E 02	0.1973E 03	0.6049E 02	-0.8456E 02	0.4269E 02	-0.2579E 06
4	3	107	0.2303E 03	-0.6199E 03	-0.2252E 03	0.2345E 05	0.4481E 04	-0.7293E 04
5	3	107	-0.4349E 02	0.6790E 02	0.8339E 02	-0.1116E 03	0.5629E 03	-0.7775E 03
6	3	107	0.5326E 01	-0.5476E 02	0.3872E 02	-0.3445E 04	0.1279E 04	-0.1285E 04
7	3	107	-0.2298E 03	-0.5492E 04	0.1448E 02	-0.2032E 02	-0.4969E 04	0.1003E 06
8	3	107	0.2226E 02	-0.7715E 03	0.8212E 02	-0.1148E 03	0.1601E 04	0.9118E 04
9	3	107	0.4116E 02	-0.3302E 04	-0.8212E 02	0.1148E 03	-0.6548E 03	0.4961E 05
10	3	107	0.9402E 04	0.2212E 04	-0.7971E 04	-0.1575E 06	0.1231E 06	-0.1311E 06
11	3	107	-0.5086E 02	0.2917E 03	0.1448E 02	0.2026E 02	-0.4258E 03	-0.3709E 04
12	3	107	0.3181E 03	-0.9023E 03	-0.3429E 03	-0.3194E 05	0.5127E 04	-0.9110E 04
13	3	107	-0.6700E 02	0.1959E 03	0.6049E 02	-0.8456E 02	0.4530E 02	-0.2562E 04
14	3	107	0.2300E 03	-0.6195E 03	-0.2247E 03	-0.2341E 05	0.4475E 04	-0.7271E 04
15	3	107	-0.3175E 02	0.1693E 02	0.8339E 02	-0.1166E 03	0.6765E 03	-0.4608E 01
16	3	107	-0.3599E 02	-0.3982E 02	0.5603E 02	-0.1986E 04	0.1092E 04	-0.4656E 03
1	4	108	0.5109E 02	0.2947E 03	0.1448E 02	-0.2023E 02	0.4305E 03	0.3741E 04
2	4	108	0.4392E 03	0.8335E 02	0.3722E 03	0.3195E 05	0.6386E 04	-0.2486E 05
3	4	108	0.6715E 02	0.1973E 03	0.6049E 02	-0.8454E 02	-0.4218E 02	0.2579E 04
4	4	108	0.3801E 03	0.4926E 02	0.3462E 03	0.2328E 05	0.4719E 04	-0.1813E 05
5	4	108	0.4349E 02	0.6790E 02	0.8339E 02	-0.1166E 03	-0.5629E 03	0.7775E 03
6	4	108	0.8880E 02	0.3309E 02	0.1281E 03	0.3212E 04	0.1595E 03	-0.2388E 04
7	4	108	0.2298E 03	-0.5492E 04	0.1448E 02	-0.2016E 02	0.4970E 04	-0.1003E 06
8	4	108	-0.2226E 02	-0.7716E 03	0.8212E 02	-0.1148E 03	-0.1601E 04	-0.9118E 04
9	4	108	-0.4116E 02	-0.3302E 04	-0.8212E 02	0.1148E 03	0.6548E 03	-0.4961E 05
10	4	108	0.9634E 04	-0.5594E 04	0.7971E 04	0.1575E 06	0.1336E 06	-0.2006E 06
11	4	108	0.5086E 02	0.2917E 03	0.1448E 02	-0.2023E 02	0.4258E 03	0.3709E 04
12	4	108	0.4388E 03	0.8012E 02	0.3718E 03	0.3190E 05	0.6380E 04	-0.2487E 05
13	4	108	0.6700E 02	0.1959E 03	0.6049E 02	-0.8454E 02	-0.4530E 02	0.2562E 04
14	4	108	0.3795E 03	0.4833E 02	0.3457E 03	0.2324E 05	0.4739E 04	-0.1811E 05
15	4	108	0.3175E 02	0.1693E 02	0.8339E 02	-0.1166E 03	-0.6765E 03	0.4607E 01
16	4	108	0.6237E 02	0.4674E 01	0.1107E 03	0.1753E 04	-0.2115E 03	-0.1661E 04
1	4	106	-0.5109E 02	-0.2947E 03	-0.1448E 02	0.2023E 02	-0.6071E 03	-0.1456E 03
2	4	106	-0.4392E 03	-0.8335E 02	-0.3722E 03	-0.3195E 05	-0.1093E 05	0.2588E 05
3	4	106	-0.6715E 02	-0.1973E 03	-0.6049E 02	0.8454E 02	-0.6953E 03	-0.1721E 03
4	4	106	-0.3801E 03	-0.4926E 02	-0.3462E 03	-0.2328E 05	-0.8942E 04	0.1873E 05
5	4	106	-0.4349E 02	-0.6790E 02	-0.8339E 02	0.1166E 03	-0.4544E 03	0.5092E 02

6	4	106	-0.8880E	02	-0.3309E	02	-0.1281E	03	-0.3212E	04	-0.1722E	04	0.2792E	04
7	4	106	-0.2298E	03	0.5492E	04	-0.1448E	02	0.2032E	02	-0.5146E	04	0.3325E	05
8	4	106	0.2226E	02	0.7716E	03	-0.8212E	02	0.1148E	03	0.5936E	03	-0.2951E	03
9	4	106	0.4116E	02	0.3302E	04	0.8212E	02	-0.1148E	03	0.3471E	03	0.9333E	04
10	4	106	-0.9834E	04	0.5594E	04	-0.7971E	04	-0.1575E	06	-0.2308E	06	0.1324E	06
11	4	106	-0.5086E	02	-0.2917E	03	-0.1448E	02	0.2023E	02	-0.6024E	03	-0.1493E	03
12	4	106	-0.4388E	03	-0.8012E	02	-0.3718E	03	-0.3190E	05	-0.1092E	05	0.2585E	05
13	4	106	-0.6700E	02	-0.1959E	03	-0.6049E	02	0.8454E	02	-0.6929E	03	-0.1721E	03
14	4	106	-0.3795E	03	-0.4833E	02	-0.3457E	03	-0.2324E	05	-0.8927E	04	0.1869E	05
15	4	106	-0.3175E	02	-0.1693E	02	-0.8339E	02	0.1166E	03	-0.3408E	03	0.2019E	03
16	4	106	-0.6237E	02	-0.4679E	02	-0.1107E	03	-0.1753E	04	-0.1139E	04	0.1718E	04
1	11	112	0.3787E	02	-0.1621E	03	-0.5109E	02	-0.6116E	03	0.1886E	04	-0.8046E	04
2	11	112	0.3956E	03	0.4930E	02	-0.4392E	03	-0.2518E	05	0.9827E	04	-0.2873E	05
3	11	112	0.1582E	03	-0.1046E	03	-0.6715E	02	-0.2664E	03	0.2407E	04	-0.4985E	04
4	11	112	0.4439E	03	0.4346E	02	-0.3801E	03	-0.1807E	05	0.8834E	04	-0.2038E	05
5	11	112	0.2181E	03	-0.6790E	02	-0.4349E	02	-0.1812E	03	0.1368E	04	-0.3058E	04
6	11	112	0.2628E	03	-0.3309E	02	-0.8880E	02	-0.2720E	04	0.2223E	04	-0.4557E	04
7	11	112	0.3787E	02	0.5625E	04	-0.2298E	03	-0.1513E	05	0.6292E	04	0.2813E	06
8	11	112	0.2148E	03	0.7482E	03	0.2226E	02	0.2705E	04	-0.8630E	03	0.3774E	05
9	11	112	-0.2148E	03	0.3325E	04	0.4116E	02	0.1165E	04	-0.1364E	04	0.1659E	06
10	11	112	0.7971E	04	0.5594E	04	-0.9968E	04	-0.9473E	05	0.2421E	06	0.1381E	06
11	11	112	0.3787E	02	-0.1591E	03	-0.5086E	02	-0.5988E	03	0.1879E	04	-0.7896E	04
12	11	112	0.3952E	03	0.5253E	02	-0.4388E	03	-0.2514E	05	0.9819E	04	-0.2852E	05
13	11	112	0.1582E	03	-0.1032E	03	-0.6700E	02	-0.2621E	03	0.2402E	03	-0.4913E	04
14	11	112	0.4434E	03	0.4439E	02	-0.3794E	03	-0.1803E	05	0.8878E	04	-0.2029E	05
15	11	112	-0.2181E	03	-0.1693E	02	-0.3175E	02	-0.1926E	03	0.8946E	03	-0.5100E	03
16	11	112	0.2454E	03	-0.4675E	02	-0.6237E	02	-0.1608E	04	0.1539E	04	-0.1712E	04
1	11	104	-0.3787E	02	0.1621E	03	0.5109E	02	0.6116E	03	0.6632E	03	-0.5842E	02
2	11	104	-0.3956E	03	-0.4930E	02	0.4392E	03	0.2518E	05	0.1213E	05	0.3120E	05
3	11	104	-0.1582E	03	0.1046E	03	0.6715E	02	0.2664E	03	0.9536E	03	-0.2441E	03
4	11	104	-0.4439E	03	-0.4346E	02	0.3801E	03	0.1807E	05	0.1011E	05	0.2255E	05
5	11	104	-0.2181E	03	0.6790E	02	0.4349E	02	0.1812E	03	0.8064E	03	-0.3365E	03
6	11	104	-0.2628E	03	0.3309E	02	0.8880E	02	0.2720E	04	0.2217E	04	0.2903E	04
7	11	104	-0.3787E	02	-0.5625E	04	0.2298E	03	0.1513E	05	0.5207E	04	-0.5836E	02
8	11	104	-0.2148E	03	-0.7482E	03	-0.2226E	02	-0.2705E	04	-0.2530E	03	-0.3315E	03
9	11	104	0.2148E	03	-0.3325E	04	-0.4116E	02	-0.1165E	04	-0.6936E	03	0.3314E	03
10	11	104	-0.7971E	04	-0.5594E	04	0.9968E	04	0.9473E	05	0.2563E	06	0.1415E	06
11	11	104	-0.3787E	02	0.1591E	03	0.5086E	02	0.5988E	03	0.6636E	03	-0.5842E	02
12	11	104	-0.3952E	03	-0.5253E	02	0.4388E	03	0.2514E	05	0.1212E	05	0.3115E	05
13	11	104	-0.1582E	03	0.1032E	03	0.6700E	02	0.2621E	03	0.9482E	03	-0.2441E	03
14	11	104	-0.4434E	03	-0.4439E	02	0.3794E	03	0.1803E	05	0.1009E	05	0.2251E	05
15	11	104	-0.2181E	03	0.1693E	02	0.3175E	02	0.1926E	03	0.6928E	03	-0.3365E	03
16	11	104	-0.2454E	03	0.4675E	02	0.6237E	02	0.1608E	04	0.1579E	04	0.1478E	04
1	12	113	0.3787E	02	-0.1621E	03	0.5109E	02	0.6116E	03	-0.1836E	04	-0.8046E	04
2	12	113	-0.3799E	03	0.1033E	04	-0.3184E	03	-0.2248E	05	0.5516E	04	0.8298E	05
3	12	113	0.1582E	03	-0.1046E	03	0.6715E	02	0.2664E	03	-0.2407E	04	-0.4985E	04
4	12	113	-0.1275E	03	0.7126E	03	-0.2303E	03	-0.1644E	05	0.3630E	04	0.5867E	05
5	12	113	0.2181E	03	-0.6790E	02	0.4349E	02	0.1812E	03	-0.1368E	04	-0.3058E	04
6	12	113	0.1734E	03	0.5476E	02	-0.5326E	01	-0.2118E	04	-0.3312E	03	0.6314E	04
7	12	113	0.3787E	02	0.5625E	04	0.2298E	03	0.1513E	05	-0.6232E	04	0.2813E	06
8	12	113	0.2148E	03	0.7482E	03	-0.2226E	02	-0.2705E	04	0.8630E	03	0.3774E	05
9	12	113	-0.2148E	03	0.3325E	04	-0.4116E	02	-0.1165E	04	0.1365E	04	0.1659E	06
10	12	113	-0.7971E	04	-0.2212E	04	-0.9536E	04	-0.7821E	05	0.2310E	06	0.3095E	05
11	12	113	0.3787E	02	-0.1591E	03	0.5086E	02	0.5987E	03	-0.1879E	04	-0.7896E	04
12	12	113	-0.3119E	03	0.1035E	04	-0.3181E	03	-0.2245E	05	0.5512E	04	0.8301E	05
13	12	113	0.1582E	03	-0.1031E	03	0.6700E	02	0.2621E	03	-0.2402E	04	-0.4913E	04
14	12	113	-0.1270E	03	0.7122E	03	-0.2300E	03	-0.1641E	05	0.3625E	04	0.5861E	05
15	12	113	0.2181E	03	-0.1693E	02	0.3175E	02	0.1926E	03	-0.8946E	03	-0.5100E	03
16	12	113	0.1907E	03	0.3982E	02	0.3599E	02	-0.1086E	04	-0.3243E	03	0.4142E	04
1	12	103	-0.3787E	02	0.1621E	03	-0.5109E	02	-0.6116E	03	-0.6632E	03	-0.5845E	02
2	12	103	0.3199E	03	-0.1033E	04	0.3184E	03	0.2248E	05	0.1040E	05	-0.3131E	05
3	12	103	-0.1582E	03	0.1046E	03	-0.6715E	02	-0.2664E	03	-0.9536E	03	-0.2441E	03

4	12	103	0.1275E 03	-0.7126E 03	0.2303E 03	0.1644E 05	0.7887E 04	0.2304E 05
5	12	103	-0.2181E 03	0.6790E 02	-0.4349E 02	-0.1812E 03	-0.8064E 03	-0.3365E 03
6	12	103	-0.1734E 03	-0.5476E 02	0.5326E 01	0.2118E 04	0.5976E 03	-0.3576E 04
7	12	103	-0.3787E 02	-0.5625E 04	-0.2298E 03	-0.1513E 05	-0.5207E 04	-0.5851E 02
8	12	103	-0.2148E 03	-0.7482E 03	0.2226E 02	0.2705E 04	0.2530E 03	-0.3314E 03
9	12	103	0.2148E 03	-0.3325E 04	0.4116E 02	0.1165E 04	0.6937E 03	0.3314E 03
10	12	103	0.7971E 04	0.2212E 04	0.9536E 04	0.7821E 05	0.2458E 06	-0.1415E 06
11	12	103	-0.3787E 02	0.1591E 03	-0.5086E 02	-0.5987E 03	-0.6635E 03	-0.5845E 02
12	12	103	0.3195E 03	-0.1035E 04	0.3181E 03	0.2245E 05	0.1039E 05	-0.3127E 05
13	12	103	-0.1582E 03	0.1031E 03	-0.6700E 02	-0.2621E 03	-0.9482E 03	-0.2441E 03
14	12	103	0.1270E 03	-0.7122E 03	0.2300E 03	0.1641E 05	0.7874E 04	-0.2299E 05
15	12	103	-0.2181E 03	0.1693E 02	-0.3175E 02	-0.1926E 03	-0.6928E 03	-0.3365E 03
16	12	103	-0.1907E 03	-0.3982E 02	-0.3599E 02	0.1086E 04	0.1443E 03	-0.2151E 04
1	44	128	-0.1410E 03	0.2633E 05	-0.5490E 01	0.8953E-01	0.1260E 06	-0.6302E 05
2	44	128	-0.2225E 03	0.1340E 05	0.7650E 04	0.1617E 06	-0.1044E 04	-0.3160E 06
3	44	128	-0.2710E 03	0.1790E 05	-0.2294E 02	0.6753E-01	0.1343E 06	-0.3925E 05
4	44	128	-0.2683E 03	0.8981E 04	0.8247E 04	0.1282E 06	-0.1011E 04	-0.2153E 06
5	44	128	-0.3029E 03	0.2384E 04	-0.3163E 02	0.9199E-02	0.4679E 05	0.1152E 05
6	44	128	-0.2672E 03	0.3991E 03	0.2632E 04	0.2187E 05	-0.4915E 04	-0.1548E 05
7	44	128	0.5720E 03	0.3112E 02	-0.5480E 01	0.4865E 00	-0.5050E 05	-0.1683E 06
8	44	128	-0.2229E 03	-0.5469E 01	-0.3116E 02	-0.2515E 00	-0.1637E 05	-0.2007E 05
9	44	128	0.1577E 03	0.5477E 01	0.3116E 02	0.7154E-01	-0.4719E 05	-0.1347E 06
10	44	128	-0.5287E 04	-0.2633E 05	0.5168E 05	0.4036E 06	-0.8463E 06	-0.5358E 06
11	44	128	-0.1417E 03	0.2630E 05	-0.5490E 02	0.9933E-01	0.1258E 06	-0.6302E 05
12	44	128	-0.2216E 03	0.1338E 05	0.7639E 04	0.1614E 06	-0.1036E 04	-0.3155E 06
13	44	128	-0.2709E 03	0.1787E 05	-0.2294E 02	0.7407E-01	0.1337E 06	-0.3918E 05
14	44	128	-0.2680E 03	0.8970E 04	0.8233E 04	0.1279E 06	-0.1019E 04	-0.2149E 06
15	44	128	-0.1900E 03	0.5887E 03	-0.3163E 02	0.1094E-01	0.1935E 05	0.1029E 05
16	44	128	-0.1900E 03	-0.1981E 03	0.1428E 04	0.1198E 05	-0.4133E 04	-0.4361E 04
1	44	130	0.1410E 03	-0.2633E 05	0.5490E 01	-0.8953E-01	-0.1259E 06	0.4922E 06
2	44	130	0.2225E 03	-0.1340E 05	-0.7650E 04	-0.1617E 06	-0.1236E 06	0.5344E 06
3	44	130	0.2710E 03	-0.1790E 05	0.2294E 02	-0.6753E-01	-0.1339E 05	0.3302E 06
4	44	130	0.2683E 03	-0.8981E 04	-0.8247E 04	-0.1282E 06	-0.1334E 06	0.3617E 06
5	44	130	0.3029E 03	-0.2384E 04	0.3163E 02	-0.9199E 04	-0.4628E 05	0.2734E 05
6	44	130	0.2672E 03	-0.3991E 03	-0.2632E 04	-0.2187E 05	-0.3799E 05	0.2199E 05
7	44	130	-0.5720E 03	-0.3112E 02	0.5480E 01	-0.4865E 00	0.5059E 05	0.1688E 06
8	44	130	0.2229E 03	0.5469E 01	0.3116E 02	0.2515E 00	0.1698E 05	0.1998E 05
9	44	130	-0.1577E 03	-0.5477E 01	-0.3116E 02	-0.7154E-01	0.4668E 05	0.1348E 06
10	44	130	0.5287E 04	0.2633E 05	-0.5168E 05	-0.4036E 06	0.3937E 04	0.1067E 06
11	44	130	0.1417E 03	-0.2630E 05	0.5490E 02	-0.9933E 03	-0.1258E 06	0.4917E 06
12	44	130	0.2216E 03	-0.1338E 05	-0.7639E 04	-0.1614E 06	-0.1235E 06	0.5336E 06
13	44	130	0.2709E 03	-0.1787E 05	0.2294E 02	-0.7407E 03	-0.1337E 06	0.3305E 06
14	44	130	0.2680E 03	-0.8970E 04	-0.8234E 04	-0.1279E 06	-0.1332E 06	0.3611E 06
15	44	130	0.1900E 03	-0.5887E 03	0.3163E 02	-0.1094E 03	-0.1883E 05	-0.6985E 03
16	44	130	0.1900E 03	0.1981E 03	-0.1428E 04	-0.1198E 05	-0.1915E 05	0.1132E 04
1	45	130	-0.1410E 03	-0.2633E 05	0.5496E 01	0.8953E-01	0.1259E 06	-0.4922E 06
2	45	130	-0.2225E 03	-0.4195E 05	0.7661E 04	0.1617E 06	0.1236E 06	-0.5344E 06
3	45	130	-0.2710E 03	-0.1790E 05	0.2295E 02	0.6753E-01	0.1339E 05	-0.3310E 06
4	45	130	-0.2683E 03	-0.2879E 05	0.8293E 04	0.1282E 06	0.1334E 06	-0.3617E 06
5	45	130	-0.3029E 03	-0.2384E 04	0.3163E 02	0.9199E-02	0.4628E 05	-0.2734E 05
6	45	130	-0.2672E 03	-0.3455E 04	0.2696E 04	0.2187E 05	0.3799E 05	-0.2199E 05
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8	45	130	-0.2229E 03	0.5517E 01	0.3114E 02	-0.2515E 00	-0.1688E 05	-0.1998E 05
9	45	130	0.1577E 03	-0.5509E 01	-0.3114E 02	0.7154E-01	-0.4668E 05	-0.1348E 06
10	45	130	-0.5223E 04	-0.2633E 05	0.5168E 05	0.4036E 06	-0.3937E 04	-0.1067E 06
11	45	130	-0.1417E 03	-0.2630E 05	0.5496E 01	0.9933E 03	0.1258E 06	-0.4917E 06
12	45	130	-0.2216E 03	-0.4190E 05	0.7650E 04	0.1614E 06	0.1235E 06	-0.5336E 06
13	45	130	-0.2709E 03	-0.1787E 05	0.2295E 02	0.7407E 03	0.1337E 06	-0.3305E 06
14	45	130	-0.2680E 03	-0.2874E 05	0.8279E 04	0.1279E 06	0.1332E 06	-0.3611E 06
15	45	130	-0.1900E 03	-0.5887E 03	0.3163E 02	0.1094E 03	0.1883E 05	0.6985E 03
16	45	130	-0.1900E 03	-0.1483E 04	0.1492E 04	0.1198E 05	0.1915E 05	-0.1132E 04
1	45	129	0.1410E 03	0.2633E 05	-0.5496E 01	-0.8953E-01	-0.1260E 06	0.6302E 05

2	45	129	0.2225E 03	0.4195E 05	-0.7661E 04	-0.1617E 06	-0.2495E 06	-0.1495E 06
3	45	129	0.2710E 03	0.1790E 05	-0.2295E 02	-0.6753E-01	-0.1343E 06	0.3925E 05
4	45	129	0.2683E 03	0.2879E 05	-0.8293E 04	-0.1282E 06	-0.2686E 06	-0.1075E 06
5	45	129	0.3029E 03	0.2384E 04	-0.3163E 02	-0.9199E-02	-0.4680E 05	-0.1152E 05
6	45	129	0.2672E 03	0.3455E 04	-0.2696E 04	-0.2187E 05	-0.8193E 05	-0.3433E 05
7	45	129	-0.5720E 03	0.3119E 02	-0.5506E 01	-0.4865E 00	0.5050E 05	0.1682E 06
8	45	129	0.2229E 03	-0.5517E 01	-0.3114E 02	0.2515E 00	0.1637E 05	0.2007E 05
9	45	129	-0.1577E 03	0.5509E 01	0.3114E 02	-0.7154E-01	0.4719E 05	0.1348E 06
10	45	129	0.5223E 04	0.2633E 05	-0.5168E 05	-0.4036E 06	-0.8394E 06	-0.3225E 06
11	45	129	0.1417E 03	0.2630E 05	-0.5496E 01	-0.9933E 03	-0.1258E 06	0.6302E 05
12	45	129	0.2216E 03	0.4190E 05	-0.7650E 04	-0.1614E 06	-0.2432E 06	-0.1493E 06
13	45	129	0.2769E 03	0.1787E 05	-0.2295E 02	-0.7407E 03	-0.1341E 06	0.3918E 05
14	45	129	0.2680E 03	0.2874E 05	-0.8279E 04	-0.1279E 06	-0.2681E 06	-0.1073E 06
15	45	129	0.1900E 03	0.5887E 03	-0.3163E 02	-0.1094E-01	-0.1935E 05	-0.1029E 05
16	45	129	0.1900E 03	0.1483E 04	-0.1492E 04	-0.1198E 05	-0.4346E 05	-0.2304E 05
1	54	127	0.1011E 05	-0.1865E 05	0.6490E 03	0.1004E 06	0.4497E 05	-0.7032E 05
2	54	127	0.2596E 05	-0.3860E 05	0.4484E 03	0.2614E 06	0.1030E 06	-0.1245E 06
3	54	127	0.1114E 05	-0.1279E 05	0.8199E 03	0.7005E 05	0.4729E 05	-0.4790E 05
4	54	127	0.2856E 05	-0.2655E 05	0.6151E 03	0.1809E 06	0.1119E 06	-0.9510E 05
5	54	127	0.4285E 04	-0.2243E 04	0.4519E 03	0.1808E 05	0.1514E 05	-0.7311E 04
6	54	127	0.9309E 04	-0.3877E 04	0.3547E 03	0.3257E 05	0.3358E 05	-0.1354E 05
7	54	127	-0.3734E 04	0.7924E 04	-0.4372E 03	-0.5383E 05	-0.1550E 05	-0.1048E 06
8	54	127	-0.1057E 04	0.1415E 04	0.2516E 02	-0.7496E 04	-0.8092E 04	-0.3060E 05
9	54	127	-0.4314E 04	0.6828E 04	-0.3789E 03	-0.5319E 05	-0.1596E 05	-0.1069E 06
10	54	127	0.8816E 05	-0.4181E 05	-0.1191E 05	0.3358E 06	0.3381E 06	-0.2585E 06
11	54	127	0.1010E 05	-0.1865E 05	0.6489E 03	0.1004E 06	0.4494E 05	-0.7029E 05
12	54	127	0.2592E 05	-0.3855E 05	0.4472E 03	0.2611E 06	0.1028E 06	-0.1242E 06
13	54	127	0.1113E 05	-0.1277E 05	0.8187E 03	0.6997E 05	0.4721E 05	-0.4778E 05
14	54	127	0.2851E 05	-0.2651E 05	0.6141E 03	0.1806E 06	0.1117E 06	-0.9489E 05
15	54	127	0.1989E 04	-0.8567E 03	0.2341E 03	0.8048E 04	0.5437E 04	0.3635E 04
16	54	127	0.5142E 04	-0.1991E 04	0.2166E 03	0.1772E 05	0.1723E 05	-0.1649E 04
1	54	142	-0.1011E 05	0.1865E 05	-0.6490E 03	-0.1004E 06	-0.5626E 05	-0.2541E 06
2	54	142	-0.2596E 05	0.3860E 05	-0.4484E 03	-0.2614E 06	-0.1138E 06	-0.5470E 06
3	54	142	-0.1114E 05	0.1279E 05	-0.8199E 03	-0.7005E 05	-0.6156E 05	-0.1746E 06
4	54	142	-0.2856E 05	0.2655E 05	-0.6151E 03	-0.1809E 06	-0.1226E 06	-0.3669E 06
5	54	142	-0.4285E 04	0.2243E 04	-0.4519E 03	-0.1808E 05	-0.2330E 05	-0.3171E 05
6	54	142	-0.9309E 04	0.3877E 04	-0.3547E 03	-0.3257E 05	-0.3975E 05	-0.5392E 05
7	54	142	0.3734E 04	-0.7924E 04	0.4372E 03	0.5383E 05	0.2311E 05	0.2427E 06
8	54	142	0.1057E 04	-0.1415E 04	-0.2516E 02	0.7496E 04	0.7654E 04	0.5522E 05
9	54	142	0.4314E 04	-0.6828E 04	0.3789E 03	0.5319E 05	0.2255E 05	0.2257E 06
10	54	142	-0.8816E 05	0.4181E 05	0.1191E 05	-0.3358E 06	-0.1339E 06	-0.4690E 06
11	54	142	-0.1010E 05	0.1865E 05	-0.6489E 03	-0.1004E 06	-0.5623E 05	-0.2542E 06
12	54	142	-0.2592E 05	0.3855E 05	-0.4472E 03	-0.2611E 06	-0.1136E 06	-0.5465E 06
13	54	142	-0.1113E 05	0.1277E 05	-0.8187E 03	-0.6997E 05	-0.6145E 05	-0.1744E 06
14	54	142	-0.2851E 05	0.2651E 05	-0.6141E 03	-0.1807E 06	-0.1224E 06	-0.3664E 06
15	54	142	-0.1989E 04	0.8567E 03	-0.2341E 03	-0.8048E 04	-0.9510E 04	-0.1851E 05
16	54	142	-0.5142E 04	0.1991E 03	-0.2166E 03	-0.1772E 05	-0.2100E 05	-0.3299E 05
1	55	143	0.1011E 05	0.1865E 05	-0.6490E 03	-0.1004E 06	0.5626E 05	0.2541E 06
2	55	143	-0.5913E 04	-0.1041E 04	-0.9706E 03	0.6096E 05	0.1925E 04	-0.5714E 05
3	55	143	0.1114E 05	0.1279E 05	-0.8199E 03	-0.7005E 05	0.6156E 05	0.1746E 06
4	55	143	-0.6295E 04	-0.7893E 03	-0.1036E 04	0.4116E 05	0.4489E 03	-0.3147E 05
5	55	143	0.4285E 04	0.2243E 04	-0.4519E 03	-0.1808E 05	0.2330E 05	0.3171E 05
6	55	143	-0.2115E 04	-0.2534E 03	-0.4196E 03	0.2755E 04	-0.1812E 04	-0.5479E 03
7	55	143	-0.3734E 04	-0.7924E 04	0.4372E 03	0.5383E 05	-0.2311E 05	-0.2427E 06
8	55	143	-0.1057E 04	-0.1415E 04	-0.2516E 02	0.7496E 04	-0.7654E 04	-0.5522E 05
9	55	143	-0.4314E 04	-0.6828E 04	0.3789E 03	0.5319E 05	-0.2255E 05	-0.2257E 06
10	55	143	-0.8914E 05	-0.4086E 05	-0.1195E 05	0.3485E 06	-0.1355E 06	-0.7047E 06
11	55	143	0.1010E 05	0.1865E 05	-0.6489E 03	-0.1004E 06	0.5623E 05	0.2542E 06
12	55	143	-0.5905E 04	-0.1036E 04	-0.9690E 03	0.6084E 06	0.1922E 04	-0.5688E 05
13	55	143	0.1113E 05	0.1277E 05	-0.8187E 03	-0.6997E 05	0.6145E 05	0.1744E 06
14	55	143	-0.6285E 04	-0.7838E 03	-0.1034E 04	0.4107E 05	0.4429E 03	-0.3131E 05
15	55	143	0.1989E 04	0.8567E 03	-0.2341E 03	-0.8048E 04	0.9510E 04	0.1851E 05

16	55	143	-0.1106E	04	-0.2818E	03	-0.2571E	03	0.1711E	04	-0.1638E	04	0.2894E	04
1	55	126	-0.1011E	05	-0.1865E	05	0.6490E	03	0.1004E	06	-0.4497E	05	0.7032E	05
2	55	126	0.5913E	04	0.1041E	04	0.9706E	03	-0.6096E	05	0.1496E	05	0.3902E	05
3	55	126	-0.1114E	05	-0.1279E	05	0.8199E	03	0.7005E	05	-0.4729E	05	0.4790E	05
4	55	126	0.6295E	04	0.7893E	03	0.1036E	04	-0.4116E	05	0.1758E	05	0.1774E	05
5	55	126	-0.4285E	04	-0.2243E	04	0.4519E	03	0.1808E	05	-0.1514E	05	0.7311E	04
6	55	126	0.2115E	04	0.2534E	03	0.4196E	03	-0.2755E	04	0.9126E	04	-0.3860E	04
7	55	126	0.3734E	04	0.7924E	04	-0.4372E	03	-0.5383E	05	0.1550E	05	0.1048E	06
8	55	126	0.1057E	04	0.1415E	04	0.2516E	02	-0.7496E	04	0.8092E	04	0.3060E	05
9	55	126	0.4314E	04	0.6828E	04	-0.3789E	03	-0.5319E	05	0.1596E	05	0.1069E	06
10	55	126	0.8914E	05	0.4086E	05	0.1195E	05	-0.3485E	06	0.3434E	06	-0.6287E	04
11	55	126	-0.1010E	05	-0.1865E	05	0.6489E	03	0.1004E	06	0.4494E	05	0.7029E	05
12	55	126	0.5905E	04	0.1036E	04	0.9690E	03	-0.6084E	05	0.1494E	05	0.3886E	05
13	55	126	-0.1113E	05	-0.1277E	05	0.8187E	03	0.6997E	05	-0.4721E	05	0.4778E	05
14	55	126	0.6285E	04	0.7838E	03	0.1034E	04	-0.4107E	05	0.1755E	05	0.1767E	05
15	55	126	-0.1989E	04	-0.8567E	03	0.2341E	03	0.8048E	04	-0.5437E	04	-0.3605E	04
16	55	126	0.1106E	04	0.2818E	03	0.2571E	03	-0.1711E	04	0.6112E	04	-0.7798E	04
1	84	167	0.5211E	04	0.1023E	03	-0.1803E	02	0.8193E	02	0.2008E	05	-0.2078E	06
2	84	167	0.5214E	04	-0.2419E	04	0.5459E	04	-0.2071E	06	-0.1361E	06	-0.2798E	06
3	84	167	0.3947E	04	0.7151E	02	0.7535E	02	0.3426E	03	-0.6915E	05	-0.1831E	06
4	84	167	0.3961E	04	-0.1048E	04	0.4695E	04	-0.1763E	06	-0.2055E	06	-0.2156E	06
5	84	167	0.9086E	04	-0.2386E	-01	-0.1039E	03	0.4725E	03	-0.1098E	06	-0.1391E	05
6	84	167	0.8494E	04	-0.1977E	03	0.1151E	04	-0.3449E	05	-0.1615E	06	-0.5518E	05
7	84	167	0.4586E	04	0.1022E	03	-0.1798E	02	0.8126E	02	-0.1028E	06	-0.3182E	06
8	84	167	-0.1910E	04	-0.1800E	02	-0.1023E	03	0.4655E	03	-0.1962E	06	0.3186E	05
9	84	167	0.1296E	04	0.1802E	02	0.1023E	03	-0.4656E	03	0.1506E	06	-0.6727E	05
10	84	167	-0.2496E	03	-0.4871E	04	-0.9684E	04	0.3380E	06	0.2767E	06	-0.1384E	06
11	84	167	0.5060E	04	0.1023E	03	-0.1803E	02	0.8192E	02	0.2031E	05	-0.2052E	06
12	84	167	0.5062E	04	-0.2416E	04	0.5440E	04	-0.2068E	06	-0.1354E	06	-0.2771E	06
13	84	167	0.3874E	04	0.7151E	02	-0.7535E	02	0.3426E	03	-0.6865E	05	-0.1802E	06
14	84	167	0.3888E	04	-0.1052E	04	0.4681E	04	-0.1759E	06	-0.2046E	06	-0.2129E	06
15	84	167	0.7239E	04	-0.2116E	03	-0.1038E	03	0.4724E	03	-0.1602E	06	-0.1246E	06
16	84	167	0.7218E	04	-0.4959E	02	0.5942E	03	-0.1968E	05	-0.1799E	06	-0.1259E	06
1	84	169	-0.5211E	04	-0.1023E	03	0.1803E	02	-0.8193E	02	-0.1932E	05	0.2093E	06
2	84	169	-0.5214E	04	0.2419E	04	-0.5459E	04	0.2071E	06	0.5694E	05	0.2447E	06
3	84	169	-0.3947E	04	-0.7152E	02	0.7535E	02	-0.3426E	03	0.7024E	05	0.1841E	06
4	84	169	-0.3961E	04	0.1048E	04	-0.4695E	04	0.1763E	06	0.1374E	06	0.2004E	06
5	84	169	-0.9086E	04	0.2386E	-01	0.1039E	03	-0.4725E	03	0.1113E	06	0.1391E	05
6	84	169	-0.8494E	04	0.1977E	03	-0.1151E	04	0.3449E	05	0.1448E	06	0.5231E	05
7	84	169	-0.4586E	04	-0.1022E	03	0.1798E	02	-0.8126E	02	0.1031E	06	0.3197E	06
8	84	169	0.1910E	04	0.1800E	02	0.1023E	03	-0.4655E	03	0.1977E	06	-0.3212E	05
9	84	169	-0.1296E	04	-0.1802E	02	-0.1023E	03	0.4656E	03	-0.1521E	06	0.6753E	05
10	84	169	0.2496E	03	0.4871E	04	0.9684E	04	-0.3380E	06	-0.1363E	06	0.6780E	05
11	84	169	-0.5060E	04	-0.1023E	03	0.1803E	02	-0.8192E	02	-0.2055E	05	0.2067E	06
12	84	169	-0.5062E	04	0.2416E	04	-0.5440E	04	0.2068E	06	0.5650E	05	0.2421E	06
13	84	169	-0.3874E	04	-0.7151E	02	0.7535E	02	-0.3426E	03	0.6974E	05	0.1813E	06
14	84	169	-0.3888E	04	0.1052E	04	-0.4681E	04	0.1759E	06	0.1367E	06	0.1976E	06
15	84	169	-0.7234E	04	0.2116E	03	0.1038E	03	-0.4724E	03	0.1617E	06	0.1246E	06
16	84	169	-0.7218E	04	0.4969E	02	-0.5942E	03	0.1968E	05	0.1713E	06	0.1252E	06
1	85	168	0.5211E	04	-0.1023E	03	0.1805E	02	-0.8214E	02	0.1982E	05	-0.2093E	06
2	85	168	0.5214E	04	-0.2624E	04	0.5495E	04	-0.2073E	06	0.9642E	05	-0.1741E	06
3	85	168	0.3947E	04	-0.7152E	02	0.7537E	02	-0.3428E	03	-0.7024E	05	-0.1841E	06
4	85	168	0.3961E	04	-0.1191E	04	0.4846E	04	-0.1770E	06	-0.3840E	04	-0.1691E	06
5	85	168	0.9086E	04	-0.2386E	-01	0.1039E	03	-0.4723E	03	-0.1113E	06	-0.1391E	05
6	85	168	0.8494E	04	-0.1977E	03	0.1359E	04	-0.3544E	05	-0.1097E	06	-0.4677E	05
7	85	168	0.4586E	04	-0.1024E	03	0.1810E	02	-0.8280E	02	-0.1031E	06	-0.3197E	06
8	85	168	-0.1910E	04	0.1808E	02	0.1023E	03	-0.4650E	03	-0.1977E	06	0.3212E	05
9	85	168	0.1295E	04	-0.1806E	02	-0.1023E	03	0.4649E	03	0.1521E	06	-0.6753E	05
10	85	168	-0.4181E	02	-0.4871E	04	-0.9684E	04	0.3380E	06	-0.1349E	06	0.6953E	05
11	85	168	0.5060E	04	-0.1023E	03	0.1805E	02	-0.8215E	02	0.2005E	05	-0.2067E	06
12	85	168	0.5062E	04	-0.2621E	04	0.5476E	04	-0.2069E	06	0.9633E	05	-0.1715E	06
13	85	168	0.3874E	04	-0.7152E	02	0.7537E	02	-0.3428E	03	-0.6974E	05	-0.1813E	06

14	85	168	0.3888E 04	-0.1195E 04	0.4833E 04	-0.1766E 06	-0.3532E 04	-0.1662E 06
15	85	168	0.7234E 04	-0.2116E -01	0.1039E 03	-0.4724E 03	-0.1617E 06	-0.1246E 06
16	85	168	0.7218E 04	-0.4959E 02	0.8020E 03	-0.2062E 05	-0.1517E 06	-0.1238E 06
1	85	166	-0.5211E 04	0.1023E 03	-0.1805E 02	0.8214E 02	-0.2008E 05	0.2078E 06
2	85	166	-0.5214E 04	0.2624E 04	-0.5495E 04	0.2073E 06	-0.1761E 06	0.1630E 06
3	85	166	-0.3947E 04	0.7152E 02	-0.7537E 02	0.3428E 03	0.6914E 05	0.1831E 06
4	85	166	-0.3961E 04	0.1191E 04	-0.4846E 04	0.1770E 06	-0.6643E 05	0.1518E 06
5	85	166	-0.9086E 04	0.2386E 03	-0.1039E 03	0.4723E 03	0.1098E 06	0.1391E 05
6	85	166	-0.8494E 04	0.1977E 03	-0.1359E 04	0.3544E 05	0.8996E 05	0.4391E 05
7	85	166	-0.4568E 04	0.1024E 03	-0.1810E 02	0.8280E 02	0.1028E 06	0.3182E 06
8	95	166	0.1910E 04	-0.1808E 02	-0.1023E 03	0.4650E 03	0.1962E 06	-0.3185E 05
9	85	166	-0.1275E 04	0.1806E 02	0.1023E 03	-0.4649E 03	-0.1506E 06	0.6727E 05
10	85	166	0.4181E 02	0.4871E 04	0.9684E 04	-0.3380E 06	0.2753E 06	-0.1402E 06
11	85	166	-0.5060E 04	0.1023E 03	-0.1805E 02	0.8215E 02	-0.2031E 05	0.2052E 06
12	85	166	-0.5062E 04	0.2621E 04	-0.5476E 04	0.2069E 06	-0.1757E 06	0.1335E 06
13	85	166	-0.3874E 04	0.7152E 02	-0.7537E 02	0.3428E 03	0.6865E 05	0.1802E 06
14	85	166	-0.3888E 04	0.1195E 04	-0.4832E 04	0.1766E 06	-0.6654E 05	0.1489E 06
15	85	166	-0.7234E 04	0.2116E 03	-0.1039E 03	0.4724E 03	0.1602E 06	0.1246E 06
16	85	166	-0.7218E 04	0.4959E 02	-0.8020E 03	0.2062E 05	0.1401E 06	0.1230E 06
1	56	144	-0.9949E 04	0.6609E 04	0.2925E 03	0.3338E 05	-0.1626E 05	0.1145E 06
2	56	144	-0.1715E 05	0.7907E 04	0.2021E 03	0.8693E 05	-0.3071E 05	0.1999E 06
3	56	144	-0.1047E 05	0.4400E 04	0.3695E 03	0.2330E 05	-0.1796E 05	0.7759E 05
4	56	144	-0.1877E 05	0.5323E 04	0.2772E 03	0.6016E 05	-0.3419E 05	0.1307E 06
5	56	144	-0.3351E 04	0.1484E 03	0.2037E 03	0.6012E 04	-0.6940E 04	0.8864E 04
6	56	144	-0.5550E 04	0.1144E 03	0.1598E 03	0.1083E 05	-0.1133E 05	0.1352E 05
7	56	144	0.3896E 04	-0.1605E 04	-0.1970E 03	-0.1790E 05	0.6945E 04	-0.1218E 06
8	56	144	0.1977E 04	-0.5142E 03	0.1134E 02	-0.2493E 04	0.2034E 04	-0.3111E 05
9	56	144	0.3394E 04	-0.6505E 03	-0.1708E 03	-0.1769E 05	0.6703E 04	-0.1089E 06
10	56	144	-0.1163E 05	0.2897E 04	-0.5366E 04	0.1117E 06	-0.1686E 05	0.9051E 05
11	56	144	-0.9941E 04	0.6608E 04	0.2925E 03	0.3339E 05	-0.1625E 05	0.1145E 06
12	56	144	-0.1713E 05	0.7894E 04	0.2016E 03	0.8683E 05	-0.3067E 05	0.1997E 06
13	56	144	-0.1045E 05	0.4394E 04	0.3690E 03	0.2327E 05	-0.1793E 05	0.7752E 05
14	56	144	-0.1873E 05	0.5315E 04	0.2767E 03	0.6007E 05	-0.3413E 05	0.1305E 06
15	56	144	-0.1055E 04	-0.6631E 02	0.1055E 03	0.2676E 04	-0.2943E 04	0.6287E 04
16	56	144	-0.2652E 04	-0.4837E 02	0.9762E 02	0.5892E 04	-0.6028E 04	0.9305E 04
1	56	125	0.9949E 04	-0.6609E 04	-0.2925E 03	-0.3338E 05	0.1117E 05	0.4596E 03
2	56	125	0.1715E 05	-0.7907E 04	-0.2021E 03	-0.8693E 05	0.2719E 05	-0.6233E 05
3	56	125	0.1047E 05	-0.4400E 04	-0.3695E 03	-0.2330E 05	0.1153E 05	-0.1029E 04
4	56	125	0.1877E 05	-0.5323E 04	-0.2772E 03	-0.6016E 05	0.2937E 05	-0.3804E 05
5	56	125	0.3351E 04	-0.1484E 03	-0.2037E 03	-0.6012E 04	0.3339E 04	-0.6282E 04
6	56	125	0.5550E 04	-0.1144E 03	-0.1598E 03	-0.1083E 05	0.8545E 04	-0.1153E 05
7	56	125	-0.3896E 04	0.1605E 04	0.1970E 03	0.1790E 05	-0.3517E 04	0.9389E 05
8	56	125	-0.1977E 04	0.5142E 03	-0.1134E 02	0.2493E 04	-0.2232E 04	0.2216E 05
9	56	125	-0.3394E 04	0.6505E 03	0.1708E 03	0.1769E 05	-0.3731E 04	0.9758E 05
10	56	125	0.1163E 05	-0.2897E 04	0.5366E 04	-0.1117E 06	0.1102E 06	-0.4010E 05
11	56	125	0.9941E 04	-0.6608E 04	-0.2925E 03	-0.3339E 05	0.1116E 05	0.4309E 03
12	56	125	0.1713E 05	-0.7894E 04	-0.2016E 03	-0.8683E 05	0.2716E 05	-0.6236E 05
13	56	125	0.1045E 05	-0.4394E 04	-0.3690E 03	-0.2327E 05	0.1151E 05	-0.1069E 04
14	56	125	0.1873E 05	-0.5315E 04	-0.2767E 03	-0.6007E 05	0.2932E 05	-0.3803E 05
15	56	125	0.1055E 04	0.6631E 02	-0.1055E 03	-0.2676E 04	0.1107E 04	-0.7440E 04
16	56	125	0.2651E 04	0.4836E 02	-0.9762E 02	-0.5892E 04	0.4330E 04	-0.1015E 04
1	57	145	-0.9949E 04	0.6609E 04	-0.2925E 03	-0.3338E 05	0.1626E 05	0.1145E 06
2	57	145	-0.2565E 04	0.5591E 04	-0.4374E 03	0.2027E 05	0.2039E 04	0.1880E 05
3	57	145	-0.1047E 05	0.4400E 04	-0.3695E 03	-0.2330E 05	0.1796E 05	0.7760E 05
4	57	145	-0.2142E 04	0.3695E 04	-0.4669E 03	0.1369E 05	0.1741E 04	0.1688E 05
5	57	145	-0.3351E 04	0.1484E 03	-0.2037E 03	-0.6012E 04	0.6940E 04	0.8864E 04
6	57	145	0.2246E 03	0.6001E 02	-0.1891E 03	0.9163E 03	0.1613E 03	0.1550E 04
7	57	145	0.3896E 04	-0.1605E 04	0.1970E 03	0.1790E 05	-0.6945E 04	-0.1218E 06
8	57	145	0.1977E 04	-0.5142E 03	-0.1134E 02	0.2493E 04	-0.2034E 04	-0.3111E 05
9	57	145	0.3394E 04	-0.6505E 03	0.1708E 03	0.1769E 05	-0.6703E 04	-0.1089E 06
10	57	145	0.1260E 05	-0.6389E 03	-0.5385E 04	0.1159E 06	-0.1803E 05	-0.2223E 06
11	57	145	-0.9941E 04	0.6608E 04	-0.2925E 03	-0.3339E 05	0.1625E 05	0.1145E 06

12	57	145	-0.2562E 04	0.5584E 04	-0.4367E 03	0.2023E 05	0.2036E 04	0.1887E 05
13	57	145	-0.1045E 05	0.4394E 04	0.3690E 03	-0.2327E 05	0.1793E 05	0.7752E 05
14	57	145	-0.2137E 04	0.3690E 03	-0.4061E 03	0.1366E 05	0.1737E 04	0.1691E 05
15	57	145	-0.1055E 04	-0.6631E 02	-0.1055E 03	-0.2676E 04	0.2942E 04	0.6286E 04
16	57	145	0.4845E 03	-0.7901E 02	-0.1159E 03	0.5690E 03	-0.4137E 02	0.2630E 04
1	57	124	0.9949E 04	-0.6609E 04	0.2925E 03	0.3338E 05	-0.1117E 05	0.4597E 03
2	57	124	0.2565E 04	-0.5591E 04	0.4374E 03	-0.1027E 05	0.5572E 04	0.7848E 05
3	57	124	0.1047E 05	-0.4400E 04	0.3695E 03	0.2330E 05	-0.1153E 05	-0.1029E 04
4	57	124	0.2142E 04	-0.3695E 04	0.4669E 04	-0.1369E 05	0.6382E 04	0.4741E 05
5	57	124	0.3351E 04	-0.1484E 03	0.2037E 03	0.6012E 04	-0.3396E 04	-0.6282E 04
6	57	124	-0.2246E 03	-0.6001E 02	0.1891E 03	-0.9163E 03	0.3129E 04	-0.5059E 03
7	57	124	-0.3896E 04	0.1605E 04	-0.1970E 03	-0.1790E 05	0.3517E 04	0.9389E 05
8	57	124	-0.1977E 04	0.5142E 03	0.1134E 02	-0.2493E 04	0.2232E 04	0.2216E 05
9	57	124	-0.3394E 04	0.6505E 03	-0.1708E 03	-0.1769E 05	0.3731E 04	0.9758E 05
10	57	124	-0.1260E 05	0.6389E 03	0.5385E 04	-0.1159E 06	0.1117E 06	0.2112E 06
11	57	124	0.9941E 04	-0.6608E 04	0.2925E 03	0.3339E 05	-0.1116E 05	0.4309E 03
12	57	124	0.2562E 04	-0.5584E 04	0.4367E 03	-0.2023E 05	0.5563E 04	0.7829E 05
13	57	124	0.1045E 05	-0.4394E 04	0.3699E 03	0.2327E 05	-0.1151E 05	-0.1068E 04
14	57	124	0.2137E 04	-0.3690E 04	0.4661E 03	-0.1366E 05	0.6373E 04	0.4731E 05
15	57	124	0.1054E 04	0.6631E 02	0.1055E 03	0.2676E 04	-0.1107E 04	-0.7440E 04
16	57	124	-0.4845E 03	0.7901E 02	0.1159E 03	-0.5690E 03	0.2058E 04	-0.4005E 04
1	58	148	-0.2231E 05	-0.8785E 04	-0.9333E 03	-0.2248E 05	-0.1527E 05	0.1043E 05
2	58	148	-0.3621E 05	-0.2196E 05	0.4306E 03	0.4951E 05	0.1539E 05	-0.2825E 06
3	58	148	-0.2427E 05	-0.6428E 04	0.1188E 04	-0.1659E 05	-0.2454E 05	0.8462E 04
4	58	148	-0.4033E 05	-0.1557E 05	0.8642E 03	0.3094E 05	-0.1939E 04	-0.1833E 06
5	58	148	-0.8861E 04	-0.2061E 04	0.6552E 03	0.2017E 04	-0.1937E 05	-0.5009E 05
6	58	148	-0.1281E 05	-0.3379E 04	0.5122E 03	0.8515E 04	-0.1267E 05	-0.7992E 05
7	58	148	0.9954E 04	0.5690E 04	-0.6195E 03	-0.1756E 04	0.1452E 05	-0.7501E 05
8	58	148	0.3482E 04	0.1357E 04	0.3966E 02	0.9073E 04	-0.5612E 04	-0.1580E 05
9	58	148	0.8525E 04	0.7569E 04	-0.5359E 03	0.1044E 05	0.1045E 05	0.8841E 05
10	58	148	0.2915E 05	-0.2764E 05	-0.1440E 05	0.7491E 05	0.5359E 06	-0.8472E 06
11	58	148	-0.2230E 05	-0.8775E 04	0.9330E 03	-0.2236E 05	-0.1526E 05	-0.1099E 05
12	58	148	-0.3616E 05	-0.2193E 05	0.4314E 03	0.4954E 05	0.1533E 05	-0.2816E 06
13	58	148	-0.2423E 05	-0.6412E 04	0.1186E 04	-0.1649E 05	-0.2250E 05	0.9002E 04
14	58	148	-0.4026E 05	-0.1554E 05	0.8630E 03	0.3097E 05	-0.1935E 04	-0.1825E 06
15	58	148	0.3279E 04	0.1253E 04	-0.3394E 03	0.1130E 04	-0.1230E 05	-0.5033E 05
16	58	148	-0.6389E 04	-0.2113E 04	0.3130E 04	0.2987E 04	-0.9529E 04	-0.5720E 05
1	58	144	0.2231E 05	0.8785E 04	-0.9333E 03	0.2248E 05	-0.5132E 05	-0.6372E 06
2	58	144	0.3621E 05	0.2196E 05	-0.4306E 03	-0.4951E 05	-0.4611E 05	-0.1284E 07
3	58	144	0.2427E 05	0.6428E 04	-0.1188E 04	0.1659E 05	-0.6022E 05	-0.4671E 06
4	58	144	0.4033E 05	0.1557E 05	-0.8642E 03	-0.3094E 05	-0.5975E 05	-0.9274E 06
5	58	144	0.8861E 04	0.2061E 04	-0.6552E 03	-0.2017E 04	-0.2767E 05	-0.9696E 05
6	58	144	0.1281E 05	0.3379E 04	-0.5122E 03	-0.8515E 04	-0.2388E 05	-0.1612E 06
7	58	144	-0.9954E 04	-0.5690E 04	0.6195E 03	0.1756E 04	0.2968E 05	0.4810E 06
8	58	144	-0.3482E 04	-0.1357E 04	-0.3966E 02	-0.9073E 04	0.2733E 04	0.1126E 06
9	58	144	-0.8525E 04	-0.7569E 04	0.5359E 03	-0.1044E 05	0.2419E 05	0.4516E 06
10	58	144	-0.2915E 05	0.2764E 05	0.1440E 05	-0.7491E 05	0.4913E 06	-0.1125E 07
11	58	144	0.2230E 05	0.8775E 04	-0.9330E 03	0.2236E 05	-0.5131E 05	-0.6371E 06
12	58	144	0.3616E 05	0.2193E 05	-0.4314E 03	-0.4954E 05	-0.4612E 05	-0.1283E 07
13	58	144	0.2423E 05	0.6412E 04	-0.1186E 04	0.1649E 05	-0.6013E 05	-0.4665E 06
14	58	144	0.4026E 05	0.1554E 05	-0.8630E 03	-0.3097E 05	-0.5967E 05	-0.9261E 06
15	58	144	-0.3279E 04	-0.1253E 04	0.3394E 03	-0.1130E 04	-0.1192E 05	-0.3905E 05
16	58	144	0.6389E 04	0.2113E 04	-0.3130E 04	-0.2987E 04	-0.1230E 05	-0.9359E 05
1	59	149	-0.2231E 05	-0.8785E 04	-0.9333E 03	0.2248E 05	0.1527E 05	0.1043E 05
2	59	149	-0.8424E 04	0.4858E 04	-0.1408E 04	0.9106E 05	0.4540E 05	0.3083E 06
3	59	149	-0.2427E 05	-0.6428E 04	-0.1188E 04	0.1659E 05	0.2454E 05	0.8462E 06
4	59	149	-0.8210E 04	0.3121E 04	-0.1503E 04	0.6233E 05	0.4639E 05	0.2081E 06
5	59	149	-0.8865E 04	-0.2061E 04	-0.6552E 03	-0.2017E 04	0.1937E 05	-0.5009E 05
6	59	149	-0.1577E 04	-0.1933E 03	-0.6086E 03	0.6205E 04	0.2121E 05	-0.1279E 05
7	59	149	0.9954E 04	0.5690E 04	0.6195E 03	0.1756E 04	-0.1452E 05	-0.7501E 05
8	59	149	0.3482E 04	0.1357E 04	-0.3966E 02	-0.9074E 04	0.5613E 04	-0.1581E 05
9	59	149	0.8525E 04	0.7569E 04	0.5359E 03	-0.1044E 05	-0.1405E 05	0.8842E 05

10	59	149	-0.2767E	05	0.3310E	05	-0.1447E	05	0.6021E	05	0.5400E	06	0.8517E	06
11	59	149	-0.2230E	05	-0.8775E	04	-0.9330E	03	0.2236E	05	0.1526E	05	0.1099E	05
12	59	149	-0.8413E	04	0.4856E	04	-0.1406E	04	0.9085E	05	0.4531E	05	0.3085E	06
13	59	149	-0.2423E	05	-0.6412E	04	-0.1186E	04	0.1649E	05	0.2450E	05	0.9002E	04
14	59	149	-0.8195E	04	0.3122E	04	-0.1500E	04	0.6216E	05	0.4630E	05	0.2083E	06
15	59	149	-0.3279E	04	-0.1253E	04	-0.3394E	03	0.1130E	04	0.1192E	05	-0.3905E	05
16	59	149	-0.3090E	03	-0.3608E	03	-0.3729E	03	0.5098E	04	0.1447E	05	-0.2022E	05
1	59	145	0.2231E	05	0.8785E	04	0.9333E	03	-0.2248E	05	0.5132E	05	-0.6372E	06
2	59	145	0.8424E	04	-0.4858E	04	0.1408E	04	-0.9106E	05	0.5537E	05	0.3834E	05
3	59	145	0.2427E	05	0.6428E	04	0.1188E	04	-0.1659E	05	0.6022E	05	-0.4671E	06
4	59	145	0.8210E	04	-0.3121E	04	0.1503E	04	-0.6233E	05	0.6033E	05	0.1459E	05
5	59	145	0.8865E	04	0.2061E	04	0.6552E	03	0.2017E	04	0.2767E	05	-0.9696E	05
6	59	145	0.1577E	04	0.1933E	03	0.6086E	03	-0.6205E	04	0.2222E	05	-0.1022E	04
7	59	145	-0.9954E	04	-0.5690E	04	-0.6195E	03	-0.1756E	04	-0.2968E	05	0.4810E	06
8	59	145	-0.3482E	04	-0.1357E	04	0.3966E	02	0.9074E	04	-0.2733E	04	0.1126E	06
9	59	145	-0.8525E	04	-0.7569E	04	-0.5359E	03	0.1044E	05	-0.2419E	05	0.4516E	06
10	59	145	0.2767E	05	-0.3310E	05	0.1447E	05	-0.6021E	05	0.4923E	06	0.1510E	07
11	59	145	0.2230E	05	0.8775E	04	0.9330E	03	-0.2236E	05	0.5131E	05	-0.6371E	06
12	59	145	0.8413E	04	-0.4856E	04	0.1406E	04	-0.9085E	05	0.4531E	05	0.3081E	05
13	59	145	0.2423E	05	0.6412E	04	0.1186E	04	-0.1649E	05	0.6013E	05	-0.4665E	06
14	59	145	0.8195E	04	-0.3122E	04	0.1500E	04	-0.6216E	05	0.6024E	05	0.1439E	05
15	59	145	0.3279E	04	0.1252E	04	0.3394E	03	-0.1130E	04	0.1230E	05	-0.5033E	05
16	59	145	0.3090E	03	0.3608E	03	0.3730E	03	-0.5098E	04	0.1215E	05	-0.5524E	04
1	71	158	-0.2224E	05	0.1356E	05	0.1258E	04	0.3983E	05	-0.6801E	04	0.2987E	06
2	71	158	-0.3371E	05	0.2023E	04	0.7753E	03	0.1583E	06	-0.4255E	05	0.1151E	05
3	71	158	-0.2398E	05	0.8429E	04	-0.4174E	03	0.1906E	05	0.6627E	04	0.1880E	06
4	71	158	-0.3820E	05	0.1228E	04	-0.7175E	03	0.1083E	06	-0.2187E	05	0.2355E	05
5	71	158	-0.8458E	04	-0.8638E	04	-0.2226E	04	-0.2665E	05	0.1530E	05	-0.2330E	06
6	71	158	-0.1203E	05	-0.8203E	04	-0.2447E	04	-0.1420E	05	0.1138E	05	-0.2240E	06
7	71	156	0.1002E	05	0.1443E	05	-0.1103E	04	-0.1931E	05	0.1922E	05	0.2317E	06
8	71	156	0.3883E	04	-0.9206E	04	-0.2875E	04	-0.1880E	05	0.3146E	05	-0.2108E	06
9	71	158	0.8124E	04	0.8491E	04	0.1966E	04	-0.3238E	04	-0.2224E	05	0.2682E	06
10	71	158	0.6164E	05	-0.1660E	05	-0.2445E	05	-0.2712E	05	0.2982E	05	-0.8336E	06
11	71	158	-0.2223E	05	0.1350E	05	0.1266E	04	0.4011E	05	-0.6842E	04	0.2980E	06
12	71	158	-0.3367E	05	0.1983E	04	0.7831E	03	0.1584E	06	-0.4250E	05	0.1122E	05
13	71	158	-0.2393E	05	0.8390E	04	-0.4080E	03	0.1933E	05	0.6551E	04	0.1877E	06
14	71	156	-0.3813E	05	0.1204E	04	-0.7074E	03	0.1084E	06	-0.2189E	05	0.2355E	05
15	71	156	-0.2872E	04	-0.5431E	04	-0.2766E	04	-0.3513E	05	0.2474E	05	-0.1538E	06
16	71	156	-0.5773E	04	-0.5677E	04	-0.2792E	04	-0.2668E	05	0.2121E	05	-0.1609E	06
1	71	148	0.2224E	05	-0.1356E	05	-0.1258E	04	-0.3983E	05	-0.1994E	05	-0.1054E	05
2	71	148	0.3371E	05	-0.2023E	04	-0.7753E	03	-0.1583E	06	0.2637E	05	0.3148E	05
3	71	148	0.2398E	05	-0.8429E	04	0.4174E	03	-0.1906E	05	0.2243E	04	-0.8926E	04
4	71	148	0.3820E	05	-0.1228E	04	0.7175E	03	-0.1083E	06	0.3712E	05	0.2551E	04
5	71	148	0.8458E	04	0.8638E	04	0.2226E	04	0.2665E	05	0.3231E	05	0.4945E	05
6	71	148	0.1203E	05	0.8203E	04	0.2447E	04	0.1420E	05	0.4012E	05	0.4970E	05
7	71	148	-0.1002E	05	-0.1443E	05	0.1103E	04	0.1931E	05	0.4230E	04	0.7490E	05
8	71	148	-0.3883E	04	0.9206E	04	0.2875E	04	0.1880E	05	0.2963E	05	0.1517E	05
9	71	148	-0.8124E	04	-0.8491E	04	-0.1966E	04	0.3238E	04	-0.1953E	05	-0.8778E	05
10	71	148	-0.6164E	05	0.1660E	05	0.2445E	05	0.2712E	05	0.4898E	06	0.4808E	06
11	71	148	0.2223E	05	-0.1350E	05	-0.1226E	04	-0.4011E	05	-0.2035E	05	-0.1111E	05
12	71	148	0.3367E	05	-0.1983E	04	-0.7831E	03	-0.1584E	06	0.2586E	05	0.3093E	05
13	71	148	0.2393E	05	-0.8390E	04	0.4080E	03	-0.1933E	05	0.2120E	04	-0.9466E	04
14	71	148	0.3813E	05	-0.1204E	04	0.7074E	03	-0.1084E	06	0.3692E	05	0.2041E	04
15	71	148	0.2872E	04	0.5431E	04	0.2766E	04	0.3513E	05	0.3433E	05	0.3841E	05
16	71	148	0.5773E	04	0.5677E	04	0.2792E	04	0.2668E	05	0.3813E	05	0.4025E	05
1	72	155	-0.2224E	05	0.1356E	05	-0.1258E	04	-0.3983E	05	0.6801E	04	0.2987E	06
2	72	155	-0.1078E	05	0.2503E	05	-0.1753E	04	0.7834E	05	-0.2935E	05	0.5893E	06
3	72	155	-0.2398E	05	0.8429E	04	0.4174E	03	-0.1906E	05	-0.6627E	04	0.1880E	06
4	72	155	-0.9751E	04	0.1550E	05	0.7889E	02	0.6833E	05	-0.3526E	05	0.3577E	06
5	72	155	-0.8458E	04	-0.8638E	04	0.2226E	04	0.2655E	05	-0.1530E	05	-0.2330E	06
6	72	155	-0.1541E	04	-0.7022E	04	0.2351E	04	0.4445E	05	-0.2466E	05	-0.1909E	06
7	72	155	0.1002E	05	0.1443E	05	0.1104E	04	0.1931E	05	-0.1922E	05	0.2317E	06

8	72	155	0.3883E 04	-0.9206E 04	0.2875E 04	0.1880E 05	-0.3145E 05	-0.2108E 06
9	72	155	0.8134E 04	0.8491E 04	-0.1966E 04	0.3239E 04	0.2224E 05	0.2682E 06
10	72	155	-0.6016E 05	0.1866E 05	-0.2406E 05	-0.2254E 05	0.3043E 05	0.3818E 06
11	72	155	-0.2232E 05	0.1350E 05	0.1266E 05	-0.4011E 05	0.6842E 04	0.2980E 06
12	72	155	-0.1077E 05	0.2495E 05	-0.1757E 04	0.7792E 05	0.2895E 05	0.5881E 06
13	72	155	-0.2393E 05	0.8390E 04	0.4080E 03	-0.1933E 05	0.6551E 04	0.1877E 06
14	72	155	-0.9733E 04	0.1545E 05	-0.7009E 01	0.6791E 05	0.3513E 05	0.3571E 06
15	72	155	-0.2872E 04	0.5431E 04	0.2766E 04	0.3513E 05	-0.2474E 05	-0.1538E 06
16	72	155	-0.1113E 03	-0.5140E 04	0.2732E 04	0.4343E 05	-0.2817E 05	-0.1451E 06
1	72	149	0.2242E 05	-0.1356E 05	0.1258E 04	0.3983E 05	0.1994E 05	-0.1054E 05
2	72	149	0.1079E 05	-0.2503E 05	0.1753E 04	-0.7834E 05	0.6630E 05	-0.5742E 05
3	72	149	0.2398E 05	-0.8423E 04	-0.4174E 03	0.1906E 05	-0.2243E 04	-0.8926E 04
4	72	149	0.9751E 04	0.1550E 05	0.7889E 02	-0.6833E 05	0.3359E 05	-0.2823E 05
5	72	149	0.8458E 04	0.8638E 04	-0.2226E 04	-0.2655E 05	-0.3201E 05	0.4945E 05
6	72	149	0.1541E 04	0.7022E 04	-0.2351E 04	-0.4445E 05	-0.2530E 05	0.4173E 05
7	72	149	-0.1002E 05	-0.1443E 05	-0.1104E 04	-0.1931E 05	-0.4230E 04	0.7490E 05
8	72	149	-0.3883E 04	0.9206E 04	0.2875E 04	-0.1880E 05	-0.2963E 05	0.1517E 05
9	72	149	-0.8134E 04	0.8491E 04	0.1966E 04	-0.3239E 04	0.1953E 05	-0.8778E 05
10	72	149	0.6016E 05	-0.1866E 05	0.2406E 05	0.2254E 05	0.4808E 06	-0.4853E 06
11	72	149	0.2232E 05	-0.1350E 05	0.1266E 04	0.4011E 05	0.2035E 05	-0.1111E 05
12	72	149	0.1077E 05	0.2495E 05	0.1757E 04	-0.7792E 05	0.6629E 05	-0.5799E 05
13	72	149	0.2393E 05	0.8390E 04	0.4080E 03	0.1933E 05	-0.2120E 04	-0.9466E 04
14	72	149	0.9733E 04	0.1545E 05	-0.7009E 02	-0.6791E 05	0.3364E 05	-0.2881E 05
15	72	149	0.2872E 04	0.5431E 04	0.2732E 04	0.3513E 05	-0.3433E 05	0.3881E 05
16	72	149	0.1113E 03	0.5140E 04	-0.2766E 04	-0.4343E 05	-0.2999E 05	0.3588E 05
1	25	119	-0.8516E 03	-0.149E 04	-0.1875E 02	0.5375E-01	-0.6368E 04	-0.8636E 04
2	25	119	-0.8672E 03	-0.1045E 05	0.6093E 03	0.1048E 06	-0.2421E 05	0.3449E 05
3	25	119	-0.9856E 03	-0.1002E 04	-0.7834E 02	0.3562E-01	-0.8068E 04	-0.4263E 04
4	25	119	-0.1004E 04	-0.7185E 04	0.4807E 03	0.7571E 05	-0.2337E 05	0.2645E 05
5	25	119	-0.3962E 03	0.7517E 02	-0.1080E 03	0.1539E-02	-0.3337E 04	0.1047E 04
6	25	119	-0.3361E 03	0.6472E 03	0.7872E 01	0.1066E 05	-0.6011E 04	0.5174E 04
7	25	119	-0.1676E 03	0.1922E 05	-0.1875E 02	0.2560E 00	0.3117E 04	-0.3149E 05
8	25	119	0.2037E 03	-0.2571E 04	-0.1064E 03	-0.1439E 00	0.1732E 04	0.1465E 04
9	25	119	0.4332E 03	0.1761E 04	0.1064E 03	0.6915E-01	0.4162E 04	0.1361E 05
10	25	119	-0.1934E 04	0.1296E 05	0.1688E 05	0.3005E 06	-0.4699E 06	-0.4818E 05
11	25	119	-0.8505E 03	-0.1454E 04	-0.1875E 02	0.5713E 03	0.6364E 04	-0.8625E 04
12	25	119	-0.8602E 03	-0.1044E 05	0.6387E 03	0.1046E 06	-0.2419E 05	0.3444E 05
13	25	119	-0.9838E 03	-0.1002E 04	-0.7834E 02	0.3883E-01	-0.8055E 04	-0.4259E 04
14	25	119	-0.1002E 04	-0.7173E 04	0.4798E 03	0.7557E 05	-0.2393E 05	0.2639E 05
15	25	119	-0.1813E 03	0.2186E 03	-0.1086E 03	0.1602E 04	-0.1340E 04	0.7421E 03
16	25	119	-0.8516E 03	-0.2023E 03	0.3921E 02	0.5904E 04	0.3318E 04	0.3058E 04
1	25	121	0.8516E 03	0.1449E 04	0.1875E 02	-0.5375E-01	0.6533E 04	-0.7968E 04
2	25	121	0.8672E 03	0.1045E 05	-0.6093E 03	-0.1048E 06	0.1723E 05	-0.1543E 06
3	25	121	0.9856E 03	0.1002E 04	0.7834E 02	-0.3562E-01	0.8966E 04	-0.7222E 04
4	25	121	0.1004E 04	0.7185E 04	-0.4807E 03	-0.7571E 05	0.1846E 05	0.1038E 06
5	25	121	0.3962E 03	-0.7517E 02	0.1080E 03	0.1539E-02	0.4544E 04	-0.1952E 03
6	25	121	0.3361E 03	0.6472E 03	-0.7872E 01	-0.1066E 05	0.5921E 04	-0.1259E 05
7	25	121	0.1676E 03	-0.1922E 05	0.1875E 02	-0.2560E 00	-0.2932E 04	0.2518E 06
8	25	121	-0.2037E 03	0.2571E 04	0.1064E 03	0.1439E 00	-0.5732E 03	-0.3032E 05
9	25	121	-0.4332E 03	-0.1761E 04	-0.1064E 03	-0.6715E-01	-0.5331E 04	0.3379E 05
10	25	121	0.1934E 04	0.1296E 05	0.1688E 05	-0.3005E 06	0.2764E 06	-0.1969E 06
11	25	121	0.8505E 03	0.1454E 04	0.1875E 02	-0.5713E 03	0.6579E 04	-0.8035E 04
12	25	121	0.8602E 03	0.1044E 05	-0.6087E 03	0.1046E 06	0.1721E 05	-0.1541E 06
13	25	121	0.9838E 03	0.1002E 04	0.7834E 02	-0.3883E 03	0.8952E 05	-0.7221E 04
14	25	121	0.1002E 04	0.7173E 04	-0.4798E 03	0.7557E 05	0.1842E 05	-0.1086E 06
15	25	121	0.1813E 03	-0.2186E 03	0.1080E 03	-0.1602E 04	0.2578E 04	-0.1763E 06
16	25	121	0.8516E 03	0.1449E 04	0.1875E 02	-0.5904E 04	0.3767E 04	-0.5378E 04
1	26	120	-0.8516E 03	0.1449E 04	0.1875E 02	-0.5375E-01	-0.6583E 04	-0.7967E 04
2	26	120	-0.8672E 03	-0.1044E 05	0.6468E 03	0.1048E 06	0.6579E 04	-0.8246E 05
3	26	120	-0.9856E 03	-0.1002E 04	0.7834E 02	0.3562E-01	-0.8966E 04	0.7222E 04
4	26	120	-0.1004E 04	-0.7185E 04	0.6374E 03	0.7571E 05	0.3720E 03	-0.5538E 05
5	26	120	-0.3962E 03	-0.7517E 02	0.1080E 03	0.1537E-02	-0.4544E 04	0.1852E 03

6	26	120	-0.3361E	03	-0.5695E	03	0.2239E	03	0.1066E	05	-0.2018E	04	-0.8292E	04
7	26	120	-0.1676E	03	-0.1922E	05	0.1875E	02	0.2560E	00	0.2902E	04	-0.2518E	06
8	26	120	0.2087E	03	0.2571E	04	0.1064E	03	-0.1439E	00	0.5732E	03	0.3093E	05
9	26	120	0.4332E	03	-0.1761E	04	-0.1064E	03	0.6915E	-01	0.5331E	04	-0.3379E	05
10	26	120	0.1775E	04	0.6377E	03	0.1688E	05	0.3005E	06	0.2922E	06	-0.6233E	04
11	26	120	-0.8505E	03	0.1454E	04	0.1875E	02	0.5713E	03	-0.6579E	04	0.8035E	04
12	26	120	-0.8660E	03	-0.3923E	04	0.6462E	03	0.1046E	06	0.3924E	04	-0.8229E	05
13	26	120	-0.9838E	03	0.1002E	04	0.7834E	02	0.3883E	03	-0.8952E	04	0.7221E	04
14	26	120	-0.1002E	04	-0.2644E	04	0.6365E	03	0.7557E	05	0.3706E	03	-0.5527E	05
15	26	120	-0.1813E	03	-0.2186E	03	0.1079E	03	0.1601E	-02	-0.2578E	04	-0.1763E	04
16	26	120	-0.1865E	03	-0.4638E	03	0.1768E	03	0.5904E	04	-0.1451E	04	-0.6040E	04
1	26	118	0.8516E	03	-0.1449E	04	-0.1875E	02	-0.5375E	-01	0.6368E	04	0.8636E	04
2	26	118	0.8672E	03	0.3932E	04	-0.6468E	03	-0.1048E	06	-0.1134E	05	0.3739E	05
3	26	118	0.9856E	03	-0.1002E	04	-0.7834E	02	-0.3562E	-01	0.8068E	04	0.4263E	04
4	26	118	0.1004E	04	0.2650E	04	-0.6374E	03	-0.7571E	05	-0.7677E	04	0.2501E	05
5	26	118	0.3962E	03	0.7517E	02	-0.1080E	03	-0.1537E	-02	0.3337E	04	-0.1047E	04
6	26	118	0.3361E	03	0.5695E	03	0.2239E	03	-0.1066E	05	-0.5472E	03	0.1765E	04
7	26	118	0.1676E	03	0.1922E	05	-0.1875E	02	-0.2560E	00	-0.3117E	04	0.3148E	05
8	26	118	-0.2087E	03	-0.2571E	04	-0.1064E	03	0.1439E	00	-0.1792E	04	-0.1462E	04
9	26	118	-0.4332E	03	0.1761E	04	0.1064E	03	-0.6915E	-01	-0.4162E	04	0.1361E	05
10	26	118	-0.1775E	04	-0.6377E	03	-0.1688E	05	-0.3005E	06	-0.4857E	06	0.1354E	05
11	26	118	0.8505E	03	-0.1454E	04	-0.1875E	02	-0.5713E	03	0.6364E	04	0.8625E	04
12	26	118	0.8660E	03	0.3923E	04	-0.6462E	03	-0.1046E	06	-0.1133E	05	0.3733E	05
13	26	118	0.9838E	03	-0.1002E	04	-0.7834E	02	-0.3883E	03	0.8055E	04	0.4259E	04
14	26	118	0.1002E	04	0.2644E	04	-0.6365E	03	-0.7557E	05	-0.7665E	04	0.2496E	05
15	26	118	0.1813E	03	0.2186E	03	-0.1079E	03	-0.1601E	-02	0.1340E	04	-0.7421E	03
16	26	118	0.1865E	03	0.4637E	03	-0.1767E	03	-0.5904E	04	-0.5753E	03	0.7250E	03
1	552	500	-0.3250E	03	-0.2204E	05	0.1764E	02	-0.1183E	00	-0.3545E	05	-0.2288E	06
2	552	500	-0.3447E	03	-0.2368E	05	-0.2449E	04	-0.2383E	06	0.8930E	04	-0.2040E	06
3	552	500	0.1605E	04	-0.1465E	05	0.7368E	02	-0.6035E	-01	-0.2333E	05	-0.1673E	06
4	552	500	0.1582E	04	-0.1659E	05	0.1910E	04	-0.1708E	06	0.9790E	04	-0.1512E	06
5	552	500	0.2882E	04	0.6577E	04	0.1016E	03	0.5002E	-01	0.1151E	05	0.4379E	05
6	552	500	0.2959E	04	0.4823E	04	0.4725E	03	-0.2765E	05	0.2111E	05	0.2596E	05
7	552	500	0.4840E	03	-0.8438E	04	0.1763E	02	-0.0609E	00	0.1850E	05	-0.1322E	06
8	552	500	0.2914E	04	0.1051E	05	0.1000E	03	0.2929E	00	0.2262E	05	0.9656E	05
9	552	500	-0.2501E	04	-0.8691E	03	-0.1000E	03	-0.2853E	00	-0.4090E	04	-0.1222E	05
10	552	500	0.9750E	04	-0.1104E	05	0.3248E	05	-0.1974E	06	0.5943E	06	-0.2994E	06
11	552	500	-0.3326E	03	-0.2198E	05	0.1764E	02	-0.1167E	02	-0.3556E	05	-0.2277E	06
12	552	500	-0.3516E	03	-0.2361E	05	0.2443E	04	-0.2380E	06	0.8738E	04	-0.2029E	06
13	552	500	0.1594E	04	-0.1459E	05	0.7368E	02	-0.5968E	03	-0.2341E	05	-0.1663E	06
14	552	500	0.1570E	04	-0.1653E	05	0.1906E	04	-0.1705E	06	0.9642E	04	-0.1503E	06
15	552	500	0.3105E	04	0.4179E	04	0.1016E	03	0.8104E	-01	0.2069E	05	0.5342E	04
16	552	500	0.3105E	04	0.3564E	04	0.3107E	03	-0.1521E	05	0.2440E	05	0.1514E	04
1	552	152	0.3250E	03	0.2204E	05	-0.1764E	02	0.1183E	00	0.3528E	05	0.1323E	05
2	552	152	0.3447E	03	0.2368E	05	-0.2449E	04	0.2383E	06	-0.3288E	05	-0.2764E	05
3	552	152	-0.1605E	04	0.1465E	05	-0.7368E	02	0.6035E	-01	0.2261E	05	0.2401E	05
4	552	152	-0.1582E	04	0.1659E	05	-0.1910E	04	0.1708E	06	-0.2847E	05	-0.1102E	05
5	552	152	-0.2882E	04	-0.6577E	04	-0.1016E	03	-0.5002E	-01	-0.1251E	05	0.2053E	05
6	552	152	-0.2959E	04	-0.4823E	04	-0.4725E	03	0.2765E	05	-0.2573E	05	0.2122E	05
7	552	152	-0.4840E	03	0.8438E	04	-0.1763E	02	0.4609E	00	-0.1867E	05	0.4968E	05
8	552	152	-0.2914E	04	-0.1051E	05	-0.1000E	03	-0.2929E	00	-0.2360E	05	0.6232E	04
9	552	152	0.2501E	04	0.8691E	03	0.1000E	03	0.2853E	00	0.5058E	04	0.3722E	04
10	552	152	-0.9750E	04	0.1104E	05	-0.3248E	05	0.1974E	06	-0.9120E	06	0.1915E	06
11	552	152	0.3326E	03	0.2198E	05	-0.1764E	02	0.1167E	02	0.3539E	05	0.1278E	05
12	552	152	0.3516E	03	0.2361E	05	-0.2443E	04	0.2380E	06	-0.3263E	05	-0.2800E	05
13	552	152	-0.1594E	04	0.1459E	05	-0.7368E	02	0.5968E	03	0.2269E	05	0.2359E	05
14	552	152	-0.1570E	04	0.1653E	05	-0.1906E	04	0.1705E	06	-0.2828E	05	-0.1138E	05
15	552	152	-0.3105E	04	-0.4179E	04	-0.1016E	03	-0.8104E	03	-0.2168E	05	0.3552E	05
16	552	152	-0.3105E	04	-0.3564E	04	-0.3107E	03	0.1521E	05	-0.2744E	05	0.3334E	05
1	553	153	-0.3250E	03	0.2204E	05	-0.1764E	02	-0.1183E	00	-0.3528E	05	-0.1323E	05
2	553	153	-0.3447E	03	0.1987E	05	0.2413E	04	-0.2383E	06	-0.1033E	06	-0.5511E	05
3	553	153	0.1605E	04	0.1465E	05	-0.7368E	02	-0.6035E	-01	-0.2261E	05	-0.2401E	05

4	553	153	0.1582E	04	0.1217E	05	0.1763E	04	-0.1708E	06	-0.7436E	05	-0.5688E	05
5	553	153	0.2881E	04	-0.6577E	04	-0.1016E	03	0.5002E	-01	0.1251E	05	-0.2053E	05
6	553	153	0.2959E	04	-0.6828E	04	0.2694E	03	-0.2765E	05	0.4953E	04	-0.2974E	05
7	553	153	0.4840E	03	0.8438E	04	-0.1764E	02	-0.4609E	00	0.1867E	05	-0.4968E	05
8	553	153	0.2914E	04	-0.1051E	05	-0.1000E	03	0.2029E	00	0.2360E	05	-0.6232E	04
9	553	153	-0.2501E	04	0.8691E	03	0.1000E	03	-0.2853E	00	-0.5058E	04	-0.3722E	04
10	553	153	-0.9287E	04	-0.1444E	05	0.3248E	05	-0.1974E	06	-0.9071E	06	0.1817E	06
11	553	153	-0.3326E	03	0.2198E	05	-0.1764E	02	-0.1167E	02	-0.3539E	05	-0.1278E	05
12	553	153	-0.3516E	03	0.1979E	05	0.2408E	04	-0.2380E	06	-0.1032E	06	-0.5458E	05
13	553	153	0.1594E	04	0.1459E	05	-0.7368E	02	-0.5968E	03	-0.2269E	05	-0.2359E	05
14	553	153	0.1570E	04	0.1212E	05	0.1759E	04	-0.1705E	06	-0.7434E	05	-0.5637E	05
15	553	153	0.3105E	04	-0.4179E	04	-0.1016E	03	0.8104E	03	-0.2168E	05	-0.3552E	05
16	553	153	0.3105E	04	-0.4779E	04	0.1076E	03	-0.1521E	05	0.1572E	05	-0.3775E	05
1	553	501	0.3250E	03	-0.2204E	05	0.1764E	02	0.1183E	00	0.3545E	05	0.2288E	06
2	553	501	0.3447E	03	-0.1987E	05	-0.2413E	04	0.2383E	06	0.7966E	05	0.2494E	06
3	553	501	-0.1605E	04	-0.1465E	05	0.7368E	02	0.6035E	-01	0.2333E	05	0.1673E	06
4	553	501	-0.1582E	04	-0.1217E	05	-0.1763E	04	0.1708E	04	0.5713E	05	0.1759E	06
5	553	501	-0.2881E	04	0.6577E	04	0.1016E	03	-0.5002E	-01	-0.1151E	05	-0.4379E	05
6	553	501	-0.2959E	04	0.6828E	04	-0.2694E	03	0.2765E	05	-0.7588E	04	-0.3704E	05
7	553	501	-0.4840E	03	-0.8438E	04	0.1764E	02	0.4609E	00	-0.1850E	05	0.1322E	06
8	553	501	-0.2914E	04	0.1051E	05	0.1000E	03	-0.2929E	00	-0.2262E	05	-0.9656E	05
9	553	501	0.2501E	04	-0.8691E	03	-0.1000E	03	0.2853E	00	0.4080E	04	0.1222E	05
10	553	501	0.9287E	04	0.1444E	05	-0.3248E	05	0.1974E	06	0.5894E	06	-0.3229E	06
11	553	501	0.3326E	03	-0.2198E	05	0.1764E	02	0.1167E	02	0.3556E	05	0.2277E	06
12	553	501	0.3516E	03	-0.1979E	05	-0.2408E	04	0.2380E	06	0.7964E	05	0.2481E	06
13	553	501	-0.1594E	04	-0.1459E	05	0.7368E	02	0.5968E	03	0.2341E	05	0.1663E	06
14	553	501	-0.1570E	04	-0.1211E	05	-0.1759E	04	0.1705E	06	0.5714E	05	0.1748E	06
15	553	501	-0.3105E	04	0.4179E	04	0.1016E	03	-0.8104E	03	-0.2069E	05	0.5342E	04
16	553	501	-0.3105E	04	0.4779E	04	-0.1076E	03	0.1521E	05	-0.1678E	05	-0.8985E	04
1	75	164	-0.2221E	05	0.1373E	05	0.1258E	04	0.3291E	05	-0.3722E	05	0.5058E	06
2	75	164	-0.3368E	05	0.2190E	04	0.7753E	03	0.1541E	06	-0.6115E	05	-0.1213E	06
3	75	164	-0.2385E	05	0.8545E	04	-0.4174E	03	0.2135E	05	0.1665E	05	0.2616E	06
4	75	164	-0.3808E	02	0.1345E	04	-0.7175E	03	0.1122E	06	-0.4651E	04	-0.1539E	06
5	75	164	-0.8289E	04	-0.8638E	04	-0.2226E	04	-0.1431E	05	0.6873E	05	-0.4864E	06
6	75	164	-0.1186E	05	-0.8203E	04	-0.2447E	04	-0.7379E	03	0.7061E	05	-0.4866E	06
7	75	164	0.1005E	05	0.1460E	05	-0.1103E	04	-0.1324E	05	0.4570E	05	0.6372E	06
8	75	164	0.4050E	04	-0.9236E	04	-0.2875E	04	-0.2992E	04	0.1034E	06	-0.4107E	06
9	75	164	0.7957E	04	0.8520E	04	0.1965E	04	-0.1405E	05	-0.6941E	05	0.5169E	06
10	75	164	0.6164E	05	-0.1660E	05	-0.2462E	05	0.1078E	06	0.6237E	05	-0.8930E	06
11	75	164	-0.2220E	05	0.1367E	05	0.1266E	04	0.3315E	05	-0.3722E	05	0.5038E	06
12	75	164	-0.3364E	05	0.2150E	04	0.7831E	03	0.1541E	06	-0.6129E	05	-0.1223E	06
13	75	164	-0.2381E	05	0.8506E	04	-0.4080E	03	0.2158E	05	0.1634E	05	0.2606E	06
14	75	164	-0.3801E	05	0.1321E	04	-0.7074E	03	0.1123E	06	-0.4937E	04	-0.1541E	06
15	75	164	-0.2702E	04	-0.5431E	04	-0.2765E	04	-0.1992E	05	0.9111E	05	-0.2995E	06
16	75	164	-0.5603E	04	-0.5677E	04	-0.2792E	04	-0.1132E	05	0.8822E	05	-0.3284E	06
1	75	156	0.2221E	05	-0.1373E	05	-0.1258E	04	-0.3291E	05	0.6831E	04	-0.1764E	06
2	75	156	0.3368E	05	-0.2190E	04	-0.7753E	03	-0.1541E	06	0.4255E	05	0.1738E	06
3	75	156	0.2385E	05	-0.8595E	04	0.4174E	03	-0.2135E	05	-0.6627E	04	-0.5649E	05
4	75	156	0.3808E	05	-0.1345E	04	0.7175E	03	-0.1122E	06	0.2137E	05	0.1862E	06
5	75	156	0.8289E	04	0.8638E	04	0.2226E	04	0.1431E	05	-0.1530E	05	0.2791E	06
6	75	156	0.1186E	05	0.8203E	04	0.2447E	04	0.7379E	03	-0.1188E	05	0.2897E	06
7	75	156	-0.1005E	05	-0.1460E	05	0.1103E	04	0.1324E	05	-0.1922E	05	-0.2870E	06
8	75	156	-0.4050E	04	0.9236E	04	0.2875E	04	0.2992E	04	-0.3146E	05	0.1890E	06
9	75	156	-0.7957E	04	-0.8520E	04	-0.1965E	04	0.1405E	05	0.2224E	05	-0.3125E	06
10	75	156	-0.6164E	05	0.1660E	05	0.2462E	05	-0.1078E	06	-0.2982E	05	0.4946E	06
11	75	156	0.2220E	05	-0.1367E	05	-0.1266E	04	-0.3315E	05	0.6842E	04	-0.1758E	06
12	75	156	0.3364E	05	-0.2150E	04	-0.7831E	03	-0.1541E	06	0.4250E	05	0.1739E	06
13	75	156	0.2381E	05	-0.8506E	04	0.4080E	03	-0.2158E	05	-0.6551E	04	-0.5643E	05
14	75	156	0.3801E	05	-0.1321E	04	0.7074E	03	-0.1123E	06	0.2188E	05	0.1858E	06
15	75	156	0.2702E	04	0.5431E	04	0.2765E	04	0.1992E	05	-0.2474E	05	0.1692E	06
16	75	156	0.5603E	04	0.5677E	04	0.2792E	04	0.1132E	05	-0.2120E	05	0.1922E	06
1	76	165	-0.2221E	05	0.1373E	05	-0.1258E	04	-0.3291E	05	0.3700E	05	0.5058E	06

2	76	165	-0.1076E	05	0.2520E	05	-0.1753E	04	0.8798E	05	0.1301E	05	0.1135E	07
3	76	165	-0.2385E	05	0.8545E	04	0.4174E	03	-0.2135E	05	-0.1665E	05	0.2616E	06
4	76	165	-0.9628E	04	0.1562E	05	0.7889E	02	0.6790E	05	-0.3716E	05	0.6792E	06
5	76	165	-0.8289E	04	-0.8638E	04	0.2226E	04	0.1431E	05	-0.6873E	05	-0.4864E	06
6	76	165	-0.1372E	04	-0.7022E	04	0.2351E	04	0.3153E	05	-0.8137E	05	-0.3675E	06
7	76	165	0.1005E	05	0.1460E	05	0.1104E	04	0.1324E	05	-0.4570E	05	0.6372E	06
8	76	165	0.4050E	04	-0.9236E	04	0.2875E	04	0.2991E	04	-0.1034E	06	-0.4107E	06
9	76	165	0.7957E	04	0.8520E	04	-0.1965E	04	0.1405E	05	0.6741E	05	0.5169E	06
10	76	165	-0.6016E	05	0.1866E	05	-0.2423E	05	0.1102E	06	0.6119E	06	0.9988E	06
11	76	165	-0.2220E	05	0.1367E	05	-0.1266E	04	-0.3315E	05	0.3722E	05	0.5038E	06
12	76	165	-0.1074E	05	0.2511E	05	-0.1757E	04	0.8758E	05	0.1323E	05	0.1132E	07
13	76	165	-0.2381E	05	0.8506E	04	0.4080E	03	-0.2158E	05	-0.1634E	05	0.2606E	06
14	76	165	-0.9610E	04	0.1556E	05	0.7008E	02	0.6752E	05	-0.3681E	05	0.6774E	06
15	76	165	-0.2702E	04	-0.5431E	04	0.2765E	04	0.1992E	05	-0.9111E	05	-0.2995E	06
16	76	165	0.5829E	02	-0.5139E	04	0.2732E	04	0.2840E	05	-0.9374E	05	-0.2686E	06
1	76	157	0.2221E	05	-0.1373E	05	0.1258E	04	0.3291E	05	-0.6801E	04	-0.1764E	06
2	76	157	0.1076E	05	-0.2520E	05	0.1753E	04	-0.8798E	05	0.2935E	05	-0.5300E	06
3	76	157	0.8289E	05	-0.8545E	04	-0.4174E	03	0.2135E	05	0.6627E	04	-0.5649E	05
4	76	157	0.9628E	04	-0.1562E	05	-0.7889E	02	-0.6790E	05	0.3526E	05	-0.3044E	06
5	76	157	0.8289E	04	0.8638E	04	-0.2226E	04	-0.1431E	05	0.1530E	05	0.2791E	06
6	76	157	0.1372E	04	0.7022E	04	-0.2351E	04	-0.3153E	05	0.2466E	05	0.1990E	06
7	76	157	-0.1005E	05	-0.1460E	05	-0.1104E	04	-0.1324E	05	0.1922E	05	-0.2870E	06
8	76	157	-0.4050E	04	0.9236E	04	-0.2875E	04	-0.2991E	04	0.3145E	05	0.1890E	06
9	76	157	-0.7957E	04	-0.8520E	04	0.1965E	04	-0.1405E	05	-0.2224E	05	-0.3125E	06
10	76	157	0.6016E	05	-0.1866E	05	0.2423E	05	-0.1102E	06	-0.3043E	05	-0.5510E	06
11	76	157	0.2220E	05	-0.1367E	05	0.1266E	04	0.3315E	05	-0.6842E	04	-0.1758E	06
12	76	157	0.1074E	05	-0.2511E	05	0.1757E	04	-0.8758E	05	0.2895E	05	-0.5290E	06
13	76	157	0.2381E	05	-0.8506E	04	-0.4080E	03	0.2158E	05	0.6551E	04	-0.5643E	05
14	76	157	0.9610E	04	-0.1556E	05	-0.7008E	02	-0.6752E	05	0.3513E	05	-0.3039E	06
15	76	157	0.2702E	04	0.5431E	04	-0.2765E	04	-0.1992E	05	0.2474E	05	0.1692E	06
16	76	157	-0.5829E	02	0.5139E	04	-0.2732E	04	-0.2840E	05	0.2817E	05	0.1452E	06
1	88	171	0.5211E	04	0.2737E	02	-0.4820E	01	-0.5849E	-01	0.1982E	05	-0.2536E	06
2	88	171	0.5214E	04	-0.2494E	04	0.5472E	04	-0.1606E	06	-0.5694E	05	-0.2890E	06
3	88	171	0.3947E	04	0.1912E	02	-0.2015E	02	-0.5169E	-02	-0.7024E	05	-0.2176E	06
4	88	171	0.3961E	04	-0.1101E	04	0.4750E	04	-0.1361E	06	-0.1374E	06	-0.2341E	06
5	88	171	0.9086E	04	-0.2386E	-01	-0.2776E	02	0.3986E	00	-0.1113E	06	-0.9114E	05
6	88	171	0.8494E	04	-0.1977E	03	0.1228E	04	-0.2429E	05	-0.1448E	06	-0.1245E	06
7	88	171	0.4586E	04	0.2724E	02	-0.4768E	01	-0.2835E	00	-0.1031E	06	-0.3587E	06
8	88	171	-0.1910E	04	-0.4787E	01	-0.2740E	02	0.6418E	-02	-0.1977E	06	0.4835E	05
9	88	171	0.1295E	04	0.4808E	01	0.2739E	02	-0.1795E	00	0.1521E	06	-0.7855E	05
10	88	171	-0.1735E	03	-0.4871E	04	-0.9684E	04	0.2557E	06	0.1363E	06	-0.6610E	05
11	88	171	0.5060E	04	0.2736E	02	-0.4817E	01	-0.4201E	-01	0.2035E	05	-0.2497E	06
12	88	171	0.5062E	04	-0.2491E	04	0.5454E	04	-0.1604E	06	-0.5650E	05	-0.2851E	06
13	88	171	0.3874E	04	0.1912E	02	-0.2015E	02	0.2212E	03	-0.6974E	05	-0.2142E	06
14	88	171	0.3888E	04	-0.1104E	04	0.4737E	04	-0.1359E	06	-0.1367E	06	-0.2307E	06
15	88	171	0.7234E	04	-0.2116E	03	-0.2775E	02	0.3319E	02	-0.1617E	06	-0.1861E	06
16	88	171	0.7218E	04	-0.4959E	02	0.6703E	03	-0.1422E	05	-0.1713E	06	-0.1865E	06
1	88	172	-0.5211E	04	-0.2737E	02	0.4820E	01	0.5849E	-01	-0.1975E	05	0.2540E	06
2	88	172	-0.5214E	04	0.2494E	04	-0.5472E	04	0.1606E	06	-0.1967E	05	0.2541E	06
3	88	172	-0.3947E	04	-0.1912E	02	0.2015E	02	0.5169E	-02	0.7052E	05	0.2179E	06
4	88	172	-0.3961E	04	0.1101E	04	-0.4750E	04	0.1361E	06	0.7091E	05	0.2187E	06
5	88	172	-0.9086E	04	0.2386E	-01	0.2776E	02	-0.3986E	00	0.1117E	06	0.9114E	05
6	88	172	-0.8494E	04	0.1977E	03	-0.1228E	04	0.2429E	05	0.1276E	06	0.1217E	06
7	88	172	-0.4586E	04	-0.2724E	02	0.4768E	01	0.2835E	00	0.1031E	06	0.3590E	06
8	88	172	0.1910E	04	0.4787E	01	0.2740E	02	-0.6418E	-02	0.1991E	06	-0.4842E	06
9	88	172	-0.1295E	04	-0.4808E	01	-0.2739E	02	0.1795E	00	-0.1525E	06	0.7861E	05
10	88	172	0.1735E	03	0.4871E	04	0.9684E	04	-0.2557E	06	-0.7094E	03	-0.2102E	04
11	88	172	-0.5060E	04	-0.2736E	02	0.4817E	01	0.4201E	-01	-0.1999E	05	0.2501E	06
12	88	172	-0.5062E	04	0.2491E	04	-0.5454E	04	0.1604E	06	-0.1985E	05	0.2502E	06
13	88	172	-0.3874E	04	-0.1912E	02	0.2015E	02	-0.2212E	03	0.7002E	05	0.2145E	06
14	88	172	-0.3888E	04	0.1104E	04	-0.4737E	04	-0.1367E	06	0.7041E	05	0.2152E	06
15	88	172	-0.7234E	04	0.2116E	03	0.2775E	02	-0.3319E	02	0.1621E	06	0.1861E	06

16	88	172	-0.7218E 04	0.4959E 02	-0.6703E 03	0.1422E 05	0.1619E 06	0.1858E 06
1	89	172	0.5211E 04	-0.2736E 02	0.4831E 01	-0.5849E -01	0.1975E 05	-0.2540E 06
2	89	172	0.5214E 04	-0.2549E 04	0.5482E 02	0.1606E 06	0.1967E 05	-0.2541E 06
3	89	172	0.3947E 04	-0.1913E 02	0.2017E 02	-0.5169E -02	-0.7052E 05	-0.2179E 06
4	89	172	0.3961E 04	-0.1139E 04	0.4791E 04	-0.1361E 06	-0.7091E 05	-0.2187E 06
5	89	172	0.9086E 04	-0.2366E 03	0.2782E 02	0.3986E 00	-0.1117E 06	-0.9114E 05
6	89	172	0.8454E 04	-0.1976E 03	0.2783E 02	-0.2429E 05	-0.1276E 06	-0.1217E 06
7	89	172	0.4586E 04	-0.2750E 02	0.4883E 02	-0.2835E 00	-0.1031E 06	-0.3590E 05
8	89	172	-0.1910E 04	0.4864E 01	0.2734E 02	0.6418E -02	-0.1981E 06	0.4842E 05
9	89	172	-0.1255E 04	-0.4843E 01	-0.2735E 02	-0.1795E 06	0.1525E 06	-0.7861E 05
10	89	172	-0.1179E 03	-0.4871E 04	-0.9684E 04	0.2557E 06	0.7094E 03	0.2102E 04
11	89	172	0.5060E 04	-0.2737E 02	0.4834E 01	-0.4201E -01	0.1992E 05	-0.2501E 06
12	89	172	0.5062E 04	-0.2544E 04	0.5463E 04	-0.1604E 06	0.1985E 05	-0.2502E 06
13	89	172	0.3874E 04	-0.1914E 02	0.2017E 02	0.2212E 03	-0.7032E 05	-0.2145E 06
14	89	172	0.3888E 04	-0.1142E 04	0.4777E 04	-0.1359E 06	-0.7042E 05	-0.1861E 06
15	89	172	0.7234E 04	-0.2116E 03	0.2783E 02	0.3319E 02	-0.1621E 06	-0.1619E 06
16	89	172	0.7218E 04	-0.4959E 02	0.7259E 03	-0.1422E 05	-0.1619E 06	-0.1858E 06
1	89	170	-0.5211E 04	0.2736E 02	-0.4831E 01	0.5849E -01	-0.1982E 05	0.2536E 05
2	89	170	-0.5214E 04	0.2549E 04	-0.5482E 02	0.1606E 06	-0.9642E 05	0.2384E 05
3	89	170	-0.3947E 04	0.1913E 02	-0.2017E 02	0.5169E -02	0.7024E 05	0.2176E 06
4	89	170	-0.3961E 04	0.1139E 04	-0.4791E 04	0.1361E 06	0.3840E 04	0.2028E 06
5	89	170	-0.9086E 04	0.2366E -01	-0.2782E 02	-0.3986E 00	0.1113E 06	0.9114E 05
6	89	170	-0.8454E 04	0.1976E 03	-0.1276E 03	0.2429E 05	0.1097E 06	0.1190E 06
7	89	170	-0.4586E 04	0.2750E 02	-0.4883E 02	0.2835E 00	0.1031E 06	0.3587E 06
8	89	170	-0.1910E 04	0.4864E 01	-0.2734E 02	-0.6418E -02	0.1977E 06	-0.4835E 05
9	89	170	-0.1295E 04	0.4871E 04	0.2735E 02	0.1795E 06	-0.1521E 06	0.8553E 05
10	89	170	-0.1179E 03	0.4871E 04	0.9684E 04	-0.2557E 06	0.1349E 06	-0.7030E 05
11	89	170	-0.5060E 04	0.2737E 02	-0.4834E 01	0.4201E -01	-0.2035E 05	-0.2497E 06
12	89	170	-0.5062E 04	0.2549E 04	-0.5463E 04	0.1604E 06	-0.9633E 05	0.2146E 06
13	89	170	-0.3874E 04	0.1914E 02	-0.2017E 02	-0.2212E 03	0.6974E 05	0.2142E 06
14	89	170	-0.3888E 04	0.1142E 04	-0.4777E 04	0.1359E 06	0.3352E 04	0.1993E 06
15	89	170	-0.3888E 04	0.1142E 04	-0.4777E 04	0.1359E 06	0.1617E 06	0.1861E 06
16	89	170	-0.7218E 04	0.4959E 02	-0.7259E 03	0.1422E 06	-0.1517E 06	0.1851E 06
1	34	125	0.1139E 03	-0.1266E 04	0.8005E 03	-0.1720E 05	-0.3135E 05	-0.7079E 05
2	34	125	0.1100E 04	0.4306E 04	0.4280E 03	-0.5338E 05	-0.2457E 05	0.7030E 05
3	34	125	0.4758E 03	-0.8796E 03	0.9184E 03	-0.1162E 05	-0.3484E 05	-0.4699E 05
4	34	125	0.1321E 04	0.2921E 04	0.6242E 03	-0.3855E 05	-0.3146E 05	0.5037E 05
5	34	125	0.6500E 03	0.7272E 01	0.3527E 03	-0.4786E 03	-0.1304E 05	-0.1188E 05
6	34	125	0.8165E 03	0.5364E 03	0.2473E 03	-0.4008E 04	-0.1124E 05	0.1305E 05
7	34	125	0.1139E 03	-0.9803E 04	-0.6215E 02	0.1432E 05	0.6135E 04	-0.1988E 06
8	34	125	0.6400E 03	-0.1881E 04	-0.1864E 03	-0.3239E 04	0.6056E 04	-0.5292E 05
9	34	125	-0.6400E 03	-0.7526E 04	-0.3920E 03	-0.5066E 04	0.1411E 05	-0.5044E 05
10	34	125	0.2445E 05	-0.3079E 04	-0.1207E 05	-0.1021E 06	-0.2740E 05	0.5602E 05
11	34	125	0.1139E 03	0.1288E 04	0.7997E 03	-0.1719E 05	-0.3102E 05	-0.7075E 05
12	34	125	0.1639E 04	0.4301E 04	0.4272E 03	-0.5330E 05	-0.2453E 05	-0.8038E 05
13	34	125	0.4758E 03	-0.8778E 03	0.9168E 03	-0.1160E 05	-0.3478E 05	-0.4682E 05
14	34	125	0.1319E 04	0.2916E 04	0.6222E 03	-0.3849E 05	-0.3141E 05	0.5036E 05
15	34	125	0.6500E 03	0.2017E 04	0.1495E 03	-0.5239E 03	-0.5526E 04	0.1088E 05
16	34	125	0.7521E 03	0.4591E 03	0.1242E 03	-0.1596E 04	-0.5774E 04	0.1667E 05
1	34	112	-0.1100E 04	-0.1286E 04	-0.8005E 03	0.1720E 05	-0.8179E 04	0.7303E 04
2	34	112	-0.1100E 04	-0.4366E 04	-0.4280E 03	0.5338E 05	0.3595E 04	0.1307E 06
3	34	112	-0.4758E 03	0.8796E 03	-0.9184E 03	-0.1162E 05	-0.1016E 05	0.3886E 04
4	34	112	-0.1321E 04	-0.2921E 04	-0.6240E 03	0.3855E 05	-0.8863E 03	0.9275E 05
5	34	112	-0.6500E 03	-0.7272E 01	-0.3527E 03	0.4786E 03	-0.4241E 04	0.1544E 04
6	34	112	-0.8165E 03	-0.5364E 03	-0.2473E 03	0.4008E 04	-0.8721E 03	0.1324E 05
7	34	112	-0.1139E 03	0.9803E 04	0.6215E 02	-0.1432E 05	-0.3090E 04	-0.2816E 06
8	34	112	-0.6400E 03	0.1881E 04	0.1864E 03	0.3239E 04	0.3079E 04	-0.3923E 05
9	34	112	0.6400E 03	0.7566E 04	0.3920E 03	0.5066E 04	0.5100E 04	-0.1644E 06
10	34	112	-0.2455E 05	-0.3079E 04	0.1207E 05	0.1021E 06	0.2976E 06	0.9486E 05
11	34	112	-0.1139E 03	0.1288E 04	-0.7997E 03	0.1719E 05	-0.8169E 04	0.7663E 04
12	34	112	-0.1099E 04	-0.4301E 04	-0.4272E 03	0.5330E 05	-0.3594E 04	0.1303E 06
13	34	112	-0.4758E 03	0.8778E 03	-0.9168E 03	0.1160E 05	-0.1014E 05	0.3814E 04

14	34	112	-0.1319E	04	-0.2916E	04	-0.6228E	05	0.3848E	05	0.8869E	03	0.9253E	05
15	34	112	-0.6560E	03	-0.2017E	03	-0.1495E	03	-0.5239E	03	-0.1831E	04	-0.1004E	04
16	34	112	-0.7521E	03	-0.4591E	03	-0.1242E	03	0.1596E	04	-0.3108E	03	0.5826E	04
1	35	124	0.1139E	03	-0.1286E	04	-0.8005E	03	0.1720E	05	0.3135E	05	-0.7079E	05
2	35	124	-0.8719E	03	-0.9093E	04	-0.1786E	04	-0.2015E	05	0.3746E	05	-0.2600E	06
3	35	124	0.4758E	03	-0.8796E	03	-0.9184E	03	0.1162E	05	0.3484E	05	-0.4699E	05
4	35	124	-0.3689E	03	-0.6246E	04	-0.1234E	04	-0.1593E	05	0.3868E	05	-0.1728E	06
5	35	124	0.6560E	03	0.7273E	01	-0.3527E	03	0.4786E	03	0.1334E	05	-0.1188E	05
6	35	124	0.4955E	03	-0.5924E	03	-0.3414E	03	-0.3877E	04	0.1045E	05	-0.1101E	05
7	35	124	0.1139E	03	-0.9803E	04	0.6215E	02	-0.1432E	05	-0.6135E	04	-0.1988E	06
8	35	124	0.6460E	03	-0.1881E	04	0.1864E	03	0.3239E	04	-0.6056E	04	-0.5292E	05
9	35	124	-0.6460E	03	-0.7526E	04	0.3920E	03	0.5066E	04	-0.1411E	05	-0.2044E	06
10	35	124	-0.2485E	05	-0.1517E	05	-0.1180E	05	-0.7631E	05	0.2853E	06	-0.4793E	06
11	35	124	0.1139E	03	-0.1288E	04	-0.7997E	03	0.1719E	05	0.3102E	05	-0.7075E	05
12	35	124	-0.8709E	03	-0.9078E	04	-0.1184E	04	-0.2011E	05	0.3741E	05	-0.2595E	06
13	35	124	0.4758E	03	-0.8778E	03	-0.9168E	03	0.1160E	05	0.3478E	05	-0.4683E	05
14	35	124	-0.3675E	03	-0.6234E	04	-0.1232E	04	-0.1589E	05	0.3861E	05	-0.1724E	06
15	35	124	0.6560E	03	0.2017E	03	-0.1495E	03	-0.5239E	03	0.5526E	04	0.1088E	05
16	35	124	0.5599E	03	-0.1627E	03	-0.1829E	03	-0.2749E	04	0.5535E	04	0.3313E	04
1	35	113	-0.1139E	03	0.1286E	04	0.8005E	03	-0.1720E	05	0.8179E	04	0.7783E	04
2	35	113	0.8719E	03	0.9093E	04	0.1186E	04	0.2015E	05	0.2063E	05	-0.1855E	06
3	35	113	-0.4758E	03	0.8796E	03	0.9184E	03	-0.1162E	05	0.1016E	05	0.3886E	04
4	35	113	0.3689E	03	0.6246E	04	0.1234E	04	0.1593E	05	0.2181E	05	-0.1332E	06
5	35	113	-0.6560E	03	-0.7273E	01	0.3527E	03	-0.4786E	03	0.4241E	04	0.1544E	04
6	35	113	-0.4955E	03	0.5924E	03	0.3414E	03	0.3877E	04	0.6290E	04	-0.1802E	05
7	35	113	-0.1139E	03	0.9803E	04	-0.6215E	02	0.1432E	05	0.3090E	04	-0.2816E	06
8	35	113	-0.6460E	03	0.1881E	04	-0.1864E	03	-0.3239E	04	-0.3079E	04	-0.3923E	05
9	35	113	0.6460E	03	0.7526E	04	-0.3920E	03	-0.5066E	04	-0.5130E	04	-0.1644E	06
10	35	113	0.2485E	05	0.1517E	05	0.1180E	05	0.7631E	05	0.2929E	06	-0.2640E	06
11	35	113	-0.1139E	03	0.1288E	04	0.7997E	03	-0.1719E	05	0.8168E	04	0.7633E	04
12	35	113	0.8709E	03	0.9078E	04	0.1184E	04	0.2011E	05	0.2061E	05	-0.1854E	06
13	35	113	-0.4758E	03	0.8778E	03	0.9168E	03	-0.1160E	05	0.1014E	05	0.3815E	04
14	35	113	0.3675E	03	0.6234E	04	0.1232E	04	0.1589E	05	0.2177E	05	-0.1330E	06
15	35	113	-0.6560E	03	-0.2017E	03	0.1495E	03	0.5239E	03	0.1831E	04	-0.1004E	04
16	35	113	-0.5599E	03	0.1627E	03	0.1829E	03	0.2749E	04	0.3429E	04	-0.1129E	05

TABLE H.2.1.3-2 CROSS SECTION PROPERTIES INPUT LISTING

BEAM NO	WEB AREA			TOTAL AREA			ACTUAL/GROSS			MOMENT OF INERTIA			POLAR			EXTREME FIBER DISTANCE				TORQUE RAD			REDUCTION FACTOR			SHEAR FACTOR	SLENDER RATIO	A/H	SE3
	AW2	AW3	AGR	G12	G13	G14	E12	E13	E14	Y23	Y34	CT	CB	CL	CR	C2	C3	Q5	Q4	Q3	Q2	Q1							
3	6.25	7.75	15.37	643.7	452.3	540.6	336.0	707.4	9.48	8.77	6.50	6.50	7.05	7.05	1.00	0.72	62.0	1.71											
4	6.25	7.75	15.37	643.7	452.3	540.6	336.0	707.4	9.48	8.77	6.50	6.50	7.05	7.05	1.00	0.72	62.0	1.71											
11	5.50	8.25	15.25	314.8	99.9	314.8	99.9	215.2	6.00	6.00	3.50	3.50	3.19	4.25	1.00	1.00	29.3	1.70											
12	5.50	8.25	15.25	314.8	99.9	314.8	99.9	215.2	6.00	6.00	3.50	3.50	3.19	4.25	1.00	1.00	29.3	1.70											
44	6.25	7.00	13.69	453.7	384.4	372.4	294.8	611.3	7.35	7.15	6.87	6.87	6.73	6.73	1.00	0.73	56.0	1.54											
45	6.25	7.00	13.69	453.7	384.4	372.4	294.8	611.3	7.35	7.15	6.87	6.87	6.73	6.73	1.00	0.73	56.0	1.54											
54	11.12	12.00	24.12	617.8	554.2	617.8	554.2	875.3	6.50	6.50	6.06	6.06	6.02	6.02	1.00	1.00	24.0	0.92											
55	11.12	12.00	24.12	617.8	554.2	617.8	554.2	875.3	6.50	6.50	6.06	6.06	6.02	6.02	1.00	1.00	24.0	0.92											
84	7.50	15.75	23.50	3256.0	1071.0	2223.8	460.7	2494.0	16.00	16.00	7.75	7.75	10.30	10.30	1.00	0.45	126.0	0.55											
85	7.50	15.75	23.50	3256.0	1071.0	2223.8	460.7	2494.0	16.00	16.00	7.75	7.75	10.30	10.30	1.00	0.45	126.0	0.55											
56	5.75	12.37	20.12	383.4	150.2	383.4	150.2	291.1	6.50	6.50	4.39	2.98	4.05	5.40	1.00	1.00	29.3	2.41											
57	5.75	12.37	20.12	383.4	150.2	383.4	150.2	291.1	6.50	6.50	4.39	2.98	4.05	5.40	1.00	1.00	29.3	2.41											
58	5.75	12.37	20.12	383.4	150.2	383.4	150.2	291.1	6.50	6.50	4.39	2.98	4.05	5.40	1.00	1.00	29.3	2.41											
59	5.75	12.37	20.12	383.4	150.2	383.4	150.2	291.1	6.50	6.50	4.39	2.98	4.05	5.40	1.00	1.00	29.3	2.41											
71	7.00	17.88	26.63	474.9	259.5	474.9	259.5	422.3	6.50	6.50	3.87	4.00	5.54	7.39	1.00	1.00	29.3	1.39											
72	7.00	17.88	26.63	474.9	259.5	474.9	259.5	422.3	6.50	6.50	3.87	4.00	5.54	7.39	1.00	1.00	29.3	1.39											
25	6.00	7.50	16.87	590.5	685.7	518.3	648.9	634.5	10.65	8.10	7.75	7.75	6.79	6.79	0.67	0.86	48.0	1.58											
26	6.00	7.50	16.87	590.5	685.7	518.3	648.9	634.5	10.65	8.10	7.75	7.75	6.79	6.79	0.67	0.86	48.0	1.58											
552	7.50	6.13	15.50	471.0	605.8	366.7	516.4	654.7	8.66	7.33	7.75	7.75	6.87	6.87	1.00	0.74	49.0	1.63											
553	7.50	6.13	15.50	471.0	605.8	366.7	516.4	654.7	8.66	7.33	7.75	7.75	6.87	6.87	1.00	0.74	49.0	1.63											
75	8.25	17.25	26.25	1623.2	176.3	1623.2	176.3	512.4	12.00	12.00	3.12	3.12	3.71	4.95	1.00	1.00	61.3	0.56											
76	8.25	17.25	26.25	1623.2	176.3	1623.2	176.3	512.4	12.00	12.00	3.12	3.12	3.71	4.95	1.00	1.00	61.3	0.56											
88	7.50	6.25	14.00	396.4	518.4	289.1	423.2	674.8	6.50	6.50	7.75	7.75	6.94	6.94	1.00	0.70	50.0	1.44											
89	7.50	6.25	14.00	396.4	518.4	289.1	423.2	674.8	6.50	6.50	7.75	7.75	6.94	6.94	1.00	0.70	50.0	1.44											
34	5.50	8.25	15.25	314.8	99.9	314.8	99.9	215.2	6.00	6.00	3.50	3.50	3.19	4.25	1.00	1.00	29.3	1.70											
35	5.50	8.25	15.25	314.8	99.9	314.8	99.9	215.2	6.00	6.00	3.50	3.50	3.19	4.25	1.00	1.00	29.3	1.70											

BEAM NO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
3	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5
4	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5
11	47.6	106.6	47.6	106.6	47.6	106.6	26.0	26.0	26.0	26.0	47.6	47.6	47.6	106.6	106.6	106.6
12	47.6	106.6	47.6	106.6	47.6	106.6	26.0	26.0	26.0	26.0	47.6	47.6	47.6	106.6	106.6	106.6
44	10.3	15.5	10.3	15.5	10.3	15.5	10.3	10.3	10.3	10.3	10.3	10.3	10.3	15.5	15.5	15.5
45	10.3	15.5	10.3	15.5	10.3	15.5	10.3	10.3	10.3	10.3	10.3	10.3	10.3	15.5	15.5	15.5
54	26.5	95.6	26.5	95.6	26.5	95.6	26.5	26.5	26.5	26.5	26.5	26.5	26.5	95.6	95.6	95.6
55	26.5	95.6	26.5	95.6	26.5	95.6	26.5	26.5	26.5	26.5	26.5	26.5	26.5	95.6	95.6	95.6
84	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3
85	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3
56	30.7	111.0	30.7	111.0	30.7	111.0	30.7	30.7	30.7	30.7	30.7	30.7	30.7	111.0	111.0	111.0
57	30.7	111.0	30.7	111.0	30.7	111.0	30.7	30.7	30.7	30.7	30.7	30.7	30.7	111.0	111.0	111.0
58	30.7	111.0	30.7	111.0	30.7	111.0	30.7	30.7	30.7	30.7	30.7	30.7	30.7	111.0	111.0	111.0
59	30.7	111.0	30.7	111.0	30.7	111.0	30.7	30.7	30.7	30.7	30.7	30.7	30.7	111.0	111.0	111.0
71	31.7	114.7	31.7	114.7	31.7	114.7	31.7	31.7	31.7	31.7	31.7	31.7	31.7	114.7	114.7	114.7
72	31.7	31.7	31.7	31.7	31.7	31.7	31.7	31.7	31.7	31.7	31.7	31.7	31.7	31.7	31.7	31.7
25	15.8	15.8	15.8	15.8	15.8	15.8	10.5	10.5	10.5	10.5	15.6	15.8	15.8	15.8	15.8	15.8
26	15.8	15.8	15.8	15.8	15.8	15.8	10.5	10.5	10.5	10.5	15.6	15.8	15.8	15.8	15.8	15.8
552	16.7	16.7	16.7	16.7	16.7	16.7	16.7	16.7	16.7	16.7	16.7	16.7	16.7	16.7	16.7	16.7
553	16.7	16.7	16.7	16.7	16.7	16.7	16.7	16.7	16.7	16.7	16.7	16.7	16.7	16.7	16.7	16.7
75	39.4	142.3	39.4	142.3	39.4	142.3	39.4	39.4	39.4	39.4	39.4	39.4	39.4	142.3	142.3	142.3
76	42.9	42.9	42.9	42.9	42.9	42.9	42.9	42.9	42.9	42.9	42.9	42.9	42.9	42.9	42.9	42.9
88	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6
89	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6
34	69.1	154.9	69.1	154.9	69.1	154.9	15.7	15.7	15.7	15.7	69.1	69.1	69.1	154.9	154.9	154.9
35	69.1	154.9	69.1	154.9	69.1	154.9	15.7	15.7	15.7	15.7	69.1	69.1	69.1	154.9	154.9	154.9

H.2.2.1 COMPUTER PROGRAM CONWLD

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C      CONWLD
C      THIS PROGRAM CALCULATE STRESSES IN THE CONNECTION WELDS
C      BETWEEN A CROSS BEAM AND A LONGITUDINAL BEAM OF THE LHM
C      CRADLE STRUCTURE
ISN 0002      DIMENSION P1(10,2,16),F2(10,2,16),F3(10,2,16),T1(10,2,16),
C      BM2(10,2,16),BM3(10,2,16)
ISN 0003      DIMENSION NCASE(16),NBEAM(10),NODE(20)
ISN 0004      DIMENSION AW2(10),AW3(10),DU(10),DD(10),DL(10),DR(10),
C      EY(10),EZ(10),YI2(10),ZI3(10),YZJ(10)
ISN 0005      WRITE(6,40)
ISN 0006      40  FORMAT(10X,'STRESS',1X,'CALCULATIONS',1X,'OF',1X,
C      'CONNECTION WELDS - LHM CRADLE STRUCTURE',////)
ISN 0007      WRITE(6,50)
ISN 0008      50  FORMAT(29X,'TABLE',1X,'OF',1X,'FORCES',1X,'AND',1X,'MOMENTS',/)
ISN 0009      WRITE(6,51)
ISN 0010      51  FORMAT(1X,'CASE',1X,'BEAM',1X,'NODE',5X,'AXIAL',7X,'SHEAR',7X,
C      'SHEAR',6X,'TORQUE',6X,'MOMENT',6X,'MOMENT')
ISN 0011      WRITE(6,52)
ISN 0012      52  FORMAT(2X,'NO',3X,'NO',3X,'NO',7X,'P1',10X,'F2',10X,'F3',10X,
C      'T1',9X,'BM2',9X,'BM3',/)
ISN 0013      KK=0
ISN 0014      DO 90 I=1,10
ISN 0015      DO 90 J=1,2
ISN 0016      KK=KK+1
ISN 0017      DO 90 K=1,16
ISN 0018      READ(5,99) NCASE(K),NBEAM(I),NODE(KK),P1(I,J,K),
C      F2(I,J,K),F3(I,J,K),T1(I,J,K),BM2(I,J,K),BM3(I,J,K)
ISN 0019      99  FORMAT(2I3,I4,6E10.3)
ISN 0020      90  WRITE(6,101) NCASE(K),NBEAM(I),NODE(KK),P1(I,J,K),F2(I,J,K),
C      F3(I,J,K),T1(I,J,K),BM2(I,J,K),BM3(I,J,K)
ISN 0021      101 FORMAT(3I5,6E12.4)
ISN 0022      WRITE(6,60)
ISN 0023      60  FORMAT(///,29X,'TABLE',1X,'OF',1X,'WELD',1X,'SECTION',1X,
C      'PROPERTIES',//)
ISN 0024      WRITE(6,61)
ISN 0025      61  FORMAT(1X,'BEAM',1X,'FLANGE',2X,'WEB',4X,'DISTANCE',1X,
C      'FROM',1X,'WELD',1X,'CENTER',4X,'WELD-BEAM',5X,
C      'MOMENT',1X,'OF',1X,'INERTIA',2X,'TORSIONAL')
ISN 0026      WRITE(6,62)
ISN 0027      62  FORMAT(2X,'NO',3X,'AREA',2X,'AREA',31X,'ECCENTRICITY',
C      24X,'INERTIA')
ISN 0028      WRITE(6,63)
ISN 0029      63  FORMAT(23X,'UP',3X,'DOWN',2X,'RIGHT',1X,'LEFT',20X,
C      'ABT',1X,'2-2',2X,'ABT',1X,'3-3')
ISN 0030      WRITE(6,64)
ISN 0031      64  FORMAT(7X,'AW2',4X,'AW3',6X,'DU',4X,'DD',4X,'DR',4X,'DL',
C      6X,'EY',4X,'EZ',9X,'YI2',6X,'ZI3',6X,'YZJ',/)
ISN 0032      DO 150 I=1,10
ISN 0033      150 READ(5,199) NBEAM(I),AW2(I),AW3(I),DU(I),DD(I),DL(I),DR(I),
C      EY(I),EZ(I),YI2(I),ZI3(I),YZJ(I)
ISN 0034      199 FORMAT(I4,8F6.2,3F9.2)
ISN 0035      DO 200 I=1,10
ISN 0036      200 WRITE(6,201) NBEAM(I),AW2(I),AW3(I),DU(I),DD(I),DL(I),DR(I),

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      C  EY(I),EZ(I),YI2(I),ZI3(I),YZJ(I)
ISN 0037 201 FORMAT(I4,1X,2F6.2,3X,4F6.2,3X,2F6.2,3X,3F9.2)
ISN 0038      WRITE(6,68)
ISN 0039 68  FORMAT('1')
ISN 0040 70  FORMAT(29X,'TABLE OF WELD STRESSES',/)
ISN 0041 71  FORMAT(1X,'CASE',1X,'BEAM',1X,'NODE',5X,'UP-LEFT',9X,
      C  'UP-RIGHT',7X,'DOWN-RIGHT',6X,'DOWN-LEFT      MIN FACTOR')
ISN 0042 72  FORMAT(2X,'NO',3X,'NO',3X,'NO',3X,'SUL2',4X,'SUL3',4X,
      C  'SUR2',4X,'SUR3',4X,'SDR2',4X,'SDR3',4X,'SDL2',4X,
      C  'SDL3      OF SAFETY',/)
ISN 0043      KK=0
ISN 0044      DO 105 I=1,10
ISN 0045      DO 105 J=1,2
ISN 0046      KK=KK+1
ISN 0047      DO 105 K=1,16
ISN 0048      IF(J.EQ.1) P1(I,J,K)=-P1(I,J,K)
ISN 0050      IF(J.EQ.1) BM2(I,J,K)=-BM2(I,J,K)
ISN 0052      IF(J.EQ.1) BM3(I,J,K)=-BM3(I,J,K)
ISN 0054      SPX=P1(I,J,K)/(AW2(I)+AW3(I))
ISN 0055      SFY=P2(I,J,K)/AW2(I)
ISN 0056      SPZ=P3(I,J,K)/AW3(I)
ISN 0057      WT1=T1(I,J,K)+P2(I,J,K)*EY(I)-P3(I,J,K)*EZ(I)
ISN 0058      WM2=BM2(I,J,K)-P1(I,J,K)*EY(I)
ISN 0059      WM3=BM3(I,J,K)+P1(I,J,K)*EZ(I)
ISN 0060      STULY=-WT1*DU(I)/YZJ(I)
ISN 0061      STULZ=-WT1*DL(I)/YZJ(I)
ISN 0062      STURY=STULY
ISN 0063      STURZ=WT1*DR(I)/YZJ(I)
ISN 0064      STDRY=WT1*DD(I)/YZJ(I)
ISN 0065      STDRZ=STURY
ISN 0066      STDLY=STDRY
ISN 0067      STD LZ=STULZ
ISN 0068      SB2UX=WM2*DU(I)/YI2(I)
ISN 0069      SB2DX=-WM2*DD(I)/YI2(I)
ISN 0070      SB3LX=WM3*DL(I)/ZI3(I)
ISN 0071      SB3RX=-WM3*DR(I)/ZI3(I)
ISN 0072      SUL2=ABS(SQRT((SPX+SB2UX+SB3LX)**2+(SFY+STULY)**2+STULZ**2))
ISN 0073      SUL3=ABS(SQRT((SPX+SB2UX+SB3LX)**2+STULY**2+(SFZ+STULZ)**2))
ISN 0074      SUR2=ABS(SQRT((SPX+SB2UX+SB3RX)**2+(SFY+STURY)**2+STURZ**2))
ISN 0075      SUR3=ABS(SQRT((SPX+SB2UX+SB3RX)**2+STURY**2+(SFZ+STURZ)**2))
ISN 0076      SDR2=ABS(SQRT((SPX+SB2DX+SB3RX)**2+(SFY+STDRY)**2+STDRZ**2))
ISN 0077      SDR3=ABS(SQRT((SPX+SB2DX+SB3RX)**2+STDRY**2+(SFZ+STDRZ)**2))
ISN 0078      SDL2=ABS(SQRT((SPX+SB2DX+SB3LX)**2+(SFY+STDLY)**2+STD LZ**2))
ISN 0079      SDL3=ABS(SQRT((SPX+SB2DX+SB3LX)**2+STDLY**2+(SFZ+STD LZ)**2))
ISN 0080      SMAX=SUL2
ISN 0081      IF(SUL3.GT.SMAX) SMAX=SUL3
ISN 0083      IF(SUR2.GT.SMAX) SMAX=SUR2
ISN 0085      IF(SUR3.GT.SMAX) SMAX=SUR3
ISN 0087      IF(SDR2.GT.SMAX) SMAX=SDR2
ISN 0089      IF(SDR3.GT.SMAX) SMAX=SDR3
ISN 0091      IF(SDL2.GT.SMAX) SMAX=SDL2
ISN 0093      IF(SDL3.GT.SMAX) SMAX=SDL3
ISN 0095      SALW=20000.
ISN 0096      IF(K.EQ.2.OR.K.EQ.4.OR.K.EQ.6.OR.K.EQ.14.OR.
      C  K.EQ.15.OR.K.EQ.16) SALW=1.33*SALW

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ISN 0093      IF(K.EQ.7.OR.K.EQ.8.OR.K.EQ.9.OR.K.EQ.10)SALW=1.25*SALW
ISN 0100      SF=SALW/(SHAX*1.414)
ISN 0101      IF(K.EQ.1)WRITE(6,70)
ISN 0103      IF(K.EQ.1)WRITE(6,71)
ISN 0105      IF(K.EQ.1)WRITE(6,72)
ISN 0107      IF(K.EQ.10) GO TO 105
ISN 0109      WRITE(6,300)NCASE(K),NBEAM(I),NODE(KK),SUL2,SUL3,SUR2,SUR3,
C   SDR2,SDR3,SDL2,SDL3,SF
ISN 0110      300 FORMAT(I4,2I5,1X,2F8.0,3X,F6.1)
ISN 0111      IF(K.EQ.15)WRITE(6,301)
ISN 0113      301 FORMAT('1')
ISN 0114      105 CONTINUE
ISN 0115      WRITE(6,250)
ISN 0116      250 FORMAT(1H1,20X,'MODIFIED INPUT DATA LISTING',///)
ISN 0117      KK=0
ISN 0118      DO 260 I=1,10
ISN 0119      DO 260 J=1,2
ISN 0120      KK=KK+1
ISN 0121      DO 260 K=1,16
ISN 0122      WRITE(6,265)NCASE(K),NBEAM(I),NODE(KK),P1(I,J,K),F2(I,J,K),
C   F3(I,J,K),T1(I,J,K),EN2(I,J,K),EN3(I,J,K)
ISN 0123      260 CONTINUE
ISN 0124      265 FORMAT(3I4,4E12.4)
ISN 0125      DO 270 I=1,10
ISN 0126      270 WRITE(6,199)NBEAM(I),AN2(I),AN3(I),DU(I),DD(I),DL(I),DR(I),
C   EY(I),EZ(I),YI2(I),ZI3(I),YZJ(I)
ISN 0127      500 STOP
ISN 0128      END

```

H.2.2.2 Explanation of Program CONWLD

<u>Lines</u>		<u>Explanation</u>
	-	Identification of program
ISN 0002	-	Array of forces and moments
ISN 0003	-	There are 10 beams, 2 modes per beam, 16 load cases
ISN 0004	-	Array of various section properties
ISN 0005-0012	-	Heading for tabulation of forces and moments
ISN 0013-0021	-	Do loop to read and print forces and moments
ISN 0022-0031	-	Heading for tabulation of section properties
ISN 0032-0037	-	Do loop to read and print section properties
ISN 0038-0042	-	Heading for tabulation of stresses and safety factors
ISN 0043-0047	-	Do loop for required calculations
ISN 0048-0052	-	Change sign of reactions P_1 , BM_2 and BM_3 at "FROM" nodes to make them consistent with "TO" nodes
ISN 0054	-	Stress due to P_1 : $f_1 = P_1 \div \text{total area}$
ISN 0055	-	Stress due to F_2 : $f_2 = F_2 \div \text{area along 2-2}$
ISN 0056	-	Stress due to F_2 : $f_3 = F_3 \div \text{area along 3-3}$
ISN 0057-0059	-	Since the center of the weld section does not necessarily coincide with the center of the beam section, the forces and moments at the center of the beam have to be translated to the center of

- the weld considering the eccentricities E_y and E_z . Torsion and bending moments at the weld center are calculated
- ISN 0060-0067 - Calculation of stresses due to torsion at each corner weld. At each corner there may be a weld in X and a weld in Y direction: $f_t = TC/J$
- ISN 0068-0071 - Calculation of stresses due to bending moments at each corner of the section, $f_b = M c/I$
- ISN 0072-0079 - Summation of stresses, direct (x) and shear (y + z) by SRSS: $f_t = [(\sum f_x)^2 + (\sum f_y)^2 + (\sum f_z)^2]^{.5}$
- ISN 0080-0093 - Determine the maximum total stress
- ISN 0095-0098 - Allowable weld stress is set at 0.40 $F_y = 20$ ksi for normal loading and increased by 33% for accidental and 25% for travel loading
- ISN 0100 - Factor of safety = stress $\div$ allowable. Factor of 1.414 corresponds to the throat dimension of a fillet weld
- ISN 0101-0114 - Printing of resulting stresses and factor of safety
- ISN 0115-0124 - Re-printing of forces and moments to verify the change in sign of the reactions at "FROM" nodes
- ISN 0125-0126 - Re-printing of section properties

TABLE H.2.2.3-1 FORCES AND MOMENTS INPUT LISTING

CASE NO	BEAM NC	NODE NO	AXIAL P1	SHEAR F2	SHEAR F3	TORQUE T1	MOMENT BX2	MOMENT BX3
1	3	105	0.5109E 02	-0.2947E 03	-0.1448E 02	0.2026E 02	0.6071E 03	0.1456E 03
2	3	105	-0.3184E 03	0.9008E 03	0.3432E 03	0.3199E 05	-0.9320E 04	0.2015E 05
3	3	105	0.6715E 02	-0.1973E 03	-0.6049E 02	0.8456E 02	0.6953E 03	0.1721E 03
4	3	105	-0.2303E 03	0.6199E 03	0.2252E 03	0.2345E 05	-0.7228E 04	0.1486E 05
5	3	105	0.4349E 02	-0.6790E 02	-0.8339E 02	0.1116E 03	0.4544E 03	-0.5092E 02
6	3	105	-0.5326E 01	0.5476E 02	-0.3872E 02	0.3445E 04	-0.8066E 03	0.1953E 04
7	3	105	0.2298E 03	0.5492E 04	-0.1448E 02	0.2032E 02	0.5146E 04	-0.3325E 05
8	3	105	-0.2226E 02	0.7715E 03	-0.8212E 02	0.1148E 03	-0.5996E 03	0.2950E 03
9	3	105	-0.4116E 02	0.3302E 04	0.8212E 02	-0.1148E 03	-0.3471E 03	-0.9333E 04
10	3	105	-0.9402E 04	-0.2212E 04	0.7971E 04	0.1575E 06	-0.2233E 06	0.1041E 06
11	3	105	0.5086E 02	-0.2917E 03	-0.1448E 02	0.2026E 02	0.6024E 03	0.1493E 03
12	3	105	-0.3181E 03	0.9023E 03	0.3429E 03	0.3194E 05	-0.9310E 04	0.2012E 05
13	3	105	0.6700E 02	-0.1959E 03	-0.6049E 02	0.8456E 02	0.6929E 03	0.1721E 03
14	3	105	-0.2300E 03	0.6195E 03	0.2247E 03	0.2341E 05	-0.7217E 04	0.1483E 05
15	3	105	0.3175E 02	-0.1693E 02	-0.8339E 02	0.1166E 03	0.3408E 03	-0.2019E 03
16	3	105	0.3599E 02	0.3982E 02	-0.5603E 02	0.1986E 04	-0.4087E 03	0.9514E 03
1	3	107	-0.5109E 02	0.2947E 03	0.1448E 02	-0.2026E 02	-0.4335E 03	-0.3741E 04
2	3	107	0.3184E 03	-0.9008E 03	-0.3432E 03	-0.3199E 05	0.5133E 04	-0.9165E 04
3	3	107	-0.6715E 02	0.1973E 03	0.6049E 02	-0.8456E 02	0.4269E 02	-0.2579E 06
4	3	107	0.2303E 03	-0.6199E 03	-0.2252E 03	-0.2345E 05	0.4481E 04	-0.7293E 04
5	3	107	-0.4349E 02	0.6790E 02	0.8339E 02	-0.1116E 03	0.5629E 03	-0.7775E 03
6	3	107	0.5326E 01	-0.5476E 02	0.3872E 02	-0.3445E 04	0.1279E 04	-0.1285E 04
7	3	107	-0.2298E 03	-0.5492E 04	0.1448E 02	-0.2032E 02	-0.4969E 04	0.1003E 06
8	3	107	0.2226E 02	-0.7715E 03	0.8212E 02	-0.1148E 03	0.1631E 04	0.9118E 04
9	3	107	0.4116E 02	-0.3302E 04	-0.8212E 02	0.1148E 03	-0.6548E 03	0.4961E 05
10	3	107	0.9402E 04	0.2212E 04	-0.7971E 04	-0.1575E 06	0.1231E 06	-0.1311E 06
11	3	107	-0.5086E 02	0.2917E 03	0.1448E 02	-0.2026E 02	-0.4258E 03	-0.3709E 04
12	3	107	0.3181E 03	-0.9023E 03	-0.3429E 03	-0.3194E 05	0.5127E 04	-0.9110E 04
13	3	107	-0.6700E 02	0.1959E 03	0.6049E 02	-0.8456E 02	0.4530E 02	-0.2562E 04
14	3	107	0.2300E 03	-0.6195E 03	-0.2247E 03	-0.2341E 05	0.4475E 04	-0.7271E 04
15	3	107	-0.3175E 02	0.1693E 02	0.8339E 02	-0.1166E 03	0.6765E 03	-0.4608E 01
16	3	107	-0.3599E 02	-0.3982E 02	0.5603E 02	-0.1986E 04	0.1092E 04	-0.4656E 03
1	4	108	0.5109E 02	0.2947E 03	0.1448E 02	-0.2023E 02	0.4335E 03	0.3741E 04
2	4	108	0.4392E 03	0.8335E 02	0.3722E 03	0.3195E 05	0.6386E 04	-0.2486E 05
3	4	108	0.6715E 02	0.1973E 03	0.6049E 02	-0.8454E 02	-0.4218E 02	0.2579E 04
4	4	108	0.3801E 03	0.4926E 02	0.3462E 03	0.2328E 05	0.4719E 04	-0.1813E 05
5	4	108	0.4349E 02	0.6790E 02	0.8339E 02	-0.1166E 03	-0.5629E 03	0.7775E 03
6	4	108	0.8880E 02	0.3309E 02	0.1281E 03	0.3212E 04	0.1595E 03	-0.2388E 04
7	4	108	0.2298E 03	-0.5492E 04	0.1448E 02	-0.2016E 02	0.4970E 04	-0.1033E 06
8	4	108	-0.2226E 02	-0.7716E 03	0.8212E 02	-0.1148E 03	-0.1601E 04	-0.9118E 04
9	4	108	-0.4116E 02	-0.3302E 04	-0.8212E 02	0.1148E 03	0.6548E 03	-0.4961E 05
10	4	108	0.9834E 04	-0.5594E 04	0.7971E 04	0.1575E 06	0.1336E 06	-0.2006E 06
11	4	108	0.5086E 02	0.2917E 03	0.1448E 02	-0.2023E 02	0.4258E 03	0.3709E 04
12	4	108	0.4388E 03	0.8012E 02	0.3718E 03	0.3190E 05	0.6380E 04	-0.2487E 05
13	4	108	0.6700E 02	0.1959E 03	0.6049E 02	-0.8454E 02	-0.4530E 02	-0.2562E 04
14	4	108	0.3795E 03	0.4833E 02	0.3457E 03	0.2324E 05	0.4709E 04	-0.1811E 05
15	4	108	0.3175E 02	0.1693E 02	0.8339E 02	-0.1166E 03	-0.6765E 03	0.4607E 01
16	4	108	0.6237E 02	0.4674E 01	0.1107E 03	0.1753E 04	-0.2115E 03	-0.1661E 04
1	4	106	-0.5109E 02	-0.2947E 03	-0.1448E 02	0.2023E 02	-0.6071E 03	-0.1456E 03
2	4	106	-0.4392E 03	-0.8335E 02	-0.3722E 03	-0.3195E 05	-0.1093E 05	0.2588E 05
3	4	106	-0.6715E 02	-0.1973E 03	-0.6049E 02	0.8454E 02	-0.6953E 03	-0.1721E 03

4	4	106	-0.3801E	03	-0.4926E	02	-0.3462E	03	-0.2328E	05	-0.8942E	04	0.1873E	05
5	4	106	-0.4349E	02	-0.6790E	02	-0.8339E	02	0.1166E	03	-0.4544E	03	0.5092E	02
6	4	106	-0.8880E	02	-0.3309E	02	-0.1281E	03	-0.3212E	04	-0.1722E	04	0.2792E	04
7	4	106	-0.2298E	03	0.5492E	04	-0.1448E	02	0.2032E	02	-0.5146E	04	0.3325E	05
8	4	106	0.2226E	02	0.7716E	03	-0.8212E	02	0.1148E	03	0.5996E	03	-0.2951E	03
9	4	106	0.4116E	02	0.3302E	04	0.8212E	02	-0.1148E	03	0.3471E	03	0.9333E	04
10	4	106	-0.9834E	04	0.5594E	04	-0.7971E	04	-0.1575E	06	-0.2338E	06	0.1324E	06
11	4	106	-0.5086E	02	-0.2917E	03	-0.1448E	02	0.2023E	02	-0.6024E	03	-0.1493E	03
12	4	106	-0.4388E	03	-0.8012E	02	-0.3718E	03	-0.3190E	05	-0.1092E	05	0.2585E	05
13	4	106	-0.6700E	02	-0.1959E	03	-0.6049E	02	0.8454E	02	-0.6929E	03	-0.1721E	03
14	4	106	-0.3795E	03	-0.4833E	02	-0.3457E	03	-0.2324E	05	-0.8927E	04	0.1869E	05
15	4	106	-0.3175E	02	-0.1693E	02	-0.8339E	02	0.1166E	03	-0.3408E	03	0.2019E	03
16	4	106	-0.6237E	02	-0.4679E	02	-0.1107E	03	-0.1753E	04	-0.1139E	04	0.1718E	04
1	25	119	-0.8516E	03	-0.1449E	04	-0.1875E	02	0.5375E-01	-0.6368E	04	-0.8636E	04	
2	25	119	-0.8672E	03	-0.1045E	05	0.6093E	03	0.1048E	06	-0.2421E	05	0.3449E	05
3	25	119	-0.9856E	03	-0.1002E	04	-0.7834E	02	0.3562E-01	-0.8068E	04	-0.4263E	04	
4	25	119	-0.1004E	04	-0.7185E	04	0.4807E	03	0.7571E	05	-0.2397E	05	0.2645E	05
5	25	119	-0.3962E	03	0.7517E	02	-0.1080E	03	0.1539E-02	-0.3307E	04	0.1047E	04	
6	25	119	-0.3361E	03	-0.6472E	03	0.7872E	01	0.1066E	05	-0.6011E	04	0.5174E	04
7	25	119	-0.1676E	03	0.1922E	05	-0.1875E	02	0.2560E	00	0.3117E	04	-0.3148E	04
8	25	119	0.2087E	03	-0.2571E	04	-0.1064E	03	-0.1439E	00	0.1792E	04	0.1465E	04
9	25	119	0.4332E	03	0.1761E	04	0.1064E	03	0.6915E-01	0.4162E	04	-0.1361E	05	
10	25	119	-0.1934E	04	-0.1296E	05	0.1688E	05	0.3005E	06	-0.4699E	06	0.4838E	05
11	25	119	-0.8505E	03	-0.1454E	04	-0.1875E	02	0.5713E	03	-0.6364E	04	-0.8625E	04
12	25	119	-0.8660E	03	-0.1044E	05	0.6087E	03	0.1046E	06	-0.2419E	05	0.3444E	05
13	25	119	-0.9838E	03	-0.1002E	04	-0.7834E	02	0.3883E-01	-0.8955E	04	-0.4259E	04	
14	25	119	-0.1002E	04	-0.7173E	04	0.4798E	03	0.7557E	05	-0.2393E	05	0.2639E	05
15	25	119	-0.1813E	03	0.2186E	03	-0.1086E	03	0.1602E	04	-0.1340E	04	0.7421E	03
16	25	119	-0.1865E	03	-0.2025E	03	-0.3921E	02	0.5904E	04	-0.3318E	04	0.3058E	04
1	25	121	0.8516E	03	0.1449E	04	0.1875E	02	-0.5375E-01	0.6533E	04	-0.7968E	04	
2	25	121	0.8672E	03	0.1045E	05	-0.6093E	03	-0.1048E	06	0.1723E	05	-0.1543E	06
3	25	121	0.9856E	03	0.1002E	04	0.7834E	02	-0.3562E-01	0.8966E	04	-0.7222E	04	
4	25	121	0.1004E	04	0.7185E	04	-0.4807E	03	-0.7571E	05	0.1846E	05	-0.1088E	05
5	25	121	0.3962E	03	-0.7517E	02	0.1080E	03	-0.1539E-02	0.4544E	04	-0.1852E	03	
6	25	121	0.3361E	03	0.6472E	03	-0.7872E	01	-0.1066E	05	0.5921E	04	-0.1259E	05
7	25	121	0.1676E	03	-0.1922E	05	0.1875E	02	-0.2560E	00	-0.2902E	04	0.2518E	06
8	25	121	-0.2087E	03	0.2571E	04	0.1064E	03	0.1439E	00	-0.5732E	03	-0.3093E	05
9	25	121	-0.4332E	03	-0.1761E	04	-0.1064E	03	-0.6715E-01	-0.5381E	04	0.3379E	05	
10	25	121	0.1934E	04	0.1296E	05	-0.1688E	05	-0.3005E	06	0.2764E	06	-0.1969E	06
11	25	121	0.8505E	03	0.1454E	04	0.1875E	02	-0.5713E	03	0.6579E	04	-0.8035E	04
12	25	121	0.8660E	03	0.1044E	05	-0.6087E	03	-0.1046E	06	0.1721E	05	-0.1541E	06
13	25	121	0.9838E	03	0.1002E	04	0.7834E	02	-0.3883E	03	0.8952E	04	-0.7221E	04
14	25	121	0.1002E	04	0.7173E	04	-0.4798E	03	-0.7557E	05	0.1846E	05	-0.1088E	06
15	25	121	0.1813E	03	-0.2186E	03	0.1080E	03	-0.1602E	04	0.2578E	04	0.1763E	04
16	25	121	0.1865E	03	0.2025E	03	0.3921E	02	-0.5904E	04	0.3767E	04	-0.5378E	04
1	26	120	-0.8516E	03	0.1449E	04	0.1875E	02	0.5375E-01	-0.6533E	04	0.7967E	04	
2	26	120	-0.8672E	03	-0.3932E	04	0.6468E	03	0.1048E	06	0.3924E	04	-0.8246E	05
3	26	120	-0.9856E	03	0.1002E	04	0.7834E	02	0.3562E-01	-0.8966E	04	0.7222E	04	
4	26	120	-0.1004E	04	-0.2650E	04	0.6374E	03	0.7571E	05	0.3720E	03	-0.5538E	05
5	26	120	-0.3962E	03	-0.7517E	02	0.1080E	03	0.1537E-02	-0.4544E	04	0.1852E	03	
6	26	120	-0.3361E	03	-0.5695E	03	0.2239E	03	0.1066E	05	-0.2018E	04	-0.8292E	04
7	26	120	-0.1676E	03	-0.1922E	05	0.1875E	02	0.2560E	00	0.2902E	04	-0.2518E	06
8	26	120	0.2087E	03	0.2571E	04	0.1064E	03	-0.1439E	00	0.5732E	03	0.3093E	05
9	26	120	0.4332E	03	-0.1761E	04	-0.1064E	03	0.6915E-01	0.5381E	04	-0.3379E	05	
10	26	120	0.1775E	04	0.6377E	03	0.1688E	05	0.3005E	06	0.2922E	06	-0.6233E	04
11	26	120	-0.8505E	03	0.1454E	04	0.1875E	02	0.5713E	03	-0.6579E	04	0.8035E	04
12	26	120	-0.8660E	03	-0.3923E	04	0.6462E	03	0.1046E	06	0.3924E	04	-0.8229E	05
13	26	120	-0.9838E	03	0.1002E	04	0.7834E	02	0.3883E	03	-0.8952E	04	0.7221E	04
14	26	120	-0.1002E	04	-0.2644E	04	0.6365E	03	0.7557E	05	0.3706E	03	-0.5527E	05
15	26	120	-0.1813E	03	-0.2186E	03	0.1079E	03	0.1601E-02	-0.2578E	04	-0.1763E	04	
16	26	120	-0.1865E	03	-0.4638E	03	0.1768E	03	0.5904E	04	-0.1451E	04	-0.6040E	04
1	26	118	0.8516E	03	-0.1449E	04	-0.1875E	02	-0.5375E-01	0.6368E	04	0.8636E	04	

2	26	118	0.8672E 03	0.3932E 04	-0.6468E 03	-0.1048E 06	-0.1134E 05	0.3739E 05
3	26	118	0.9856E 03	-0.1002E 04	-0.7834E 02	-0.3562E-01	0.8068E 04	0.4263E 04
4	26	118	0.1004E 04	0.2650E 04	-0.6374E 03	-0.7571E 05	-0.7677E 04	0.2501E 05
5	26	118	0.3962E 03	0.7517E 02	-0.1080E 03	-0.1537E-02	0.3337E 04	-0.1047E 04
6	26	118	0.3361E 03	0.5695E 03	-0.2239E 03	-0.1066E 05	-0.5472E 03	0.1765E 04
7	26	118	0.1676E 03	0.1922E 05	-0.1875E 02	-0.2560E 00	-0.3117E 04	0.3148E 05
8	26	118	-0.2087E 03	-0.2571E 04	-0.1064E 03	0.1439E 00	-0.1792E 04	-0.1462E 04
9	26	118	-0.4332E 03	0.1761E 04	0.1064E 03	-0.6915E-01	-0.4162E 04	0.1361E 05
10	26	118	-0.1775E 04	-0.6377E 03	-0.1688E 05	-0.3005E 06	-0.4857E 06	0.1354E 05
11	26	118	0.8505E 03	-0.1454E 04	-0.1875E 02	-0.5713E 03	0.6364E 04	0.8625E 04
12	26	118	0.8660E 03	0.3923E 04	-0.6462E 03	-0.1046E 06	-0.1133E 05	0.3733E 05
13	26	118	0.9838E 03	-0.1002E 04	-0.7834E 02	-0.3883E 03	0.8055E 04	0.4259E 04
14	26	118	0.1002E 04	0.2644E 04	-0.6365E 03	-0.7557E 05	-0.7665E 04	0.2496E 05
15	26	118	0.1813E 03	0.2186E 03	-0.1079E 03	-0.1601E-02	0.1340E 04	-0.7421E 03
16	26	118	0.1865E 03	0.4637E 03	-0.1767E 03	-0.5904E 04	-0.5753E 03	0.7250E 03
1	44	128	-0.1410E 03	0.2633E 05	-0.5490E 01	0.8953E-01	0.1260E 06	-0.6302E 05
2	44	128	-0.2225E 03	0.1340E 05	0.7650E 04	0.1617E 06	-0.1044E 04	-0.3160E 06
3	44	128	-0.2710E 03	0.1790E 05	-0.2294E 02	0.6753E-01	0.1343E 06	-0.3925E 05
4	44	128	-0.2683E 03	0.8981E 04	0.8247E 04	0.1282E 06	-0.1011E 04	-0.2153E 06
5	44	128	-0.3029E 03	0.2384E 04	-0.3163E 02	0.9199E-02	0.4679E 05	0.1152E 05
6	44	128	-0.2672E 03	0.3991E 03	0.2632E 04	0.2187E 05	-0.4915E 04	-0.1548E 05
7	44	128	-0.5720E 03	0.3112E 02	-0.5480E 01	0.4865E 00	-0.5050E 05	-0.1683E 06
8	44	128	-0.2229E 03	-0.5469E 01	-0.3116E 02	-0.2515E 00	-0.1637E 05	-0.2007E 05
9	44	128	0.1577E 03	0.5477E 01	0.3116E 02	0.7154E-01	-0.4719E 05	-0.1347E 06
10	44	128	-0.5287E 04	-0.2633E 05	0.5168E 05	0.4036E 06	-0.8463E 06	-0.5358E 06
11	44	128	-0.1417E 03	0.2630E 05	-0.5490E 02	0.9933E-01	0.1258E 06	-0.6302E 05
12	44	128	-0.2216E 03	0.1338E 05	0.7639E 04	0.1614E 06	-0.1036E 04	-0.3155E 06
13	44	128	-0.2709E 03	0.1787E 05	-0.2294E 02	0.7407E-01	0.1337E 06	-0.3918E 05
14	44	128	-0.2680E 03	0.8970E 04	0.8233E 04	0.1279E 06	-0.1019E 04	-0.2149E 06
15	44	128	-0.1900E 03	0.5887E 03	-0.3163E 02	0.1094E-01	0.1935E 05	0.1029E 05
16	44	128	-0.1900E 03	-0.1981E 03	0.1428E 04	0.1198E 05	-0.4133E 04	-0.4361E 04
1	44	130	0.1410E 03	-0.2633E 05	0.5490E 01	-0.8953E-01	-0.1259E 06	0.4922E 06
2	44	130	0.2225E 03	-0.1340E 05	-0.7650E 04	-0.1617E 06	-0.1236E 06	0.5344E 06
3	44	130	0.2710E 03	-0.1790E 05	0.2294E 02	-0.6753E-01	-0.1339E 06	0.3310E 06
4	44	130	0.2683E 03	-0.8981E 04	-0.8247E 04	-0.1282E 06	-0.1334E 06	0.3617E 06
5	44	130	0.3029E 03	-0.2384E 04	0.3163E 02	-0.9199E 04	-0.4628E 05	0.2734E 05
6	44	130	0.2672E 03	-0.3991E 03	-0.2632E 04	-0.2187E 05	-0.3799E 05	0.2199E 05
7	44	130	-0.5720E 03	-0.3112E 02	0.5480E 01	-0.4865E 00	0.5059E 05	0.1688E 06
8	44	130	-0.2229E 03	0.5469E 01	0.3116E 02	0.2515E 00	0.1638E 05	0.1998E 05
9	44	130	-0.1577E 03	-0.5477E 01	-0.3116E 02	-0.7154E-01	0.4668E 05	0.1348E 06
10	44	130	0.5287E 04	0.2633E 05	-0.5168E 05	-0.4036E 06	0.3937E 04	0.1067E 06
11	44	130	0.1417E 03	-0.2630E 05	0.5490E 02	-0.9933E 03	-0.1258E 06	0.4917E 06
12	44	130	0.2216E 03	-0.1338E 05	-0.7639E 04	-0.1614E 06	-0.1235E 06	0.5336E 06
13	44	130	0.2709E 03	-0.1787E 05	0.2294E 02	-0.7407E 03	-0.1337E 06	0.3305E 06
14	44	130	0.2680E 03	-0.8970E 04	-0.8234E 04	-0.1279E 06	-0.1332E 06	0.3611E 06
15	44	130	0.1900E 03	-0.5887E 03	0.3163E 02	-0.1094E 03	-0.1883E 05	-0.6985E 03
16	44	130	0.1900E 03	0.1981E 03	-0.1428E 04	-0.1198E 05	-0.1915E 05	0.1132E 04
1	45	130	-0.1410E 03	-0.2633E 05	0.5496E 01	0.8953E-01	0.1259E 06	-0.4922E 06
2	45	130	-0.2225E 03	-0.4195E 05	0.7661E 04	0.1617E 06	0.1236E 06	-0.5344E 06
3	45	130	-0.2710E 03	-0.1790E 05	0.2295E 02	0.6753E-01	0.1339E 06	-0.3310E 06
4	45	130	-0.2683E 03	-0.2879E 05	0.8293E 04	0.1282E 06	0.1334E 06	-0.3617E 06
5	45	130	-0.3029E 03	-0.2384E 04	0.3163E 02	0.9199E-02	0.4628E 05	-0.2734E 05
6	45	130	-0.2672E 03	-0.3455E 04	0.2696E 04	0.2187E 05	0.3799E 05	-0.2199E 05
7	45	130	-0.5720E 03	-0.3119E 02	0.5506E 01	0.4865E 00	-0.5059E 05	-0.1688E 06
8	45	130	-0.2229E 03	0.5517E 01	0.3114E 02	-0.2515E 00	-0.1688E 05	-0.1998E 05
9	45	130	-0.1577E 03	-0.5509E 01	-0.3114E 02	0.7154E-01	-0.4668E 05	-0.1348E 06
10	45	130	-0.5223E 04	-0.2633E 05	0.5168E 05	0.4036E 06	-0.3937E 04	-0.1067E 06
11	45	130	-0.1417E 03	-0.2630E 05	0.5496E 01	0.9933E 03	0.1258E 06	-0.4917E 06
12	45	130	-0.2216E 03	-0.4190E 05	0.7650E 04	0.1614E 06	0.1235E 06	-0.5336E 06
13	45	130	-0.2709E 03	-0.1787E 05	0.2295E 02	0.7407E 03	0.1337E 06	-0.3305E 06
14	45	130	-0.2680E 03	-0.2874E 05	0.8279E 04	0.1279E 06	0.1332E 06	-0.3611E 06
15	45	130	-0.1900E 03	-0.5887E 03	0.3163E 02	0.1094E 03	0.1883E 05	0.6985E 03

16	45	130	-0.1900E 03	-0.1483E 04	0.1492E 04	0.1198E 05	0.1915E 05	-0.1132E 04
1	45	129	0.1410E 03	0.2633E 05	-0.5496E 01	-0.8953E-01	-0.1260E 06	0.6302E 05
2	45	129	0.2225E 03	0.4195E 05	-0.7661E 04	-0.1617E 06	-0.2435E 06	-0.1495E 06
3	45	129	0.2710E 03	0.1790E 05	-0.2295E 02	-0.6753E-01	-0.1343E 06	0.3925E 05
4	45	129	0.2683E 03	0.2879E 05	-0.8293E 04	-0.1282E 06	-0.2636E 06	-0.1075E 06
5	45	129	0.3029E 03	0.2384E 04	-0.3163E 02	-0.9199E-02	-0.4680E 05	-0.1152E 05
6	45	129	0.2672E 03	0.3455E 04	-0.2696E 04	-0.2187E 05	-0.8193E 05	-0.3433E 05
7	45	129	-0.5720E 03	0.3119E 02	-0.5506E 01	-0.4865E 00	0.5050E 05	0.1682E 06
8	45	129	0.2229E 03	-0.5517E 01	-0.3114E 02	0.2515E 00	0.1637E 05	0.2007E 05
9	45	129	-0.1577E 03	0.5509E 01	0.3114E 02	-0.7154E-01	0.4719E 05	0.1348E 06
10	45	129	0.5223E 04	0.2633E 05	-0.5168E 05	-0.4036E 06	-0.8384E 06	-0.3225E 06
11	45	129	0.1417E 03	0.2630E 05	-0.5496E 01	-0.9933E 03	-0.1258E 06	0.6302E 05
12	45	129	0.2216E 03	0.4190E 05	-0.7650E 04	-0.1614E 06	-0.2432E 06	-0.1493E 06
13	45	129	0.2709E 03	0.1787E 05	-0.2295E 02	-0.7407E 03	-0.1341E 06	0.3918E 05
14	45	129	0.2680E 03	0.2874E 05	-0.8279E 04	-0.1279E 06	-0.2681E 06	-0.1073E 06
15	45	129	0.1900E 03	0.5887E 03	-0.3163E 02	-0.1094E-01	-0.1935E 05	-0.1029E 05
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1	552	500	-0.3250E 03	-0.2204E 05	0.1764E 02	-0.1183E 00	-0.3545E 05	-0.2288E 06
2	552	500	-0.3447E 03	-0.2368E 05	-0.2449E 04	-0.2383E 06	0.8930E 04	-0.2040E 06
3	552	500	0.1605E 04	-0.1465E 05	0.7368E 02	-0.6035E-01	-0.2333E 05	-0.1673E 06
4	552	500	0.1582E 04	-0.1659E 05	0.1910E 04	-0.1708E 06	0.9790E 04	-0.1512E 06
5	552	500	0.2882E 04	0.6577E 04	0.1016E 03	0.5002E-01	0.1151E 05	0.4379E 05
6	552	500	0.2959E 04	0.4823E 04	0.4725E 03	-0.2765E 05	0.2111E 05	0.2596E 05
7	552	500	0.4840E 03	-0.8438E 04	0.1763E 02	-0.4609E 00	0.1850E 05	-0.1322E 06
8	552	500	0.2914E 04	0.1051E 05	0.1000E 03	0.2929E 00	0.2262E 05	0.9656E 05
9	552	500	-0.2501E 04	-0.8691E 03	-0.1000E 03	-0.2853E 00	-0.4080E 04	-0.1222E 05
10	552	500	0.9750E 04	-0.1104E 05	0.3248E 05	-0.1974E 06	0.5943E 06	-0.2994E 06
11	552	500	-0.3326E 03	-0.2198E 05	0.1764E 02	-0.1167E 02	-0.3556E 05	-0.2277E 06
12	552	500	-0.3516E 03	-0.2361E 05	0.2443E 04	-0.2380E 06	0.8738E 04	-0.2029E 06
13	552	500	0.1594E 04	-0.1459E 05	0.7368E 02	-0.5968E 03	-0.2341E 05	-0.1663E 06
14	552	500	0.1570E 04	-0.1653E 05	0.1906E 04	-0.1705E 06	0.9642E 04	-0.1503E 06
15	552	500	0.3105E 04	0.4179E 04	0.1016E 03	0.8104E-01	0.2069E 05	0.5342E 04
16	552	500	0.3105E 04	0.3564E 04	0.3107E 03	-0.1521E 05	0.2440E 05	0.1514E 04
1	552	152	0.3250E 03	0.2204E 05	-0.1764E 02	0.1183E 00	0.3528E 05	0.1323E 05
2	552	152	0.3447E 03	0.2368E 05	-0.2449E 04	0.2383E 06	-0.3288E 05	-0.2764E 05
3	552	152	-0.1605E 04	0.1465E 05	-0.7368E 02	0.6035E-01	0.2261E 05	0.2401E 05
4	552	152	-0.1582E 04	0.1659E 05	-0.1910E 04	0.1708E 06	-0.2847E 05	-0.1102E 05
5	552	152	-0.2882E 04	-0.6577E 04	-0.1016E 03	-0.5002E-01	-0.1251E 05	0.2053E 05
6	552	152	-0.2959E 04	-0.4823E 04	-0.4725E 03	0.2765E 05	-0.2573E 05	0.2122E 05
7	552	152	-0.4840E 03	0.8438E 04	-0.1763E 02	0.4609E 00	-0.1867E 05	0.4968E 05
8	552	152	-0.2914E 04	-0.1051E 05	-0.1000E 03	-0.2929E 00	-0.2360E 05	0.6232E 04
9	552	152	0.2501E 04	0.8691E 03	0.1000E 03	0.2853E 00	0.5053E 04	0.3722E 04
10	552	152	-0.9750E 04	0.1104E 05	-0.3248E 05	0.1974E 06	-0.9120E 06	0.1915E 06
11	552	152	0.3326E 03	0.2198E 05	-0.1764E 02	0.1167E 02	0.3539E 05	0.1278E 05
12	552	152	0.3516E 03	0.2361E 05	-0.2443E 04	0.2380E 06	-0.3263E 05	-0.2800E 05
13	552	152	-0.1594E 04	0.1459E 05	-0.7368E 02	0.5968E 03	0.2269E 05	0.2359E 05
14	552	152	-0.1570E 04	0.1653E 05	-0.1906E 04	0.1705E 06	-0.2828E 05	-0.1138E 05
15	552	152	-0.3105E 04	-0.4179E 04	-0.1016E 03	-0.8104E 03	-0.2168E 05	0.3552E 05
16	552	152	-0.3105E 04	-0.3564E 04	-0.3107E 03	0.1521E 05	-0.2744E 05	0.3334E 05
1	553	153	-0.3250E 03	0.2204E 05	-0.1764E 02	-0.1183E 00	-0.3528E 05	-0.1323E 05
2	553	153	-0.3447E 03	0.1987E 05	0.2413E 04	-0.2383E 06	-0.1033E 06	-0.5511E 05
3	553	153	0.1605E 04	0.1465E 05	-0.7368E 02	-0.6035E-01	-0.2261E 05	-0.2401E 05
4	553	153	0.1582E 04	0.1217E 05	0.1763E 04	-0.1708E 06	-0.7436E 05	-0.5688E 05
5	553	153	0.2882E 04	-0.6577E 04	-0.1016E 03	0.5002E-01	0.1251E 05	-0.2053E 05
6	553	153	0.2959E 04	-0.6828E 04	0.2694E 03	-0.2765E 05	0.4953E 04	-0.2974E 05
7	553	153	0.4840E 03	0.8438E 04	-0.1764E 02	-0.4609E 00	0.1867E 05	-0.4968E 05
8	553	153	0.2914E 04	-0.1051E 05	-0.1000E 03	0.2029E 00	0.2360E 05	-0.6232E 04
9	553	153	-0.2501E 04	0.8691E 03	0.1000E 03	-0.2853E 00	-0.5058E 04	-0.3722E 04
10	553	153	-0.9287E 04	-0.1444E 05	0.3248E 05	-0.1974E 06	-0.9071E 06	0.1817E 06
11	553	153	-0.3326E 03	0.2198E 05	-0.1764E 02	-0.1167E 02	-0.3539E 05	-0.1278E 05
12	553	153	-0.3516E 03	0.1979E 05	0.2408E 04	-0.2380E 06	-0.1032E 06	-0.5458E 05
13	553	153	0.1594E 04	0.1459E 05	-0.7368E 02	-0.5968E 03	-0.2269E 05	-0.2359E 05

14	553	153	0.1570E	04	0.1212E	05	0.1759E	04	-0.1705E	06	-0.7434E	05	-0.5637E	05
15	553	153	0.3105E	04	-0.4779E	04	-0.1016E	03	0.8104E	03	-0.2168E	05	-0.3552E	05
16	553	153	0.3105E	04	-0.4779E	04	0.1076E	03	-0.1521E	05	0.1572E	05	-0.3775E	05
1	553	501	0.3250E	03	-0.2204E	05	0.1764E	02	0.1183E	00	0.3545E	05	0.2288E	06
2	553	501	0.3447E	03	-0.1987E	05	-0.2413E	04	0.2383E	06	0.7966E	05	0.2494E	06
3	553	501	-0.1605E	04	-0.1465E	05	0.7368E	02	0.6035E	-01	0.2333E	05	0.1673E	06
4	553	501	-0.1582E	04	-0.1217E	05	-0.1763E	04	0.1708E	04	0.5713E	05	0.1759E	06
5	553	501	-0.2881E	04	0.6577E	04	0.1016E	03	-0.5002E	-01	-0.1151E	05	-0.4379E	05
6	553	501	-0.2959E	04	0.6828E	04	-0.2694E	03	0.2765E	05	-0.7588E	04	-0.3704E	05
7	553	501	-0.4840E	03	-0.8438E	04	0.1764E	02	0.4609E	00	-0.1850E	05	0.1322E	06
8	553	501	-0.2914E	04	0.1051E	05	0.1000E	03	-0.2929E	00	-0.2262E	05	-0.9656E	05
9	553	501	0.2501E	04	-0.8691E	03	-0.1000E	03	0.2853E	00	0.4030E	04	0.1222E	05
10	553	501	0.9287E	04	0.1444E	05	-0.3248E	05	0.1974E	06	0.5894E	06	-0.3229E	06
11	553	501	0.3326E	03	-0.2198E	05	0.1764E	02	0.1167E	02	0.3556E	05	0.2277E	06
12	553	501	0.3516E	03	-0.1979E	05	-0.2408E	04	0.2380E	06	0.7964E	05	0.2481E	06
13	553	501	-0.1594E	04	-0.1459E	05	0.7368E	02	0.5968E	03	0.2341E	05	0.1663E	06
14	553	501	-0.1570E	04	-0.1211E	05	-0.1759E	04	0.1705E	06	0.5714E	05	0.1748E	06
15	553	501	-0.3105E	04	0.4779E	04	0.1016E	03	-0.8104E	03	-0.2069E	05	0.5342E	04
16	553	501	-0.3105E	04	0.4779E	04	-0.1076E	03	0.1521E	05	-0.1678E	05	-0.8985E	04
1	84	167	0.5211E	04	0.1023E	03	-0.1803E	02	0.8193E	02	0.2038E	05	-0.2078E	06
2	84	167	0.5214E	04	-0.2419E	04	0.5459E	04	-0.2071E	06	-0.1361E	06	-0.2798E	06
3	84	167	0.3947E	04	0.7151E	02	-0.7535E	02	0.3426E	03	0.6915E	05	-0.1831E	06
4	84	167	0.3961E	04	-0.1048E	04	0.4695E	04	-0.1763E	06	-0.2055E	06	-0.2156E	06
5	84	167	0.9086E	04	-0.2386E	-01	-0.1039E	03	0.4725E	03	-0.1098E	06	-0.1391E	05
6	84	167	0.8494E	04	-0.1977E	03	0.1151E	04	-0.3449E	05	-0.1615E	06	-0.5518E	05
7	84	167	0.4586E	04	0.1022E	03	-0.1798E	02	0.8126E	02	-0.1028E	06	-0.3182E	06
8	84	167	-0.1910E	04	-0.1800E	02	-0.1023E	03	0.4655E	03	-0.1962E	06	0.3186E	05
9	84	167	0.1296E	04	0.1802E	02	0.1023E	03	-0.4656E	03	0.1506E	06	-0.6727E	05
10	84	167	-0.2496E	03	-0.4871E	04	-0.9684E	04	0.3380E	06	0.2757E	05	-0.1384E	06
11	84	167	0.5060E	04	0.1023E	03	-0.1803E	02	0.8192E	02	0.2031E	05	-0.2052E	06
12	84	167	0.5062E	04	-0.2416E	04	0.5440E	04	-0.2068E	06	-0.1354E	06	-0.2771E	06
13	84	167	0.3874E	04	0.7151E	02	-0.7535E	02	0.3426E	03	-0.6865E	05	-0.1802E	06
14	84	167	0.3888E	04	-0.1052E	04	0.4681E	04	-0.1759E	06	-0.2046E	06	-0.2129E	06
15	84	167	0.7239E	04	-0.2116E	03	-0.1038E	03	0.4724E	03	-0.1602E	06	-0.1246E	06
16	84	167	0.7218E	04	-0.4959E	02	0.5942E	03	-0.1968E	05	-0.1799E	06	-0.1259E	06
1	84	169	-0.5211E	04	-0.1023E	03	0.1803E	02	-0.8193E	02	-0.1982E	05	-0.2093E	06
2	84	169	-0.5214E	04	0.2419E	04	-0.5459E	04	0.2071E	06	0.5694E	05	0.2447E	06
3	84	169	-0.3947E	04	-0.7152E	02	0.7535E	02	-0.3426E	03	0.7024E	05	0.1841E	06
4	84	169	-0.3961E	04	0.1048E	04	-0.4695E	04	0.1763E	06	0.1374E	06	0.2004E	06
5	84	169	-0.9086E	04	0.2386E	-01	0.1039E	03	-0.4725E	03	0.1113E	06	0.1391E	05
6	84	169	-0.8494E	04	0.1977E	03	-0.1151E	04	0.3449E	05	0.1448E	06	0.5231E	05
7	84	169	-0.4586E	04	-0.1022E	03	0.1798E	02	-0.8126E	02	0.1031E	06	0.3197E	06
8	84	169	0.1910E	04	0.1800E	02	0.1023E	03	-0.4655E	03	0.1977E	06	-0.3212E	05
9	84	169	-0.1296E	04	-0.1802E	02	-0.1023E	03	0.4656E	03	-0.1521E	06	0.6753E	05
10	84	169	0.2496E	03	0.4871E	04	0.9684E	04	-0.3380E	06	-0.1363E	06	0.6780E	05
11	84	169	-0.5060E	04	-0.1023E	03	0.1803E	02	-0.8192E	02	-0.2035E	05	0.2067E	06
12	84	169	-0.5062E	04	0.2416E	04	-0.5440E	04	0.2068E	06	0.5650E	05	0.2421E	06
13	84	169	-0.3874E	04	-0.7151E	02	0.7535E	02	-0.3426E	03	0.6974E	05	0.1813E	06
14	84	169	-0.3888E	04	0.1052E	04	-0.4681E	04	0.1759E	06	0.1367E	06	0.1976E	06
15	84	169	-0.7234E	04	0.2116E	03	0.1038E	03	-0.4724E	03	0.1617E	06	0.1246E	06
16	84	169	-0.7218E	04	0.4969E	02	-0.5942E	03	0.1968E	05	0.1713E	06	0.1252E	06
1	85	168	0.5211E	04	-0.1023E	03	0.1805E	02	-0.8214E	02	0.1992E	05	-0.2093E	06
2	85	168	0.5214E	04	-0.2624E	04	0.5495E	04	-0.2073E	06	0.9642E	05	-0.1741E	06
3	85	168	0.3947E	04	-0.7152E	02	0.7537E	02	-0.3428E	03	-0.7024E	05	-0.1841E	06
4	85	168	0.3961E	04	-0.1191E	04	0.4846E	04	-0.1770E	06	-0.3840E	04	-0.1691E	06
5	85	168	0.9086E	04	-0.2386E	-01	0.1039E	03	-0.4723E	03	-0.1113E	06	-0.1391E	05
6	85	168	0.8494E	04	-0.1977E	03	0.1359E	04	-0.3544E	05	-0.1097E	06	-0.4677E	05
7	85	168	0.4586E	04	-0.1024E	03	0.1810E	02	-0.8280E	02	-0.1031E	06	-0.3197E	06
8	85	168	-0.1910E	04	0.1808E	02	0.1023E	03	-0.4650E	03	-0.1977E	06	0.3212E	05
9	85	168	0.1295E	04	-0.1806E	02	-0.1023E	03	0.4649E	03	0.1521E	06	-0.6753E	05
10	85	168	-0.4181E	02	-0.4871E	04	-0.9684E	04	0.3380E	06	-0.1349E	06	0.6953E	05
11	85	168	0.5060E	04	-0.1023E	03	0.1805E	02	-0.8215E	02	0.2035E	05	-0.2067E	06

12	85	168	0.5062E 04	-0.2631E 04	0.5476E 04	-0.2069E 06	0.9633E 05	-0.1715E 06
13	85	168	0.3874E 04	-0.7152E 02	0.7537E 02	-0.3428E 03	-0.6974E 05	-0.1813E 06
14	85	168	0.3888E 04	-0.1195E 04	0.4833E 04	-0.1768E 06	-0.3532E 04	-0.1662E 06
15	85	168	0.7234E 04	-0.2116E-01	0.1039E 03	-0.4724E 03	-0.1617E 06	-0.1246E 06
16	85	168	0.7218E 04	-0.4959E 02	0.8000E 03	-0.2062E 05	-0.1517E 06	-0.1238E 06
1	85	166	-0.5211E 04	0.1023E 03	-0.1805E 02	0.8214E 02	-0.2038E 05	0.2078E 06
2	85	166	-0.5214E 04	0.2634E 04	-0.5495E 04	0.2073E 06	-0.1761E 06	0.1630E 06
3	85	166	-0.3947E 04	0.7152E 02	-0.7537E 02	0.3428E 03	0.6914E 05	0.1831E 06
4	85	166	-0.3861E 04	0.1191E 04	-0.4846E 04	0.1770E 06	-0.6643E 05	0.1518E 06
5	85	166	-0.9086E 04	0.2386E 03	-0.1039E 03	0.4723E 03	0.1098E 05	0.1391E 05
6	85	166	-0.8494E 04	0.1977E 03	-0.1359E 04	0.3544E 05	0.8996E 05	0.4391E 05
7	85	166	-0.4566E 04	0.1024E 03	-0.1810E 02	0.8280E 02	0.1962E 06	-0.3185E 05
8	85	166	-0.1310E 04	-0.1808E 02	-0.1033E 03	0.4650E 03	-0.1506E 06	-0.6727E 05
9	85	166	-0.1275E 04	0.1806E 02	0.1033E 03	-0.4649E 03	-0.2753E 06	-0.1402E 06
10	85	166	0.4181E 02	0.4871E 04	0.9684E 04	-0.3380E 06	0.2753E 06	-0.1402E 06
11	85	166	-0.5060E 04	0.1023E 03	-0.1805E 02	0.8215E 02	-0.2031E 05	0.2052E 06
12	85	166	-0.5062E 04	0.2631E 04	-0.5476E 04	0.2069E 06	-0.1757E 05	0.1335E 06
13	85	166	-0.3874E 04	0.7152E 02	-0.7537E 02	0.3428E 03	0.6865E 05	0.1802E 06
14	85	166	-0.3888E 04	0.1195E 04	-0.4833E 04	-0.1768E 06	-0.6654E 05	0.1489E 06
15	85	166	-0.7234E 04	0.2116E 04	0.8000E 03	-0.4724E 03	-0.1632E 06	0.1246E 06
16	85	166	-0.7218E 04	0.4959E 02	-0.8020E 03	0.2062E 05	0.1431E 06	0.1230E 06

TABLE H.2.2.3-2 CROSS SECTION PROPERTIES INPUT LISTING

BEAM NO	FLANGE AREA	WEB AREA	DISTANCE FROM WELD CENTER				WELD-BEAM ECCENTRICITY		MOMENT OF INERTIA			TORSIONAL INERTIA
			UP DU	DOWN DD	RIGHT DR	LEFT DL	EY	EZ	ABT 2-2 YI2	ABT 3-3 ZI3	YZJ	
3	3.75	5.00	6.51	5.49	6.50	6.50	-0.51	0.0	174.35	275.56	449.91	
4	3.75	5.00	6.51	5.49	6.50	6.50	-0.51	0.0	174.35	275.56	449.91	
25	3.12	4.50	9.35	9.15	7.50	7.50	-0.10	0.0	445.52	324.25	769.77	
26	3.12	4.50	9.35	9.15	7.50	7.50	-0.10	0.0	445.52	324.25	769.77	
44	7.81	12.58	6.00	6.00	11.16	14.59	0.0	5.59	395.71	1649.03	2044.74	
45	7.81	12.58	6.00	6.00	11.16	14.59	0.0	5.59	395.71	1649.03	2044.74	
552	4.00	3.00	6.64	5.36	7.75	7.75	-0.64	0.0	192.10	283.10	475.20	
553	4.00	3.00	6.64	5.36	7.75	7.75	-0.64	0.0	192.10	283.10	475.20	
84	7.75	6.00	6.00	6.00	7.75	7.75	0.0	0.0	351.00	515.54	866.54	
85	7.75	6.00	6.00	6.00	7.75	7.75	0.0	0.0	351.00	515.54	866.54	

CASE NO	BEAM NO	NODE NO	UP-LEFT			UP-RIGHT			DOWN-LEFT			MIN FACTOR OF SAFETY
			SUL2	SUL3	SUR2	SUR3	SDR2	SDR3	SDL2	SDL3		
1	3	105	88.	33.	85.	26.	79.	18.	77.	12.	161.6	
2	3	105	511.	604.	1002.	1110.	802.	684.	1069.	917.	16.9	
3	3	105	68.	42.	63.	32.	54.	22.	52.	19.	208.9	
4	3	105	378.	445.	751.	825.	577.	495.	788.	687.	22.8	
5	3	105	30.	29.	31.	28.	19.	17.	20.	22.	450.0	
6	3	105	62.	77.	98.	100.	78.	63.	103.	100.	182.4	
7	3	105	1607.	564.	1811.	1009.	1570.	647.	1703.	925.	9.8	
8	3	105	211.	23.	212.	38.	203.	23.	204.	27.	83.3	
9	3	105	938.	244.	929.	204.	888.	228.	885.	219.	18.9	
10	3	105	7932.	7422.	12491.	12760.	4441.	5613.	8876.	8715.	1.4	
11	3	105	87.	33.	84.	26.	78.	18.	76.	12.	163.1	
12	3	105	510.	603.	1000.	1109.	801.	683.	1068.	916.	12.8	
13	3	105	67.	42.	63.	32.	54.	22.	51.	19.	210.1	
14	3	105	377.	444.	750.	823.	576.	494.	786.	686.	22.9	
15	3	105	14.	22.	23.	26.	5.	15.	13.	22.	713.0	
16	3	105	36.	50.	47.	47.	45.	30.	59.	60.	311.3	