CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

CNWRA
CONTROLLED
COPY 408

Doug Gute 210.522.2307

Names, sample signatures, initials & phone numbers are shown on page 1.

Repository Design and Thermal-Mechanical Effects

This notebook documents the work being done to develop conceptual models including process-level drip shield and waste package analyses and rockfall study for upgrading the SEISMO module to be included in the future version of the Total-system Performance Assessment (TPA) code. See the Operations Plan for Repository Design and Thermal-Mechanical Effects (RDTME) for more details.

The qualifications required of the staff supporting this endeavor are as follows:

a) Computational Continuum Mechanics / Finite Element Analysis
b) Material Science / Metallurgy
c) Rock Mechanics
d) Civil and Mechanical Engineering
e) Geological Science and Engineering

CNWRA Staff:

Doug Gute
Simon Hsiung
Darrell Dunn
Asad Chowdhury

Outside Consulting Staff:

814-865-3102 Ted Krauthammer Theodor Krauthammer, TK
814-863-9787 Chang-Soo Park [signature], CS park

Doug Gute 6/30/2000

June 29, 2000 Time : 09:00 ~ 12:40

M.O.M

Place : Sackett 217 conference room

Attendant : Dr Ted Krauthammer
Dr G. Douglas Gute
Joonhong Lim
Chang-Soo Park

(1) To distribute

① "Center for nuclear waste regulatory analyses" (Quality Assurance procedure) & (Administrative procedure)

② "Rockfall on drip shield analysis" - Report

③ DWG Sheet 1 of 2 (SR Drip Shield)
sketch no. sk-0148 Rev 04

④ Figure I-1 Precast invert with cast-in place haunch

⑤ "Assessment of mechanical response of drip shields under repository environment" - progress report (May 2000)

⑥ Abaqus example input (3 pages)

(2) To explain and discuss

① Scientific notebook
- Don't use wipe out
- correction method : one line in the middle & date

② Project
- Note ABAQUS Explicit version & Revision no.
- creep : not our scope
- Elastic rock
- To analyze a section between two ribs

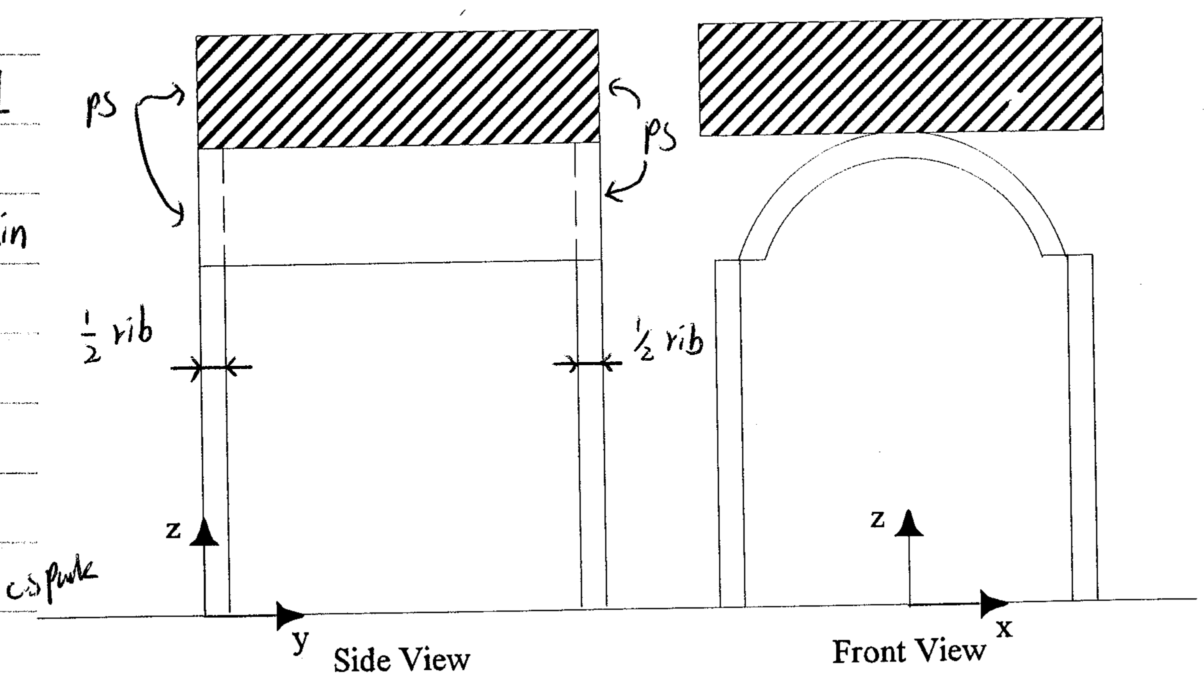
- To use symmetry
- use uniform mesh
- Estimate dimensions from thickness & weight
- Unit : Newton, kg, meter and second
- First to do scenario 1
- if possible
  Change the rock density and rock geometry
  → to check difference
- July 10
  - to define the geometry and mesh of scenario 1
  - Rock definition

June 30, 2000 Time 8:00 ~ 12:30

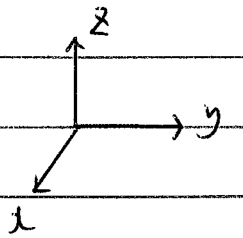
Review the project

Scenario 1

ps: plain strain



plain strain : x-z planes



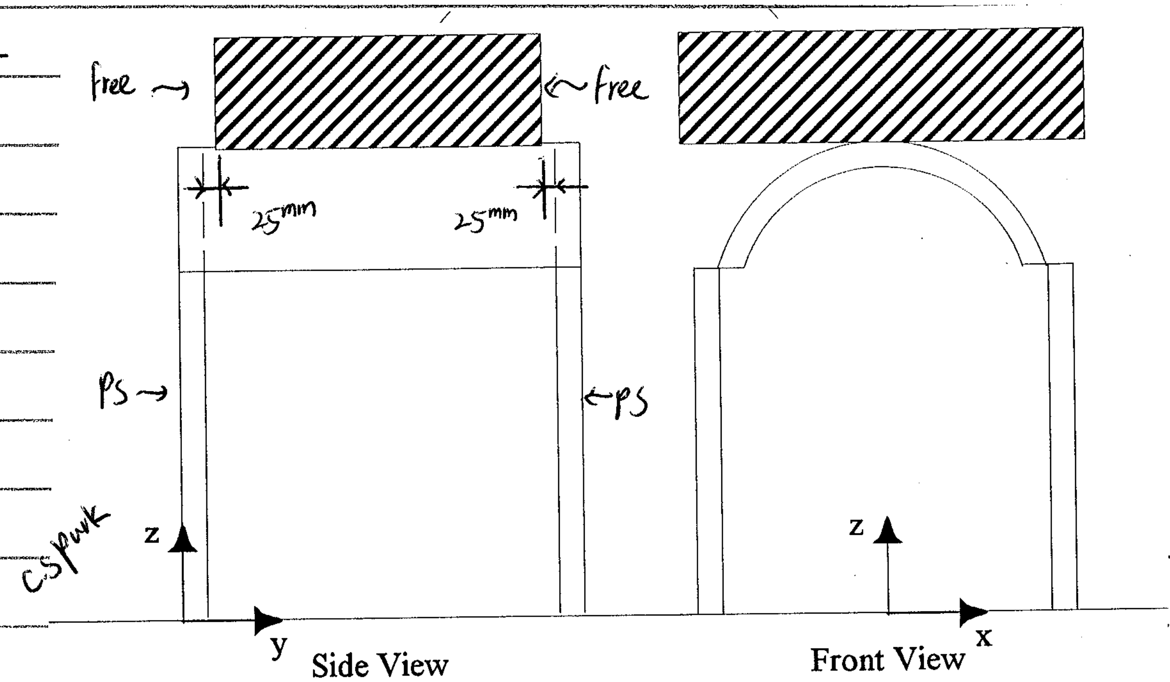
y-displacement equals zero on x-z planes

$\varepsilon_y = 0$ $\gamma_{xy} = 0$ $\gamma_{yz} = 0$

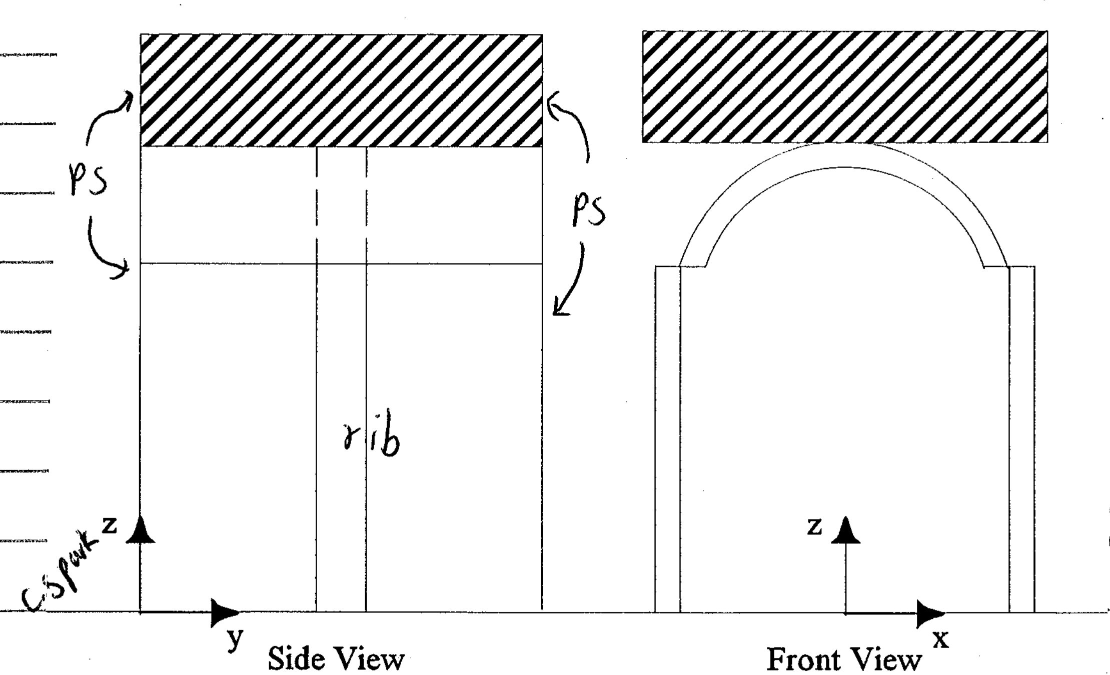
$\Rightarrow \tau_{xy} = 0$ $\tau_{yz} = 0$

$\sigma_x, \sigma_y, \sigma_z$ and τ_{xz} may have nonzero values.

Scenario 2



Scenario 3



- Element type
  8-node hexagonal solid elements
- Mesh should be uniform throughout the entire structure.
  An aspect ratio as close to 1x1x1 for all elements

Solid Element Selection Summary

Information potentially subject to copyright protection was redacted from this location and also the bottom of the page. The redacted material is from the reference information listed below the boxes.

c.s.park

 Introduction to ABAQUS/Standard and ABAQUS/Explicit

Solid Element Selection Summary

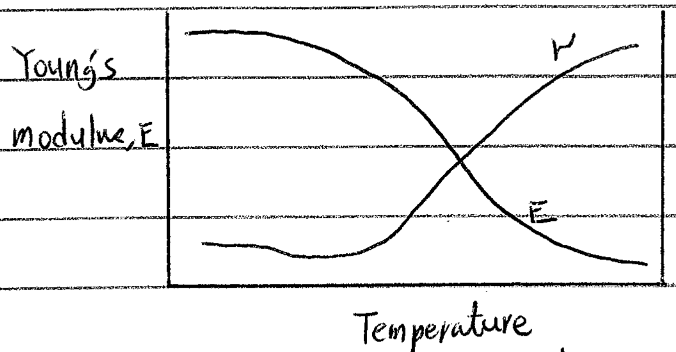
c.s.park

 Introduction to ABAQUS/Standard and ABAQUS/Explicit

◦ Material

Poisson's Ratio will be assumed to be temperature independent

cf)



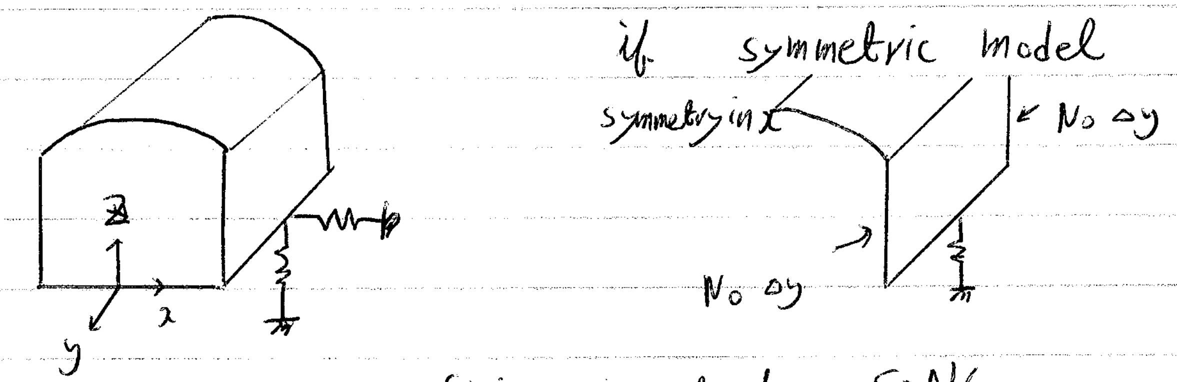
		Density (kg/m^3)	Poisson's Ratio
① Titanium Grade 7	150°C	4512	0.32
(SB 265 R52400)	260°C	4512	0.32
① Titanium Grade 24	150°C	4512	0.32
(SB 265 R56400)	260°C	4512	0.32
② Rock		2700	0.21

② The rock block material will only be allowed to respond to the impact in a simple elastic.

◦ Boundary

- The invert floor will be defined as an analytical rigid surface
- A contact boundary surface will be defined between the inner drip shield surface and the waste package
- Waste Package will be modeled as an analytical rigid surface

① Each set of two springs will be attached to a node midway along the length of the drip shield



Spring constant : 50 N/m

② Each set of two springs will be attached to a node midway along the length of the rock block

◦ Initial Conditions.

① All of the drip shield nodes and the reference nodes for the invert and waste package analytical will be assigned an initial upward velocity of 1 m/s

② All of the rock nodes will be assigned an various initial downward velocity

* note ① - Drip shield

② - Rock block

July 2 , 2000 Time : 10:00 ~ 12:00

- Review DWG

1 Drip shield plate 1 & 2 Dimension vs mass
  → Not clear : length and height
  → Not Clear : relation with drip shield connector

2 Base : type ? inner of dripshied bottom

3 Bulkhead (4ea) → with support beam large (no match - center)

4 Peripheral bulkhead (2ea) : Front aren ?

5 Internal Support plate (10ea) - between bulkhead
  Location ?

6 External support plate (10ea) - between support beam - large
  Location ?

7 Support beam - connector (6ea)
  Location ?

8 Drip shield Connector plate 1 & 2
  Dimension ?

9 Drip shield connector guide
  Location

* Note (Next page - use no.)

July 2

No.	COMPONENT NAME	MATERIAL	THICKNESS	MASS (KG)	QTY ROD
1	DRIP SHIELD PLATE-1	SB-265 R52400	15	837	1
2	DRIP SHIELD PLATE-2	SB-265 R52400	15	780	2
3	BASE	SB-575 NO6022	10	55	2
4	BULKHEAD	SB-265 R56400	38	45	4
5	PERIPHERAL BULKHEAD	SB-265 R56400	48	56	2
6	POST	SB-265 R56400	100	5.6	2
7	INTERNAL SUPPORT PLATE	SB-265 R52400	12.7	16	10
8	EXTERNAL SUPPORT PLATE	SB-265 R52400	12.7	27	10
9	LIFTING PLATE	SB-265 R56400	50	17	4
10	SUPPORT BEAM-CONNECTOR	SB-265 R56400	102	27	6
11	SUPPORT BEAM-LARGE	SB-265 R56400	76	37	8
12	DRIP SHIELD CONNECTOR GUIDE	SB-265 R52400	50	30	2
13	DRIP SHIELD CONNECTOR PLATE-1	SB-265 R52400	15	142	1
14	DRIP SHIELD CONNECTOR PLATE-2	SB-265 R52400	15	89	2
15	DRIP SHIELD CONNECTOR GUIDE-A	SB-265 R52400	50	26	1
16	DRIP SHIELD CONNECTOR GUIDE-B	SB-265 R52400	50	31	1
	DRIP SHIELD ASSEMBLY	-	-	4203	1

C.S Park

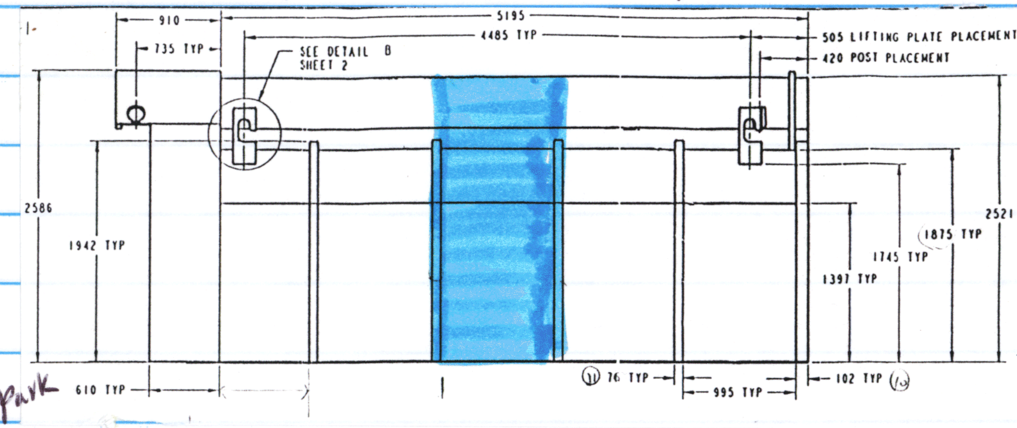
Time : 16:30 ~ 18:00

- Discussion with Juan-hong Lim
  - The interval difference : 4 bulkhead vs 11 support beam-large
  - Follow Drawing dimension or recalculate the dimension using the mass ?
  - Support beam - large - dimension ?

July 3, 2000 Time 9:00 ~ 12:00 14:00 ~ 16:00 with Dr Ted kravitz

Questionnaire (DWG for meeting)

1. We need the detail DWG and section DWG .
2. Make the model in this marked part ? Yes

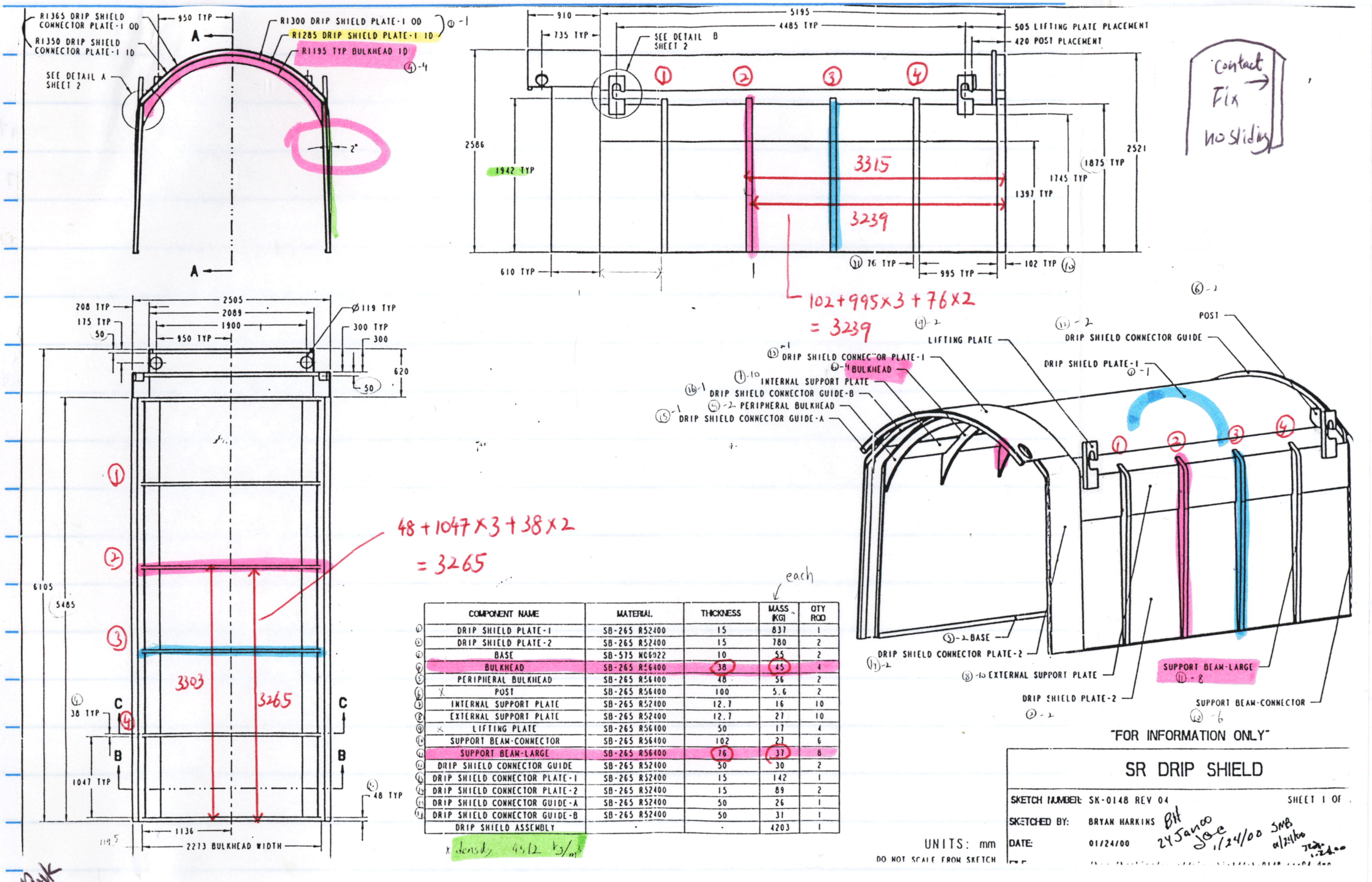


C.S park

Fig 1

3. 4 Bulkhead (4ea) vs 11 Support beam - large (8ea)
   → Location problem (Interval isn't match) Fig 2

	Bulkhead	Support beam large
(1)	$48 + 1047 \times 4 + 38 \times 3 = 4350$	$102 + 995 \times 4 + 76 \times 3 = 4310$
(2)	$48 + 1047 \times 3 + 38 \times 2 = 3265$	$102 + 995 \times 3 + 76 \times 2 = 3239$
(3)	$48 + 1047 \times 2 + 38 = 2180$	$102 + 995 \times 2 + 76 \times 1 = 2168$
(4)	$48 + 1047 = 1095$	$102 + 995 = 1097$



	COMPONENT NAME	MATERIAL	THICKNESS	MASS (KG) each	QTY RQD
1	DRIP SHIELD PLATE-1	SB-265 R52400	15	837	1
2	DRIP SHIELD PLATE-2	SB-265 R52400	15	780	2
3	BASE	SB-575 N06022	10	55	2
4	BULKHEAD	SB-265 R56400	38	45	4
5	PERIPHERAL BULKHEAD	SB-265 R56400	48	56	2
6	X POST	SB-265 R56400	100	5.6	2
7	INTERNAL SUPPORT PLATE	SB-265 R52400	12.7	16	10
8	EXTERNAL SUPPORT PLATE	SB-265 R52400	12.7	27	10
9	X LIFTING PLATE	SB-265 R56400	50	17	4
10	SUPPORT BEAM-CONNECTOR	SB-265 R56400	102	27	6
11	SUPPORT BEAM-LARGE	SB-265 R56400	76	37	8
12	DRIP SHIELD CONNECTOR GUIDE	SB-265 R52400	50	30	2
13	DRIP SHIELD CONNECTOR PLATE-1	SB-265 R52400	15	142	1
14	DRIP SHIELD CONNECTOR PLATE-2	SB-265 R52400	15	89	2
15	DRIP SHIELD CONNECTOR GUIDE-A	SB-265 R52400	50	26	1
16	DRIP SHIELD CONNECTOR GUIDE-B	SB-265 R52400	50	31	1
	DRIP SHIELD ASSEMBLY	-	-	4203	1

x density 4512 kg/m³

C.S Bulk

Fig 2

	Bulk head	support beam -large	
(1)	4350 ~ 4388	4310 ~ 4386	
(2)	3265 ~ 3303	3239 ~ 3315	ok
(3)	2180 ~ 2218	2168 ~ 2244	ok
(4)	1095 ~ 1133	1097 ~ 1173	

* Bulkhead & Rib (Support beam - large) in the same vertical plane in spite of little offset the DWG

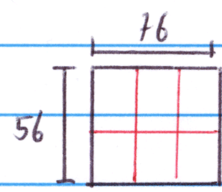
⑪ support beam - large shape

Not clear.

How to define the connection area?

→ Contact surface - Fixed contact

thk: 76mm



$4512 \times 1.942 \times 0.076 \times x = 37$

Mesh : divide into 3 element through thickness

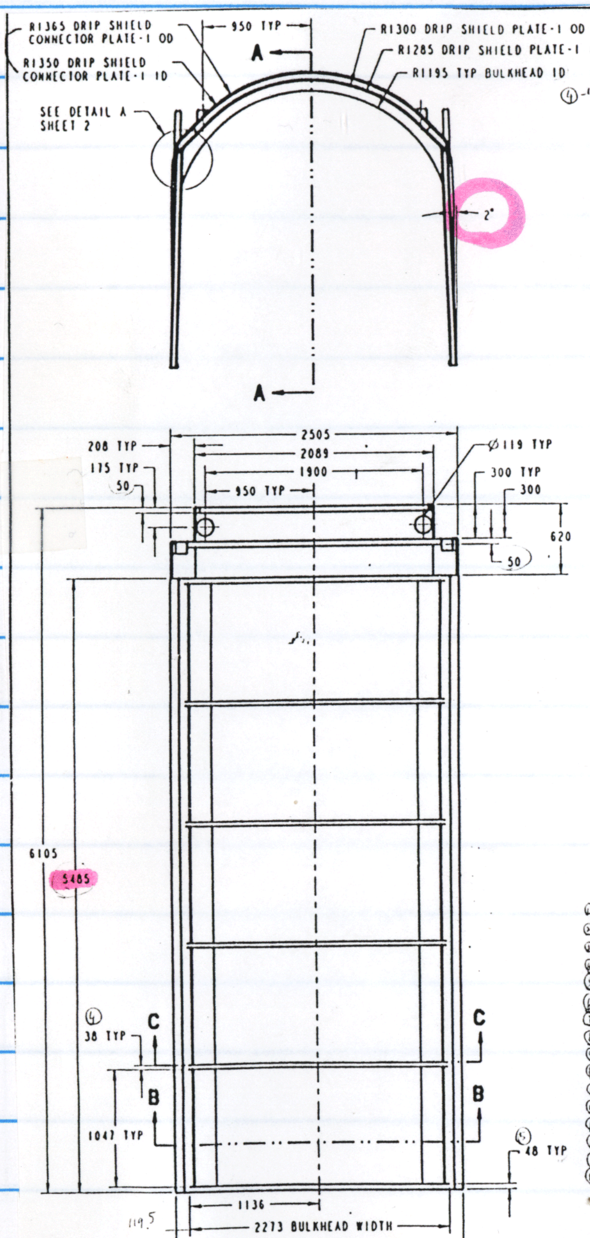
①&② Drip shield plate 1 & 2 Dimension? Fig 3

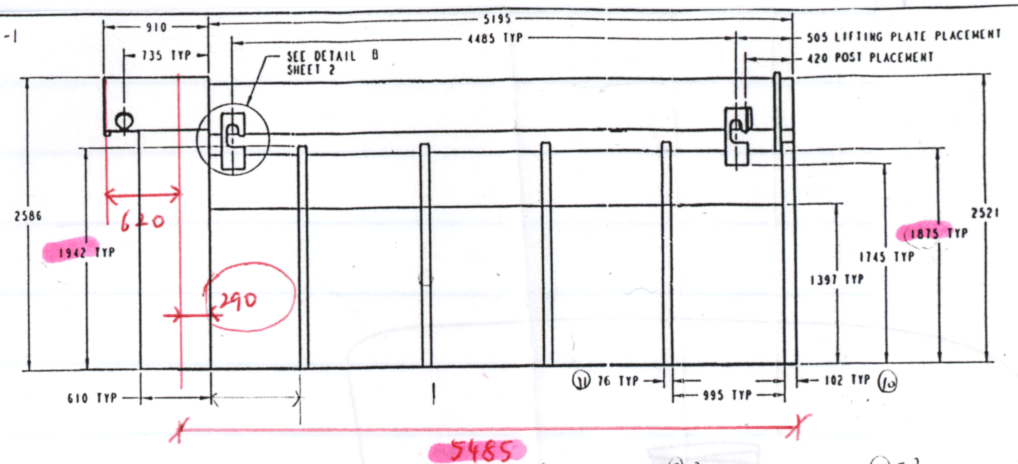
Check diff

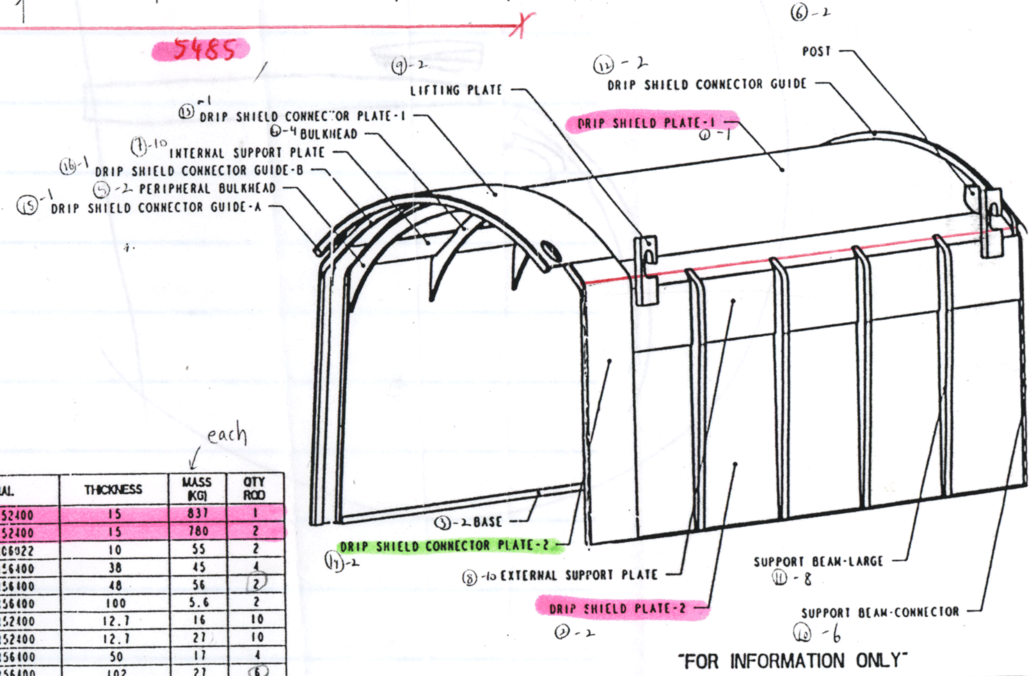
Lenghth $102 + 995 \times 5 + 76 \times 4 + 102 = 5483$ vs 5485^{mm} 2^{mm}

$5.485 \times 0.05 \times x \times 4512 = 780$ $x = 2101$ (Height)

Height 1942^{mm} vs 1875^{mm}







each

	COMPONENT NAME	MATERIAL	THICKNESS	MASS (KG)	QTY RQD
1	DRIP SHIELD PLATE-1	SB-265 R52400	15	837	1
2	DRIP SHIELD PLATE-2	SB-265 R52400	15	780	2
3	BASE	SB-575 N06022	10	55	2
4	BULKHEAD	SB-265 R56400	38	45	4
5	PERIPHERAL BULKHEAD	SB-265 R56400	48	56	2
6	X POST	SB-265 R56400	100	5.6	2
7	INTERNAL SUPPORT PLATE	SB-265 R52400	12.7	16	10
8	EXTERNAL SUPPORT PLATE	SB-265 R52400	12.7	27	10
9	X LIFTING PLATE	SB-265 R56400	50	17	4
10	SUPPORT BEAM-CONNECTOR	SB-265 R56400	102	27	6
11	SUPPORT BEAM-LARGE	SB-265 R56400	76	37	8
12	DRIP SHIELD CONNECTOR GUIDE	SB-265 R52400	50	30	2
13	DRIP SHIELD CONNECTOR PLATE-1	SB-265 R52400	15	142	1
14	DRIP SHIELD CONNECTOR PLATE-2	SB-265 R52400	15	89	2
15	DRIP SHIELD CONNECTOR GUIDE-A	SB-265 R52400	50	26	1
16	DRIP SHIELD CONNECTOR GUIDE-B	SB-265 R52400	50	31	1
	DRIP SHIELD ASSEMBLY	-	-	4203	1

* density 4512 kg/m^3

"FOR INFORMATION ONLY"

UNITS: mm
DO NOT SCALE FROM SKETCH

SR DRIP SHIELD

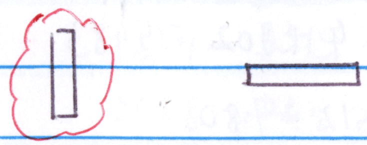
SKETCH NUMBER:	SK-0148 REV 04	SHEET 1 OF 2
SKETCHED BY:	BRYAN HARKINS BH 24Jan00	Joe 1/24/00 SMB 01/24/00
DATE:	01/24/00	

CSpak

Fig 3

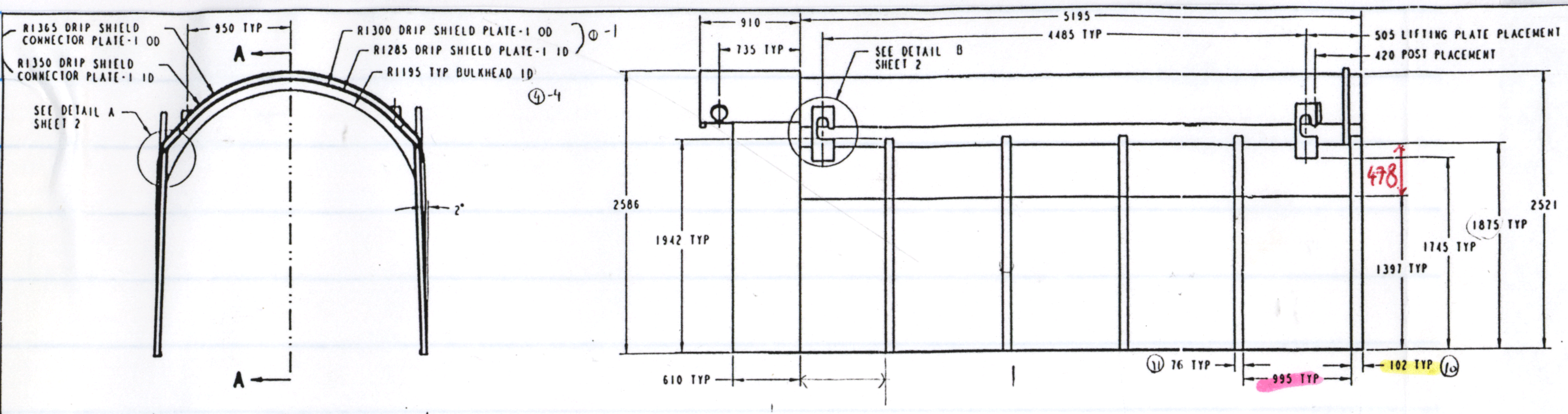
① Base t : 10 mm 55 kg : Fig 4

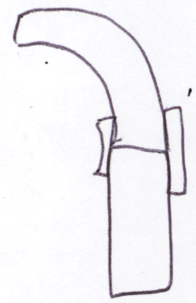
Shape ?

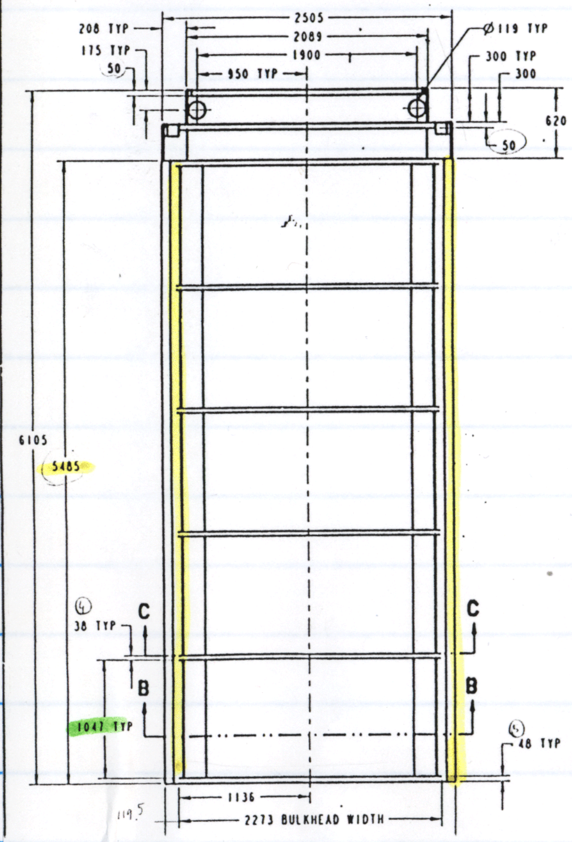


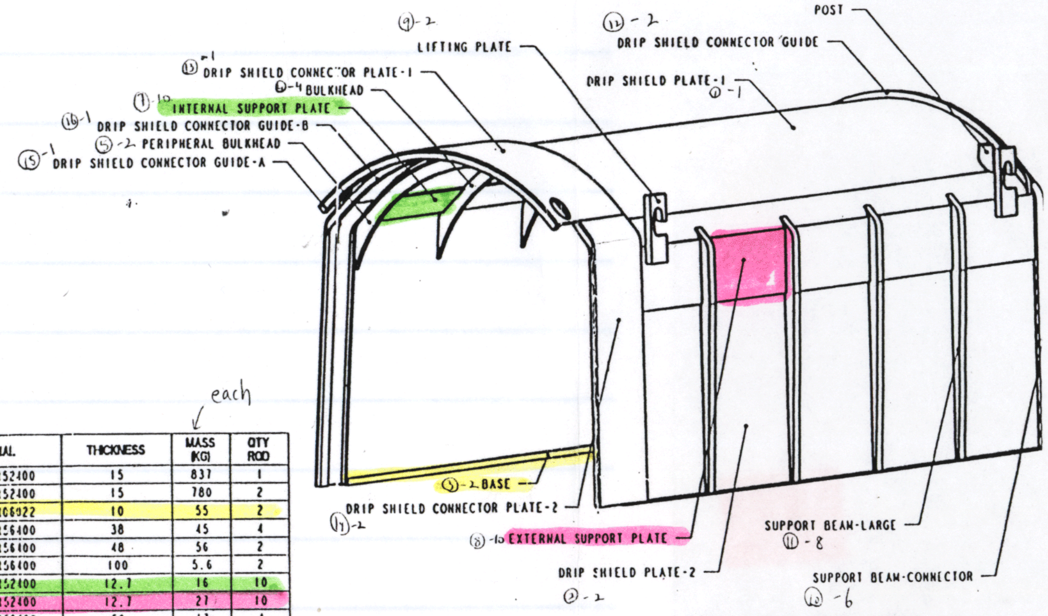
⑦ & ⑧ Internal support plate thk : 12.7 mm 16 kg

External support plate 12.7 mm 27 kg









each

	COMPONENT NAME	MATERIAL	THICKNESS	MASS (KG)	QTY ROD
①	DRIP SHIELD PLATE-1	SB-265 R52400	15	837	1
②	DRIP SHIELD PLATE-2	SB-265 R52400	15	780	2
③	BASE	SB-575 N06022	10	55	2
④	BULKHEAD	SB-265 R56400	38	45	4
⑤	PERIPHERAL BULKHEAD	SB-265 R56400	48	56	2
⑥	X POST	SB-265 R56400	100	5.6	2
⑦	INTERNAL SUPPORT PLATE	SB-265 R52400	12.7	16	10
⑧	EXTERNAL SUPPORT PLATE	SB-265 R52400	12.7	27	10
⑨	X LIFTING PLATE	SB-265 R56400	50	17	4
⑩	SUPPORT BEAM-CONNECTOR	SB-265 R56400	102	27	6
⑪	SUPPORT BEAM-LARGE	SB-265 R56400	76	37	8
⑫	DRIP SHIELD CONNECTOR GUIDE	SB-265 R52400	50	30	2
⑬	DRIP SHIELD CONNECTOR PLATE-1	SB-265 R52400	15	142	1
⑭	DRIP SHIELD CONNECTOR PLATE-2	SB-265 R52400	15	89	2
⑮	DRIP SHIELD CONNECTOR GUIDE-A	SB-265 R52400	50	26	1
⑯	DRIP SHIELD CONNECTOR GUIDE-B	SB-265 R52400	50	31	1
	DRIP SHIELD ASSEMBLY		-	4203	1

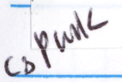
* density 4512 kg/m³

UNITS: mm

DO NOT SCALE FROM SKETCH

"FOR INFORMATION ONLY"

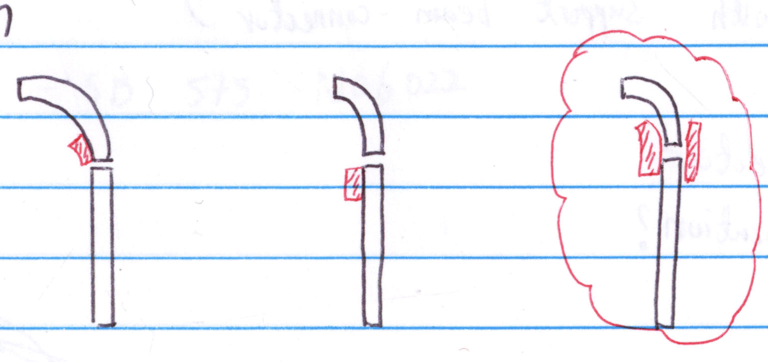
SR DRIP SHIELD		
SKETCH NUMBER:	SK-0148 REV 04	SHEET 1 OF 2
SKETCHED BY:	BRYAN HARKINS	BH
DATE:	01/24/00	24 Jan 00 Joe 1/24/00 SMB 1/24/00

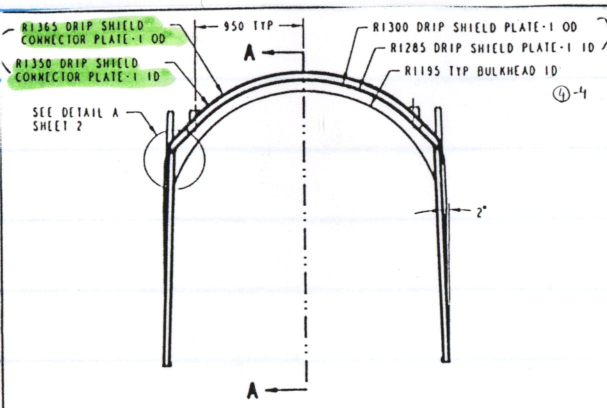


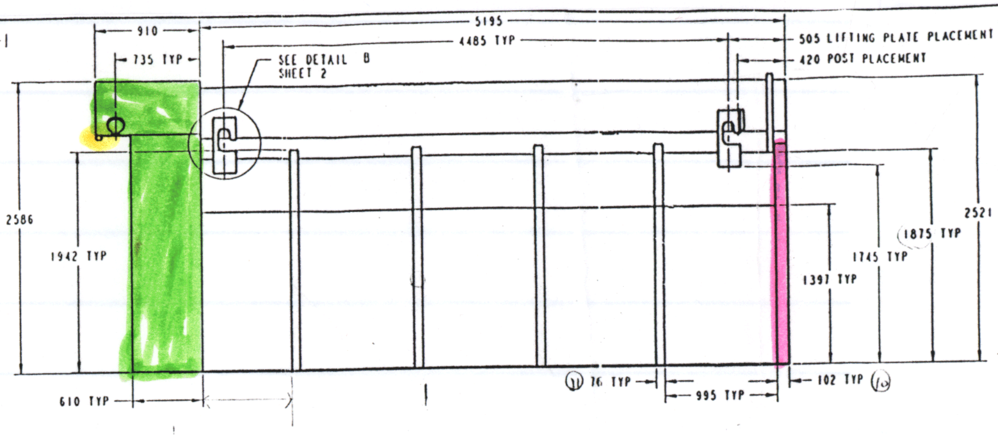
copy

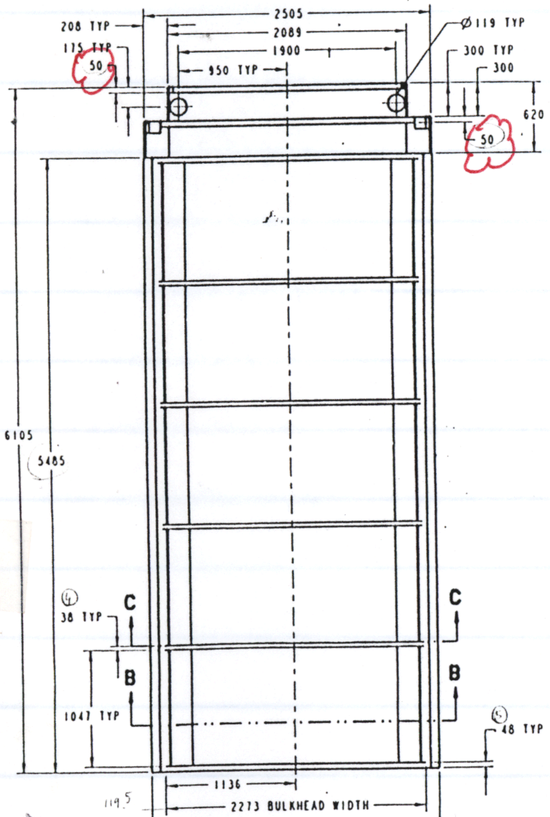
Fig 4

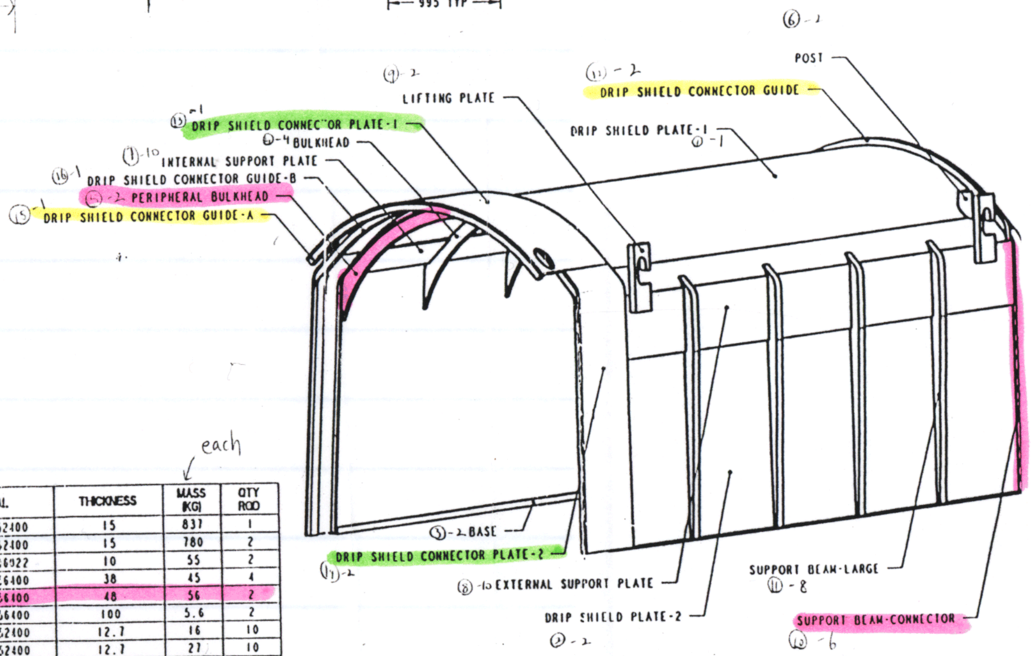
Location











each

	COMPONENT NAME	MATERIAL	THICKNESS	MASS (KG)	QTY RQD
①	DRIP SHIELD PLATE-1	SB-265 R52400	15	837	1
②	DRIP SHIELD PLATE-2	SB-265 R52400	15	780	2
③	BASE	SB-575 N06022	10	55	2
④	BULKHEAD	SB-265 R56400	38	45	4
⑤	PERIPHERAL BULKHEAD	SB-265 R56400	48	56	2
⑥	X POST	SB-265 R56400	100	5.6	2
⑦	INTERNAL SUPPORT PLATE	SB-265 R52400	12.7	16	10
⑧	EXTERNAL SUPPORT PLATE	SB-265 R52400	12.7	27	10
⑨	X LIFTING PLATE	SB-265 R56400	50	17	4
⑩	SUPPORT BEAM-CONNECTOR	SB-265 R56400	102	27	6
⑪	SUPPORT BEAM-LARGE	SB-265 R56400	76	37	8
⑫	DRIP SHIELD CONNECTOR GUIDE	SB-265 R52400	50	30	2
⑬	DRIP SHIELD CONNECTOR PLATE-1	SB-265 R52400	15	142	1
⑭	DRIP SHIELD CONNECTOR PLATE-2	SB-265 R52400	15	89	2
⑮	DRIP SHIELD CONNECTOR GUIDE-A	SB-265 R52400	50	26	1
⑯	DRIP SHIELD CONNECTOR GUIDE-B	SB-265 R52400	50	31	1
	DRIP SHIELD ASSEMBLY	.	.	4203	1

x density 4512 kg/m^3

UNITS: mm
DO NOT SCALE FROM SKETCH

"FOR INFORMATION ONLY"

SR DRIP SHIELD		
SKETCH NUMBER:	SK-0148 REV 04	SHEET 1 OF 2
SKETCHED BY:	BRYAN HARKINS	BH
DATE:	01/24/00	24Jan00 Joe 1/24/00 SMB 01/24/00
FILE:	/home/harkins/...	

CS park

Fig 5

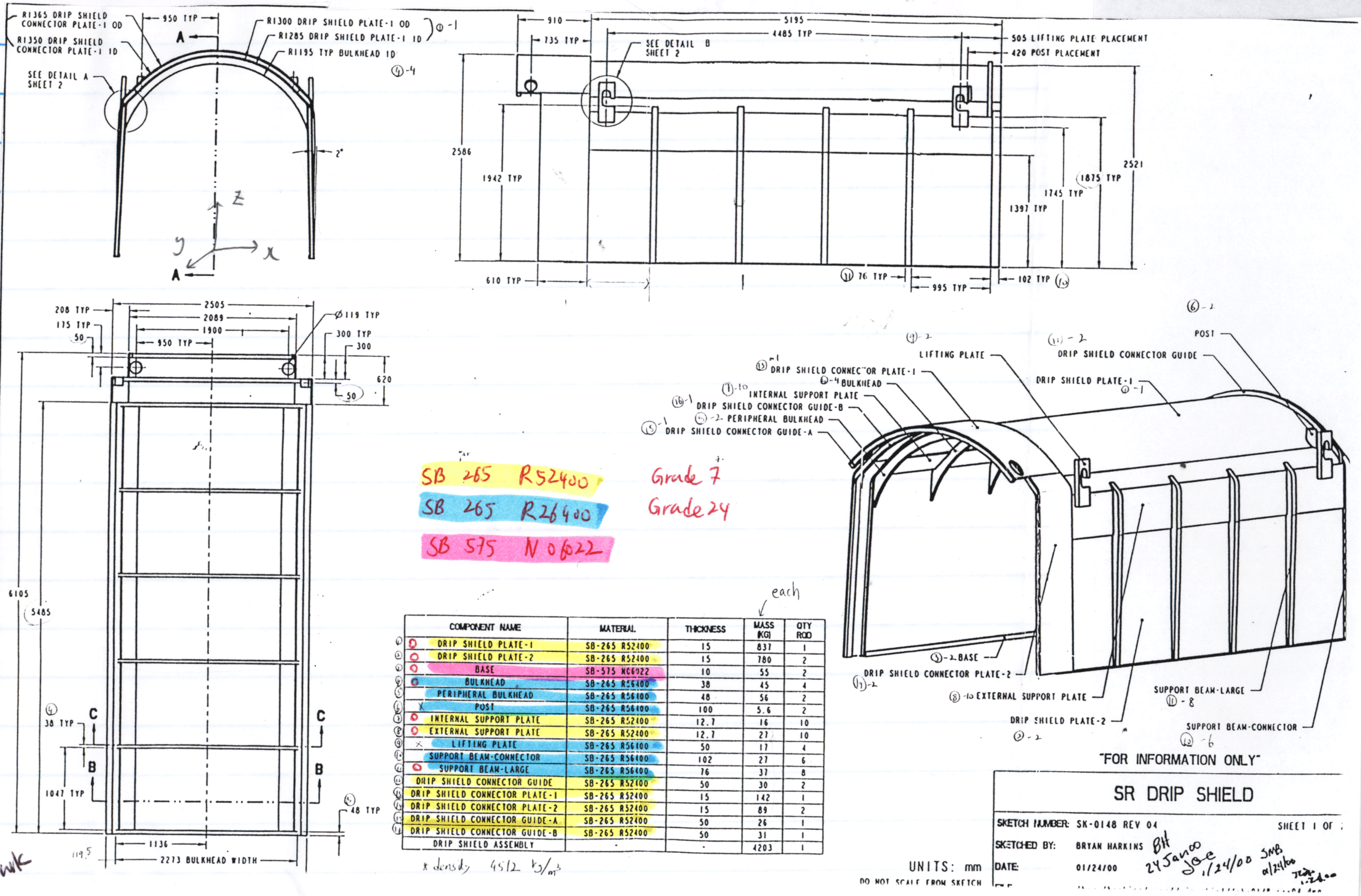
⑤ Peripheral bulkhead : 2^{ea}
 · Location ? (with support beam - connector)
 · Dimension ?

⑩ support beam - connector
 Q'ty : 6 ← location ?

July 4 Time: 15:30 ~ 16:30

Review the DWG and material check

- Material



SB 265 R52400 Grade 7

SB 265 R26400 Grade 24

SB 575 N06022

	COMPONENT NAME	MATERIAL	THICKNESS	MASS (KG) each	QTY ROD
① O	DRIP SHIELD PLATE-1	SB-265 R52400	15	837	1
② O	DRIP SHIELD PLATE-2	SB-265 R52400	15	780	2
③ O	BASE	SB-575 N06022	10	55	2
④ O	BULKHEAD	SB-265 R56400	38	45	4
⑤	PERIPHERAL BULKHEAD	SB-265 R56400	48	56	2
⑥ X	POST	SB-265 R56400	100	5.6	2
⑦ O	INTERNAL SUPPORT PLATE	SB-265 R52400	12.7	16	10
⑧ O	EXTERNAL SUPPORT PLATE	SB-265 R52400	12.7	27	10
⑨ X	LIFTING PLATE	SB-265 R56400	50	17	4
⑩	SUPPORT BEAM-CONNECTOR	SB-265 R56400	102	27	6
⑪ O	SUPPORT BEAM-LARGE	SB-265 R56400	76	37	8
⑫	DRIP SHIELD CONNECTOR GUIDE	SB-265 R52400	50	30	2
⑬	DRIP SHIELD CONNECTOR PLATE-1	SB-265 R52400	15	142	1
⑭	DRIP SHIELD CONNECTOR PLATE-2	SB-265 R52400	15	89	2
⑮	DRIP SHIELD CONNECTOR GUIDE-A	SB-265 R52400	50	26	1
⑯	DRIP SHIELD CONNECTOR GUIDE-B	SB-265 R52400	50	31	1
	DRIP SHIELD ASSEMBLY	-	-	4203	1

* density 4512 kg/m³

C.S. Park

③ Base - SB 575 N06022

July 5, 2000 Time : 9:00 ~ 11:00

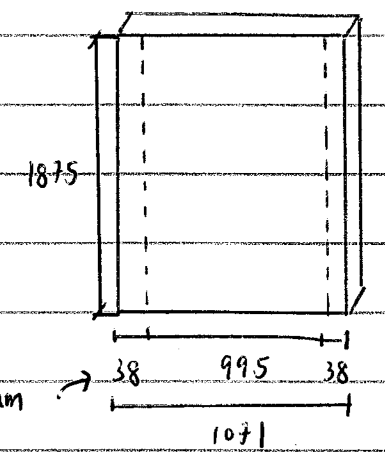
Geometry

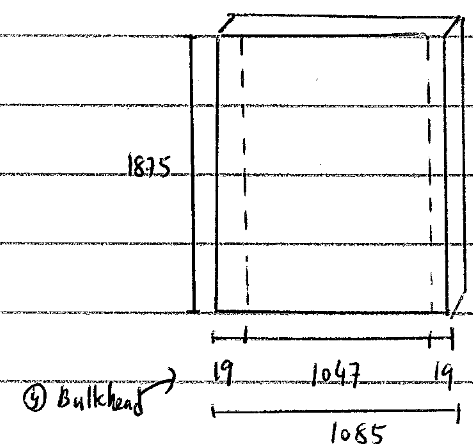
Drip shield plate 1 & 2

case I

② Drip shield plate 2 thk : 15 mm

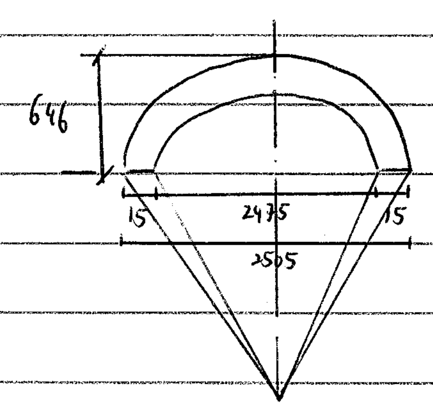
case I ☆ case 2

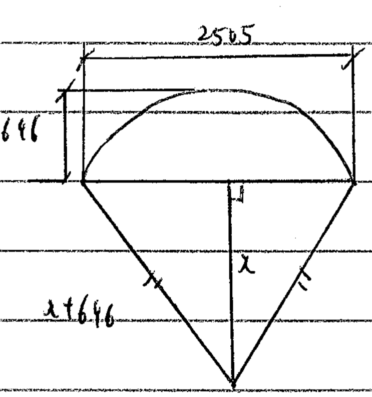




① Drip shield plate 1 thk : 15 mm

$2521 - 1875 = 646$ mm





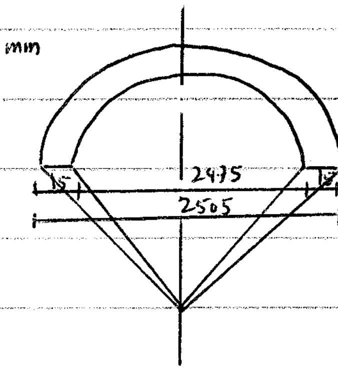
$(1252.5)^2 + x^2 = (x+646)^2$ $x : 891.2$ mm

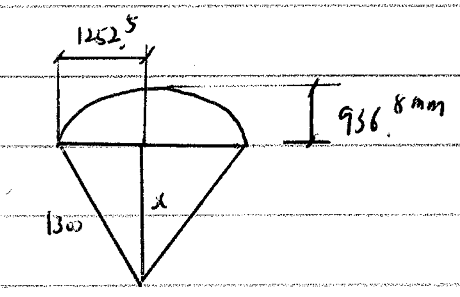
~~OD R : 1537 mm~~

Case II

① Drip shield plate 1

OD R=1300 mm

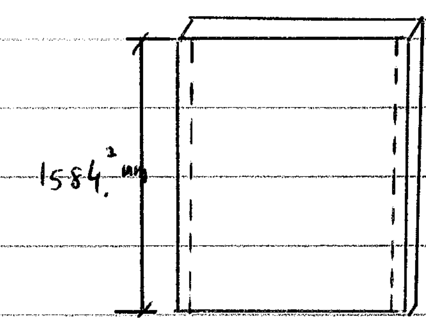




$(1252.5)^2 + x^2 = (1300)^2$ $x = 348.2$

$1285 - 348.2 = 936.8$ mm

② Drip shield plate 2



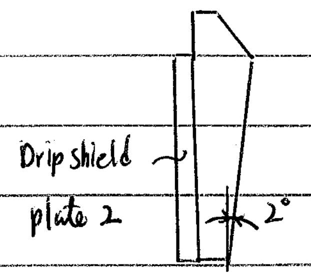
$2521 - 936.8 = 1584.2$ mm

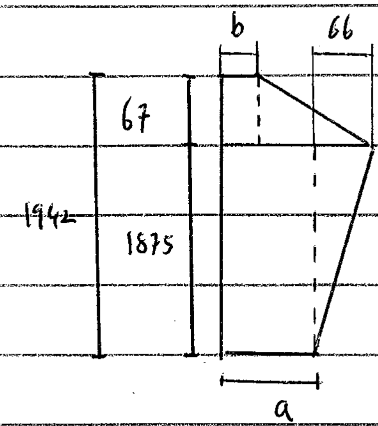
We choose to make model in Case I - Case 2 in our project (Follow the DWG dimension)

⑪ support beam - large

thk : 76 mm We use the half of thickness t : 38 mm

Mass : 37 kg We use the half of mass 18.6 kg



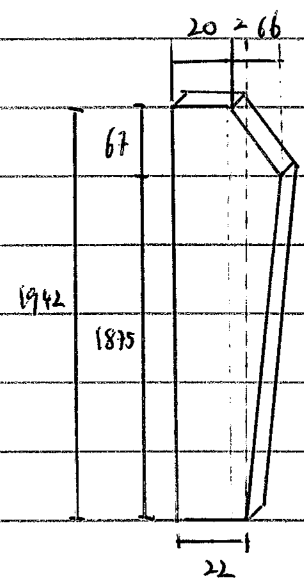


$\tan 2^\circ = \frac{x}{1875}$

$x = 65.48^{mm}$
$= 66^{mm}$

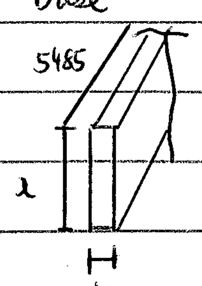
$\{ 0.067 \times b + 0.067 \times (0.066 + a - b) \times \frac{1}{2} + 1.875 \times a + 1.875 \times 0.066 \times \frac{1}{2} \} \times 0.038 \times 4512$
$= 18.5\ kg$

$b = 0.02\ m = 20^{mm}$ $a = 0.023 = 23^{mm}$



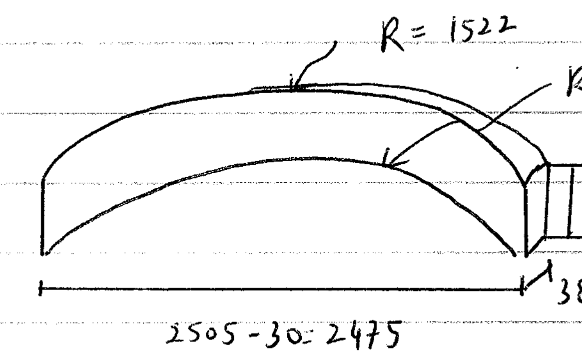
Time 16:00 ~ 17:00

③ Base thk : 10^{mm} 55 kg



$5.485 \times 0.01 \times x \times 4512 = 55$
$x = 222^{mm}$

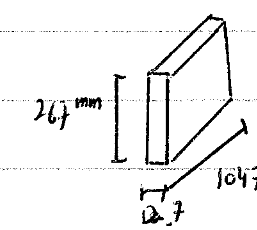
④ Bulkhead — Drip shield plate 1 — diff
ID R 1195 — ID R 1285 — 90^{mm}



thk : 38^{mm}

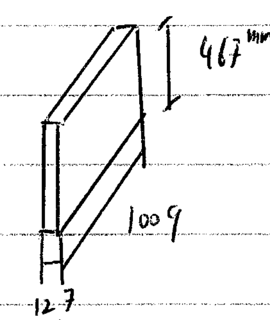
if) 2273 bulkhead width from DWG

⑦ Internal plate thk : 12.7^{mm} 16 kg



$1.047 \times 0.0127 \times x \times 4512 = 16$
$x = 267^{mm}$

⑧ External plate thk : 12.7^{mm} 27 kg



$0.0127 \times 1.009 \times x \times 4512 = 27$
$x = 0.467^{m} \rightarrow 467^{mm}$
VS $1875 - 1397 = 478^{mm}$

July 6 Time 9:00 ~ 10:30

Review the DWG and Check the geometry.

Review scientific Note

To distribute

① Scientific Note

② DWG sheet 2 of 2

sk-0148 Rev 05

· Detail A / Detail B

· Section A-A / Section B-B / Section C-C

③ Fig 4

Modified Steel invert with Ballast - Elevation

④ Fig 5

Modified Steel Invert with Ballast - Perspective

⑤ Fig 6

Steel sets with welded - wire fabric

⑥ Fig 7

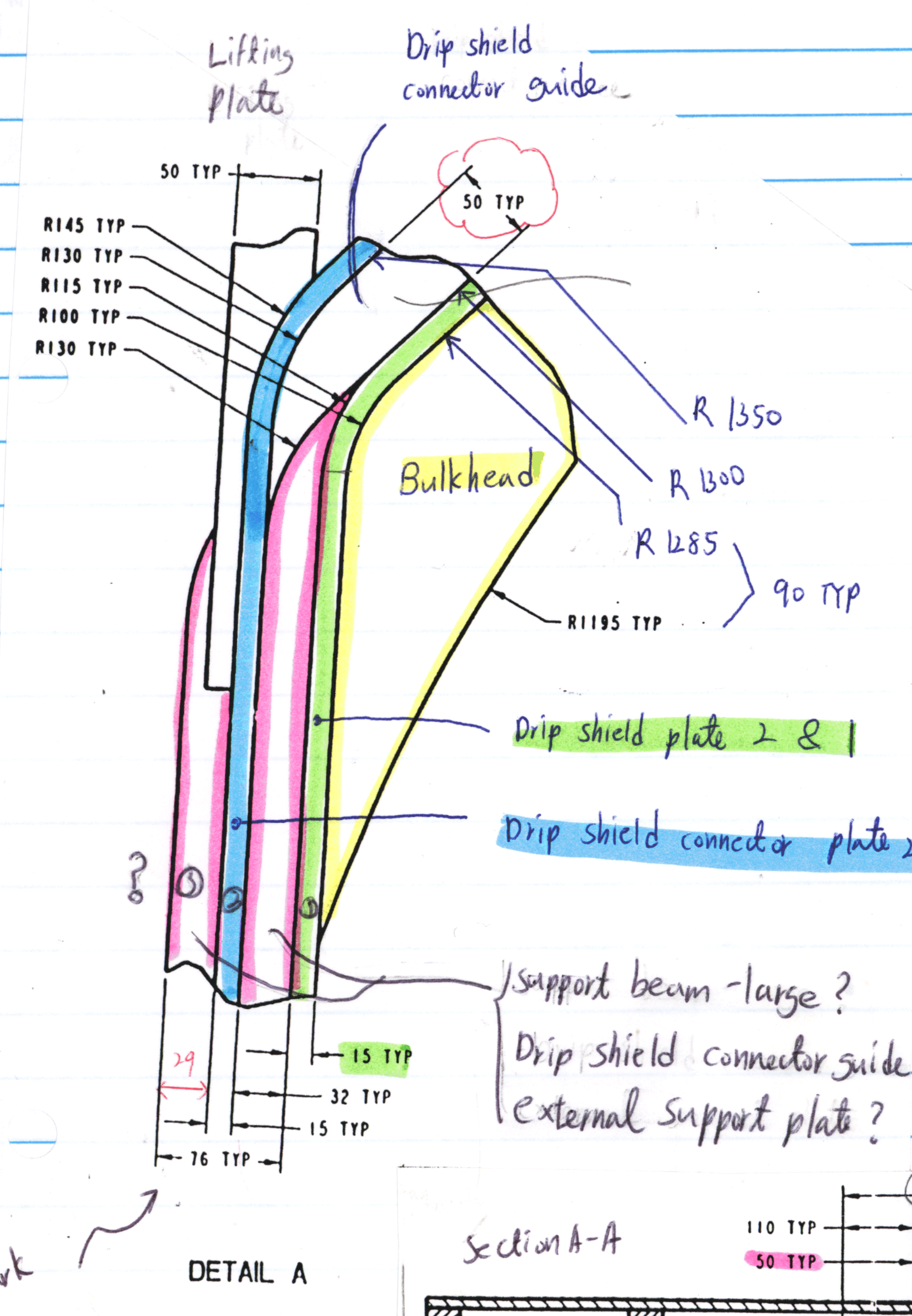
Fully grouted Rock bolts with sets

Time 17:30 ~ 19:00

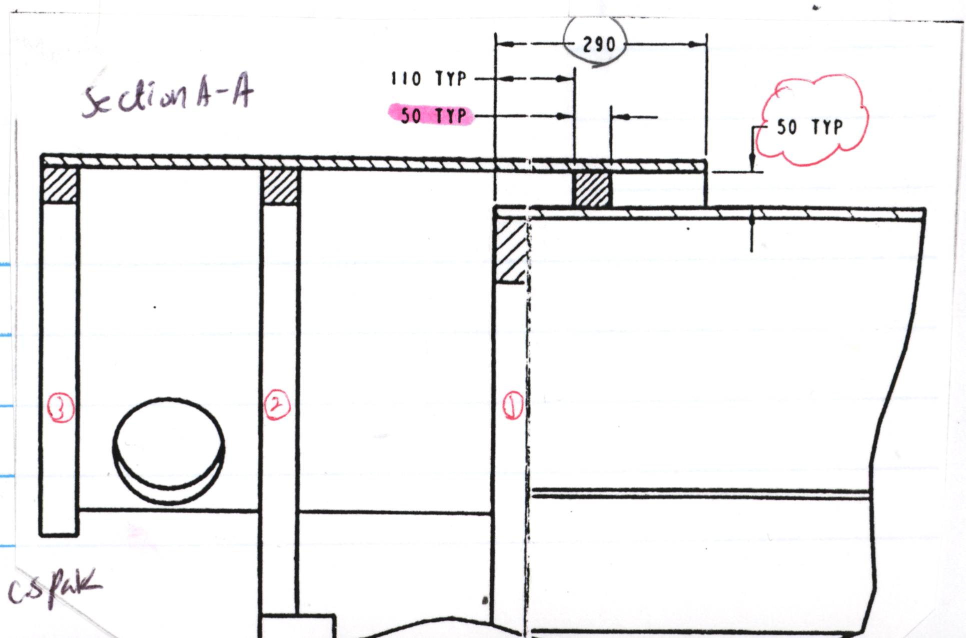
Review and check DWG sheet 2 of 2 and Fig 4~7

We can't understand ③ { support beam - large ?
Drip shield connector guide
External support plate

Our assumption no is correct in section A-A ?



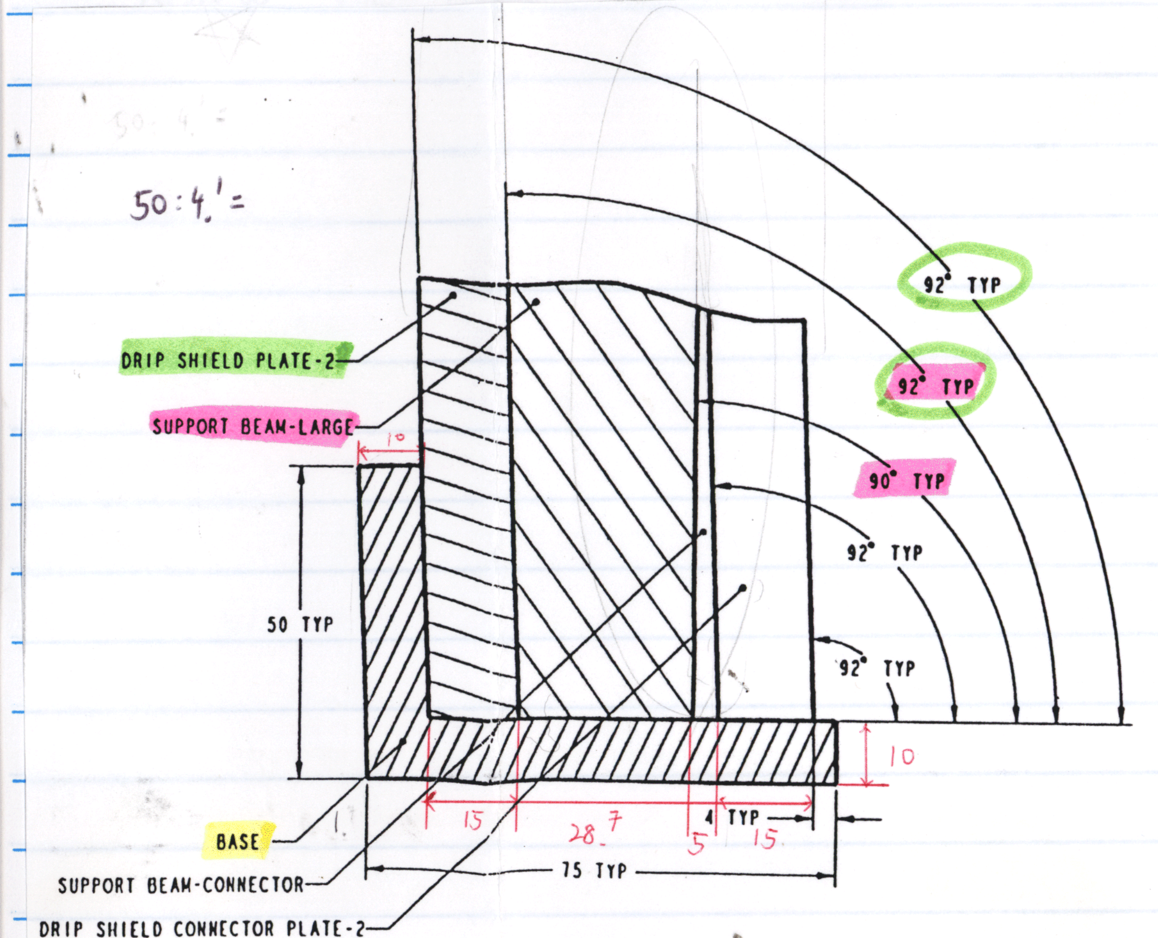
Not thk of support beam - large



July 7, 2000 Time 9:00 – 12:00 14:00 ~ 14:30

with Dr Ted Krauthammer

50 : 4.' =



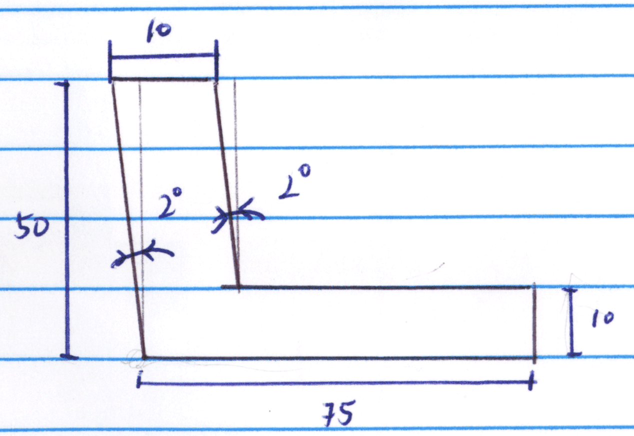
SECTION C-C

$4' : 50 = 0.8 : x$

$x = 9.8^{mm} \rightarrow 10^{mm}$

CS Park

③ Base



Variable dimension ?

where?

support beam connector (6ea)

thk : 102mm Mass : 27 kg

location?

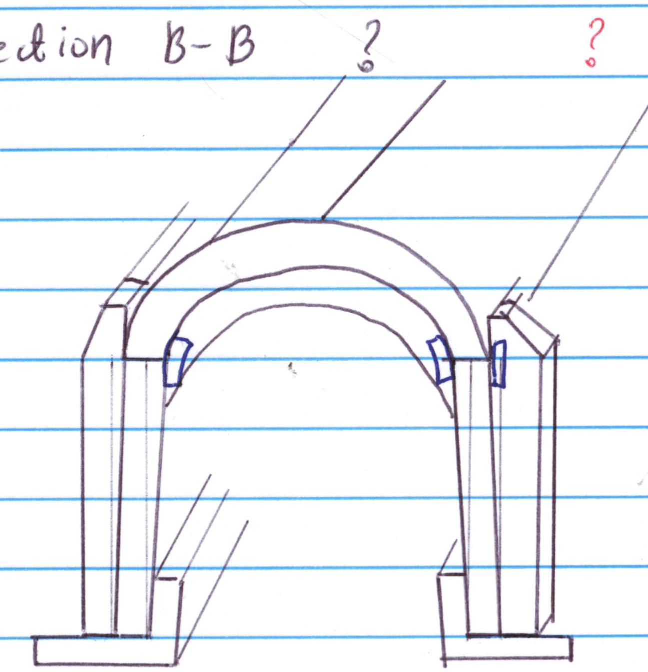
Drip shield connector plate 2 (2ea)

thk: 15mm Mass : 89 kg

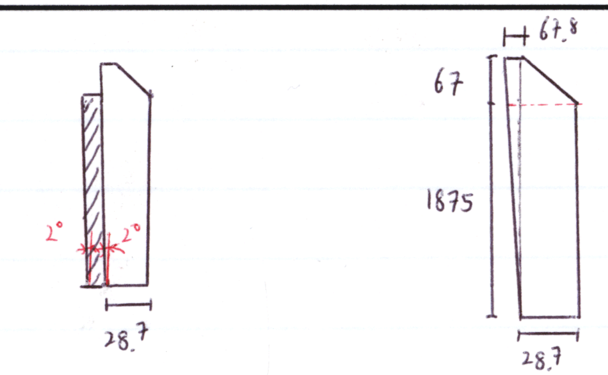
· We use the dimension of base as above.

- Don't consider support beam connector & Drip shield connect to plate 2 in our model

· Section B-B ? ?



unit : mm

Item	Description	Demension (W x H x t)
Support beam-large t: 76mm We use the half of thk. t: 38mm Target Mass: 37kg We use the half of mass. 18.5kg	 $\tan 2° = \frac{x}{1875}$ $x = 65.48 = 65.5$ $\tan 2° = \frac{x}{1942}$ $x = 67.82 = 67.8^{mm}$ $\} 2.3^{mm}$ $\{0.0287 \times 1.875 + 0.0655 \times 1.875 \times \frac{1}{2} + 0.067 \times 0.0287 \times \frac{1}{2} + (0.0678 + 0.0023) \times 0.067 \times \frac{1}{2}\} \times 0.038 \times 4512$ $= 20.3$ kg	

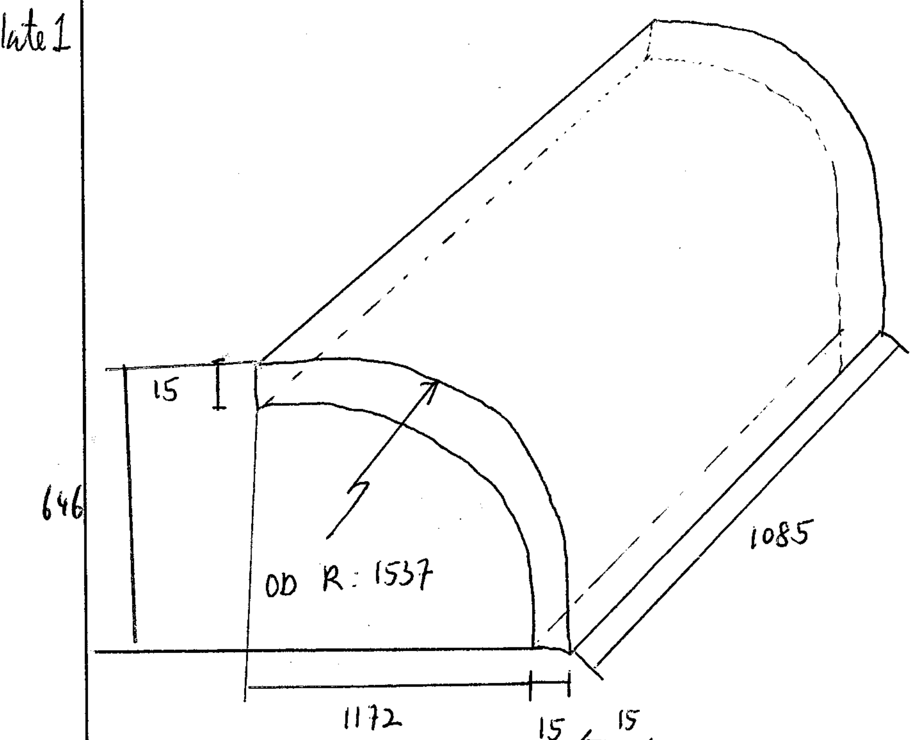
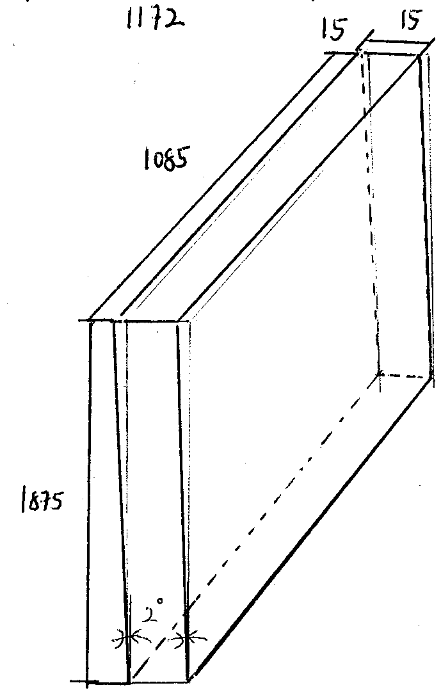
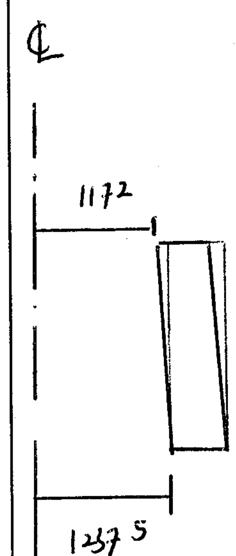
CS Park

July 8 Time 9:00 ~ 12:00

- The final dimension for making model of FEM. Rev 0

Park **Project : Rockfall on Drip Shield Analysis**

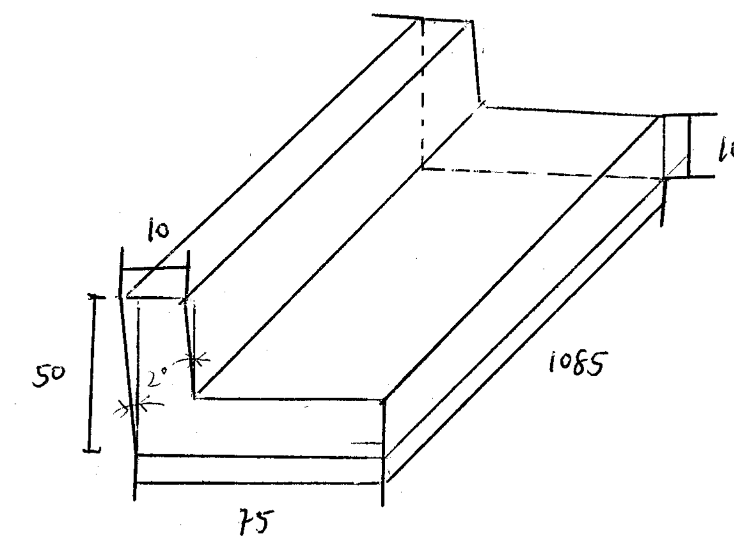
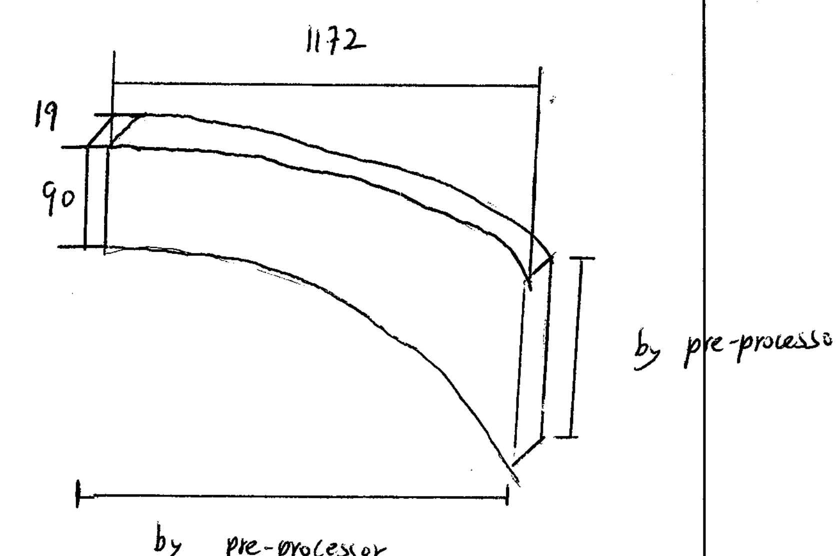
Date:July, ,2000
Unit : mm

Item	Description	Demension (W x H x t)
① Drip shield plate1		
② Drip shield plate2		

BOQ

Project : Rockfall on Drip Shield Analysis

Date:July, ,2000
Unit : mm

Item	Description	Demension (W x H x t)
③ Base		
④ Bulkhead (2ea)		

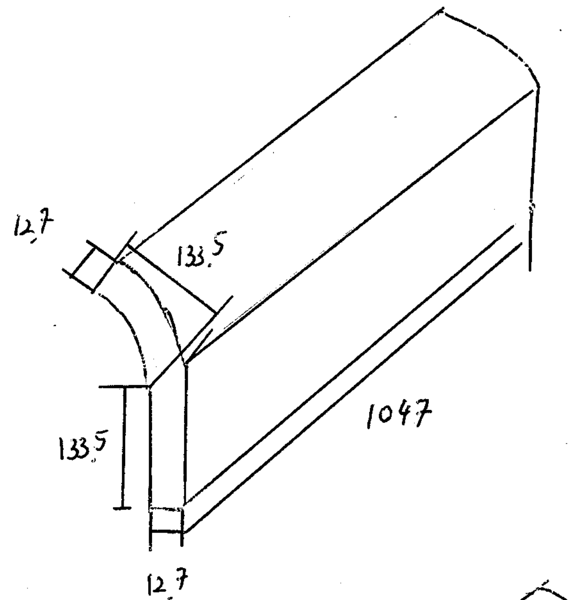
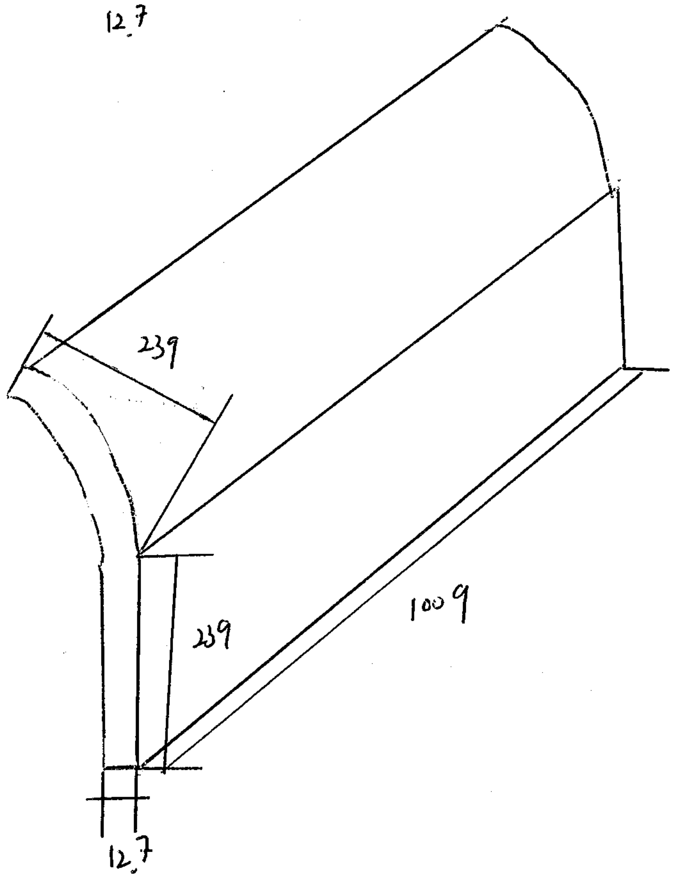
C.S park

CS Park

BOQ

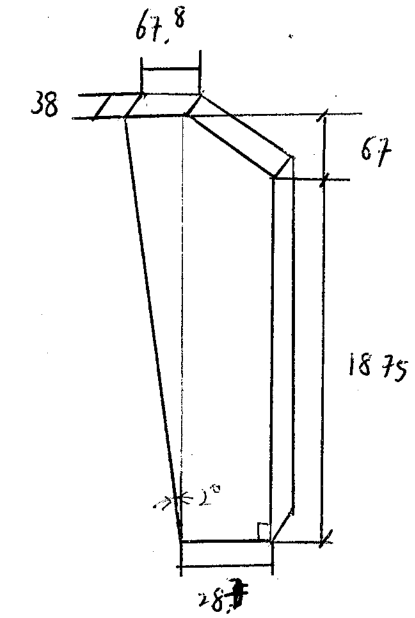
Project : Rockfall on Drip Shield Analysis

Date:July, ,2000
Unit : mm

Item	Description	Demension (W x H x t)
⑦ Internal support -plate		
⑧ External support plate		

Project : Rockfall on Drip Shield Analysis

Date:July, ,2000
Unit : mm

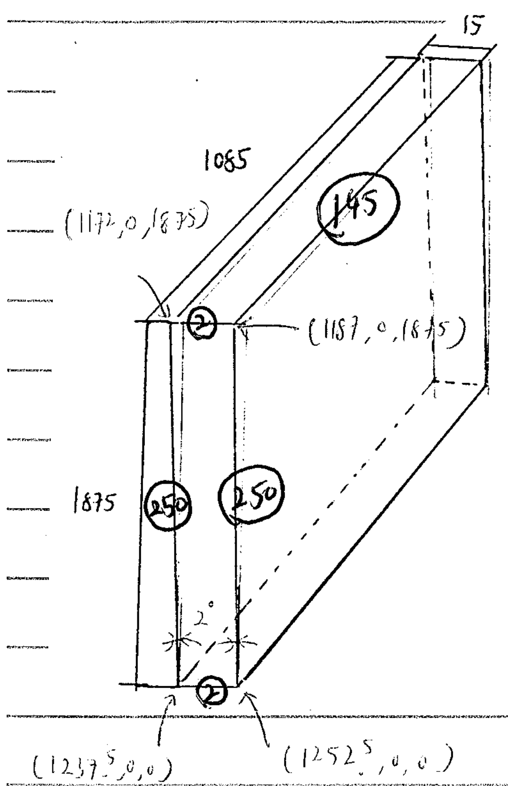
Item	Description	Demension (W x H x t)
⑪ Support beam-large (2ea)		

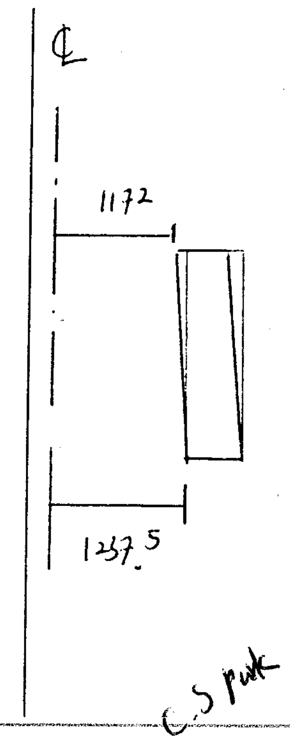
CS Park

Jul 9, 2000 Time 13:00 ~ 18:00

- To make the finite element model (Drip shield)
  - Geometry
  - Mesh
    ⇒ divide into 2 element through thickness.
  - boundary condition : Contact surface - Fixed contact
    - Drip shield plate 1 & 2
    - Drip shield plate 1 & 2 - Internal support plate
    - Drip shield plate 1 & 2 - External support plate
    - Drip shield plate 2 - base
    - Drip shield plate 2 - Support beam - large
    - Drip shield plate 1 & 2 - bulk head
    - Support beam - base
    - Internal support plate - bulkhead External support plate - Support beam-large

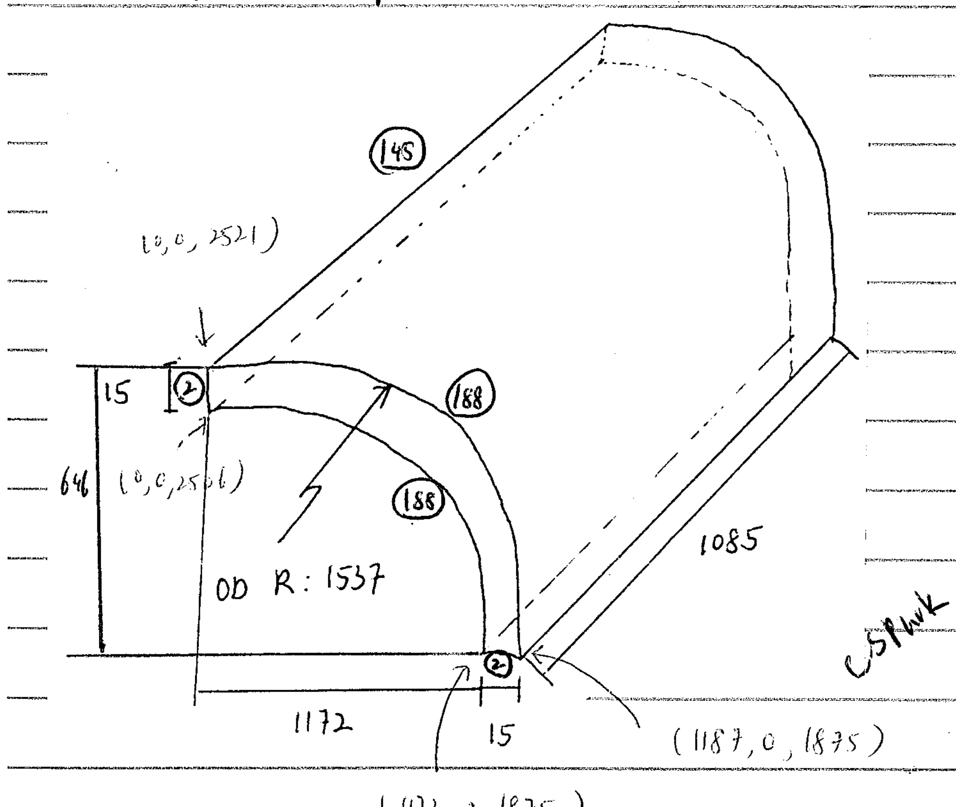
② Drip shield plate 2



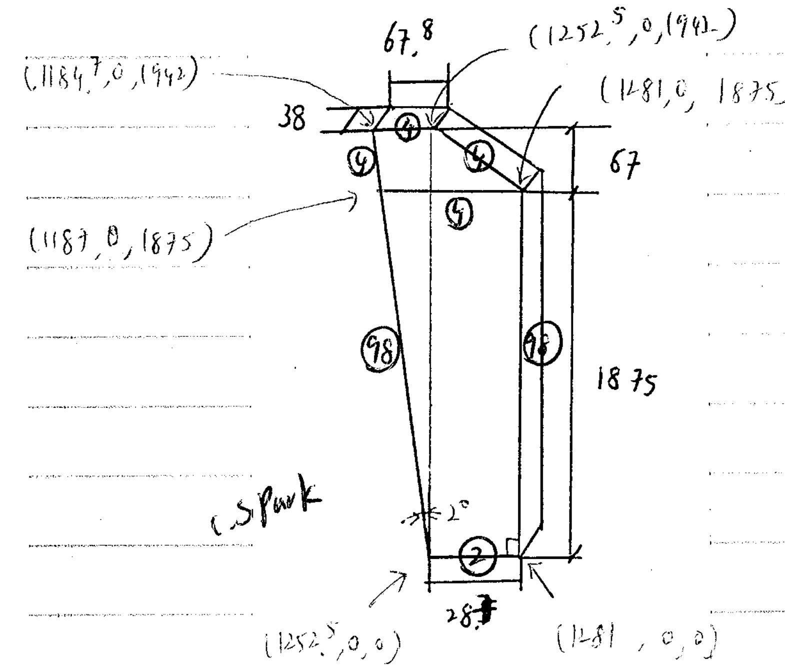


No. of mesh

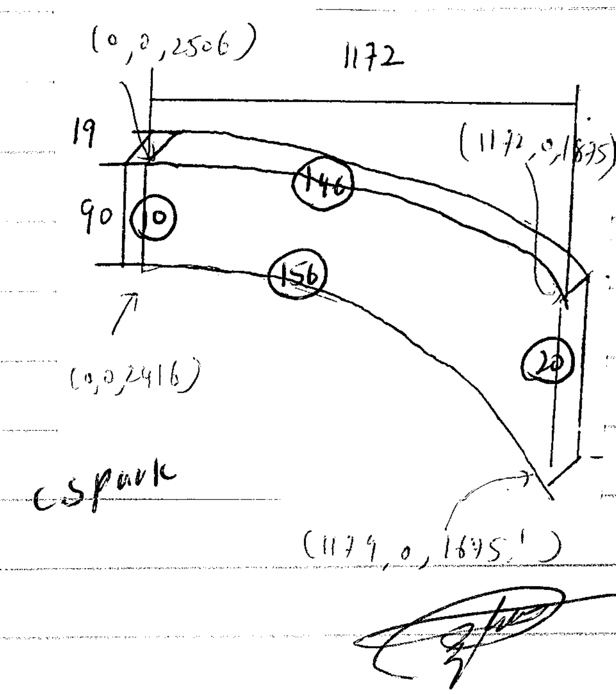
① Drip Shield plate 1



⑪ Support beam large

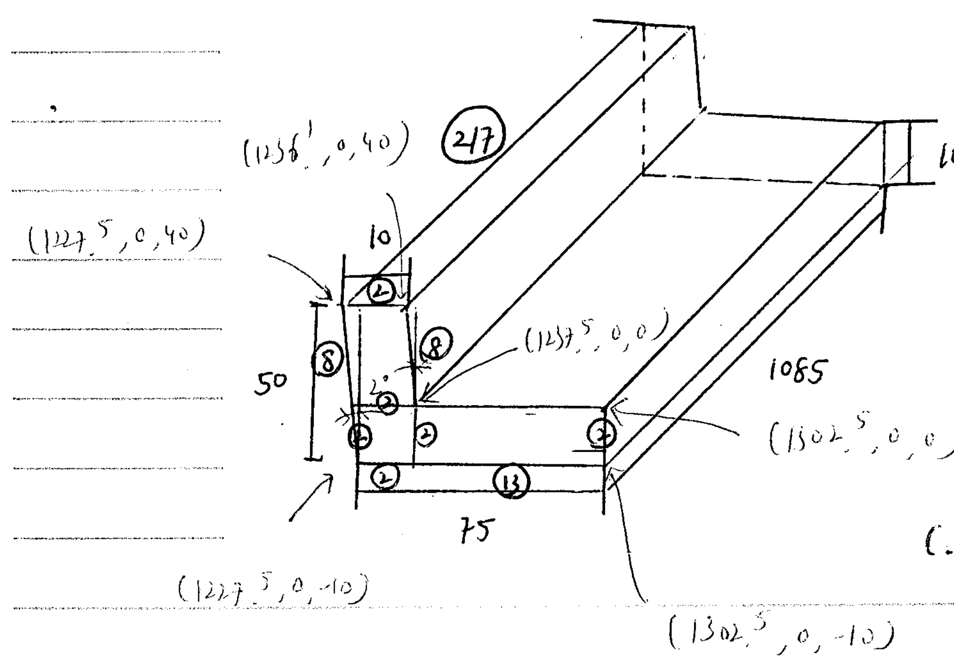


④ Bulk head

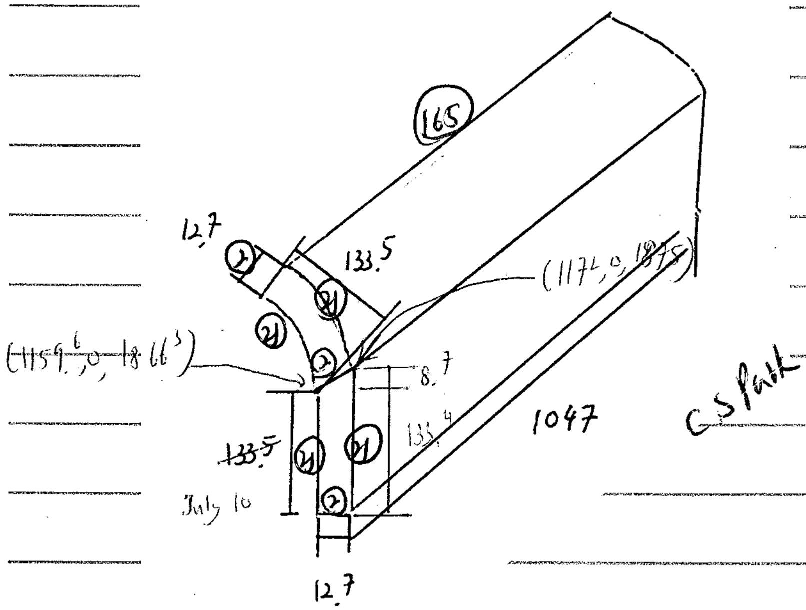


July 10, 2000 Time 12:00~18:00

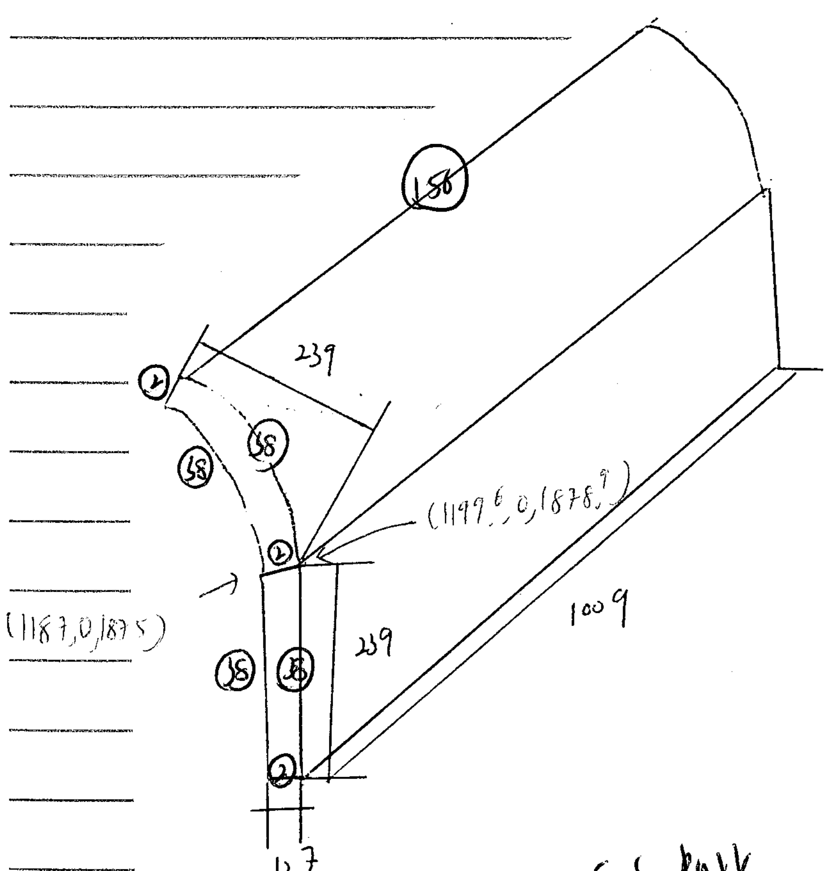
③ Base



⑦ Internal support plate



⑧ External support plate



C.S. Park

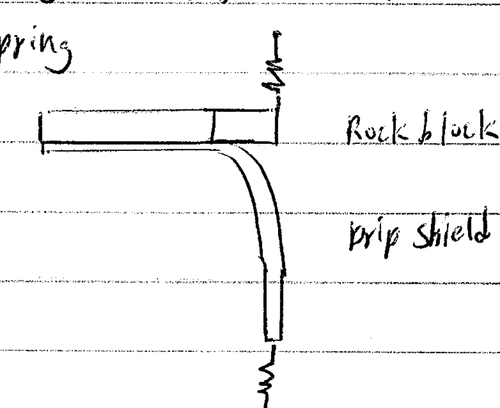
July 11, 2000 Time 13:00~16:00 16:00 ~20:00

- Tied contact is a simple way to bond surfaces together permanently (source : Introduction to Abaqus)
- The slave surface should be meshed more finely than the master surface.

Master	Slave	Type
Drip shield plate 2 (wall)	Base	Tied
Drip shield plate 2	Internal support plate	Tied
Drip shield plate 2	External support plate	Tied
Drip shield plate 1 (Roof)	Internal support plate	Tied
Drip shield plate 1	External support plate	Tied
Support beam - large	Drip shield plate 2	Tied
Support beam - large	Base	Tied
Bulkhead	Drip shield plate 1	Tied
Bulkhead	Drip shield plate 2	Tied
Bulkhead	Internal support plate	Tied
Support beam - large	External support plate	Tied
Rock block	Dripshied plate 1	Small

- Meeting with Dr. Ted Krauthammer (16:00 ~ 16:30)

Spring



July 12, 2000 Time: 15:00 ~ 19:00 21:00 ~ 01:00

- To make rock block model

Mass: 2000 kg We applied the half of mass: 1000 kg

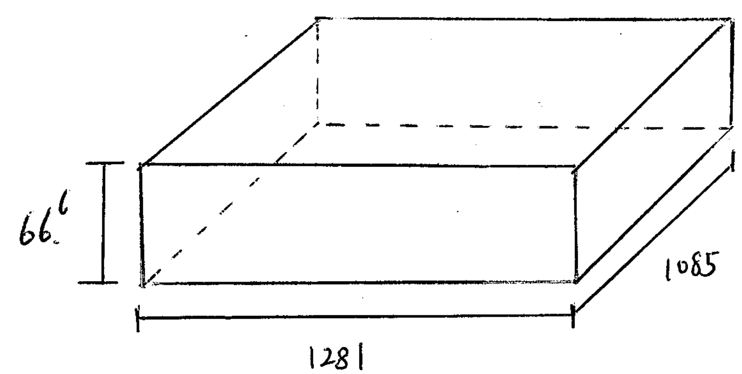
(No. of mesh)

Rock block: mass 500 kg

Half of mass 250 kg

Density 2700 kg/m³

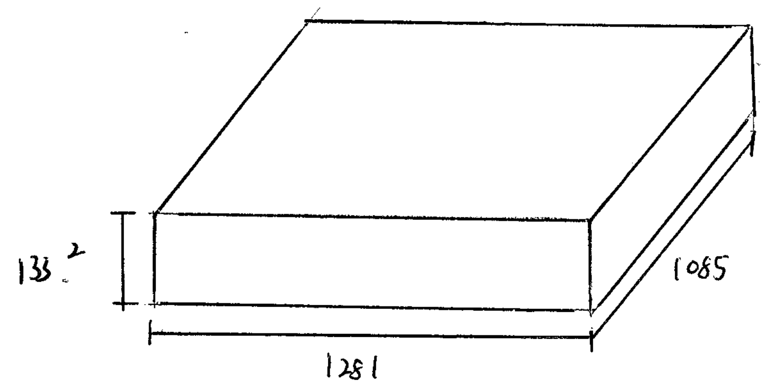
unit: mm



$1.281 \times 1.085 \times H \times 2700 = 250$

Mass: 1000 kg

Half of mass 500 kg



$1.281 \times 1.085 \times H \times 2700 = 500$

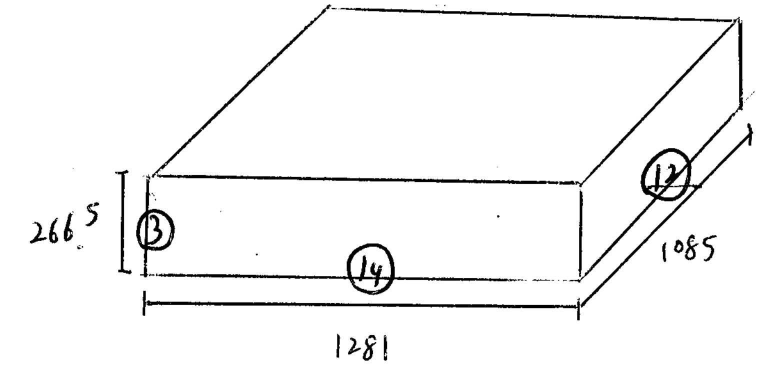
C.S Park

Density: 2700 kg/m³

Rock block

mass: 2000 kg

Half of mass: 1000 kg

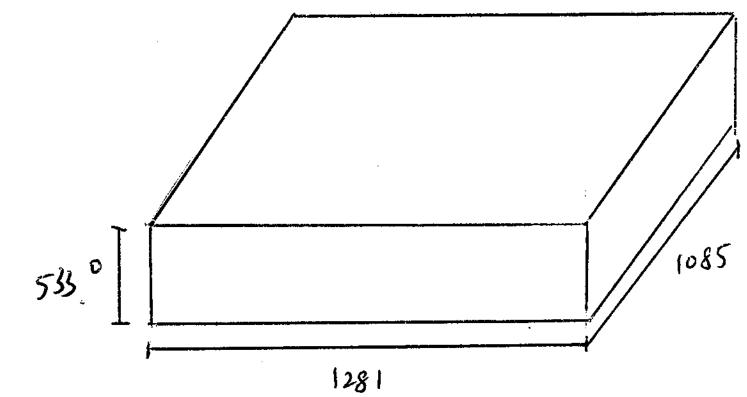


$1.281 \times 1.085 \times H \times 2700 = 1000$

Rock block

mass: 4000 kg

Half of mass: 2000 kg



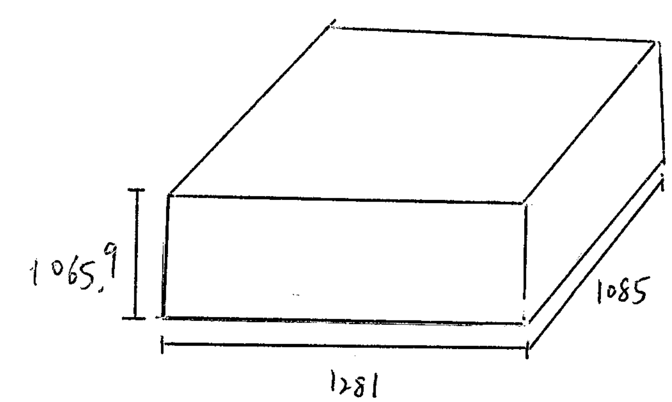
$1.281 \times 1.085 \times H \times 2700 = 2000$

C.S Park

Rock block

mass: 8000 kg

Half of mass: 4000 kg



$1.281 \times 1.085 \times H \times 2700 = 4000$

C.S Park

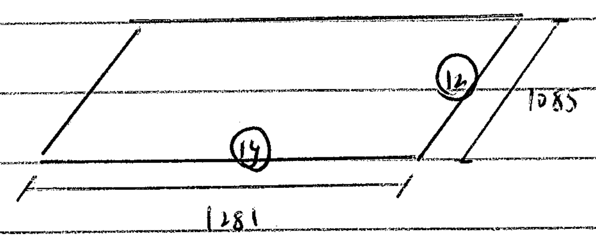
Our model is permulation no 7

- Rock block mass : 2000 kg
- Rock block impact velocity (m/s) : 7.000

- Rigid plate and spring

Ref node for top rigid plate : 292159

Ref node for bottom rigid plate : 292160



Spring constant : 50 N/m

- All of the drip shield nodes : initial upward velocity - 1 m/s

- plane strain condition (x-z planes)

Drip shield , Rock block

From: Ted Krauthammer <tedk@psu.edu> Save Address - Block Sender
To: dgute@swri.org Save Address
CC: Joonhong Lim <jxl387@psu.edu>, Chang-Soo Park <cxp409@psu.edu> Save Address
Subject: Update
Date: Tue, 11 Jul 2000 16:14:42 -0400

Reply Reply All Forward Delete Previous

Doug:

Joonhong and Chang-Soo are almost done with the mesh development. What they have left is to set the boundary conditions and to model the rock. This should be done by tomorrow afternoon. The model is very large (more than 180k elements, and close to 40 MB of Patran data). Since I'll be in Chicago tomorrow, I've asked them to communicate with you directly about the input file transfer. It looks like the bast approach is to place the file on one of our servers, and you will be able to FTP it over to your site. They will provide the information to you about that arrangement.

Ted

C.S Park

July 13, 2000 Time : 10:00 ~ 11:00

- Test run : (Error message)

From: Doug Gute <dgute@swri.edu>
Reply-To: dgute@swri.edu
To: "'Joonhong Lim'" <jhlim@hotmail.com>
CC: "'Ted Krauthammer'" <tedk@psu.edu>
Subject: Input Deck Review
Date: Thu, 13 Jul 2000 14:30:34 -0500

Gentlemen:

I have not been able to thoroughly review your input deck because I was assigned another task that has to be completed today. I do have some initial comments, however, based on a cursory review. First, I noticed that you are using rigid elements. Please remove these and use an analytical rigid surface instead. There are several reasons for using this approach as opposed to rigid elements that I don't have time to get into right now. Second, as I requested in our meeting, use node and element sets in defining your boundary conditions. Although this is not necessary for the model to run properly and does not affect solution efficiency, it makes the input deck much easier to read and understand. This is a standard practice used by experienced FE modelers. Finally, the nodes and elements for the drip shield and rock block should be defined in separate element sets. This helps tremendously in organizing the input deck and is necessary to request total energy output results for the two entities (i.e., drip shield and rock block) separately.

I hope to look at the input in more detail either tonight or first thing Friday morning.

Doug

C.S Park

July 14, 2000

From: Doug Gute <dgute@swri.edu>
Reply-To: dgute@swri.edu
To: "'Ted Krauthammer'" <tedk@psu.edu>, "'Joonhong Lim'" <jhlim@hotmail.com>
CC: "Asadul Chowdhury (achowdhury)" achowdhury@gargol.cnwra.swri.edu>, "Simon Hsiung (shsiung)" shsiung@swri.edu>

Subject: Drip Shield Model
Date: Fri, 14 Jul 2000 14:30:00 -0500

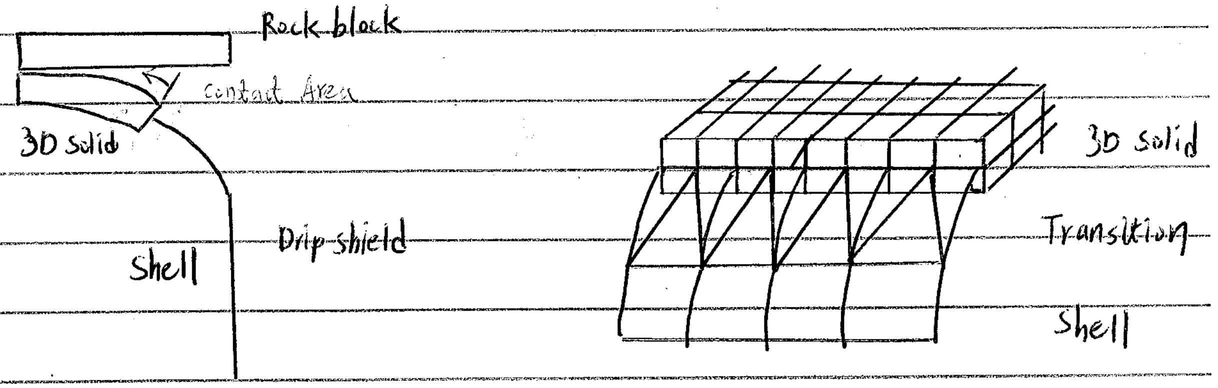
I finally got a chance to look at the drip shield model more closely today.
I want to emphasize that you've done a very good job in constructing the model. After giving it some thought, however, I've decided to make a few changes to the model myself. Most of this will be to address some personal preferences of mine in how the model is organized. So please focus your efforts on updating the waste package and drip shield notebooks until I return the input deck to you. I hope to have this done by Tuesday (July 18'th).

Doug

C.S Park

July 17, 2000 Time 11:00 ~ 12:00

- Discussion with Dr Ted Krauthammer & Joonhong
  - To use shell element Type: S4R
    → To reduce no of mesh element



-----Original Message-----
From: Ted Krauthammer [mailto:tedk@psu.edu]
Sent: Monday, July 17, 2000 7:28 AM
To: dgute@swri.edu
Subject: Re: Drip Shield Model

Doug:

Thanks for your comments. I have reviewed the material, too, after my return from Chicago, and I made a few suggestions. Nevertheless, we can wait for your modifications. Now, I have been thinking about the expected response of the drip shield under a plane strain condition, and I have a strong expectation that the dominant response will be flexural (although some localized buckling is possible at locations where the structure may lock, such at the rail, etc.). As a result, I think that we can expedite the analysis by using shell elements, instead of the solid elements. If the drip shield will not exhibit large flexural deformations (which is not what I expect), we may need to check for other responses, but I suspect that shear may not be a significant problem for the system under the present assumptions.

As you notes, we have more than 190K elements. The runs are expected to be very long, and generate huge output files. This could become a significant problem, since we may need to make special arrangements with our Center for Academic Computing for a much larger allocation of storage and memory than they typically assign.

In summary, I think that by trying several runs with a simplified model, we should obtain a pretty good understanding of the expected behavior. Then, we can decide if we with to modify our approach to the more detailed mesh.

What do you think?

Ted

C.S Park

From: Ted Krauthammer <tedk@psu.edu> Save Address - Block Sender
To: dgute@swri.edu Save Address
CC: Joonhong Lim <jxl387@psu.edu>, Chang-Soo Park <cxp409@psu.edu> Save Address
Subject: RE: Drip Shield Model
Date: Mon, 17 Jul 2000 11:42:51 -0400

Reply Reply All Forward Delete Previous

Doug:

Thanks. We can try something like this, and see how much advantage we get.

Ted

p.s., I'll be on travel from this afternoon through Thursday night.

At 09:48 AM 07/17/2000 -0500, you wrote:

Ted:

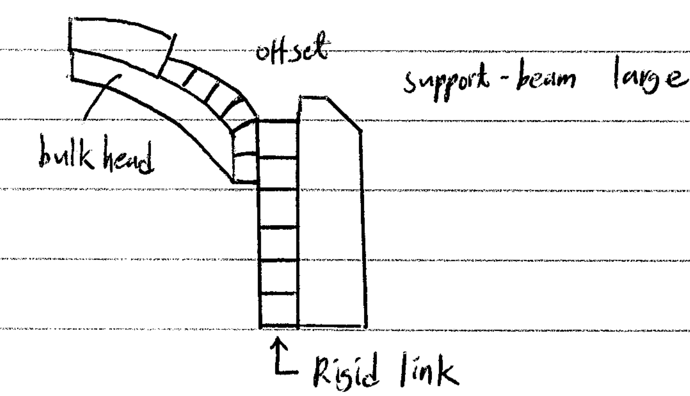
The only thing I'm worried about in using shell elements is that we will miss the out-of-plane normal stress contribution in the region of the rock block and drip shield contact interface. I believe this will have a significant contribution to the maximum shear stresses calculated in this area because this is a compressive normal stress and the other principal stresses will be primarily tensile membrane stresses. Conceptually, I agree with your earlier suggestion that we use solid elements for the rock block and drip shield contact interface region and shell elements for the rest of the structure. The difficulty lies in the time required to set up the multi-point constraints between the solid and shell elements. This may be worth pursuing, however, given the number of runs that have to be performed. What do you think?

Doug

C.S Park

Time : 15:00 ~ 16:00

- We use the offset & rigid link for modifying the model



July 19, 2000

From: Doug Gute <dgute@swri.edu>
Reply-To: dgute@swri.edu
To: "'Ted Krauthammer'" <tedk@psu.edu>, "'Joonhong Lim'" <jhlim@hotmail.com>
Subject: Drip Shield Model Update
Date: Wed, 19 Jul 2000 08:44:46 -0500

Gentlemen:

I just wanted to let all of you know that I've made some revisions in the drip shield mesh. These are listed below:

I've remeshed some of the components to eliminate the large number of tied surface definitions
I've added a material definition for Alloy 22 for the base component
I redefined some of the elements that were not originally defined as C3D8R to this designation
Some missed node equivalencing was taken care of
Because of the similarities between scenarios 1 and 3 and symmetry considerations, I've cut the model in half along the y-axis. As a result, scenario 3 no longer needs to be considered and the model size has been reduced proportionately.
I will be finishing the definition of the analytical rigid surfaces and other boundary conditions today. Please focus your efforts on defining the output requests.
I will send you a summary of the node and element set definitions used in the model when it is completed.

Please call me at the number provided below if you have any questions.

Doug

C S Park

July 20, 2000 Time : 16:00 ~ 18:00

From: Doug Gute <dgute@swri.edu>
Reply-To: dgute@swri.edu
To: "'Joonhong Lim'" <jhlim@hotmail.com>
CC: "'Ted Krauthammer'" <tedk@psu.edu>, "Asadul Chowdhury (achowdhury)" achowdhury@gargol.cnwra.swri.edu>, "Simon Hsiung (shsiung)" shsiung@swri.edu>
Subject: Model is Finished!!!
Date: Thu, 20 Jul 2000 11:48:00 -0500

Joonhong:

I've put the drip shield input deck onto your ftp site. The name of the file is halfds.inp.

C S Park

Another significant change that I made that I forgot to mention is the geometry of the internal and external drip shield plate components. Please note the change when you review the mesh.

In addition, I have not run a data check on the input deck. You may encounter some syntax errors with the input. I have tried my best to ensure that this will not happen, but I may very well have missed something.

Also, set the TIME MARKS output parameter to NO where appropriate. I have noticed that the stability of the solution can be affected if this parameter is set to YES.

I also changed the mesh of the rock block slightly in the region where the rock block will impact the drip shield near the bulkhead. The change is intended to improve the resolution of the kinematic requirements in this area.

Once you have all the bugs worked out with the output requests, send me a copy of the input deck. I'd like to double check it before you begin submitting the "production" runs. We only have a limited time, so I want to make our best effort to get it right the first time!

As always, don't hesitate to call me if you have any questions. Moreover, please consult me before making any assumptions. If you're not sure about something, let me take the responsibility for making the decision.

Doug

- Check input file and prepare to run

Rev0

```
*******************************************************************
**
** SI UNITS:
**
**      Force = Newtons
**      Length (Displacement) = Meters
**      Mass = Kilograms
**      Density = Kilograms / cubic meter
**      Pressure (Stress) = Newtons / square meter (Pascals)
**      Energy = Newton-meters (Joules)
**      Time = Second
*******************************************************************
**
**      Node Sets:
**
**               INVERT - Reference node for the invert rigid surface
**              WSTPCKG - Reference node for the waste package rigid surface
**              DSNODES - All drip shield nodes
**             RCKNODES - All rock block nodes
**             RCKXSYMM - Rock block nodes where x-symm. B.C.s are applied
**             RCKYSYM1 - Rock block nodes where y-symm. B.C.s are applied
**                        (located at the "front" of the drip shield)
**             RCKYSYM2 - Rock block nodes where y-symm. B.C.s are applied
**                        (located at the "back" of the drip shield)
**              DSXSYMM - Drip shield nodes where x-symm. B.C.s are applied
**             DSYSYMM1 - Drip shield nodes where y-symm. B.C.s are applied
**                        (located at the "front" of the drip shield)
**             DSYSYMM2 - Drip shield nodes where y-symm. B.C.s are applied
**                        (located at the "back" of the drip shield)
**
**      Element Sets:
**
**              DSPLATE - Drip shield plate component elements
**             BULKHEAD - Bulkhead component elements
**              SPPRTBM - Support beam component elements
**                 BASE - Base component elements
**             EXTPLATE - External support plate component elements
**             INTPLATE - Internal support plate component elements
**              DRPSHLD - All drip shield elements
**              RCKBLCK - All rock block elements
**             ODSCNTCT - Elements used to define the "outer" drip shield
**                        surface interacting with the rock block
**             IDSCNTCT - Elements used to define the "inner" drip shield
**                        surface interacting with the waste package
**             BASCNTCT - Elements used to define the base surface
**                        interacting with the invert
**             RCKCNTCT - Elements used to define the rock block surface
**                        interacting with the drip shield
**
**      Surfaces:
**
**              ODSSURF - "Outer" drip shield surface generated from
**                        element set ODSCNTCT
**              IDSSURF - "Inner" drip shield surface generated from
**                        element set IDSCNTCT
**             BASESURF - drip shield base surface generated from
**                        element set BASCNTCT
**              RCKSURF - Rock surface generated from element set RCKCNTCT
**               WPSURF - Waste package rigid surface
**             INVRTSRF - Invert rigid surface
**
**      Contact Pairs:
**
**             IMPCTZON - Contact interaction between the "outer" drip shield
**                        and rock block surfaces
**              DSWPZON - Contact interaction between the "inner" drip shield
**                        and waste package surfaces
**             DSINVZON - Contact interaction between the drip shield base
**                        and invert surfaces
**
*******************************************************************
```

CS/Pak/k

Pak

- Check input file and prepare to run

RevO

Oaklc

CsPak

```
*HEADING
 ROCK BLOCK IMPACT WITH THE DRIP SHIELD
**
*PREPRINT, ECHO=NO, HISTORY=YES, MODEL=NO
**
*NODE, NSET=DSNODES
      1,  1.2525          ,  0.0             ,  0.01
      2,  1.2522225346947,  0.0             ,  0.0180000007995

          ----------------------------------------------

*ELEMENT, TYPE=C3D6, ELSET=DSPLATE
  36375,     753,  114572,     502,    1506,   56089,    1255
  36751,    1506,   56089,    1255,    2259,   56652,    2008

          ----------------------------------------------

*ELEMENT, TYPE=C3D6, ELSET=BULKHEAD
 100468,    2232,    2233,  116060,    1479,    1480,  118786
 100472,    2236,  116220,    2235,    1483,  118789,    1482

          ----------------------------------------------

*ELEMENT, TYPE=C3D6, ELSET=SPPRTBM
 302981,  110333,  110334,  110336,  111366,  111368,  111367
 303088,  110409,  110407,  110408,  111474,  111473,  111477

          ----------------------------------------------

*ELEMENT, TYPE=C3D8R, ELSET=DSPLATE
      1,     252,     253,       2,       1,     754,     757,     756,      755,
      2,     253,     254,       3,       2,     757,     759,     758,      756,

          ----------------------------------------------

*ELEMENT, TYPE=C3D8R, ELSET=BULKHEAD
 100000,  115868,  115870,  115865,  115866,  115764,  115765,  115766,  115767,
 100001,  115870,  115863,  115864,  115865,  115765,  115768,  115769,  115766,

          ----------------------------------------------

*ELEMENT, TYPE=C3D8R, ELSET=BASE
 200000,     508,     507,   96138,   96137,    1261,    1260,   96984,   96983,
 200001,     507,     506,   96139,   96138,    1260,    1259,   96985,   96984,

          ----------------------------------------------

*ELEMENT, TYPE=C3D8R, ELSET=SPPRTBM
 300000,   98801,   98836,   98803,   98802,   96141,   96142,   96143,   96144,
 300001,   98836,    3391,    3389,   98803,   96142,    2638,    2636,   96143,

          ----------------------------------------------

*ELEMENT, TYPE=C3D8R, ELSET=EXTPLATE
 400000,   98712,   98713,   98744,   98711,   98837,   98838,   98839,   98840,
 400001,   98711,   98744,    3511,    3513,   98840,   98839,    4264,    4266,

          ----------------------------------------------

*ELEMENT, TYPE=C3D8R, ELSET=INTPLATE
 500000,   69112,  115823,  115822,   62321,  121598,  121605,  121604,  121599,
 500001,   62321,  115822,   56547,   56550,  121599,  121604,   57110,   57113,

          ----------------------------------------------

*ELEMENT, TYPE=C3D8R, ELSET=RCKBLCK
 900000,  900060,  900061,  900151,  900150,  900062,  900063,  900153,  900152,
 900001,  900030,  900000,  900120,  900180,  900031,  900002,  900122,  900181,

          ----------------------------------------------
```

```
*SOLID SECTION, ELSET=DSPLATE, MATERIAL=TIGRD7
**
*SOLID SECTION, ELSET=BULKHEAD, MATERIAL=TIGRD24
**
*SOLID SECTION, ELSET=BASE, MATERIAL=ALLOY22
**
*SOLID SECTION, ELSET=SPPRTBM, MATERIAL=TIGRD24
**
*SOLID SECTION, ELSET=EXTPLATE, MATERIAL=TIGRD7
**
*SOLID SECTION, ELSET=INTPLATE, MATERIAL=TIGRD7
**
*SOLID SECTION, ELSET=RCKBLCK, MATERIAL=ROCK
**
*NSET, NSET=RCKXSYMM
 900000,  900001,  900030,  900045,  900060,  900061,  900090,  900105,
 900120,  900121,  900150,  900151,  900180,  900195,  900210,  900225,
**
*NSET, NSET=DSYSYMM1
      1,       2,       3,       4,       5,       6,       7,       8,
      9,      10,      11,      12,      13,      14,      15,      16,
         ------------------------------------------------

*NSET, NSET=DSYSYMM2
  54217,   54218,   54219,   54220,   54221,   54222,   54223,   54224,
  54225,   54226,   54227,   54228,   54229,   54230,   54231,   54232,
         ------------------------------------------------
                    → BASCNTCT
*ELSET, ELSET=BSCNTCT
 200000,  200001,  200002,  200003,  200004,  200005,  200006,  200007,
 200008,  200009,  200010,  200011,  200012,  200013,  200014,  200015,
         ------------------------------------------------

*ELSET, ELSET=ODSCNTCT
  36003,   36004,   36006,   36009,   36010,   36012,   36015,   36016,
  36018,   36021,   36022,   36024,   36026,   36028,   36030,   36032,
         ------------------------------------------------

*ELSET, ELSET=RCKCNTCT
 900017,  900021,  900025,  900029,  900033,  900037,  900041,  900043,
 900045,  900047,  900049,  900051,  900053,  900055,  900057,  900059,
         ------------------------------------------------

*NSET, NSET=RCKYSYM1
 900240,  900241,  900242,  900243,  900244,  900245,  900246,  900247,
 900248,  900249,  900250,  900251,  900252,  900253,  900254,  900345,
         ------------------------------------------------

*NSET, NSET=RCKYSYM2
 900330,  900331,  900332,  900333,  900334,  900335,  900336,  900337,
 900338,  900339,  900340,  900341,  900342,  900343,  900344,  900435,
         ------------------------------------------------

*NSET, NSET=DSXSYMM
  55156,   55157,   55158,   55535,   55536,   55539,   56098,   56099,
  56102,   56661,   56662,   56665,   57224,   57225,   57228,   57792,
         ------------------------------------------------

* ELSET, ELSET=DRPSHLD
 DSPLATE, BULKHEAD, SPPRTBM, BASE, EXTPLATE, INTPLATE,
**
*ELSET, ELSET=IDSCNTCT
    974,     975,     976,     977,     978,     979,     980,     981,
    982,     983,     984,     985,     986,     987,     988,     989,

         ------------------------------------------------

**
```

csParlc

Pavle

park

```
*MATERIAL, NAME=TIGRD7
*DENSITY
 4512.0   , 0.0
*ELASTIC, TYPE = ISOTROPIC
 100.7E+09, 0.32  , 0.0
*PLASTIC, HARDENING=ISOTROPIC
 174.1E+06, 0.0000, 0.0
 299.5E+06, 0.1793, 0.0
**
*MATERIAL, NAME=TIGRD24
*DENSITY
 4512.0    0.0
*ELASTIC, TYPE = ISOTROPIC
 107.2E+09, 0.32  , 0.0
*PLASTIC, HARDENING=ISOTROPIC
 658.1E+06, 0.0000, 0.0
 827.0E+06, 0.0876, 0.0
**
*MATERIAL, NAME=ALLOY22
*DENSITY
 8691.5   , 0.0
*ELASTIC, TYPE = ISOTROPIC
 197.2E+09, 0.32  , 0.0
*PLASTIC, HARDENING=ISOTROPIC
 254.7E+06, 0.0000, 0.0
 984.7E+06, 0.3666, 0.0
**
*MATERIAL, NAME=ROCK
*DENSITY
 2700.0   , 0.0
*ELASTIC, TYPE = ISOTROPIC
 33.30E+09, 0.21  , 0.0
*******************************************************************
**      Define spring required to prevent rigid body translation
**      in the vertical direction
**
*NODE, NSET=SPRNGNOD
  700000, 1.2280, 0.0000, -1.0000
**
*ELEMENT, TYPE=SPRINGA, ELSET=SPRINGS
  700000,  700000, 96965
**
*SPRING, ELSET=SPRINGS
  50.0,
*******************************************************************
**      Define the invert analytical rigid surface reference node
**
*NODE, NSET=INVERT
  800000, 0.0000, 0.0000, 0.0000
*RIGID BODY, REF NODE=800000
*******************************************************************
**      Define the waste package analytical rigid surface
**      reference node
**
*NODE, NSET=WSTPCKG
  800001, 2.7500, 0.0000, 1.0430
*RIGID BODY, REF NODE=800001
*******************************************************************
**      Fix all the DOF of the invert and waste package rigid surface
**      reference nodes except vertical translation.
**
**      Apply the various displacement symmetry conditions.
**
*BOUNDARY, TYPE=DISPLACEMENT
    INVERT, 1, 2
    INVERT, 4, 6
   WSTPCKG, 1, 2
   WSTPCKG, 4, 6
  RCKXSYMM, 1
  RCKYSYM1, 2
  RCKYSYM2, 2

   DSXSYMM, 1
  DSYSYMM1, 2
  DSYSYMM2, 2
```

C.S park

C.S park

```
**********************************************************************
**
**      All drip shield nodes and the invert and waste package
**       rigid body reference nodes will have a vertical upward
**      velocity of 1 m/s at time equal to zero.
**
**      All rock nodes will have a vertical downward velocity
**      at time equal to zero. This value is assigned here.
**
*INITIAL CONDITIONS, TYPE=VELOCITY
  DSNODES, 3,  1.0000
   INVERT, 3,  1.0000
  WSTPCKG, 3,  1.0000
 RCKNODES, 3, -7.0000
**********************************************************************
**********************************************************************
**
*STEP, NLGEOM=YES
 ROCK BLOCK IMPACT WITH TITANIUM DRIP SHIELD
**
*DYNAMIC, EXPLICIT
  , 0.035
**
*MONITOR, DOF=3, NODE=95579
**********************************************************************
**
**      Define the contact surfaces between the rock block and drip
**      shield in terms of element sets
**
*SURFACE DEFINITION, NAME=RCKSURF
 RCKCNTCT,
*SURFACE DEFINITION, NAME=ODSSURF
 ODSCNTCT,
**
**      The rock block contact surface is forced to be the master
**      surface by the WEIGHT=1.0 parameter
**
*CONTACT PAIR, OP=ADD, WEIGHT=1.0, CPSET=IMPCTZON
 RCKSURF, ODSSURF
**********************************************************************
**
**      Define the contact surfaces between the drip shield and
**      waste package. The drip shield contact surface is defined in
**      terms of an element set and the waste package is an analytical
**      rigid surface
**
*SURFACE DEFINITION, NAME=IDSSURF
 IDSCNTCT,                                        1.0350
**                     1.0350                                       July 24
*RIGID SURFACE, TYPE=CYLINDER, NAME=WPSURF, REF NODE=800001
 0.0000, 0.0000, 2.0350, 1.0000, 0.0000, 2.0350
 0.0000, 1.0000, 2.0350 ← 1.0350
 START,  0.000000,  1.000000
 CIRCL,  0.866025, -0.500000, 0.000000, 0.000000
 CIRCL, -0.866025, -0.500000, 0.000000, 0.000000
 CIRCL,  0.000000,  1.000000, 0.000000, 0.000000
**
*CONTACT PAIR, OP=ADD, CPSET=DSWPZON
 WPSURF, IDSSURF
```

C.S Park

Time : 19:00 ~ 20:00

```
*********************************************************************
**      Define the contact surfaces between the drip shield base and
**      invert. The drip shield base contact surface is defined in
**      terms of an element set and the invert is an analytical
**      rigid surface
**
*SURFACE DEFINITION, NAME=BASESURF
 BASCNTCT,
**
*RIGID SURFACE, TYPE=CYLINDER, NAME=INVRTSRF, REF NODE=800001
 0.0000, 0.0000, 0.0000, 1.0000, 0.0000, 0.0000
 0.0000, 1.0000, 0.0000
 START,  0.000000,  0.000000
  LINE,  1.280000,  0.000000
 CIRCL,  1.290000,  0.010000, 1.280000, 0.010000
  LINE,  1.290000,  0.136000
 CIRCL,  1.300000,  0.146000, 1.300000, 0.136000
  LINE,  2.300000,  0.146000
**
*CONTACT PAIR, OP=ADD, CPSET=DSINVZON
 INVRTSRF, BASESURF
*********************************************************************
**      Apply volumetric gravity loads to the drip shield and
**      rock block elements
**
*DLOAD, OP=NEW
 DRPSHLD, GRAV, 9.81, 0.0, 0.0, -1.0
 RCKBLCK, GRAV, 9.81, 0.0, 0.0, -1.0
*********************************************************************
**      Set the upward velocity of the invert and waste package to
**      a constant 1 m/s
**
*BOUNDARY, TYPE=VELOCITY, OP=MOD
   INVERT, 3, 3, 1.0
  WSTPCKG, 3, 3, 1.0
*********************************************************************
**
*RESTART, WRITE, OVERLAY
**
*OUTPUT, HISTORY, VARIABLE=PRESELECT, TIME INTERVAL=0.001
**
*OUTPUT, HISTORY, TIME INTERVAL=0.00005
*NODE OUTPUT, NSET=WSTPCKG
 RF,
*NODE OUTPUT, NSET=INVERT
 RF,
**
*OUTPUT, FIELD, VARIABLE=PRESELECT, NUMBER INTERVAL=10, TIME MARKS=NO
*ELEMENT OUTPUT, ELSET=DRPSHLD
 SP, MISES,
*ELEMENT OUTPUT, ELSET=ROCK   RCKBLCK
 SP, MISES
*CONTACT OUTPUT, CPSET=IMPCTZON, VARIABLE=ALL
*CONTACT OUTPUT, CPSET=DSWPZON, VARIABLE=ALL
*CONTACT OUTPUT, CPSET=DSINVZON, VARIABLE=ALL
**
*OUTPUT, FIELD, NUMBER INTERVAL=200, TIME MARKS=NO
*NODE OUTPUT, NSET=WSTPCKG
 RF,
*NODE OUTPUT, NSET=INVERT
 RF,
**
*FILE OUTPUT, NUMBER INTERVAL=20, TIME MARKS=NO
*NODE FILE
 U, V, A, COORD
*EL FILE, ELSET=DRPSHLD
 S, SP, MISES, ENER
*EL FILE, ELSET=RCKBLCK
 S, SP, MISES, ENER
*ENERGY FILE
**

*HISTORY OUTPUT, TIME INTERVAL=0.001
*NODE HISTORY, NSET=WSTPCKG
 RF
*NODE HISTORY, NSET=INVERT
 RF,
**
**
*PRINT, ALLKE=YES, CRITICAL ELEMENT=YES, ETOTAL=YES
**
**
*END STEP
```

July 24

C.S Park

July 21, 2000 Time: 14:00 ~ 18:00

- Find the syntax error (Look at Input File)

① * ELSET , ELSET = BSCNTCT

⇒ BASCNTCT

② ELSET , ELSET = DRPSHLD

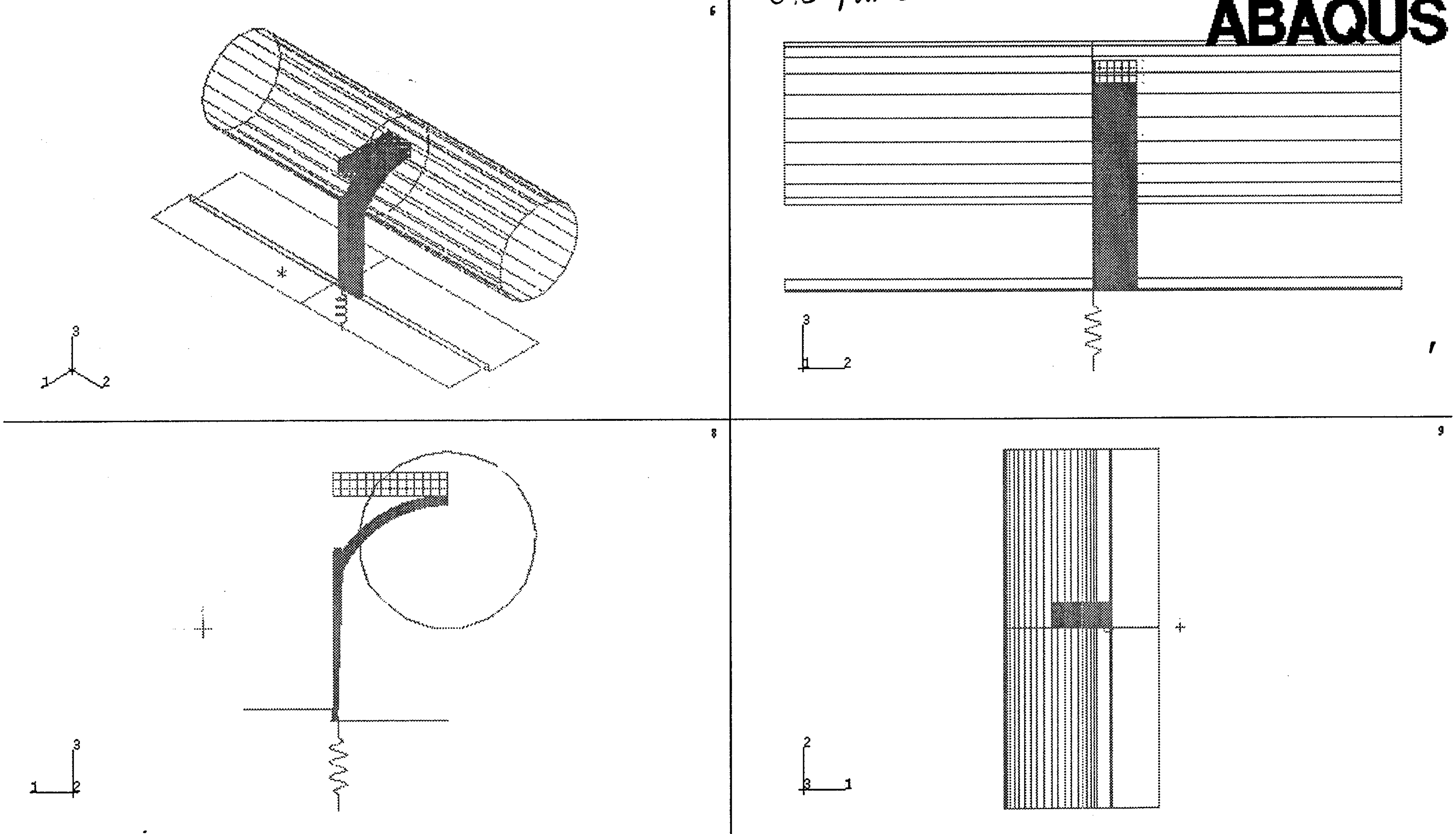
*

③ * ELEMENT OUTPUT , ELSET = ROCK

⇒ RCKBLCK

July 22, 2000 Time: 15:00 ~ 17:00

C.S Park



· Location problem

→ Waste Package rigid surface should be within dripshield

· Z direction : -1 m (down 1 m : Assume)

* Rigid surface : Define an analytical rigid surface

Type : Cylinder

⇒ to define a three-dimensional rigid surface by providing connected line segments and then sweeping them along a specified generator vector

First line

X_a, Y_a, Z_a, X_b, Y_b, Z_b

Second line

X_c, Y_c, Z_c : Local cylinder generator vector

July 24, 2000 Time : 8:00 ~ 11:15 (11:00 ~ 11:15)

Meeting with Dr Ted Krauthammer ~~& Joonhong~~

Check list

① * Element, Type = C3D6, ELSET = DSPLATE

* Element, Type = C3D8R, ELSET = DSPLATE

(Bulkhead, support beam - large)

② Hourglass control ?

③ Tied contact of components of dripshield ?

④ Temperature

* Material, name = TIGRD7

* Density

4512.0, 0.0 Temp.

* Elastic, Type = Isotropic

100.7E+09, 0.32, 0.0

⑤ * Monitor, Dof = 3, Node = 95579

⑥ * Ref node = 800000

800001

⑦ * Boundary, Type = velocity, op = Mod

Invert, 3, 3, 1.0

WSPPCKG, 3, 3, 1.0

∘ Modify the input file

- Overlap { Dripshield and waste Package
Base and invert line

```
*RIGID SURFACE, TYPE=CYLINDER, NAME=WPSURF, REF NODE=800001
 0.0000, 0.0000, 1.0350, 1.0000, 0.0000, 1.0350
 0.0000, 1.0000, 1.0350
 START,  0.000000,  1.000000
 CIRCL,  0.866025, -0.500000, 0.000000, 0.000000
 CIRCL, -0.866025, -0.500000, 0.000000, 0.000000
 CIRCL,  0.000000,  1.000000, 0.000000, 0.000000


*RIGID SURFACE, TYPE=CYLINDER, NAME=INVRTSRF, REF NODE=800001
 0.0000, 0.0000, -1.0000, 1.0000, 0.0000, -1.0000
 0.0000, 1.0000, -1.0000
 START,  0.000000,  1.000000
**  LINE,  1.280000,  1.000000
** CIRCL,  1.290000,  1.010000, 1.280000, 1.010000
 LINE, 1.3030000, 1.0
 CIRCL, 1.3130000, 1.01, 1.303, 1.01
**  LINE,  1.290000,  1.136000
 LINE, 1.3130, 1.1360
** CIRCL,  1.300000,  1.146000, 1.300000, 1.136000
 CIRCL, 1.3230, 1.1460, 1.3230, 1.1360
**  LINE,  2.300000,  1.146000
 LINE, 2.3230, 1.1460
**
```

C.S Park

Time : ~~1:00 ~ 5:00~~ 13:00 ~ 17:00
July 24

Test run

Case 1 Time period of the step 0.001

Case 2 Time period of the step 0.0005

Error check and review out file

From: Ted Krauthammer <tedk@psu.edu> Save Address - Block Sender
To: dgute@swri.edu Save Address
CC: Joonhong Lim <jxl387@psu.edu>, Chang-Soo Park <cxp409@psu.edu> Save Address
Subject: Re: DS Update
Date: Mon, 24 Jul 2000 16:36:45 -0400

Reply Reply All Forward Delete Previous

Doug:

Thanks for the update. We had another meeting today, and went over these.

As for the WP's notebook, we are doing it as fast as possible, between work on the DS.

Ted

At 10:52 AM 07/24/2000 -0500, you wrote:

Ted:

I've received a number of questions from Joonhong. I believe I've been able to resolve all but one. The one outstanding issue is the appropriate placement of the WP relative to the drip shield and invert. The data I used to locate the WP in the model I sent up last week was from a 1998 emplacement drift invert design document. It would appear, however, that this information is no longer valid because, as Joonhong pointed out, the WP surface extends into the drip shield. I have instructed Joonhong to comment out the WP contact surface data for now and focus his efforts on getting the model to run without it. This should only require commenting out five or so lines. We will provide you with updated information with regard to this matter as soon as we can identify a document that has the most recent dimensions.

On another front, Simon has asked that the WP scientific notebook be returned to us as soon as it is completed so we can "close it out."

Doug

C.S Park

July 25, 2000 Time : 17:00 ~ 19:00

· Test run : Allocated memory Storage problem

· * Output → odb file occupied the large space

- Check Abaqus manual

July 26, 2000 Time : 17:00 ~ 20:00

From: Doug Gute <dgute@swri.edu>
Reply-To: dgute@swri.edu
To: "'Joonhong Lim'" <jhlim@hotmail.com>
Subject: Model Modification Files
Date: Wed, 26 Jul 2000 16:46:02 -0500

Joonhong:

The attached files are now at your ftp site. They are entitled 'BASCNTCT.txt' and 'DS_Model_Revisions.txt'

BASCNTCT.txt - contains a new set list for ELSET=BASCNTCT. Replace the old set list with this one.

DS_Model_Revisions.txt - contains changes for the invert and WP rigid analytical surfaces. The reference node for the WP rigid surface has also been changed to the center of the WP.

Doug

C.S Park

* Modify the input file

* Output : delete

→ * History out , Time interval = 0.0

* Node history

U

* El history

S

* energy history

ALLKE

* Replace input file from client and test run

Perl

```
***********************************************************************
**
**    Define the waste package analytical rigid surface
**    reference node
**
*NODE, NSET=WSTPCKG
  800001, 0.0000, 0.0000, 1.0120
*RIGID BODY, REF NODE=800001
***********************************************************************

***********************************************************************
**
**    Define the contact surfaces between the drip shield and
**    waste package. The drip shield contact surface is defined in
**    terms of an element set and the waste package is an analytical
**    rigid surface
**
*SURFACE DEFINITION, NAME=IDSSURF
 IDSCNTCT,
**
*RIGID SURFACE, TYPE=CYLINDER, NAME=WPSURF, REF NODE=800001
 0.0000, 0.0000, 1.0120, 1.0000, 0.0000, 1.0120
 0.0000, 1.0000, 1.0120
 START,  0.000000,  0.822000
 CIRCL,  0.711873, -0.411000, 0.000000, 0.000000
 CIRCL, -0.711873, -0.411000, 0.000000, 0.000000
 CIRCL,  0.000000,  0.822000, 0.000000, 0.000000
**
*CONTACT PAIR, OP=ADD, CPSET=DSWPZON
 WPSURF, IDSSURF
***********************************************************************
**
**    Define the contact surfaces between the drip shield base and
**    invert. The drip shield base contact surface is defined in
**    terms of an element set and the invert is an analytical
**    rigid surface
**
*SURFACE DEFINITION, NAME=BASESURF
 BASCNTCT,
**
*RIGID SURFACE, TYPE=CYLINDER, NAME=INVRTSRF, REF NODE=800001
 0.0000, 0.0000, 0.0000, 1.0000, 0.0000, 0.0000
 0.0000, 1.0000, 0.0000
 START,  0.000000,  0.000000
  LINE,  1.321000,  0.000000
 CIRCL,  1.331000,  0.010000, 1.321000, 0.010000
  LINE,  1.331000,  0.384000
 CIRCL,  1.341000,  0.394000, 1.341000, 0.384000
  LINE,  2.341000,  0.394000
**
*CONTACT PAIR, OP=ADD, CPSET=DSINVZON
 INVRTSRF, BASESURF
***********************************************************************

*ELSET, ELSET=BASCNTCT
    1501,    1502,    1503,    1504,    1505,    1506,    1507,    1508,
    1509,    1510,    1511,    1512,    1513,    1514,    1515,    1516,
```

C.S Park

July 27, 2000 Time 9:30 ~ 11:30

- Test run
- Syntax error check

  *spring, Elset :springs → *spring, Elset = springs

  50 → 50

- Time period of the step : 0.001

July 28, 2000 Time 9:00 ~ 12:00

- Test run

  Time period of the step : 0.001

  Time period of the step : 0.002

- Abaqus post job = name memory = 30000000
- Abaqus post problem → no show displacement : convert

From: Ted Krauthammer [mailto:tedk@psu.edu]
Sent: Friday, July 28, 2000 10:28 AM
To: dgute@swri.org
Subject: Update

Doug:

A couple of updates.

1. We seem to have a problem with storage from Abaqus runs. The 0.1 ms run that we did took up about 250MB of storage, and this was for limited output. The full output might be twice as large. Although it may not scale linearly, but running a 20 ms simulation could generate up to 100 GB. I have been in touch with our computer center, and they are looking into what can be done.

Have you tried running the case? It would be interesting to see how much storage it generated on your system.

CS Park

Ted

At 02:15 PM 07/28/2000 -0500, you wrote:
Ted:

Thanks for the info.!

Memory management for the output is definitely a problem. I found that I had to limit my whole model output requests to "snap shots" corresponding to specific times of interest. Unfortunately, I had to run the same job at least twice to discern when the appropriate times for requesting the whole model output should be. For the current model, I would suggest requesting the displacement output for only two nodes at small time increments throughout the entire analysis. One of these nodes would be the node located at the bottom of the support beam at the x and y symmetry BC intersection. The other would be located on the inside of the drip shield at the other x and y symmetry BC intersection. I suspect that one these nodes would impact the WP before any of the others. I would also limit element stress output data for small time increments throughout the entire analysis to those elements that have been identified as likely candidates for experiencing material failure. I would only request whole model data at the times when the displacements are at a maximum and one or two other instances that you think are worth looking at. For instance, (i) right after the rock block and drip shield impact event has been initiated (I'm kind of curious as to the normal (sigma-z) stress levels generated in the elements participating in the contact right after impact); (2) when the DS impacts the WP (in the event it does hit the WP); and (3) when the system has reached steady state.

I have not attempted to run the model locally. Primarily because of these output and memory issues. Resolving these types of problems is time consuming and oftentimes frustrating. But I've found that the time spent in formulating an efficient output data management scheme pays off in the long run. Especially when we have this many different permutations to analyze.

I'll send the business cards to you some time next week.

Thanks again for the update and I hope my suggestions help at least a little bit.

Doug

C.S.Park

Doug:

Thanks for your thoughts. We have proceeded along the same ideas. Nevertheless, I hate to run a problem with limited output, and find out that we "missed the boat". It might be better to request more output that we may need, and discard what is not useful, than to be forced to rerun problems. In any case, our storage needs have become an interesting problem for the Academic Computing Center. They will probably develop a scheme to provide much more extensive storage than is typical currently, and we should be able to use it efficiently.

July 29, 2000 Time 9:00 ~ 12:00 17:00 ~ 19:00

* Input file changes

Rev 2

```
RESTART, WRITE, OVERLAY
**
**
*NSET, NSET=IM_NODE
55156
*ELSET, ELSET=IM_ELE
36004
*HISTORY OUTPUT, TIME INTERVAL=0.0
*NODE HISTORY, NSET=IM_NODE
U, V, A
*EL HISTORY, ELSET=IM_ELE
S, LE,
*ENERGY HISTORY, ELSET=DSPLATE
ALLKE, ALLIE
*ENERGY HISTORY
ALLKE, ALLIE, ALLWK
*END STEP
```

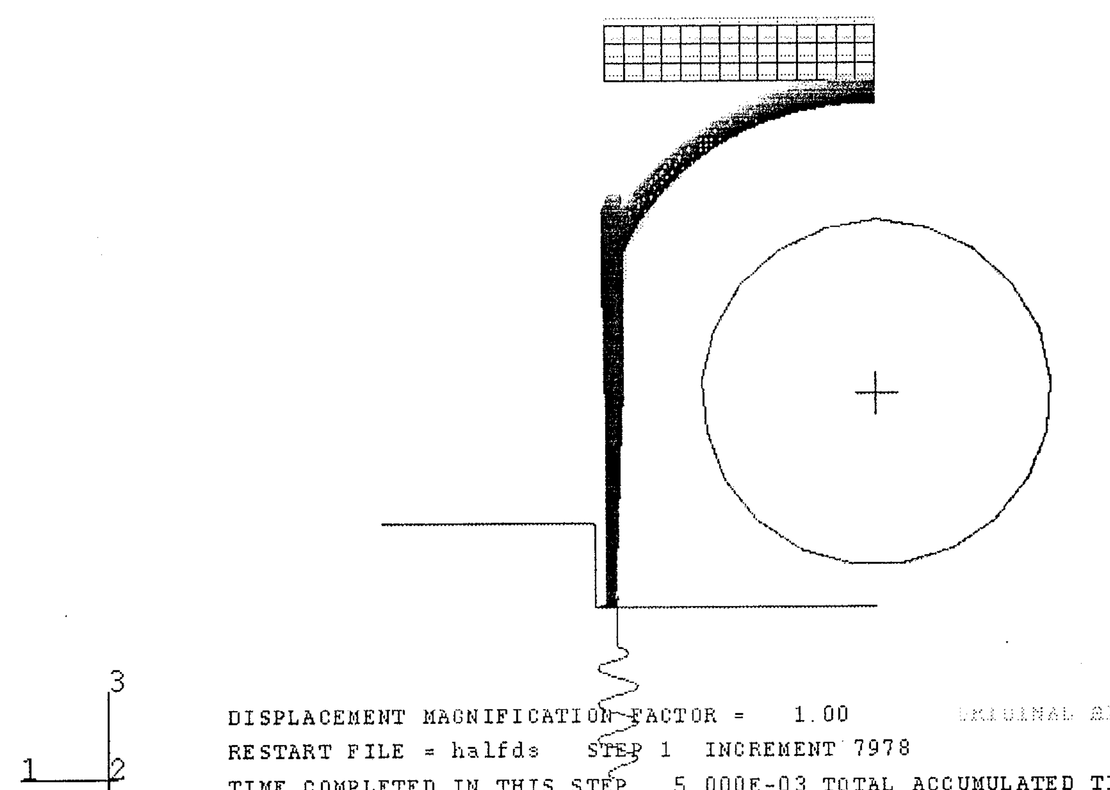
C.S Park

* Abaqus job=halfds convert=all Check output result

Time period of the step 0.005

C.S Park

1

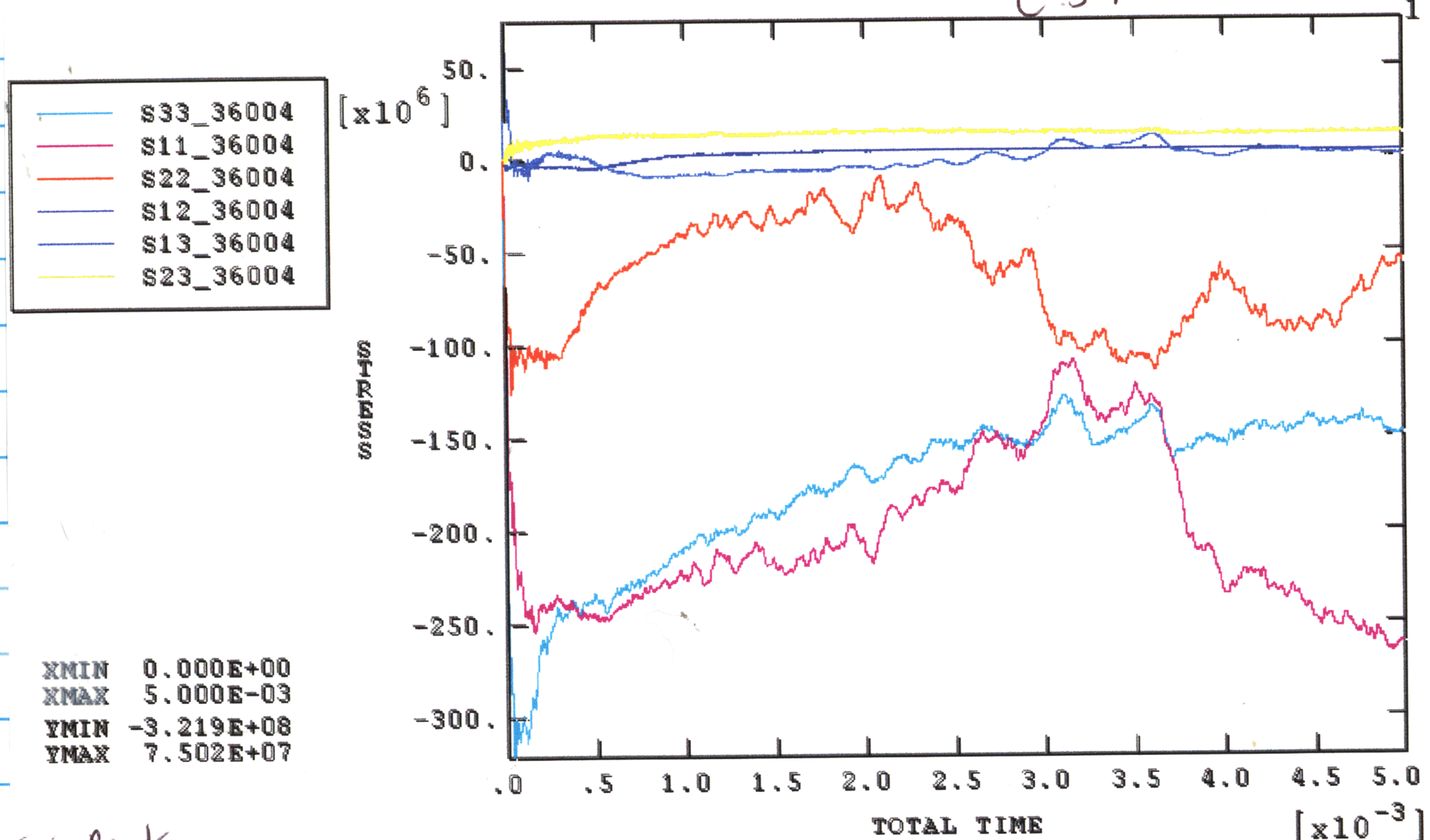



```
DISPLACEMENT MAGNIFICATION FACTOR =   1.00        ORIGINAL MESH     DISPLACED MESH
RESTART FILE = halfds   STEP 1  INCREMENT 7978
TIME COMPLETED IN THIS STEP   5.000E-03 TOTAL ACCUMULATED TIME   5.000E-03
ABAQUS VERSION: 5.8-14   DATE: 29-JUL-2000   TIME: 17:27:28
```

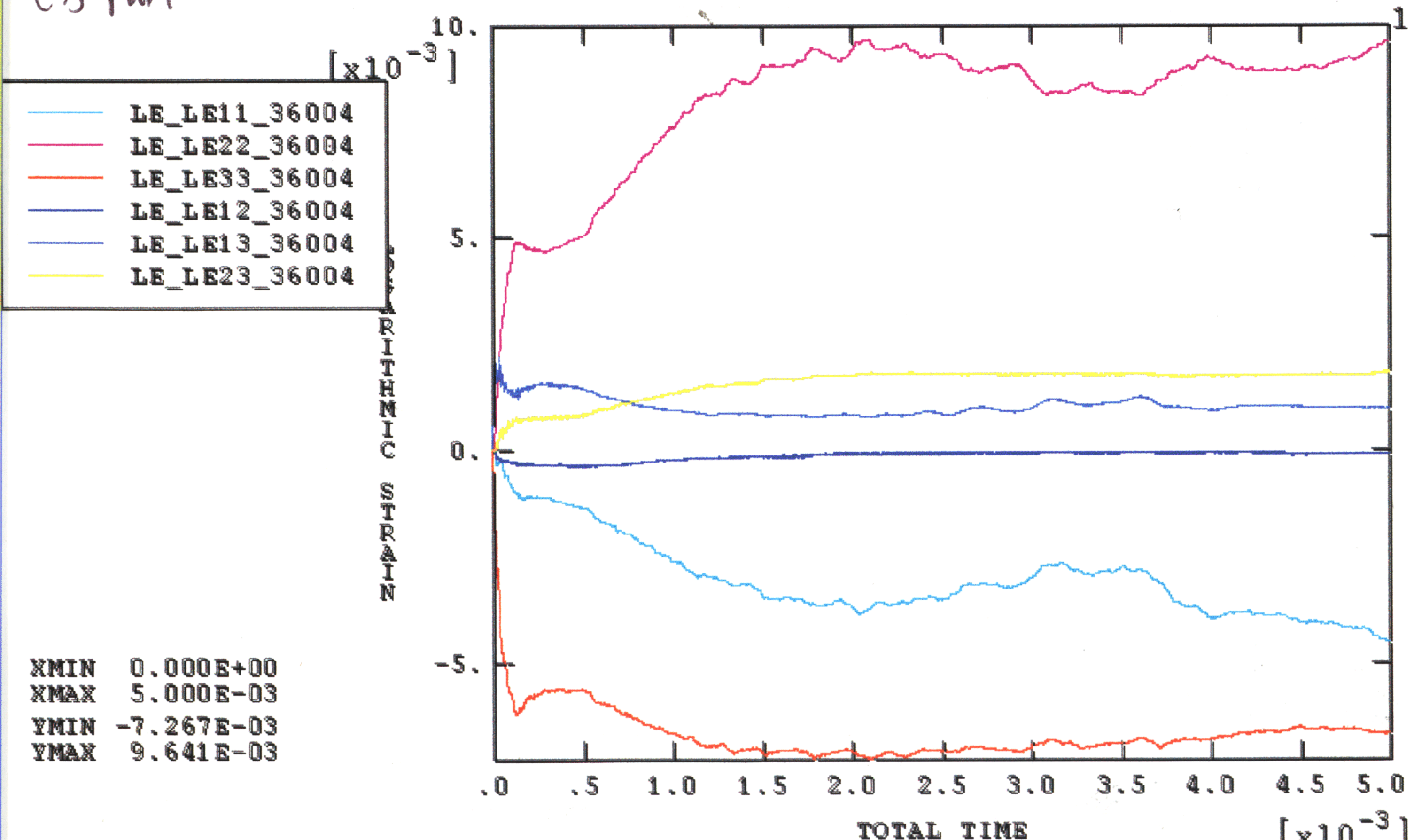
July 30, 2000   Time 13:00 ~ 15:00

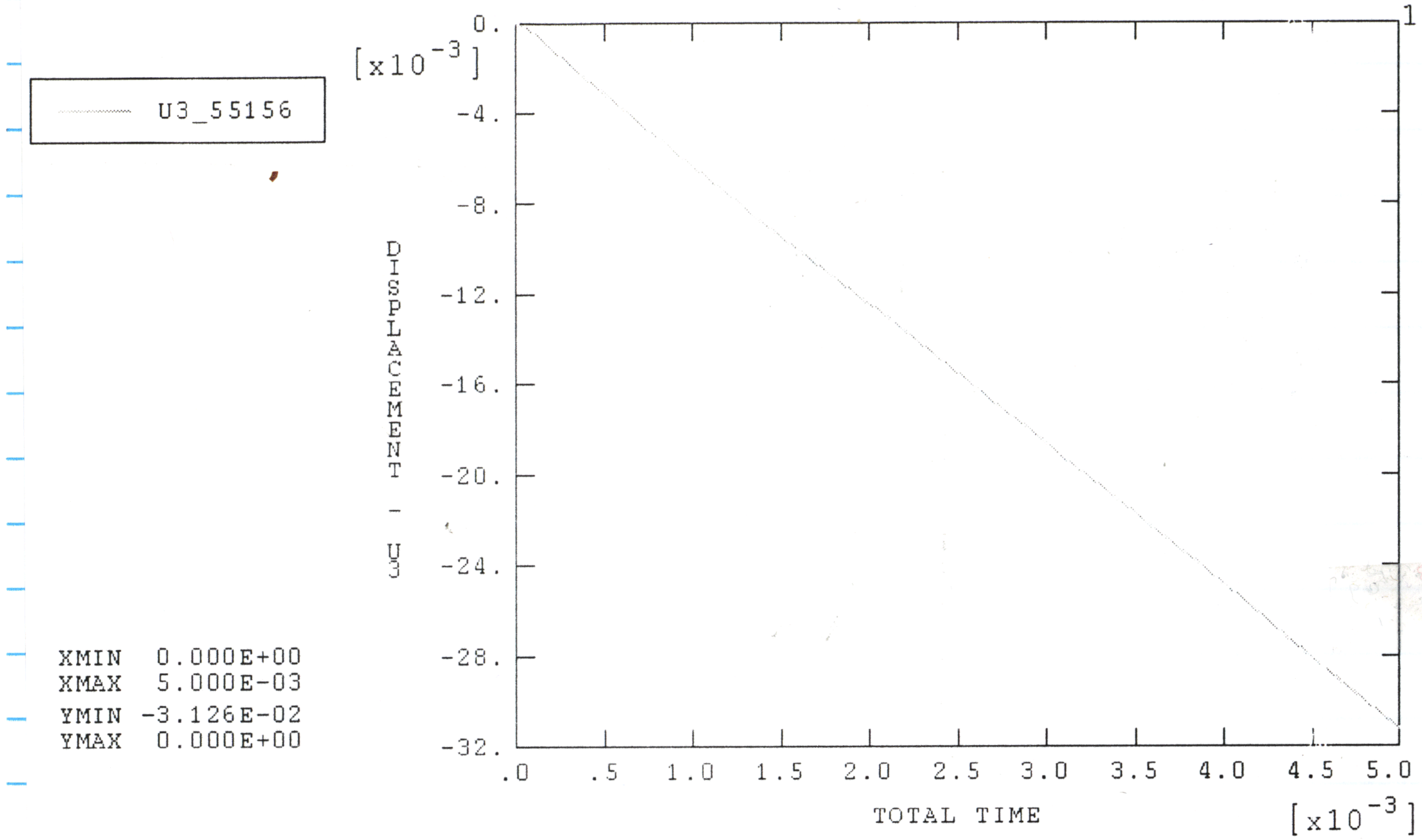
* Output X-Y plot

C.S Park



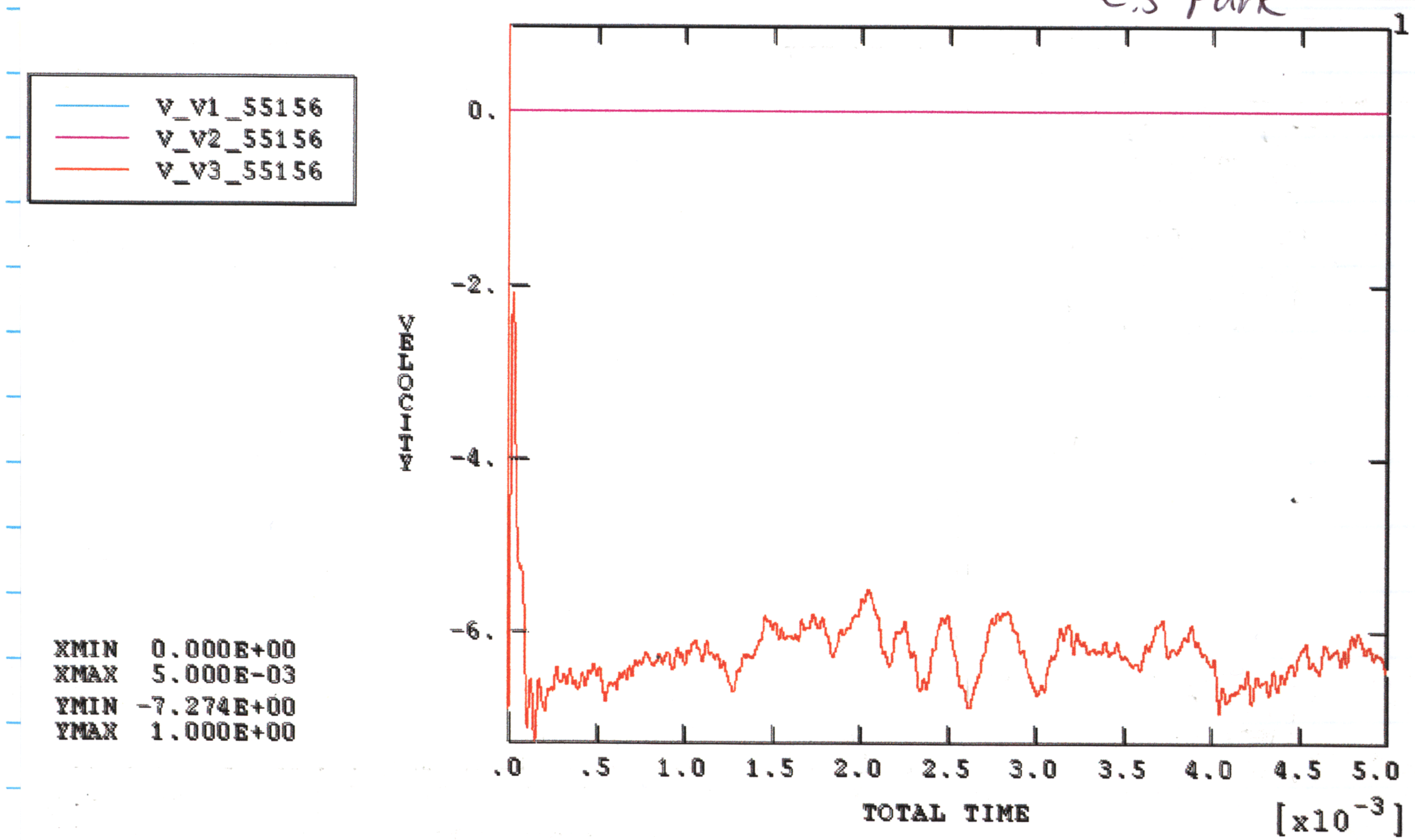
C.S Park

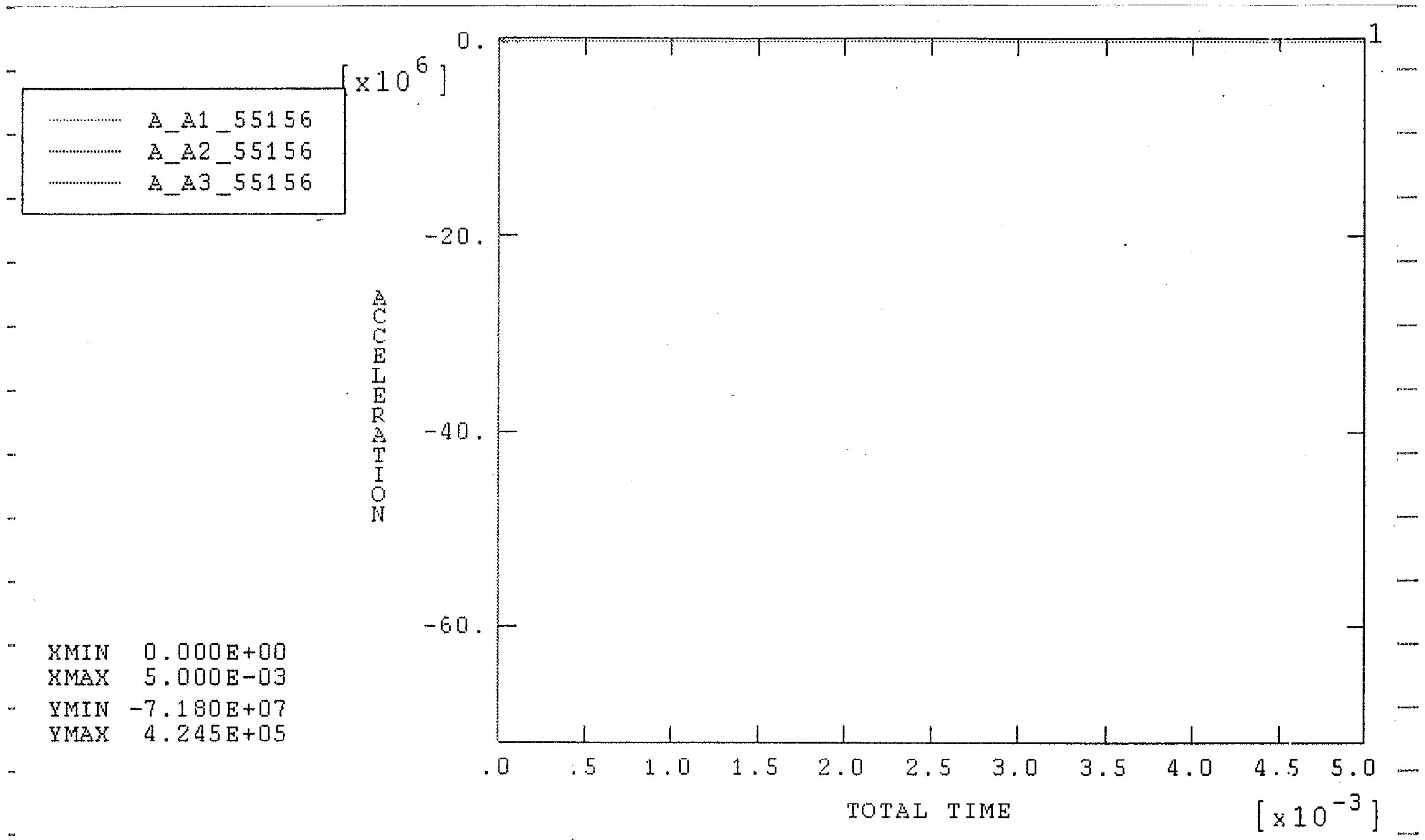




C.S Park

C.S Park





C.S Park

S : All Stress Component

S_{ij} : ij - component of stress ($i \le j \le 3$)

LE : All logarithmic Strain component

LE_{ij} : ij Component of logarithmic strain ($i \le j \le 3$)

U : Displacement components

V : Velocity Component (both translation and rotation)

* File output : both translation and rotation
* History output : translation only

(Rotation results should be requested by components)

V_n : $\dot{u}_n$ velocity component ($n=1,2,3$)

A : Acceleration components (both translation and rotation)

* File output : both translation and rotation
* History output : translation only

(Rotation results should be requested by components)

A_n : $\ddot{u}_n$ acceleration component ($n=1,2,3$).

ALLKE : Kinetic energy

ALLIE : Total strain energy

(ALLIE = ALLSE + ALLPD + ALLCD + ALLAE)

ALLSE : recoverable strain energy (elastic strain energy)

ALLPD : Energy dissipated by rate - independent and rate-dependent plastic deformation (Plastic strain energy)

ALLCD : Energy dissipated by viscoelasticity

ALLAE : "Artificial" strain energy associated with constraints used to remove singular modes

ALLWK External work (Available only for the whole model)

※ ETotal : Energy balance defined as

ALLKE + ALLIE + ALLVD + ALLFD - ALLWK

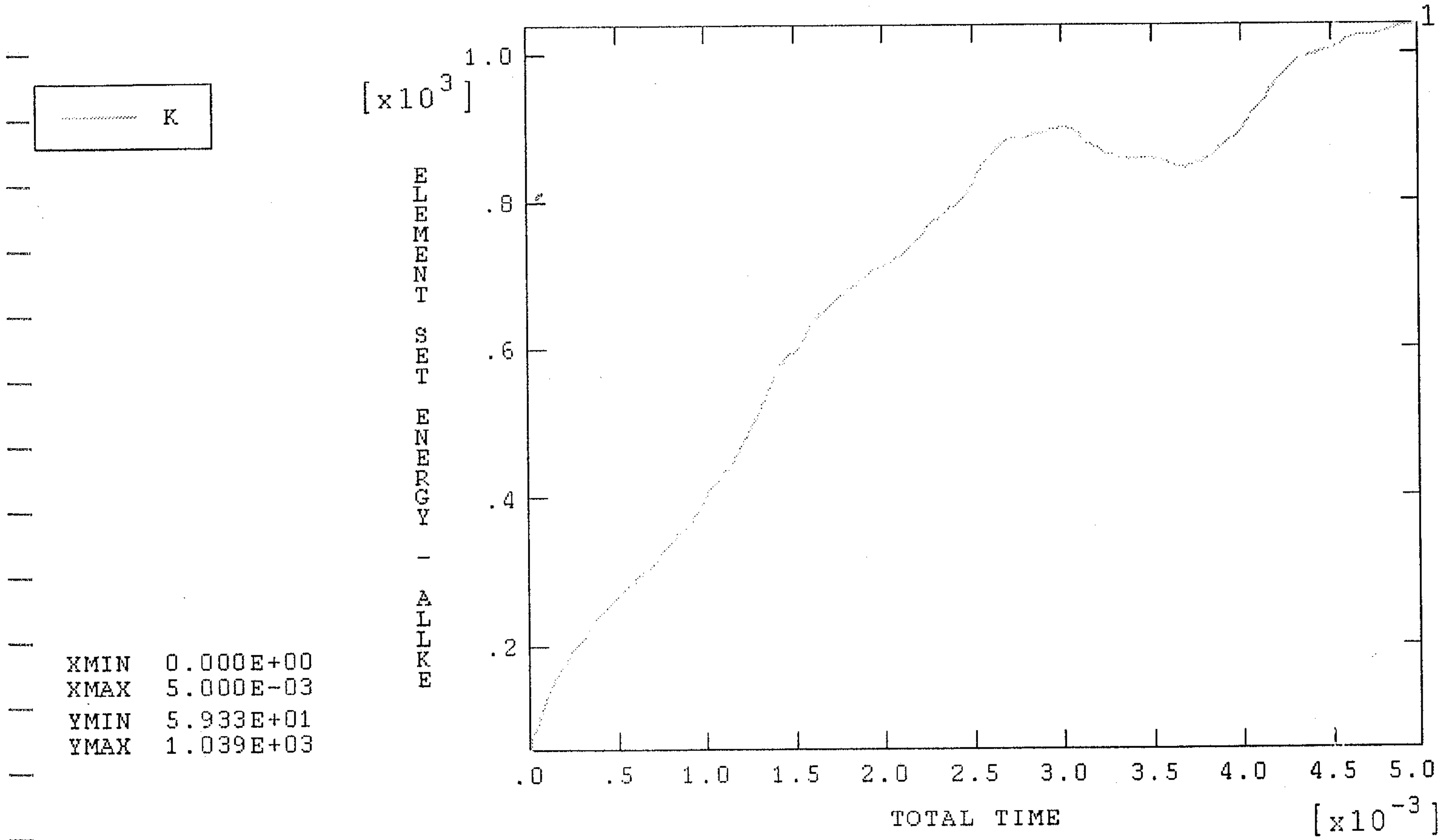
(Available only for the whole model)

ALLVD : Energy dissipated by viscous effects

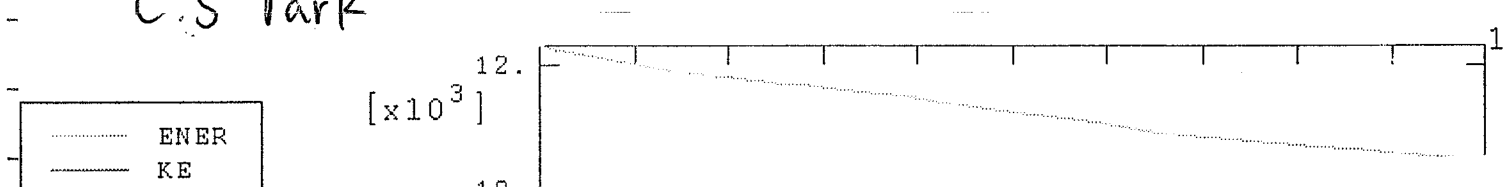
ALLFD : total energy dissipated through frictional effect

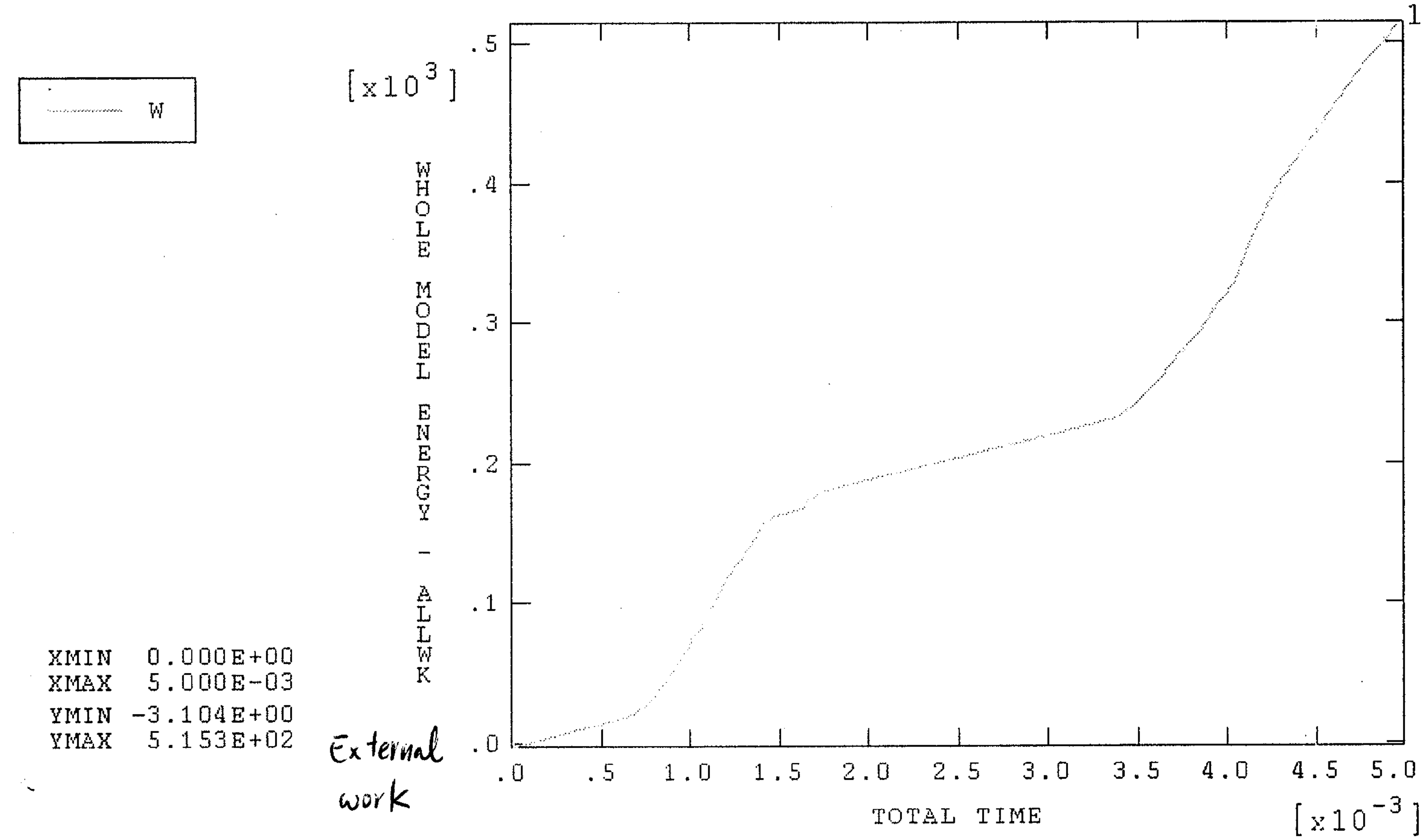
(Available only for the whole model)

Strain energy is defined as the energy absorbed by the structure during the loading process
(Sometimes strain energy is referred to as internal work ~~to~~ to distinguish it from the external work done by the load)



C.S Park

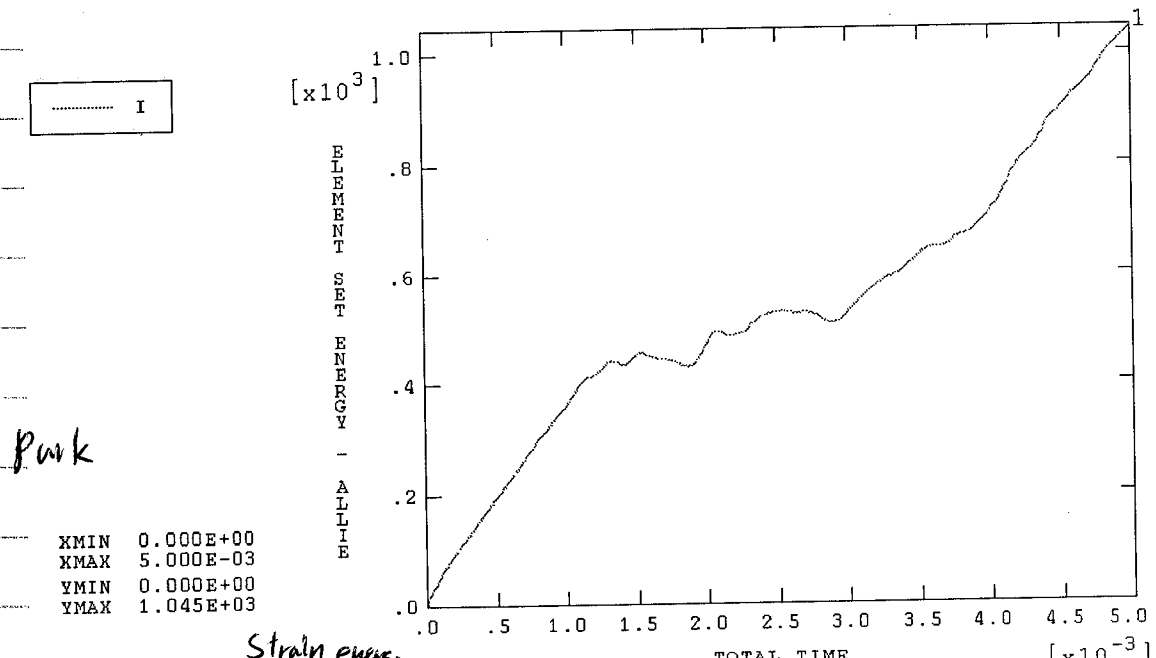




External work

C.S Park

July 31, 2000 Time 8:00 ~ 12:30 (11:50 ~ 12:30)



C.S Park

Strain energy

Analysis Output

For each analysis the following data is required:

ETOTAL ALLSE ALLPD ALLKE

- Time-history plots of the total energy, elastic strain-energy, plastic strain-energy, kinetic energy, and artificial energy for the drip shield for each analysis permutation. This data will also be provided in a MS Excel spreadsheet.
  ALLAE
- Time-history plots of the total energy, elastic strain-energy, plastic strain-energy, kinetic energy, and artificial energy for the rock block for each analysis permutation. This data will also be provided in a MS Excel spreadsheet.
  S MISES SENER
- Separate time-history plots of the maximum shear stress, Von Mises stress, and strain-energy density for those element(s) exhibiting the greatest magnitudes of these measures during the analysis for each analysis permutation. This data will also be provided in a MS Excel spreadsheet.
  RF
- Time-history plots of the resultant reaction forces for the reference nodes of the invert and waste package analytical surfaces for each analysis permutation. This data will also be provided in a MS Excel spreadsheet.
  V_3
- Time-history plots of the drip shield and waste package clearance for each analysis permutation. This data will also be provided in a MS Excel spreadsheet.

C.S Park

Finite element analysis permutations.

Permutation No.	Rock Block Mass (kg)	Rock Block Impact Velocity (m/s)	Rock Block Kinetic Energy (J)
1	500	7.0000	12250.0000
2	500	9.8995	24500.0251
3	500	14.0000	49000.0000
4	1000	7.0000	24500.0000
5	1000	9.8995	49000.0501
6	1000	14.0000	98000.0000
7	2000	7.0000	49000.0000
8	2000	9.8995	98000.1003
9	2000	14.0000	196000.0000
10	4000	7.0000	98000.0000
11	4000	9.8995	196000.2005
12	4000	2.4749	12250.2600
13	8000	7.0000	196000.0000
14	8000	1.7500	12250.0000
15	8000	2.4749	24500.5200

* decide the command (keyword) of output.
* We choose the case 7 { Rock block mass : 2000 kg; Rock block impact velocity (m/s) : 7; Rock Block kinetic energy (J) : 49000 }

⇒ Our model is quater of total model.

∴ kinetic energy (J) = 12,250 J (by formulae $\frac{1}{2}mv^2$)

~~Strain energy (J)~~ : July 31 c.s.park

Total energy (J) : 12,250 J (by graph)

* Meeting with Pr Ted Krauthammer and Joonhong Lim
  The drip shield has the initial ground motion (up 1 m/s)
  → Our graph doesn't show this energy. why?

Aug 1, 2000 Time 8:00 ~ 12:00

* Modify the input file (to set the energy graph)

Rev2_1

```
*RESTART, WRITE, OVERLAY
**
**
*NSET, NSET=IM_NODE
55156
*ELSET, ELSET=IM_ELE
36004
*HISTORY OUTPUT, TIME INTERVAL=0.0
*NODE HISTORY, NSET=IM_NODE
U, V, A
*EL HISTORY, ELSET=IM_ELE
S, SP, MISES, SENER
*NODE HISTORY, NSET=WSTPCKG
RF,
*NODE HISTORY, NSET=INVERT
RF,
*ENERGY HISTORY, ELSET=DSPLATE
ALLSE, ALLPD, ALLKE, ALLAE
*ENERGY HISTORY, ELSET=RCKBLCK
ALLSE, ALLPD, ALLKE, ALLAE
*ENERGY HISTORY
ETOTAL,
**ENERGY HISTORY
**ALLKE, ALLIE, ALLWK
*END STEP
```

C S park

* Error : segmentation fault

* Energy balance

The approach is to request the Eke only for an element set containing the deformable elements in the model using the * ENERGY OUTPUT or * ENERGY HISTORY option

* Run and check

Aug 7, 2000 Time 14:00 ~ 14:40

* Meeting with Dr Ted Krauthammer and Joonhong Lim
  - Storage problem
  - To use parallel system for reducing the runing time
  - Make an appointment for meeting of staff of CAC

Aug 10, 2000 Time 10:00 ~ 11:30

* Meeting with Senior research programmer (system administrator)
  To extend the storage space
  To set up parallel system (Access authority)

log in : ssh fo7n01.cac.psu.edu -l jxl387

New directory

small scratch (4GB)
/gpfs/scratch/jxl387
large scratch (200GB)
/stuff1/jxl387

Abaqus parallel

/:/rs.aix/usr/local/abaqus_smp/abaqus job=
cpus=(1~8) interactive memory=50000000

Abaqus viewer & CAE

ssh h2.pkph.psu.edu

Source /usr/local/setup/abaqus setup.csh

abaqus viewer
CAE

Time 14:45 ~ 15:00

* Meeting with Dr Ted Krauthammer and Joonhong Lim
  - Time period of the step : 10ms
  - Add the more point to check (S, SP, MISES, SENER & energy)
  - To report progress by e-mail

Aug 11, 2000 Time 9:00 ~ 12:00

- Run the rev 1 (* output) and rev2_1 (* History output)
- Parallel doesn't work. (~~cut~~ CPUS = 1) Aug 11

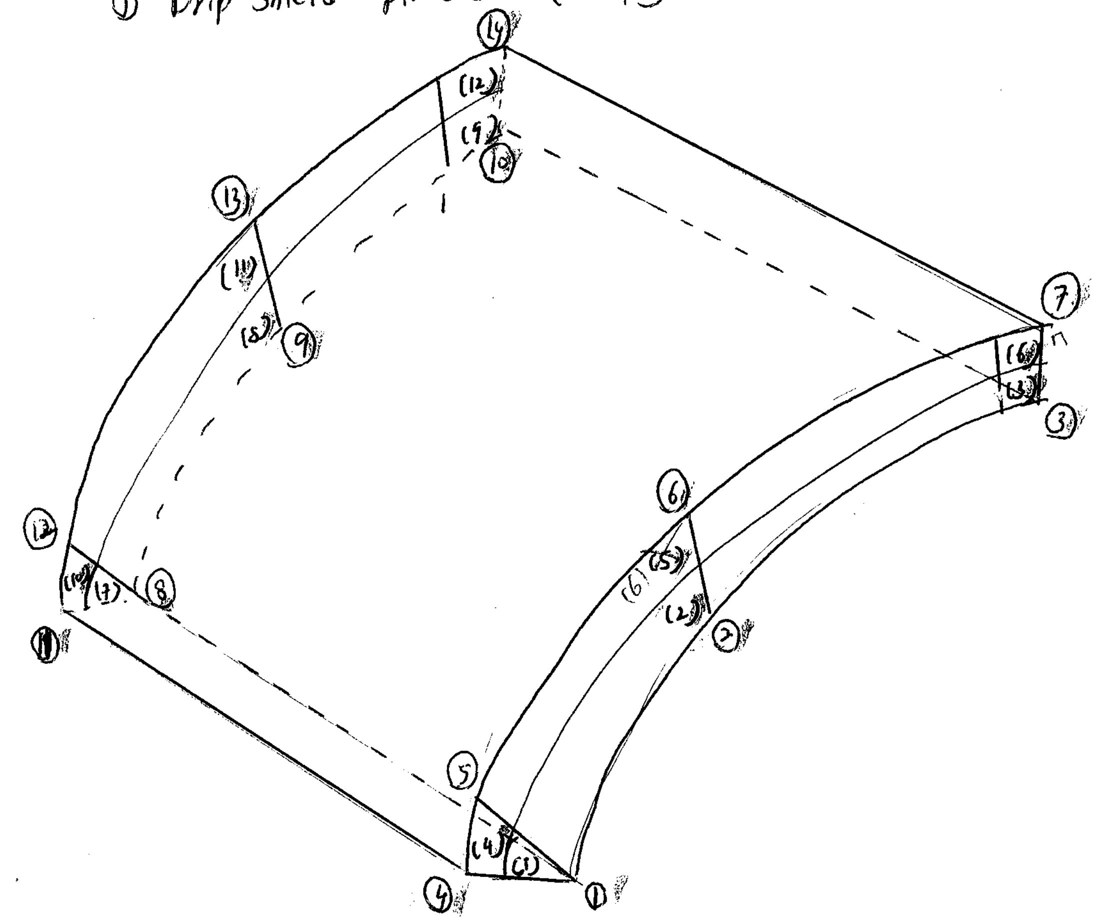
rev1 → File name : ds_rev0
rev2_1 → File name : ds10_1
} ~~10ms (Test run)~~

Aug 12, 2000 Time 10:00 ~ 12:00, 13:00 ~ 16:00

- Check the abaqus viewer and CAE in lab.
- File name : ds_rev1
  File name : ds10_2
  } ~~15ms (Test run)~~

- Additional point of model for output
  ○ : node no
  ( ) : element no

① Drip shield plate 1 (Roof)

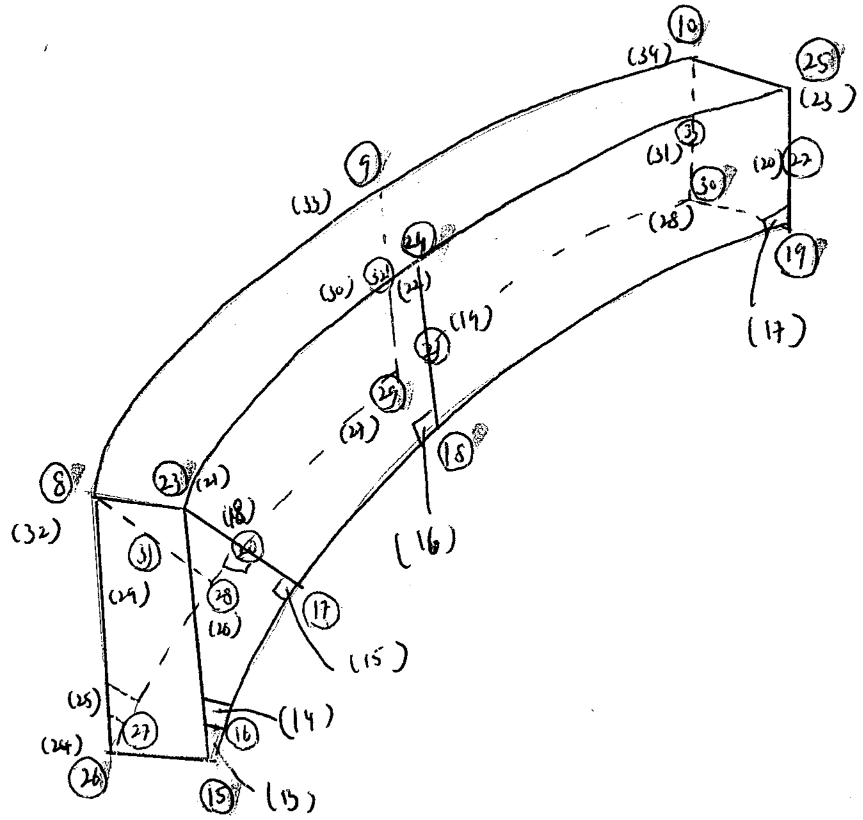


C.S Park

① 54969	② 95877	③ 95579	④ 54717	⑤ 96135
⑥ 95879	⑦ 95582	⑧ 753	⑨ 55260	⑩ 55158 (0, 0, 2.54)
⑪ 251	⑫ 114571	⑬ 55054	⑭ 55156	

(1) 63071	(2) 62899	(3) 62698	(4) 63072	(5) 62900
(6) 62700	(7) 36375	(8) 36205	(9) 36002	(10) 36376
(11) 36206	(12) 36004			

4 Bulkhead



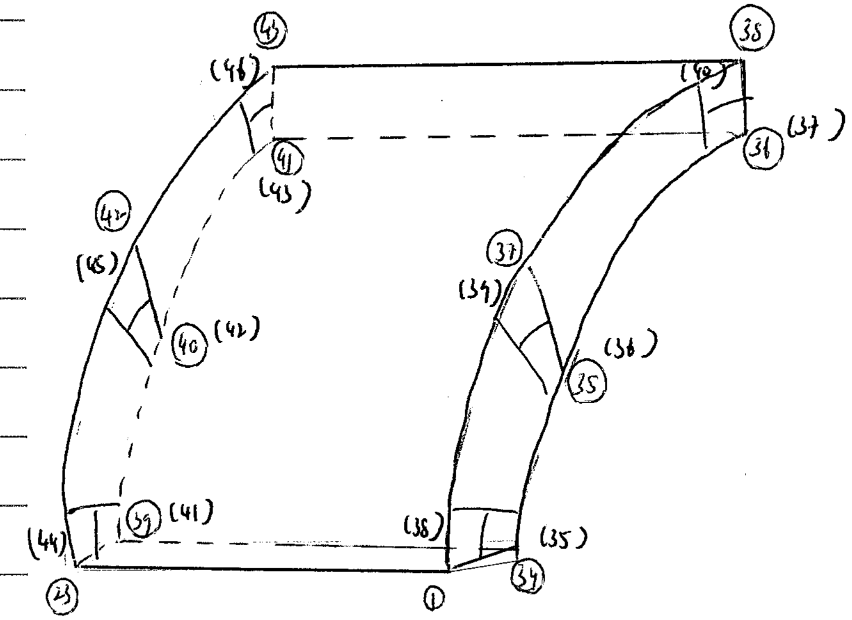
C S Park

15 2232	16 116060	17 115809	18 116465	19 116363
20 115815	21 117195	22 116357	23 2259	24 56400
25 56099	26 726	27 121397	28 121022	29 122285
30 123490	31 121033	32 122299	33 123502	

(0, 0, 2.45)

(13) 100468	(14) 100469	(15) 100608	(16) 101349	(17) 102552
(18) 100098	(19) 101369	(20) 102565	(21) 100040	(22) 101297
(23) 102505	(24) 103079	(25) 103080	(26) 103219	(27) 103960
(28) 105163	(29) 102709	(30) 103980	(31) 105176	(32) 102651
(33) 103908	(34) 105116			

7 Internal support plate

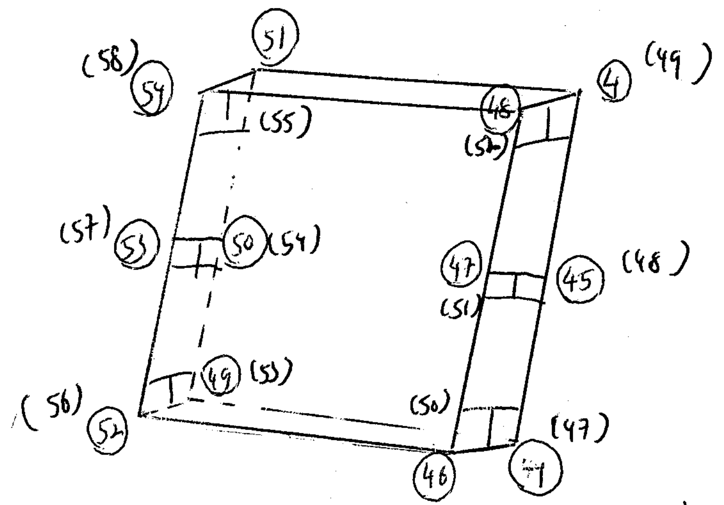


C S park

34 128705	35 128669	36 128636	37 96081	38 96027
39 115820	40 67968	41 115823	42 56601	43 56547

(35) 505038	(36) 505002	(37) 504968	(38) 505039	(39) 505003
(40) 504969	(41) 500070	(42) 500036	(43) 500000	(44) 500071
(45) 500037	(46) 500001			

⑧ External support plate

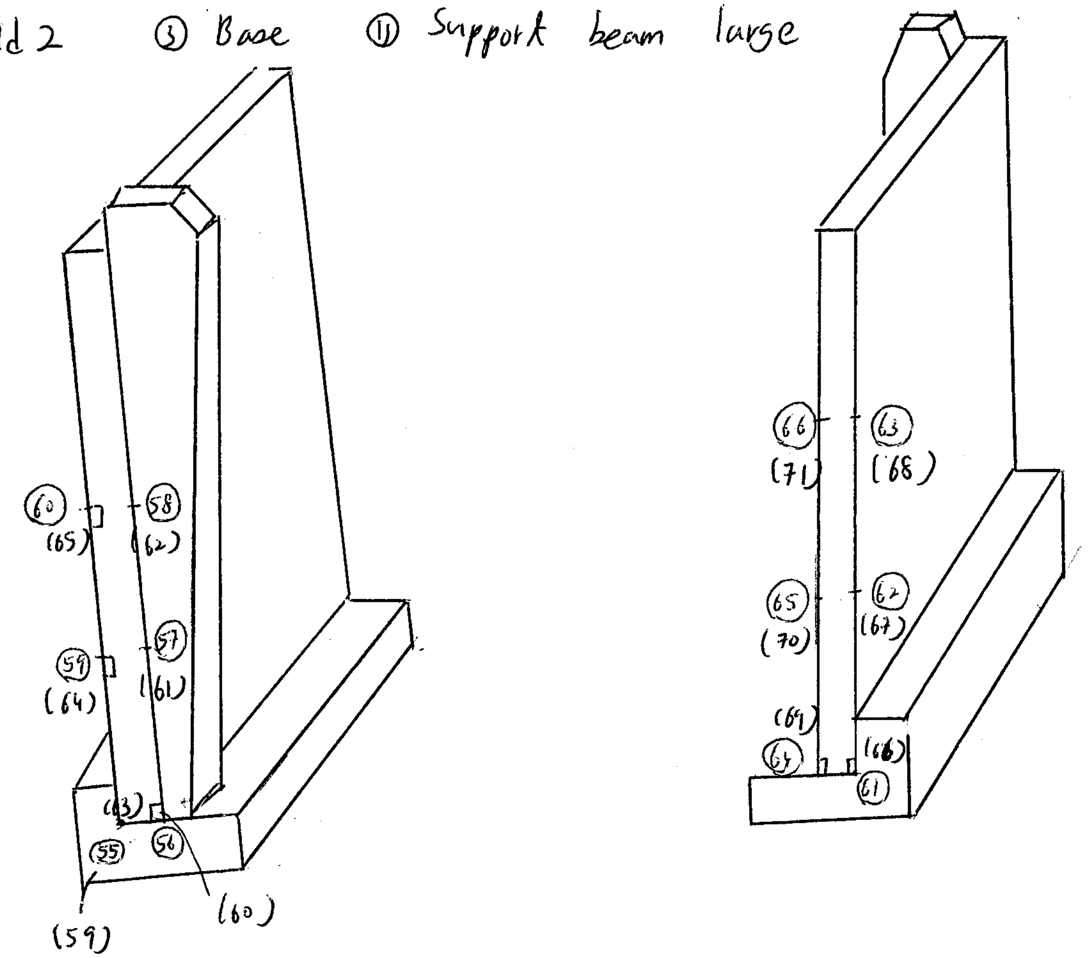


C.S park

44 54593	45 54155	46 107403	47 107341	48 ~~3389~~ 107279
49 3389	50 3451	51 3513	52 98802	53 98771
54 98712				

(47) 408431	(48) 408369	(49) 408309	(50) 408430	(51) 408368
(52) 408308	(53) 400123	(54) 400062	(55) 400001	(56) 400122
(57) 400063	(58) 400000			

② Drip shield 2 ③ Base ⑪ Support beam large



C.S Park

55 503	56 1	57 81	58 177	59 583
60 679	61 54719	62 54815	63 54899	64 54218
65 54409	66 54577			

(59) 200005	(60) 1	(61) 81	(62) 177	(63) 251
(64) 331	(65) 427	(66) 35751	(67) 35847	(68) 35931
(69) 35501	(70) 35597	(71) 35681		

Aug 13, 2006 Time 13:00 ~ 16:00

- Modify the input file (Additional point)

```
*NSET, NSET=IM_NODE
54969, 95877, 95579, 54717, 96135, 95879, 95582, 753, 55260, 55158,
251, 114571, 55054, 55156, 2232, 116060, 115809, 116465, 116363, 115815,
117195, 116357, 2259, 56400, 56099, 726, 121397, 121022, 122285, 123490,
121033, 122299, 123502, 118750, 128669, 128636, 96081, 96027, 115820,
67968, 115823, 56601, 56547, 54593, 54655, 107403, 107341, 3389, 107279,
3451, 3513, 98802, 98771, 98712, 503, 1, 81, 177, 583, 679, 54719, 54815,
54899, 54218, 54409, 54577

*ELSET, ELSET=IM_ELE
63071, 62899, 62698, 63072, 62900, 62700, 36375, 36205, 36002, 36376,
36206, 36004, 100468, 100469, 100608, 101349, 102552, 100098, 101369,
102565, 100040, 101297, 102505, 103079, 103080, 103219, 103960, 105163,
102709, 103980, 105176, 102651, 103908, 105116, 505038, 505002, 504968,
505039, 505003, 504969, 500070, 500036, 500000, 50071, 50037, 500001,
408431, 408369, 408309, 408430, 408368, 408308, 400123, 400062, 400001,
400122, 400063, 400000, 200005, 1, 81, 177, 251, 331, 427, 35751, 35847,
35931, 35501, 35597, 35681
```

C.S Park

- Test run (15ms) show that time period of the step is not enough. (The displacement continues to move the same direction) → "Restart"

Aug 14, 2006 Time 16:00 ~ 18:00

- Modify the LL script
- Check the finite element analysis permutations

Rock density changes

Rock block mass (kg)	density
500	675
1000	1350
2000	2700
4000	5400
8000	10800


```
#!/bin/csh -f

# @ job_type = serial
# @ class = abaqus

# Set the following value to the number of CPUs you use in your
# Abaqus application (cpus= field)

# @ resources = ConsumableCpus(1)

# @ error  = err.$(jobid).$(stepid)
# @ output = out.$(jobid).$(stepid)


# @ wall_clock_limit = 72:00:00
# @ queue

 echo "Job started on `hostname` `date` `whoami`"

# Set CPUs equal to CPUs desired (8 max, 4 recomended)
# Value MUST equal Consumable CPUs above
# You may experiment with this value,
# however leave it set = 1 if you get running errors

/:/rs_aix/usr/local/abaqus_smp/abaqus job=p4 memory=50000000 cpus=1 interactive

 echo "Job completed `hostname` `date` `whoami`"
```

C.S Park

Aug 16, 2006 Time 14:00 ~ 18:00

- Test run (35 ms) show that time period of the step is not enough, too.

```
*HEADING
CONTINUE THE DRIP SHILED ANALYSIS(15MS~35MS)
*RESTART,READ,STEP=1
**
*STEP, NLGEOM=YES
*DYNAMIC, EXPLICIT
 ,  0.02
*END STEP
```

C.S Park

Aug 17, 2000 Time 14:00 ~ 18:00

- To make 15 input file (Permutation No 1 ~ 15)
- Modify the inputfile

*dynamic, explicit

, 0.040 (or) , 0.035 (or) , 0.050

* Initial conditions, velocity

Rcknodes, 3, { -7.0000
-9.8995
-14.0000
-1.7500
-2.4749

* Material, Name = Rock

* Density

{ 675 , 0.0
1350
2700
5400
10800

Aug 18, 2000 Time 14:00 ~ 15:00

- submit the case 1, 2, 15

Case 1 : 35 ms

Case 2 : 35 ms

Case 4 : 40 ms

Aug 20, 2000 Time 10:00 ~ 11:00

- Run the case 3, 4, 5, 6

case 3, 4, 5, 6 - 35 ms

Aug 21, 2000 Time 11:30 ~ 12:15

- Meeting with Dr Ted Krauthammer and Joonhong
  - → To discuss about runing time
  - → Case 15 : extend time period of the step 50 ms
    (if X-Y plot keeps the same direction for displacement)

Aug 22, 2000 Time 13:00 ~ 14:00

- Run the case 7, 8, 9, 10

case 7, 8, 9, 10

35 ms 40 ms 50 ms

Aug 23, 2000 Time 13:00 ~ 14:00

- abaqus recover job = case 9 and case 10

Aug 24, 2000 Time : 14:00 ~ 17:00

- To make the batch file for output

set, xy print file = p1

- We can use the data by spread sheet.

Aug 25, 2000 Time 13:00 ~ 17:00

- Run the case 11, 12, 13, 14 : 50 ms
- To make the batch file from case 1 to case 5

C.S.Park

```
*************************************************************
**Displacement
reset, all
sel, file=p1

read curve, name=un54969, var=u, node=54969
set, xy print file=p1_u1.txt
print curve
un54969
*************************************************************
**Velocity
reset, all
sel, file=p1

read curve, name=vn54969, var=v, node=54969
set, xy print file=p1_v1.txt
print curve
vn54969
*************************************************************
**Acceleraction
reset, all
sel, file=p1

read curve, name=an54969, var=a, node=54969
set, xy print file=p1_a1.txt
print curve
an54969
*************************************************************
**mises
reset, all
sel, file=p1

read curve, name=me62698, var=mises,    ele=62698
set, xy print file=p1_m3.txt
print curve
me62698
```



```
*************************************************************
**stress
reset, all
sel, file=p1

read curve, nase=se62698, var=s,    ele=62698
set, xy print file=p1_s3.txt
print curve
se62698
*************************************************************
**Node history nset=Wstpckg
reset, all
sel, file=p1

read curve, name=rn800001, var=rf,    node=800001

set, xy print file=p1_rf1.txt
print curve
rn800001
```

C.S Park

```
**Node history nset=invert
reset, all
sel, file=p1

read curve, name=rn800000, var=rf,    node=800000

set, xy print file=p1_rf2.txt
print curve
rn800000
*******************************************************
**Energy history at Dripshield plate
reset, all
sel, file=p1

read curve, name=se_ds, var=allse,    elset=dsplate
read curve, name=pd_ds, var=allpd,    elset=dsplate
read curve, name=ke_ds, var=allke,    elset=dsplate
read curve, name=ae_ds, var=allae,    elset=dsplate

set, xy print file=p1_ener1.txt
print curve
se_ds
pd_ds
ke_ds
ae_ds
*******************************************************
**Energy history at rockblock
reset, all
sel, file=p1

read curve, name=se_rb, var=allse,    elset=rckblck
read curve, name=pd_rb, var=allpd,    elset=rckblck
read curve, name=ke_rb, var=allke,    elset=rckblck
read curve, name=ae_rb, var=allae,    elset=rckblck

set, xy print file=p1_ener2.txt
print curve
se_rb
pd_rb
ke_rb
ae_rb
```

```
****************************************
**Energy history
reset, all
sel, file=p1

read curve, name=to_all, var=etotal
read curve, name=ke_all, var=allke
read curve, name=ie_all, var=allie
read curve, name=wk_all, var=allwk

set, xy print file=p1_ener3.txt
print curve
to_all
ke_all
ie_all
wk_all
```

C.S park

Time 19:00 ~ 22:00

- Run the batch file in post - abaqus

Post abaqus

* Input
File name: 01

- Import text file from unix account by FTP

Aug 26, 2000 Time 9:00 ~ 12:00

- To make the batch file from case 6 to case 15
- Run the batch file in abaqus post from case 6 to case 10
- Import text file which produce by batch file from case 6 to case 10

Time 13:00 ~ 17:00

- Run the batch file in abaqus post from case 11 to case 15
- Import text file from case 11 to case 15

Aug 27, 2000 Time 10:00 ~ 12:00

To make the X-Y plot of displacement by Excel

- Drip shield plate 1 (Roof) node 3, 10 in case 1
- Data line is over 32,000 (Maximun line)
  → to modify the scope of lines

Time 13:00 ~ 17:00

To make the X-Y plot of displacement by Excel

- Drip shield plate 1 (Roof) node 3, 10 from case 2 case 9

Time 19:00 ~ 22:00

To make the X-Y plot of displacement from case 10 to case 15 by Excel

Aug 28, 2000 Time 13:00 ~ 17:00

· Case 1, 2, 3, 4, 5, 12 have enough time period of the step
· The other need to extend the time period of the step
  - To make the restart input file (P69)
  - Case 6, 7, 8, 9 rerun the abaqus (+10ms)

/:/rs_aix/usr/local/abaqus_smp/abaqus job=P6_EX
interactive memory=50000000 oldjob=p6

Time 19:00 ~ 22:00

· To make X-Y plot of Energy at dripshield, at rockblock and total for meeting (case 1)

Aug 29, 2000 Time : 14:00 ~ 18:00

- Continue to make X-Y plot of reaction force at reference node and mises and stress (case 1) for meeting
- To check the status of rerunning : O.K

Time 20:00 ~ 22:00

- To make X-Y plot of velocity and acceleration in 1 node

Aug 30, 2000 Time 12:30 ~ 16:00

- Check the result of restart file

  case 6, 7, 8 has enough time period of the step

  - case 6, 7 : 45^{ms}
  - case 8 : 50^{ms}

  case 9 need to extend the time period of the step

  (not enough to increase 10^{ms})

  - Rerun the restart file ($+20^{ms}$)

Time 19:00 ~ 21:00

To make the standard excel file to improve the Speed of work (The excel file is so big : 50 MB)

Aug 31, 2000 Time 14:00 ~ 18:00 (Meeting from 16:00 ~ 17:00 with Dr. Ted Krauthammer)

· Continue to make the standard excel file

· To report the status of work

Sep 1, 2000 Time 18:00~22:00

· To modify the X-Y plot in case 6,7,8

· Update the data and make the displacement curve at node 3,10,19 in case 6,7,8

* Displacement

Case 1 : node 3,10,19 (Permutation No 1~15)
⇒ Excel file, graph

Case 2_1 : node 60,63 (Permutation No 1~15)
⇒ Excel file, graph

Case 2_2 : node 59,62 (Permutation No 1~15)
⇒ Text file

Case 3 : node 55,61 (Permutation No 1~15)
⇒ Excel file, graph

Case 4 : node 1,8
⇒ Text file

* Energy

Energy at DS
Energy at Rock block
Total Energy
} Excel file, graph (Permutation No 1~15)

* Reaction at WP (Permutation No 1~15)
⇒ Excel file, graph

* Stress

Case 1 : Element 6,12 (Permutation No 1~15)
⇒ Excel file, graph

Case 2 : Element 22 (Permutation No 1~15)
⇒ Excel file, graph
Element 18,21,23 (Permutation No 1~15)
⇒ Text file

Case 3 : Element 39,42 (Permutation No 1~15)
⇒ Excel file, graph

Case 4 : Element 48,54 (Permutation No 1~15)
⇒ Excel file, graph

Case 5 : Element 60,66 (Permutation No 1~15)
⇒ ~~Excel~~ cs park Text file

Case 6 : Element 61,70 (Permutation No 1~15)
⇒ Text file

Case 7 : Element 62,71 (Permutation No 1~15)
⇒ Excel file, graph

Case 8 : Element 63,69 (Permutation No 1~15)
⇒ Excel file, graph

Case 9 : Element 59 (Permutation No 1~15)
⇒ Text file

* Von mises Stress

Case 1 : Element 6,12 (Permutation No 1~15)
⇒ Excel file, graph

Case 2 : Element 22 (Permutation No 1~15)
⇒ Excel file, graph
Element 18,21,23 (Permutation No 1~15)
⇒ Text file

Case 3 : Element 39,42 (Permutation No 1~15)
⇒ Excel file, graph

Case 4 : Element 48,54 (Permutation No 1~15)
⇒ Excel file, graph

Case 5 : Element 60,66 (Permutation No 1~15)
⇒ Text file

Case 6 : Element 61,70 (Permutation No 1~15)
⇒ Text file

Case 7 : Element 62,71 (Permutation No 1~15)
⇒ Excel file, graph

Case 8 : Element 63,69 (Permutation No 1~15)
⇒ Excel file, graph

Case 9 : Element 59 (Permutation No 1~15)
⇒ Text file

Permutation No	ABAQUS Runing Time (ms)
1	35
2	35
3	35
4	35
5	35
6	45
7	45
8	50
9	85
10	80
11	100
12	50
13	100
14	70
15	75

· These data are large for Excel
Divide 3 Sections (only Permutation No 11,13 → 4 Sections)
0 ~ 3.000 E-02
3.000 E-02 ~ 6.000 E-02
6.000 E-02 ~ 9.000 E-02
9.000 E-02 ~ 10.000 E-02

Sep 2, 2000 Time 14:00~16:00

Rerun : Case 9

Resubmit : cases 11 and 13

To divide the work cases

	Stress																		
	case1		case2				case3		case4		case5		case6		case7		case8		case9
	6	12	18	21	22	23	39	42	48	54	60	66	61	70	62	71	63	69	59
P1																			
P2																			
P3																			
P4																			
P5																			
P6																			
P7																			
P8																			
P9																			
P10																			
P11																			
P12																			
P13																			
P14																			
P15																			

	Von mises stress																		
	case1		case2				case3		case4		case5		case6		case7		case8		case9
	6	12	18	21	22	23	39	42	48	54	60	66	61	70	62	71	63	69	59
P1																			
P2																			
P3																			
P4																			
P5																			
P6																			
P7																			
P8																			
P9																			
P10																			
P11																			
P12																			
P13																			
P14																			
P15																			

C.S. Park

	Displacement										
	case1			case2				case3		case4	
	3	10	19	60	63	59	62	55	61	1	8
P1											
P2											
P3											
P4											
P5											
P6											
P7											
P8											
P9											
P10											
P11											
P12											
P13											
P14											
P15											

C.S Park

	Energy			Reaction	
	Ener1	Ener2	Ener3	RF1	RF2
P1					
P2					
P3					
P4					
P5					
P6					
P7					
P8					
P9					
P10					
P11					
P12					
P13					
P14					
P15					

C.S Park

Sep 3, 2000 Time 13:00~15:00

To modify the standard excel file

(cover the stress graphs which have 6 kinds value)

Sep 4, 2000 Time 13:00~17:00

· Rerun Case 10

- To summary the X-Y plot of displacement at nodes 3,10,19

Sep 5, 2000 Time 18:00~22:00

- Restart Case 9

· To make the X-Y plot of displacement at node 22,39,42

Sep 6, 2000 Time : 14:00~18:00

· To make the X-Y plot of displacement at node 22,39,42

Sep 7, 2000 Time 11:00~12:00 14:00~17:00

· Continue to make the X-Y plot of displacement at node 22,39,42

Sep 8, 2000 Time 15:00~18:00

· Restart case 13

· To make the X-Y plot of displacement at node 48,54,62,71

Sep 9, 2000 Time 19:00~21:00

Continue to make the X-Y plot of displacement at node 48, 54, 62, 71

Sep 10, 2000 Time 15:00~17:00

Continue to make the X-Y plot of displacement at node 48, 54, 62, 71

· Restart Case 11

Sep 11, 2000 Time 16:00~20:00

To make the X-Y plot of displacement at node 63, 69

Sep 12, 2000 Time 19:00~22:00

To make the X-Y plot of the displacement at node 63, 69

Sep 13, 2000 Time 14:00~18:00

To add the X-Y plot of displacement (Cases 9, 11, 10, 13)

Sep 14, 2000 Time : 13:00~16:00

To add the X-Y plot of the displacement

Sep 15, 2000 Time : 17:00 ~ 21:00

To make the summary table for the displacement (clearance between DS and WP)

The clearance between WP and DS

	Impact condition			node 3		Clearance (mm)	node 10		node 19		Clearance (mm)
	Energy	Mass(kg)	velocity(m/s)	Displacement (mm)	time(sec)		Displacement (mm)	time	Displacement (mm)	time(sec)	
Case1	12250	500	7.0000	-36.02	0.012	634.28	-35.87	0.012	-35.73	0.012	544.38
Case2	24500	500	9.8995	-60.78	0.015	606.24	-60.54	0.017	-60.23	0.017	514.97
Case3	49000	500	14.0000	-112.40	0.019	560.98	-108.50	0.021	-107.80	0.021	463.36
Case4	24500	1000	7.0000	-70.20	0.022	589.50	-69.61	0.022	-69.20	0.022	501.08
Case5	49000	1000	9.8995	-136.30	0.028	518.12	-120.60	0.026	-119.70	0.026	445.89
Case6	98000	1000	14.0000	-264.60	0.033	384.41	-223.60	0.035	-222.50	0.035	334.79
Case7	49000	2000	7.0000	-154.90	0.038	489.04	-131.70	0.037	-130.70	0.037	424.52
Case8	98000	2000	9.8995	-283.40	0.046	362.74	-240.30	0.045	-239.10	0.045	307.71
Case9	196000	2000	14.0000	-532.00	0.072	77.96	-485.70	0.076	-484.20	0.076	31.76
Case10	98000	4000	7.0000	-304.50	0.065	312.01	-260.00	0.066	-258.60	0.066	267.79
Case11	196000	4000	9.8995	-567.00	0.095	39.58	-509.00	0.085	-507.30	0.085	-0.21
Case12	12250	4000	2.4749	-54.25	0.041	586.33	-53.51	0.041	-52.78	0.041	496.37
Case13	196000	8000	7.0000	-549.20	0.094	58.36	-500.40	0.094	-498.50	0.094	-0.24
Case14	12250	8000	1.7500	-64.87	0.064	562.64	-59.91	0.059	-59.03	0.059	473.66
Case15	24501	8000	2.4749	-118.30	0.074	489.84	-96.04	0.065	-95.04	0.065	432.43

node 3 & 10 : the bottom point at the top of dripshield

node 3 : location without bulkhead

node 10 : location with bulkhead

node 19 : the bottom point at the top of bulkhead

Clearance = Height at node - Top of WP -upward WP

Location	Height (mm)	Init. Clearance (mm)
node 3 & 10	2516	682
node 19	2426	592
Top of WP	1834	
Center of WP	1012	
Radius of WP	822	

Clearance

C.S Park

Sep 16, 2000 Time 13:00 ~ 15:00
- To capture the displacement graph by photo editor

Sep 17, 2000 Time : 18:00 ~ 20:00
- To capture the displacement graph by photo editor

Sep 18, 2000 Time 13:00 ~ 17:00
- To capture the displacement graph by photo editor.

Sep 19, 2000 Time 13:00 ~ 17:00 19:00 ~ 23:00
- To make the X-Y plot of Energy at DS, Rockblock and Total

Sep 20, 2000 Time 13:00 ~ 17:00 19:00 ~ 23:00
- To make the X-Y plot of Energy at DS, Rockblock and Total

Sep 21, 2000 Time 13:00 ~ 17:00 19:00 ~ 23:00
- To make the X-Y plot of Energy at DS, Rockblock and Total
- To capture the Energy graphs by photo editor

Sep 22, 2000 Time 14:00 ~ 17:00 19:00 ~ 24:00
- To capture the energy graphs by photo editor

Sep 23, 2000 Time : 10:00 ~ 12:00 13:00 ~ 17:00
- To make the X-Y plot of Reaction at WP

Sep 24, 2000 Time 13:00 ~ 17:00 19:00 ~ 23:00
- To make the X-Y plot of Reaction at WP
- To capture the reaction at WP graphs

Sep 25, 2000 Time 13:00 ~ 17:00 18:00 ~ 22:00
- To make the X-Y plot of stress

Sep 26, 2000 Time 13:00 ~ 17:00

- To make the X-Y plot of Stress

Sep 27, 2000 Time 22:00 ~ 24:00

- To make the X-Y plot of stress

Sep 28, 2000 Time 13:00 ~ 17:00 19:00 ~ 23:00

- To make the X-Y plot of stress

Sep 29, 2000 Time 13:00 ~ 17:00 18:00 ~ 22:00

- To make the X-Y plot of Von mises stress

Sep 30, 2000 Time 11:00 ~ 14:00 15:00 ~ 17:00 19:00 ~ 21:00

To make the X-Y plot of Von mises Stress
To capture the graph by photo editor

Oct 1, 2000 Time : 13:00 ~ 17:30 19:00 ~ 23:00

- To capture the graphs by photo editor.
- To summary the reaction, stress and Von misee stress.

Oct 2, 2000 Time 13:00 ~ 17:00 19:00 ~ 23:00

- To summary the reaction Stress and Von misee stress.
- To make the report

Oct 3, 2000 Time 13:00 ~ 17:00 19:00 ~ 23:00

- To make the report

Oct 4, 2000 Time 14:00 ~ 16:00 18:00 ~ 20:00

- To make the report

Oct 5, 2000 Time 19:00 ~ 21:00

- To modify the report

Oct 6, 2000 Time 14:00 ~ 17:00

To modify the report

Oct 9, 2000 Time 19:00 ~ 21:00

To modify the report

I have reviewed this scientific notebook and find it in agreement with QAP-001.

4-12-05