

HIPAVE

Overview



MINCAD
Systems

rev. August 2005



HIPAVE- Powerful and user-friendly

- **HIPAVE 5.0 is a major step forward in pavement design:
- a fully integrated system with superior design power and ease of use**



the best of the old and the new...

- **HIPAVE 5.0 draws on the proven technology of earlier versions of CIRCLY software [used on thousands of pavement designs over 20 years] and APSDS (Airport Pavement Structural Design System).**
- **Our system introduces a number of powerful new features:**
 - **enormous input data flexibility**
 - **extensive data-base saving re-entry of frequently used data**
 - **new parameters easily defined**



all important design inputs:

TRAFFIC

- any combination of vehicle types or load configurations
- any wheel layout
- braking or vertical loads
- varying contact stress distributions

MATERIALS

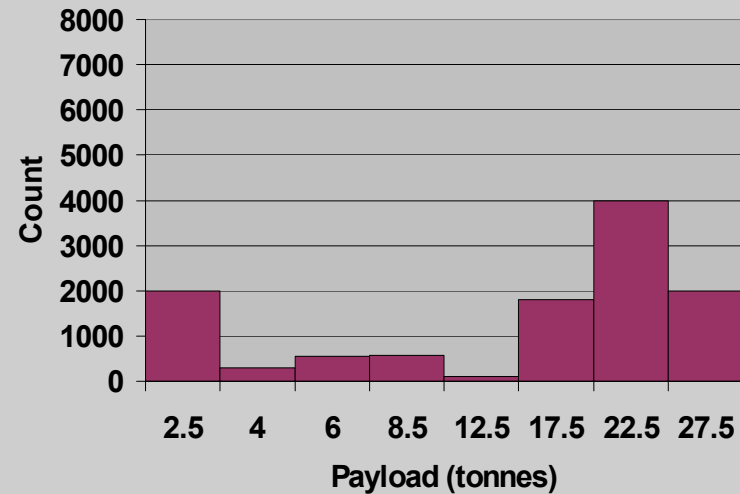
- any damage model
- isotropic or anisotropic

Sample Traffic Mix

Vehicle Model A



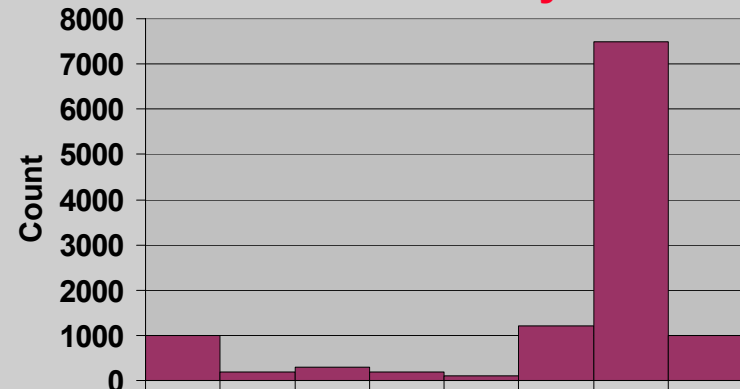
Vehicle Model A – Payload Distribution



Vehicle Model B



Vehicle Model B – Payload Distribution



Comprehensive range of vehicle types



Forklift, Mast Lift



Tractor-Trailers, Trucks



Straddle Carriers

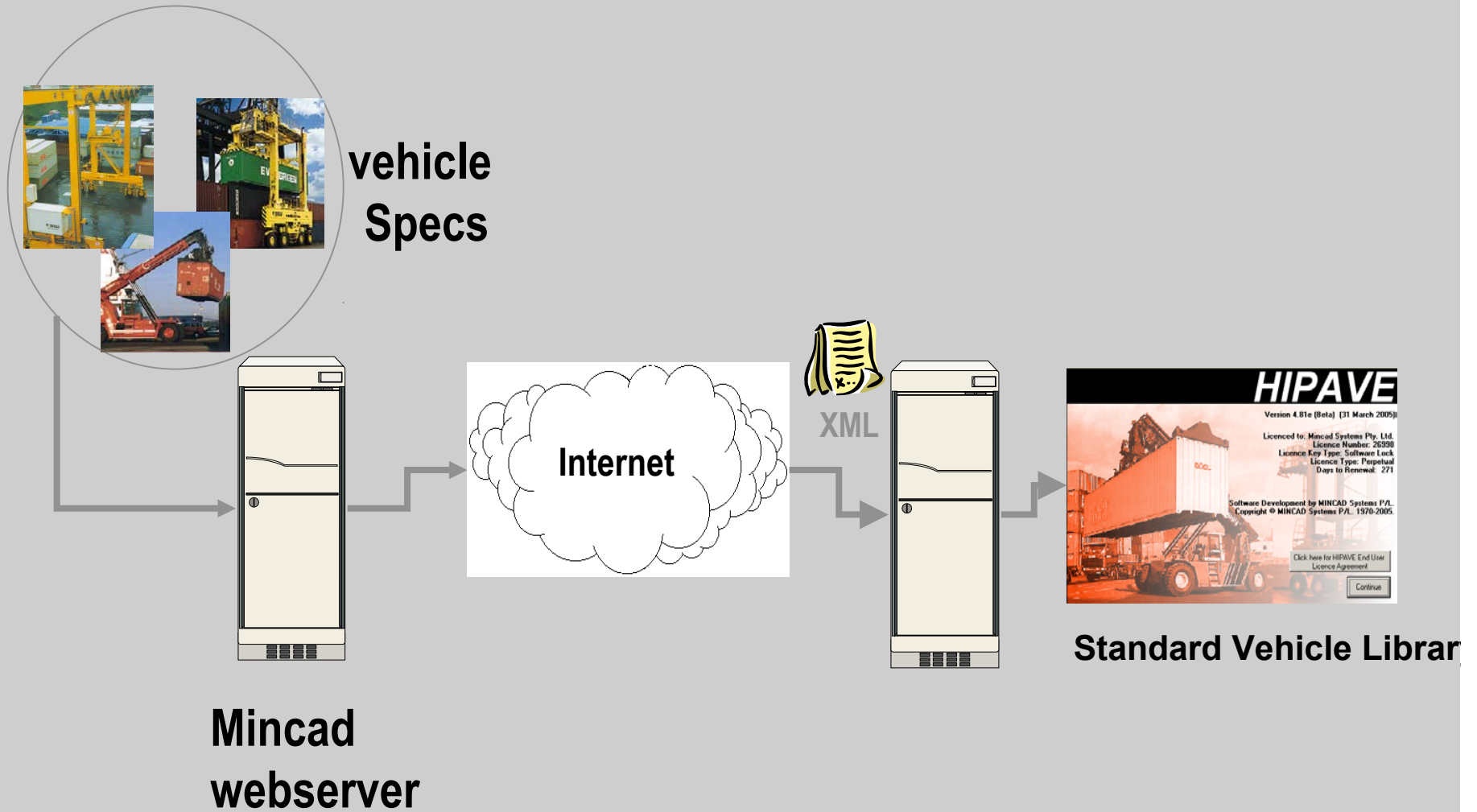


Reach Stackers



Rubber Tyred Gantry

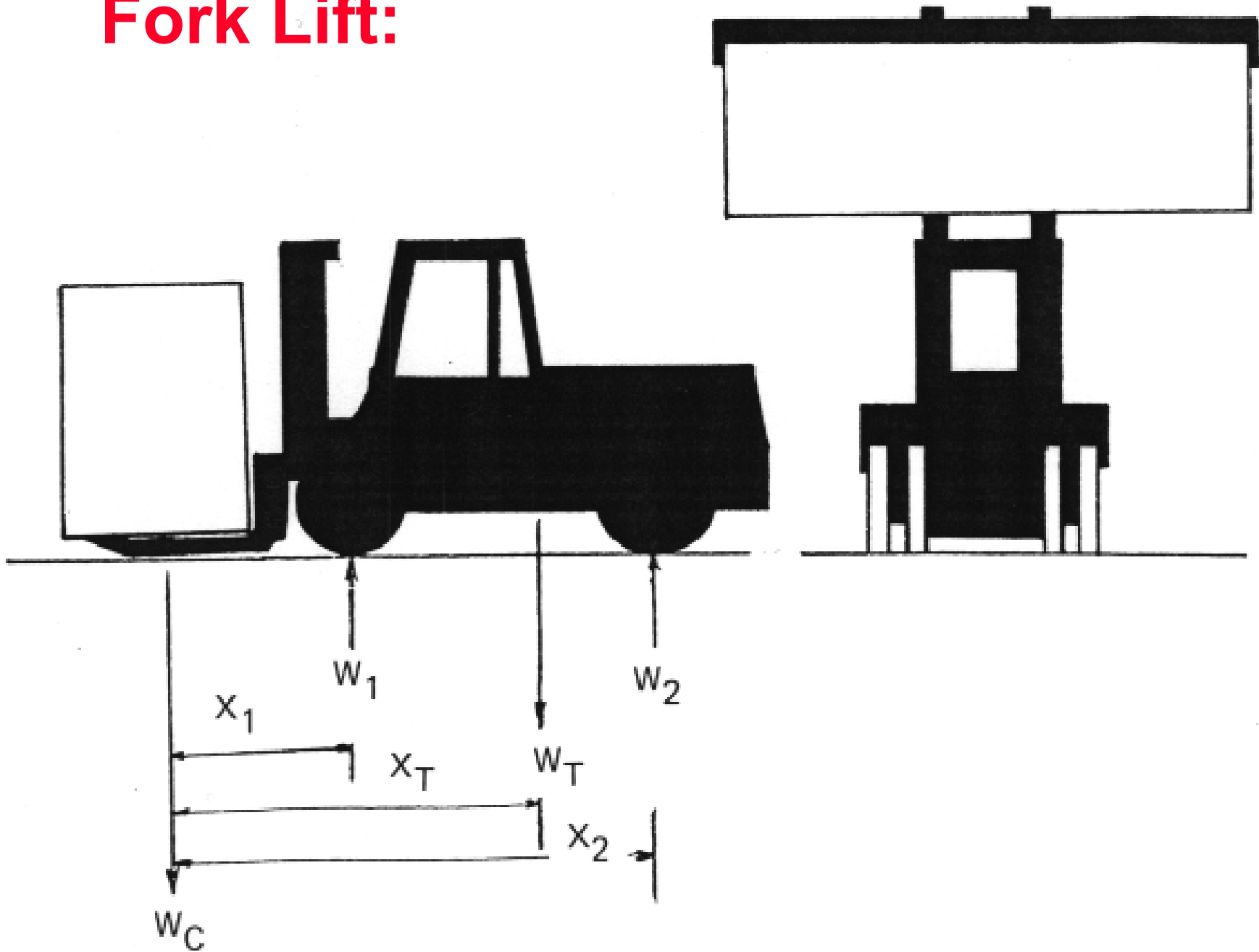
Standard Vehicle Library – automatically updated from webservice



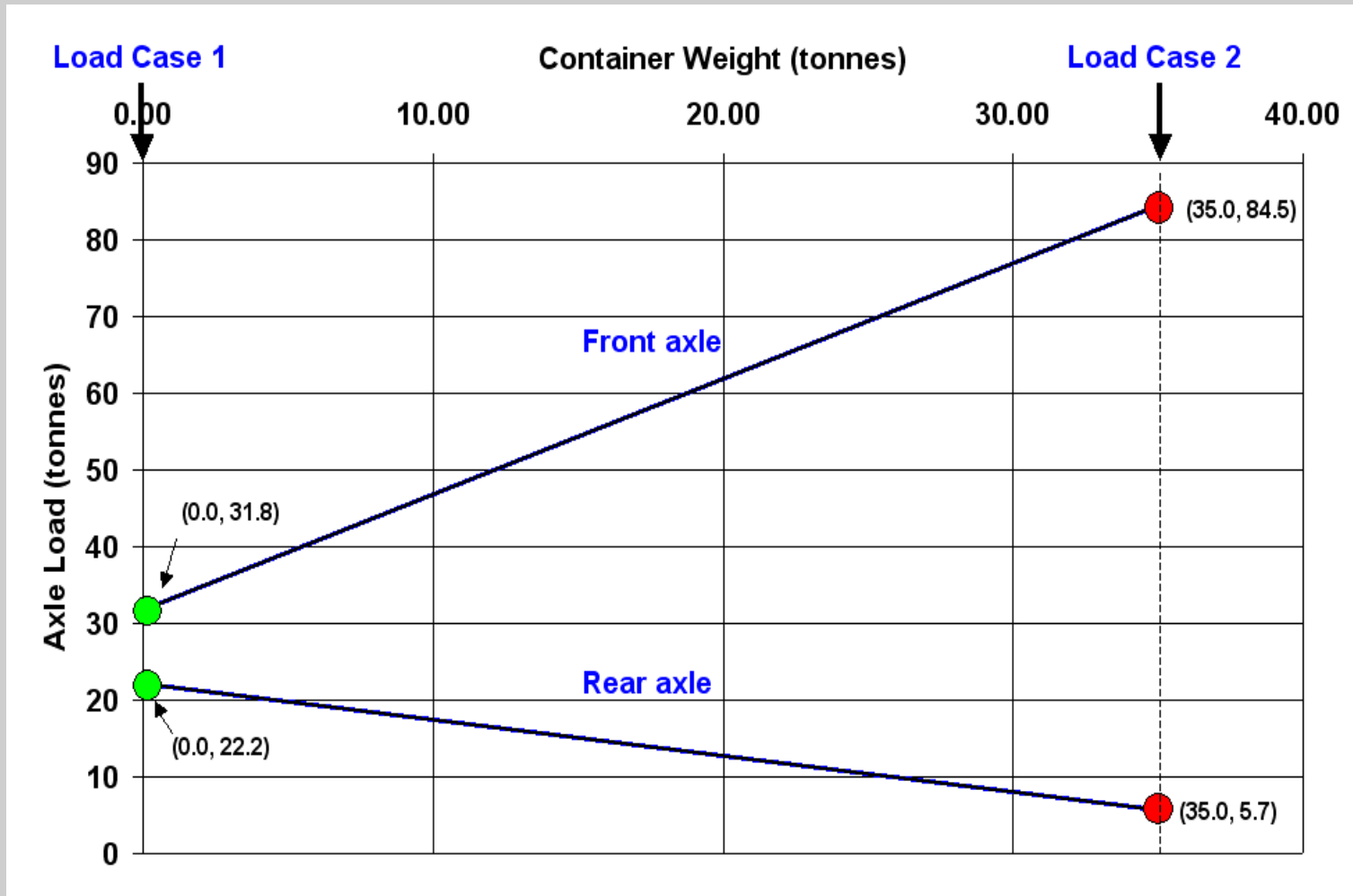


Automatic Calculation of Wheel Loads for Container Vehicles...

Fork Lift:



Fork Lift: Axle Load vs. Container Mass



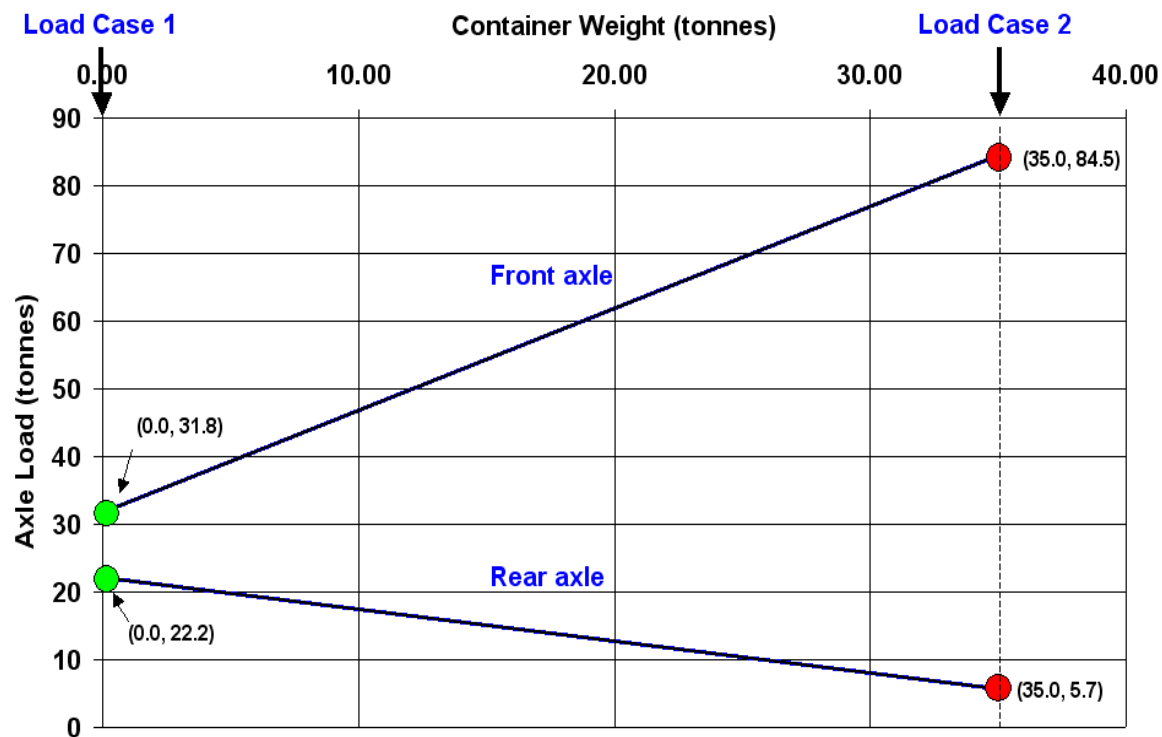
HIPAVE: Axle Load vs. Container Mass

Kalmar DCD370-12

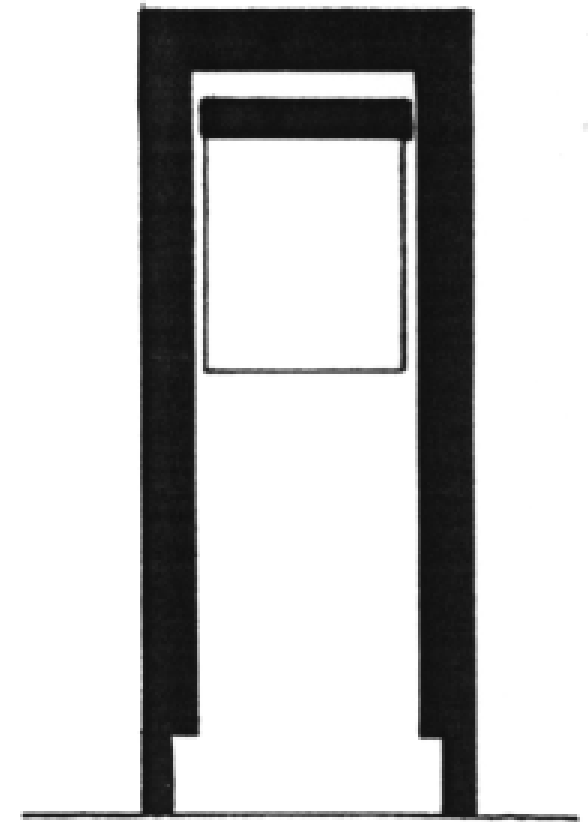
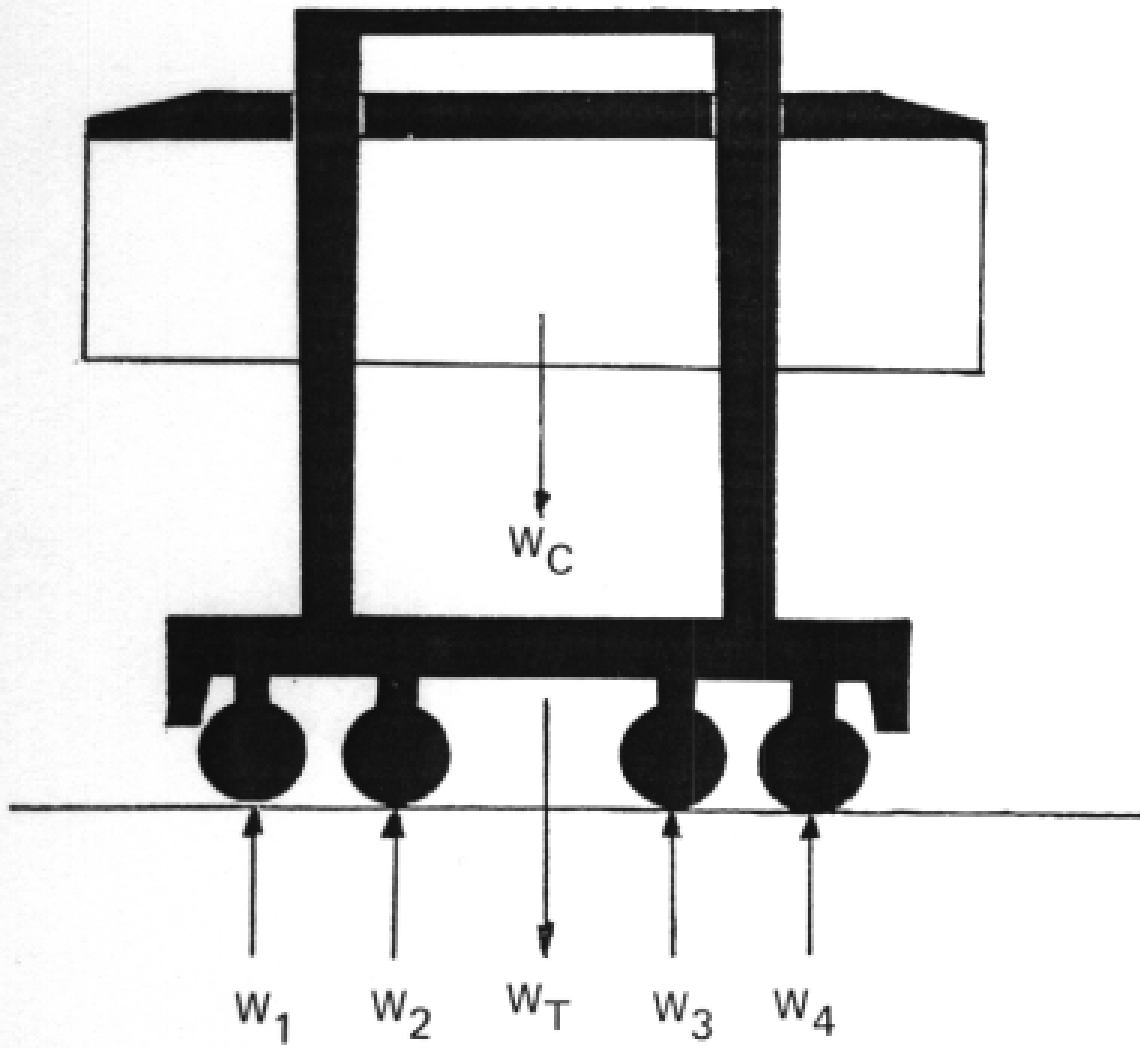
Characteristics:

Payload (Load Case 1): Payload (Load Case 2):

Component No.	Tyre Pressure	Axle Load: (Load Case 1)	Axle Load: (Load Case 2)	Number of Wheels
1	0.90	31.78	84.51	4
2	0.90	22.15	5.70	2



Straddle Carrier



Straddle Carrier

Vehicle Models | Load Components and Locations

Type: Manufacturer: Scope:

ID	Title	Plot Label	Scope
▶ KalmESC340fc	Kalmar ESC340 front cabin	Kalmar ESC340	Library
KalmESC340sc	Kalmar ESC340 side cabin	Kalmar ESC340	Library
KalmESC350	Kalmar ESC350 front cabin, twin lift	Kalmar ESC350	Library
KalmESC440	Kalmar ESC440 front cabin	Kalmar ESC440	Library
KalmESC450	Kalmar ESC450 front cabin, twin lift	Kalmar ESC450	Library

Straddle Carrier characteristics conveniently specified in terms of 4 simple parameters...

Kalmar ESC340 front cabin

Characteristics:

Number of Axle Rows: Total Number of Wheels:

Tyre Pressure: Unladen Weight:

Custom Payload Distribution



Spectrum Spectrum Components Wander

Two Forklift Models - each using Custom Payload Distribution

ID	Title	Movements	Graph Label
HysterH40C	Hyster H40.00E-16CH	1.00E+05	
HysterH48	Hyster H48.00E	5.00E+04	

New

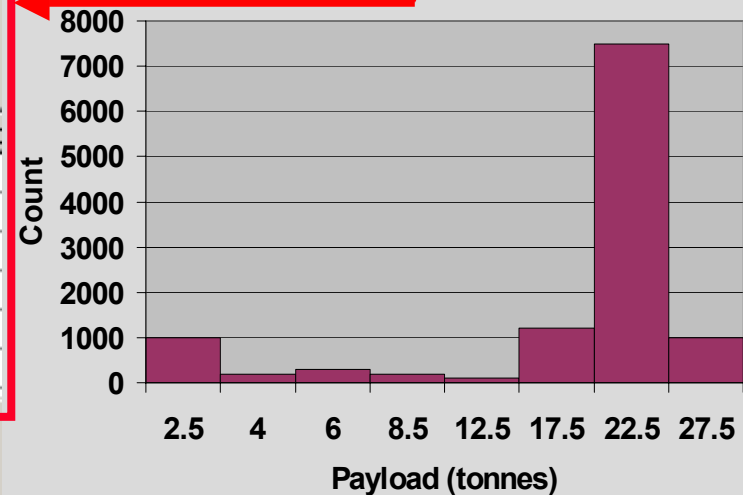
Delete

Payload Distribution:

Distribution Type: Custom

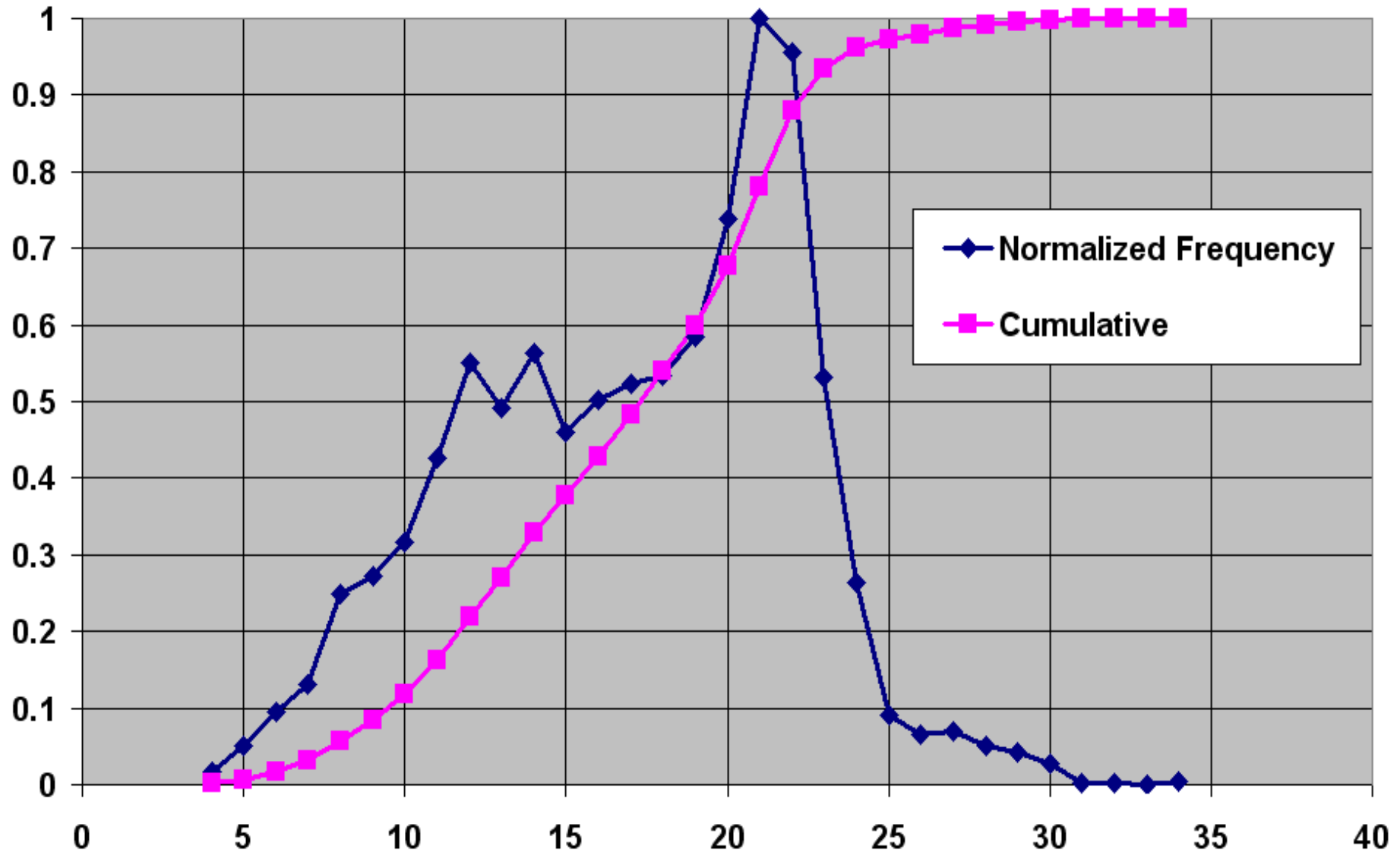
	Payload	Count	Normalized Movements	Ac
	2.50	1000	0.087	
	4.00	200	0.017	
	6.00	300	0.026	
	8.50	200	0.017	
	12.50	100	0.009	
	17.50	1200	0.104	

New



Standard Container Weight Distribution

e.g. British Ports Association (1996) - 40 ft containers



Standard Payload Distribution



Payload Distributions

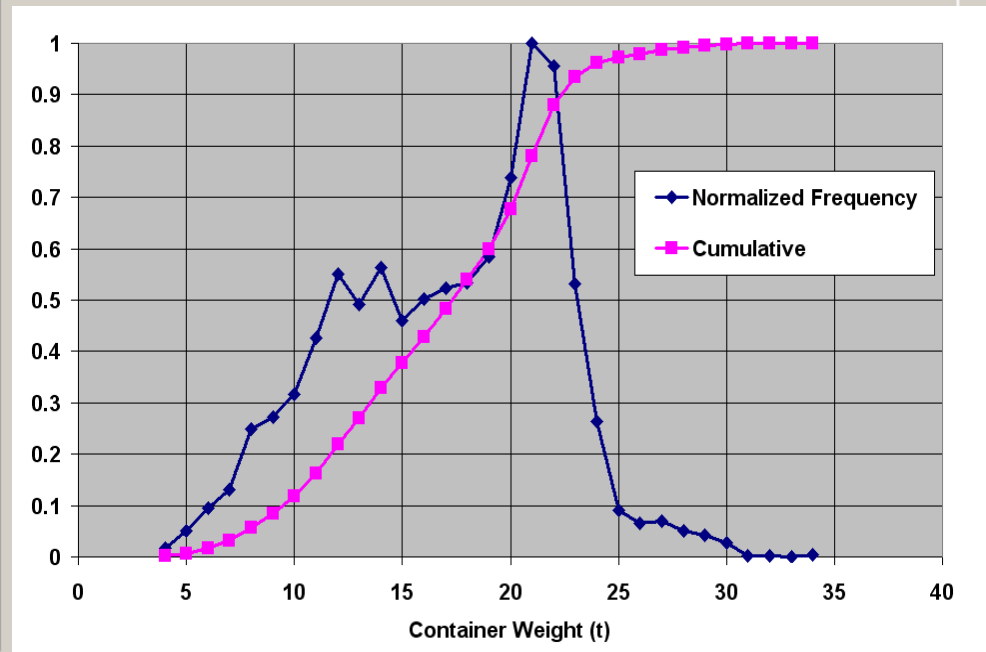
Distribution Details

e.g. British Ports Association (1996) - 40 ft containers

British Ports Association Guide 1996 - 100% x 20ft

	Payload	Count	Normalized Movements
▶	2.00	0.46	0.005
	3.00	1.49	0.015
	4.00	2.95	0.029
	5.00	3.96	0.040
	6.00	3.94	0.039
	7.00	3.97	0.040
	8.00	3.72	0.037
	9.00	3.41	0.034
	10.00	3.66	0.037
	11.00	4.04	0.040
	12.00	4.50	0.045
	13.00	4.41	0.044
	14.00	4.67	0.047
	15.00	5.63	0.056
	16.00	6.13	0.061
	17.00	6.21	0.062
	18.00	6.46	0.065
	19.00	7.58	0.076
	20.00	9.19	0.092
	21.00	6.72	0.067
	22.00	4.08	0.041

Can be used in multiple Traffic Spectrums



New

Delete



Lateral Vehicle Wander

- **A critical design parameter**
- **A normal distribution is assumed**
- **Standard Deviation of wander distribution can vary with vehicle type**



Dynamic Load Factors

- **Dynamic Load Factors used by the British Ports Association Design Guide**
- **Simple way to account for effects of dynamic loading from:**
 - **cornering, accelerating, braking and surface unevenness.**
- **These simple multipliers are applied to the design loads**
- **Can vary with each axle**
- **HIPAVE lets you use your own values**



The pavement system...

HIPAVE realistically models pavement response:

- **any combination of layer thicknesses and elastic properties**
- **state of the art damage indicators**

Typical layered pavement model

	Thickness (mm)	Modulus (MPa)	Poisson's Ratio
Asphalt	200	2800	0.4
Base Course/ Subbase Course	110	600	0.35
	150	600	0.35
	150	480	0.35
	150	240	0.35
	150	120	0.35
	150	60	0.35
Subgrade CBR = 3	Infinite	30	0.45

✓ anisotropic properties
can be used

How damage models are defined

- A damage model relates pavement life to an indicator of damage such as subgrade compressive strain, etc.
- The models are of the form:

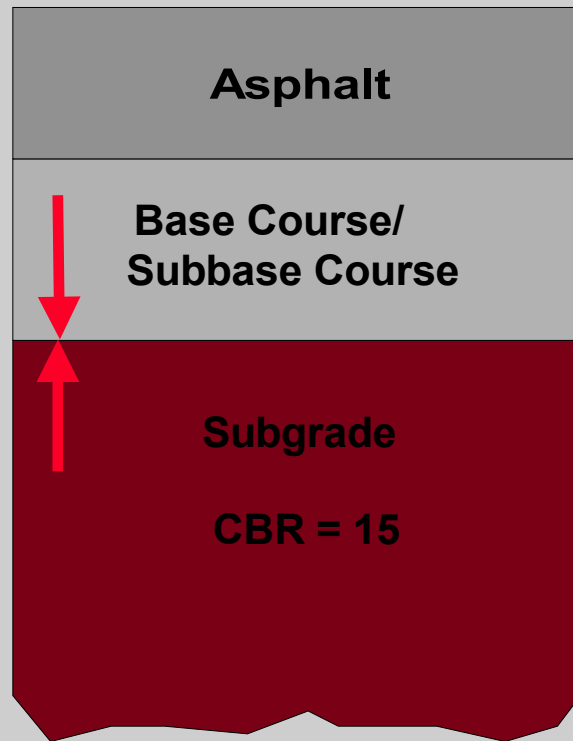
$$N = \left(\frac{k}{\varepsilon} \right)^b$$

where N is the predicted life
(repetitions to failure)
k is a material constant
b is the damage exponent
 ε is the induced strain

You can choose damage indicators

Example:

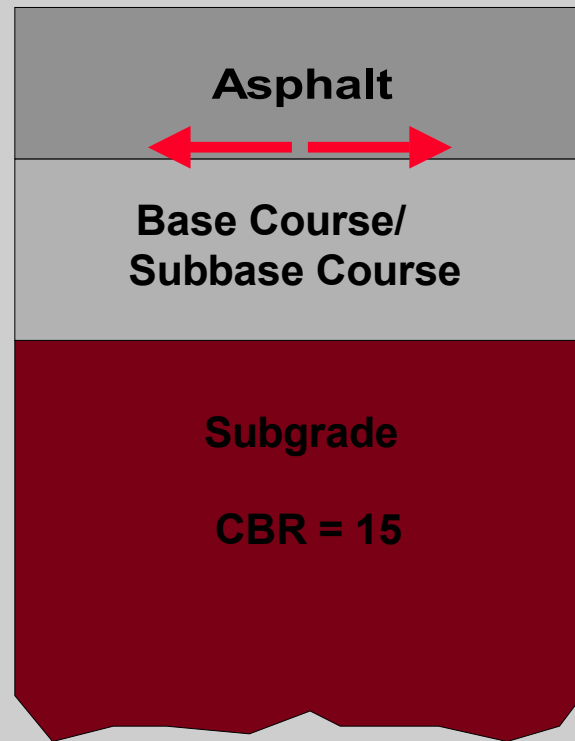
Vertical
strain



You can choose damage indicators

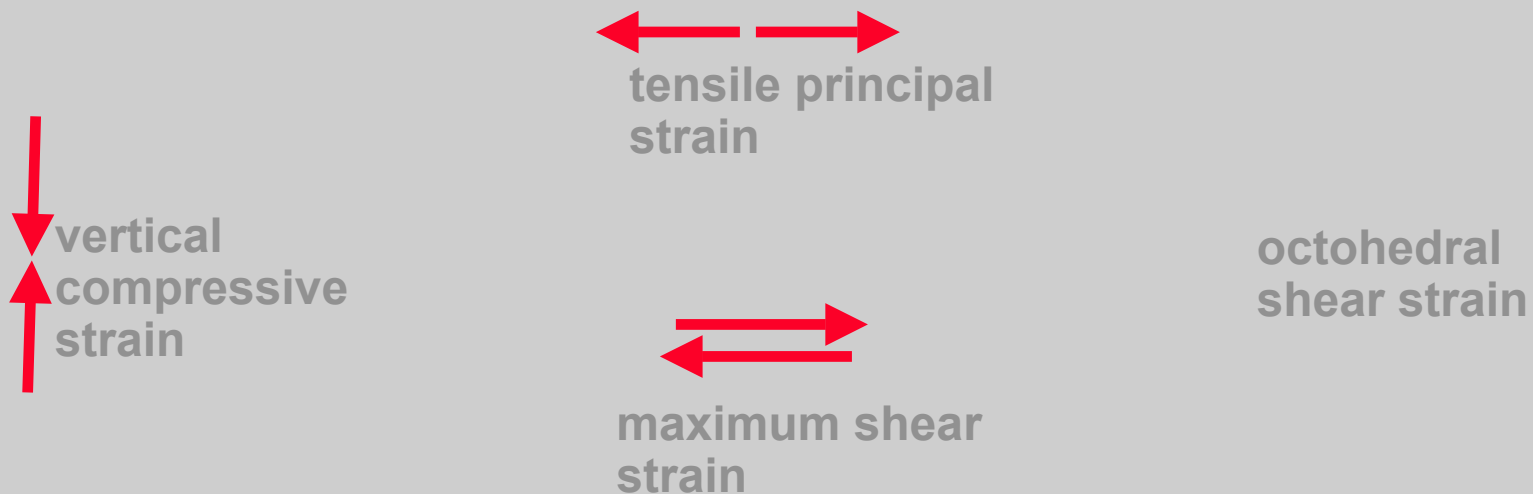
Example:

Tensile
strain



HIPAVE handles all damage models

- you can define new models
- models can use any deflection, strain or stress component, e.g.:





HIPAVE gives *fast* results:

- **Once parameters are defined, typical runs take only seconds on Pentium PCs**
- **Even the most complex combinations of vehicles and the most complicated pavement structures take seconds, not hours!**



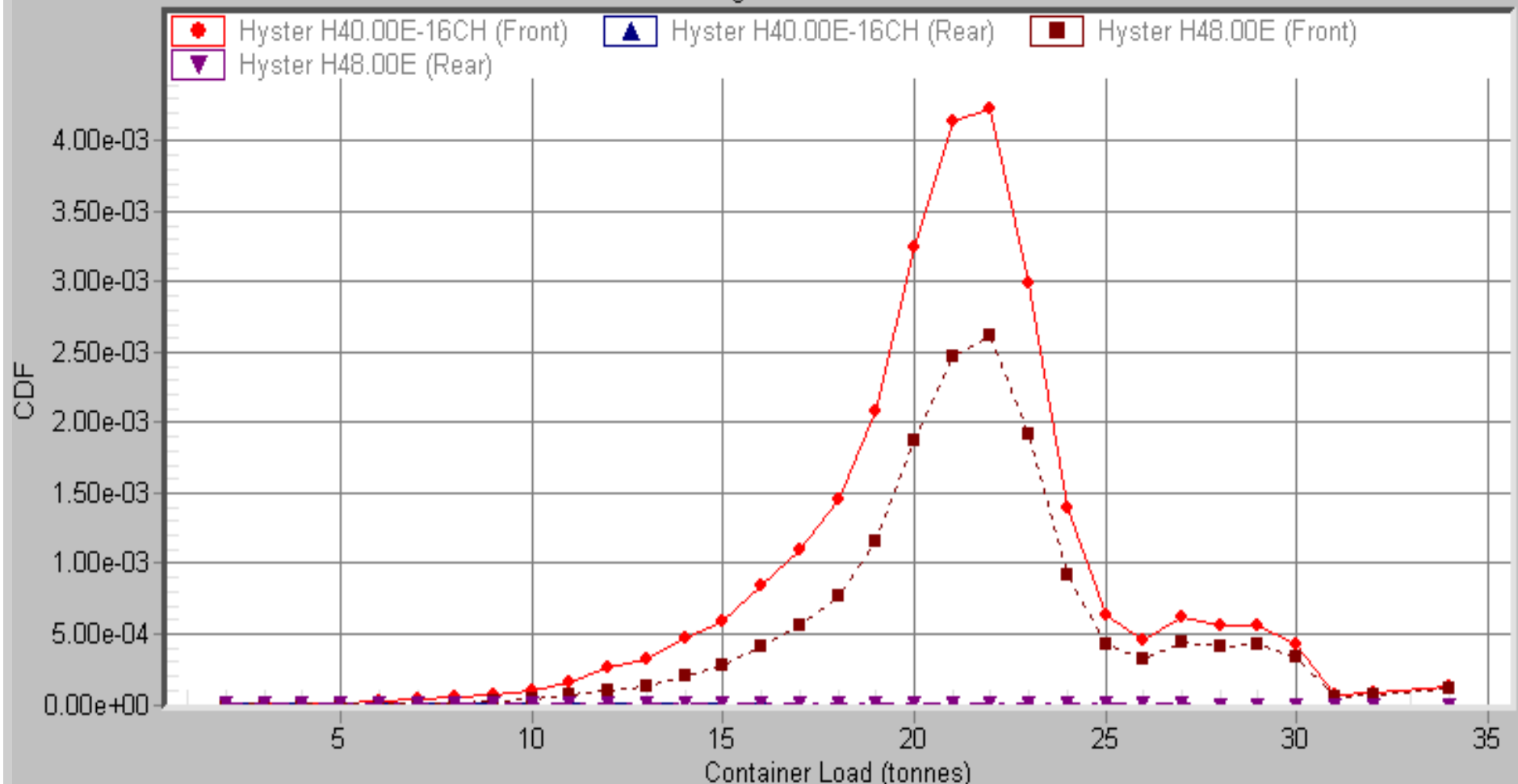
Results presentation

high quality plots can be output on any printer

Sample Damage Factor vs. Container Mass

Example 1 - Traffic Mix consisting of two main Forklift Models

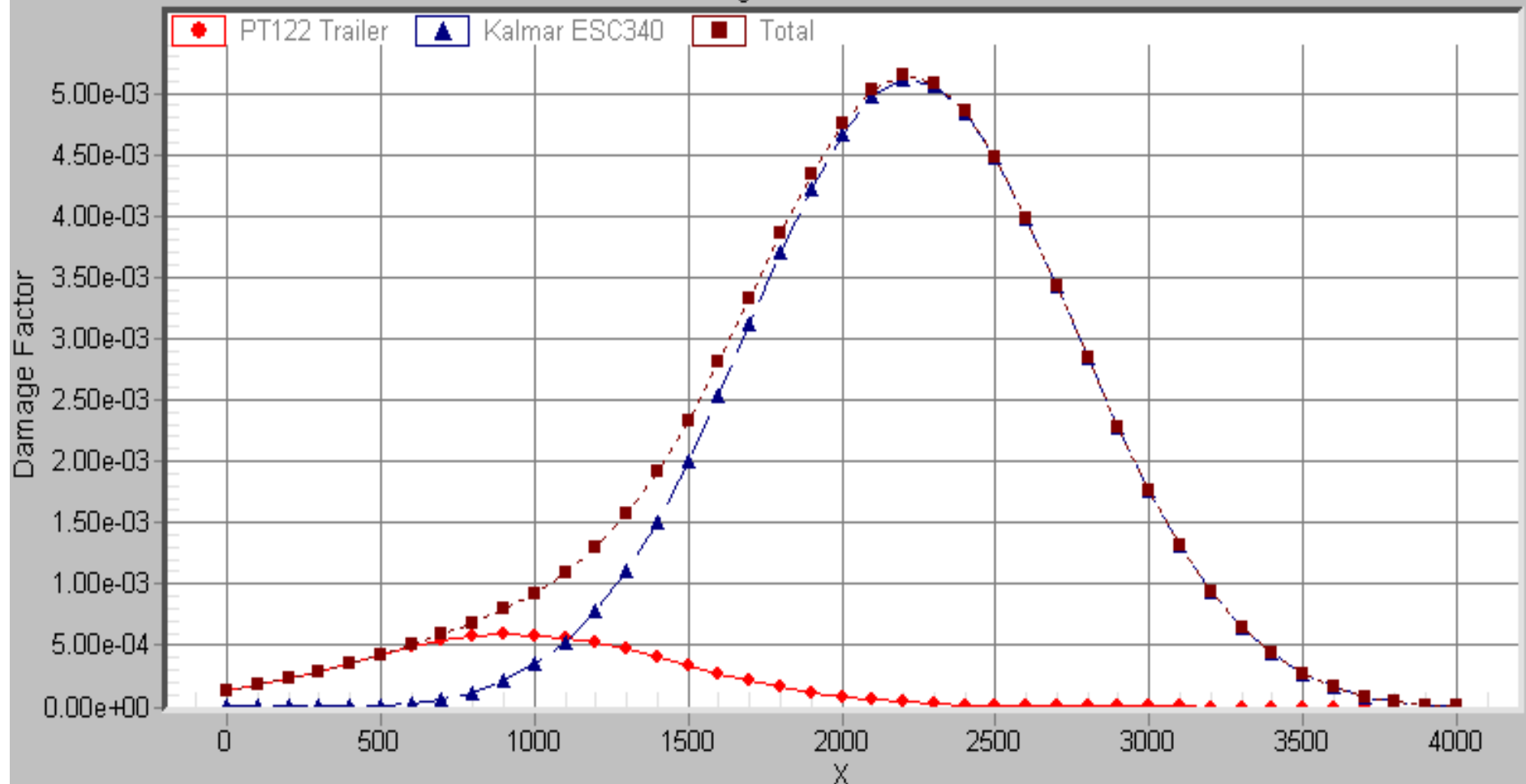
Subgrade CBR=6



Sample Damage Factor vs. Distance

Doha Case Study - Load Case B - Straddle and Tractor-Trailer - import distn.

Subgrade CBR15

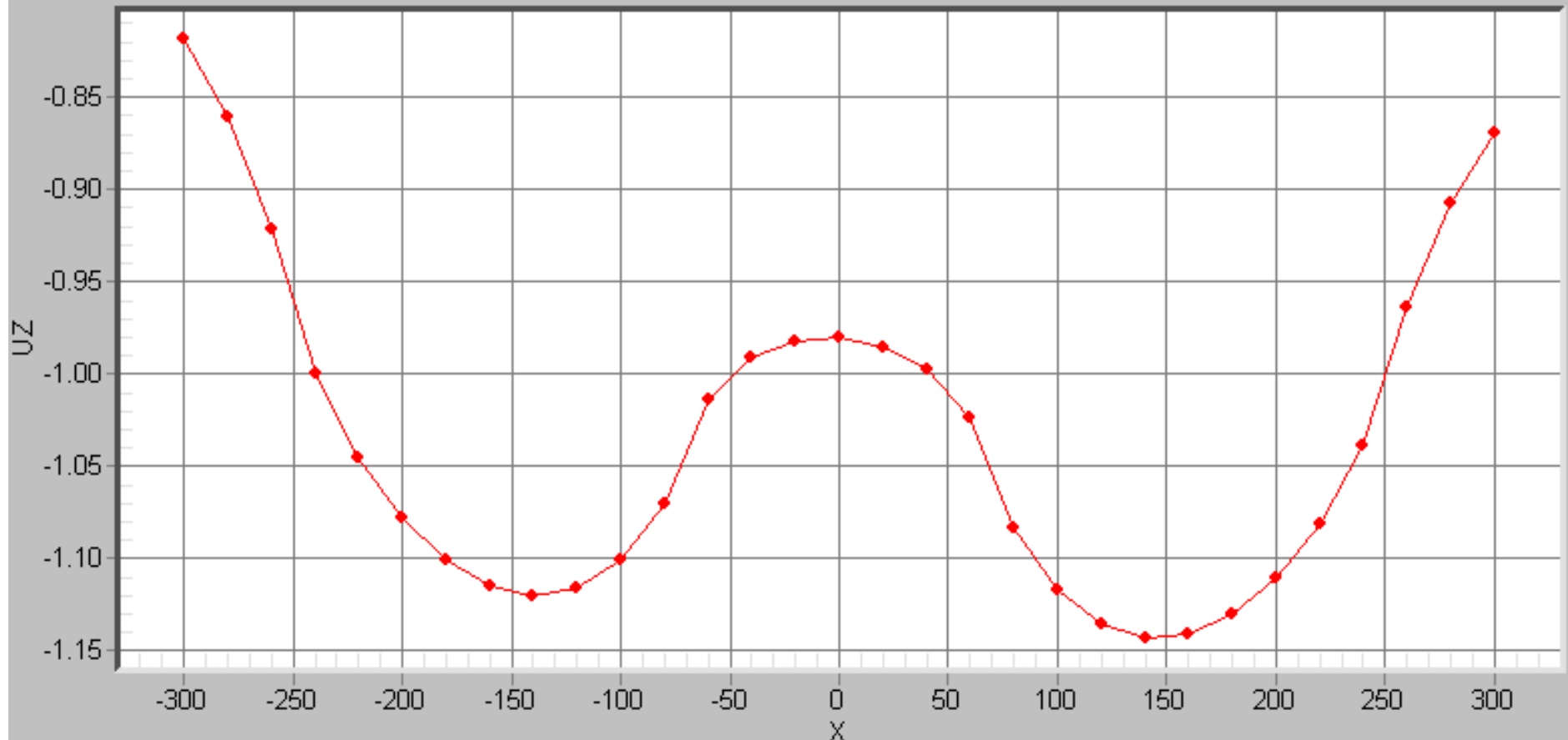


Results presentation

any deflection, strain or stress component,
e.g. surface displacements

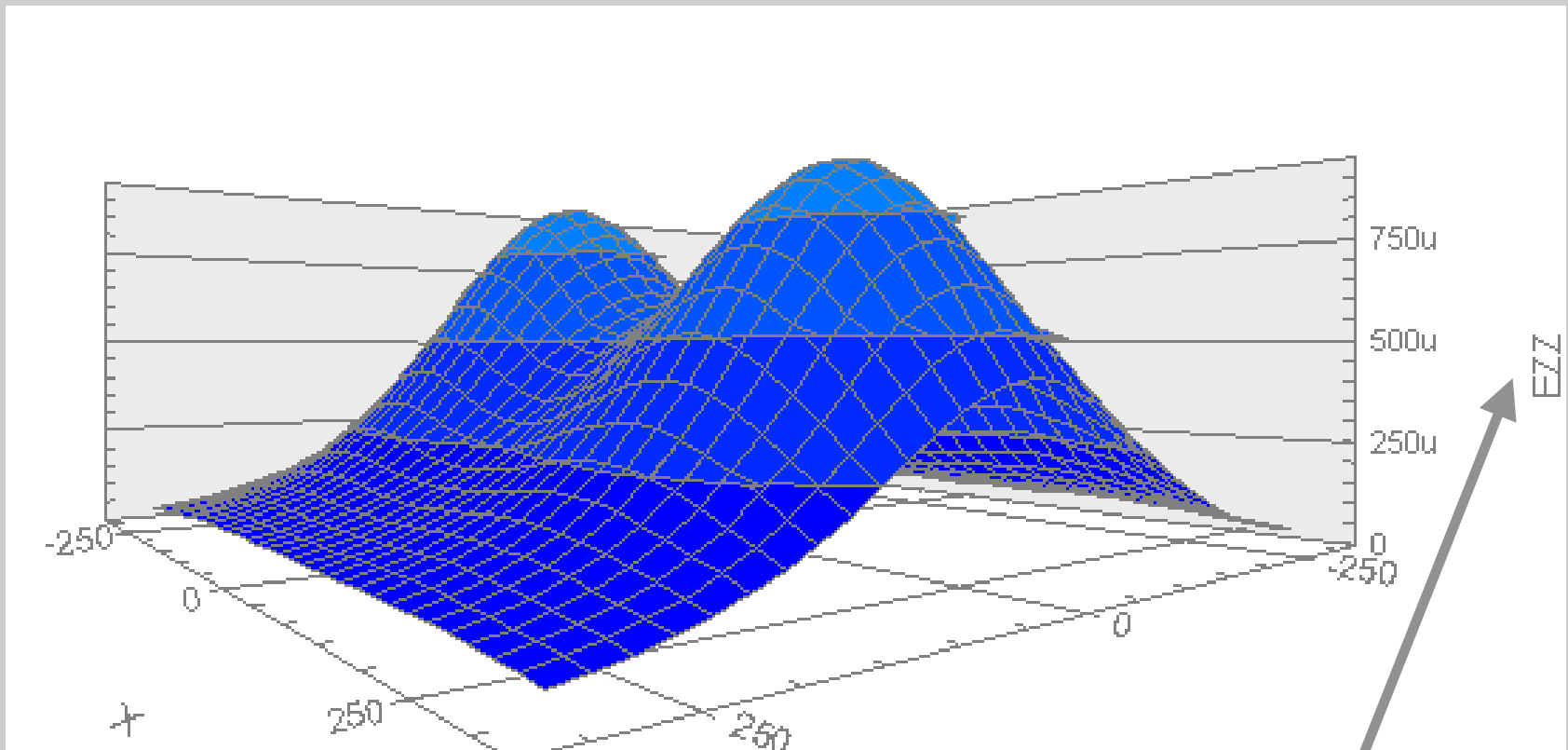
Austrroads 2004 - Example 1 - Unbound Granular Pavement - Selected Z-values

Z= 0.000



Results presentation

any deflection, strain or stress component,
e.g. strain pulse under dual wheels

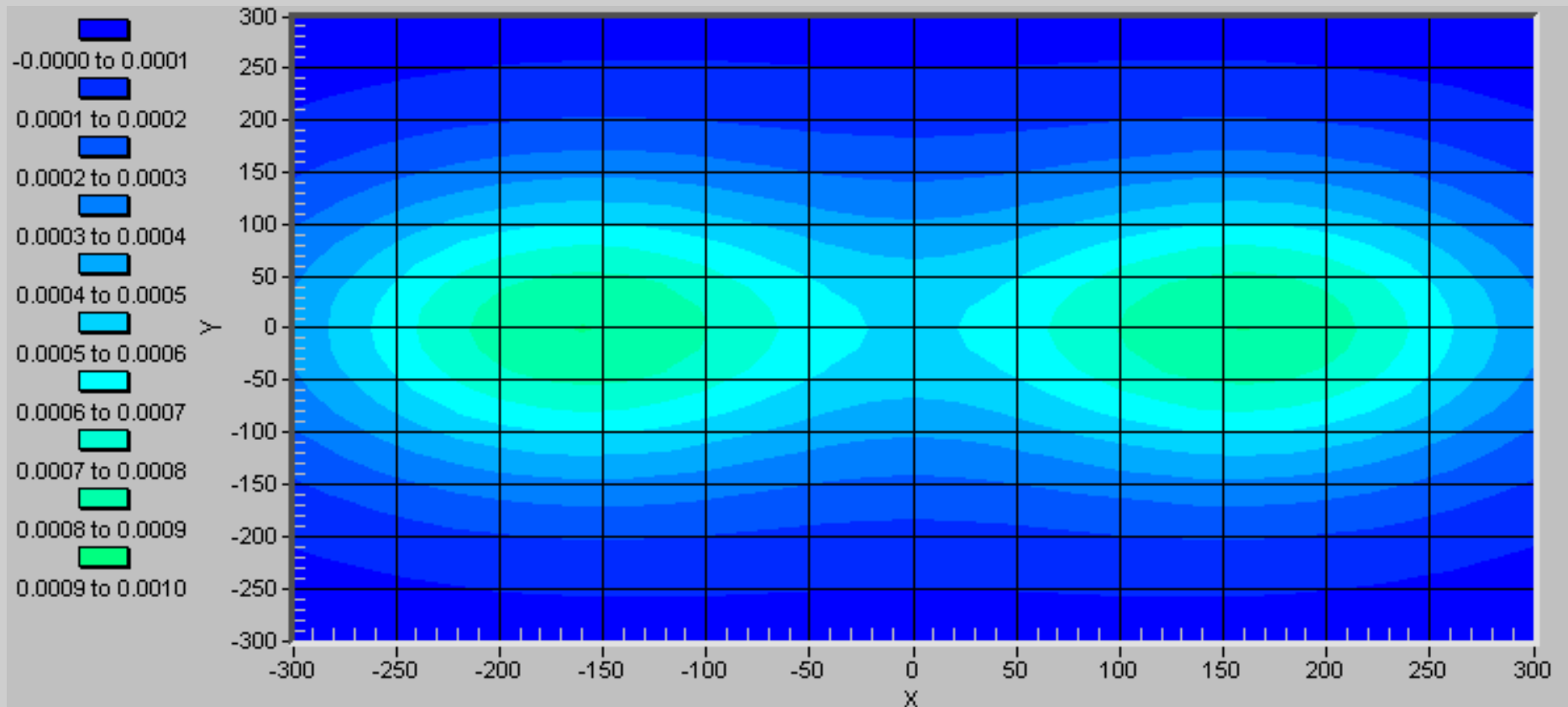


Vertical strain

Results presentation

any deflection, strain or stress component,
e.g. strain pulse under dual wheels

Vertical strain



Automatic Thickness Design

HIPAVE: Example 1 - [Damage Calculation Details]

File Edit Analysis Options Help

Calculate damage factors
 Calculate selected results at user-defined z-values

Parametric Analysis

Traffic Spectrum: Two Forklift Models - each using Standard Payload Distribution

Summary | Reliability

Design thickness of layer highlighted below Calculate Cost

No.	ID	Title	Minimum Thickness	Maximum Thickness	Current Thickness	CDF
1	Asph2800	Asphalt- 2800MPa			100.00	2.01E-02
2	BBBase	Barker-Brabston (Base)			200.00	
3	BBSubbase	Barker-Brabston (Subbase)			525.31	
4	cbr6	Subgrade CBR=6			0.00	1.01E+00

Here is the thickness determined for this example

The criterion used is for CDF=1.0

This analysis takes a few seconds on a

No.	Use in Max CDF	Material type	Performance Criterion	Multiplier
1	<input checked="" type="checkbox"/>	Asphalt (asphalt)	Shell asphalt criterion	1.00
			Wardle, Rodway and Rickards (2001)	1.00

Cost Calculation

HIPAVE: Example for Cost Optimization - [Damage Calculation Details]

File Edit Analysis Options Help

TITLE $\sum d_i$ MAX Import

Calculation option:
 Calculate damage factors Calculate selected results at user-defined z-values

Parametric Analysis

Traffic Spectrum: Example for Cost Optimization - forklift - simple custom payload distr.

Summary | Reliability

Design thickness of layer highlighted below Calculate Cost Total Cost: \$53.93/m²

No.	ID	Title	Current Thickness	CDF
1	Asph3000	Asphalt- 3000 MPa, VB=11%	50.00	1.00E+00
2	BBBase	Barker-Brabston (Base)	392.21	
3	BBSubbase	Barker-Brabston (Subbase)	920.00	
4	cbr6	Subgrade CBR=6	0.00	5.61E-01

Performance Criteria and Traffic multipliers:

No.	Material Type	Performance Criterion	Multiplier
1	Asphalt (new)	Asphalt- 3000 MPa, VB=11%	1.00
4	Subgrade (isotropic)	CBR=6, Wardle, Rodway and Rickards (2001)	1.00

Cost Calculation

CIRCLY: Economic Analysis - Pavement Option A1 - [Materials]

File Edit Analysis Options Help



Elastic Materials Performance **Costs** Material Types

Entry of Unit Material Costs

Asphalt

ID	Title	Cost/Volume [\$/m3]	Cost/Weight [\$/tonne]	Weight/Volume [tonne/m3]	Cost/Area [\$/m2]
▶ 14H-40	Size 14 Type H - 40km/h		\$115.00	2.50	\$0.00
20R-40	Size 20 Type R - 40km/h		\$125.00	2.50	\$0.00
20T-40	Size 20 Type T - 40km/h		\$115.00	2.50	\$0.00
Asph2000	Asphalt- 2000MPa	\$240.00			\$0.00
Asph2800	Asphalt- 2800MPa	\$240.00			\$0.00
Asph3000	Asphalt- 3000 MPa, VB=11%	\$248.88			\$8.88
Asphalt	Asphalt- 1400 MPa	\$240.00			\$0.00
AustSize14	Austrroads 2004- Example 3- Size 14				
AustSize20	Austrroads 2004- Example 3- Size 20				



Automatic Parametric Analysis

- **Automatically loop through one or two thickness ranges**
- **Simultaneously design the thickness of another layer**
- **Lets you fine-tune layer thicknesses to minimize construction and maintenance costs**

Cost Optimization Example

Thickness

Unit Cost

$T_1 = 50 \text{ mm}$

Asphalt: Asphalt- 3000 MPa, VB=11%

\$240 / m³

$T_2 = ?$

Base

\$60 / m³

$T_3 = ?$

Sub-base

\$20 / m³

Subgrade, CBR = 6

Cost Optimization Case Study

Summary of Results

Layer 3 Thickness	Layer 2 Thickness	Max. CDF	Total Cost (\$/m ²)
700	445	1.0	52.7
800	368	1.0	50.1
900	289	1.0	47.4
1000	275	1.0	48.5
1100	275	1.0	50.5

Minimum Cost

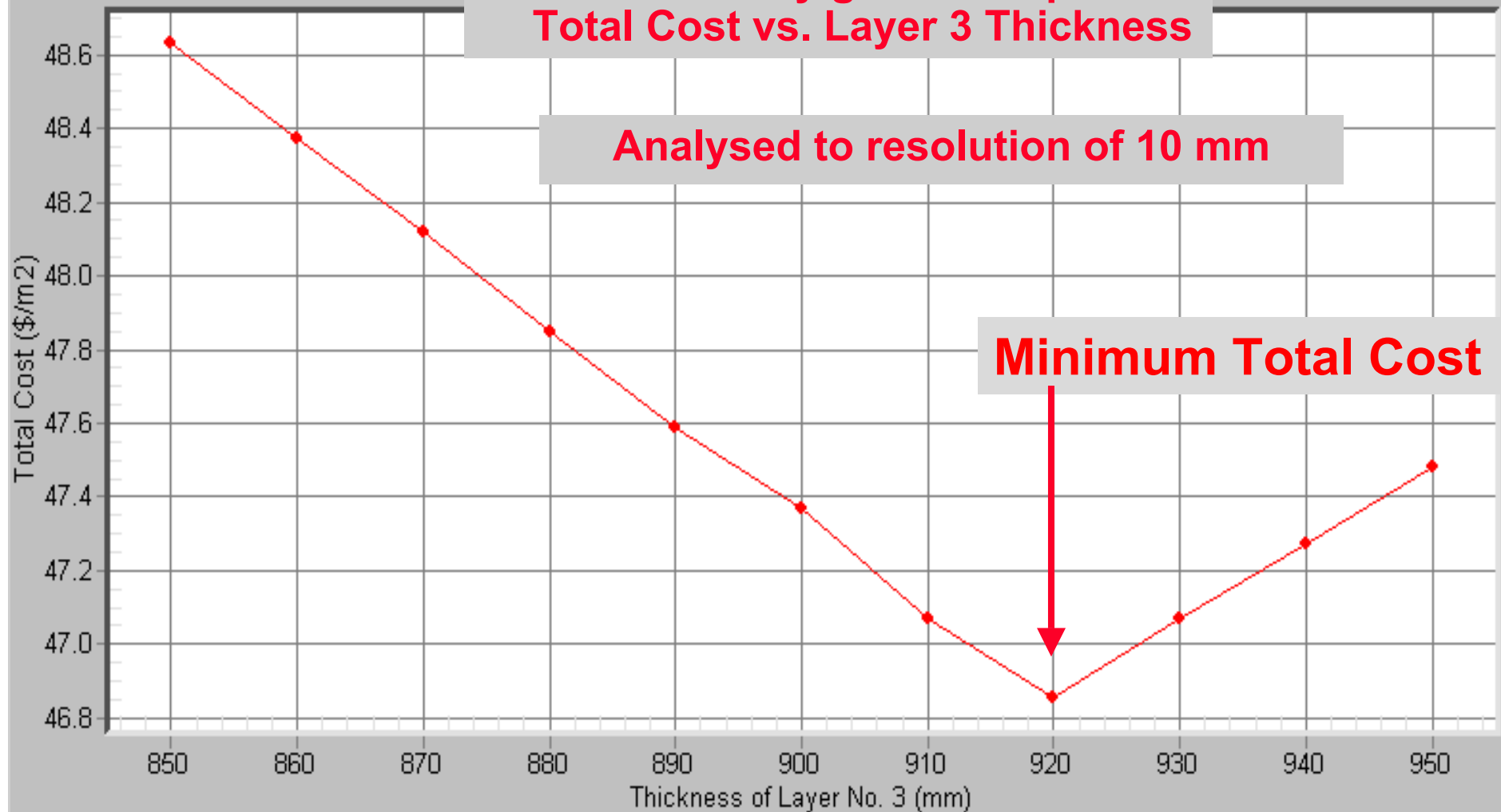


Cost Optimization: How it works....

Parameter: Total Cost

Automatically generated plot:
Total Cost vs. Layer 3 Thickness

Analysed to resolution of 10 mm



In summary.....



A complete design system.....

- **models actual traffic spectrum**
- **models all design vehicle loads**
- **uses multi-layered pavement**
- **predicts pavement life with user-defined state-of-the-art damage models**



HIPAVE - easy to use.....

- **complete integrated system**
- **runs on IBM-compatible PCs**
- **rapid analysis**
- **ready-to-use databases for vehicle loading, pavement composition and damage models**
- **new parameters easily defined**
- **quality hard copies of results on any printer or plotter**



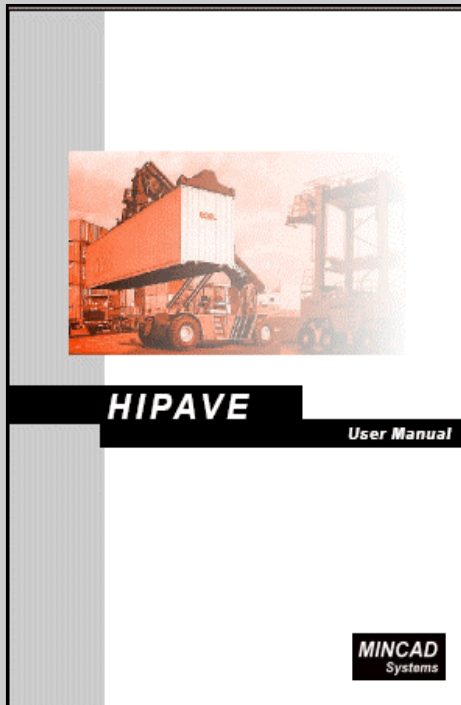
How does HIPAVE differ from CIRCLY and APSDS?

- a comparison of the features of our three pavement design packages....

Feature Comparison

	CIRCLY 5.0	APSDS 4.0	HIPAVE 5.0
Application Profile:	Road pavements- streets, roads, highways	Airport pavements	Container and intermodal terminal pavements
Key Core Features:	no wander	rigorous wander algorithm	rigorous wander algorithm
	parametric analysis		parametric analysis
	economic analysis		economic analysis
	support for 2004 Austroads Pavement Design Guide	Barker-Brabston heavy duty unbound materials <i>New</i>	Barker-Brabston heavy duty unbound materials
			Standard Vehicle Library with automatic updates
			Automatic calculation of axle loads from vehicle geometry and container mass
			automatic treatment

Technical Support



- **Comprehensive 105 page User Manual includes worked examples**
- **Users are notified of updates**
- **Latest version can be downloaded from website**

HIPAVE



MINCAD
Systems

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