HAL Cars & Short-Line Track

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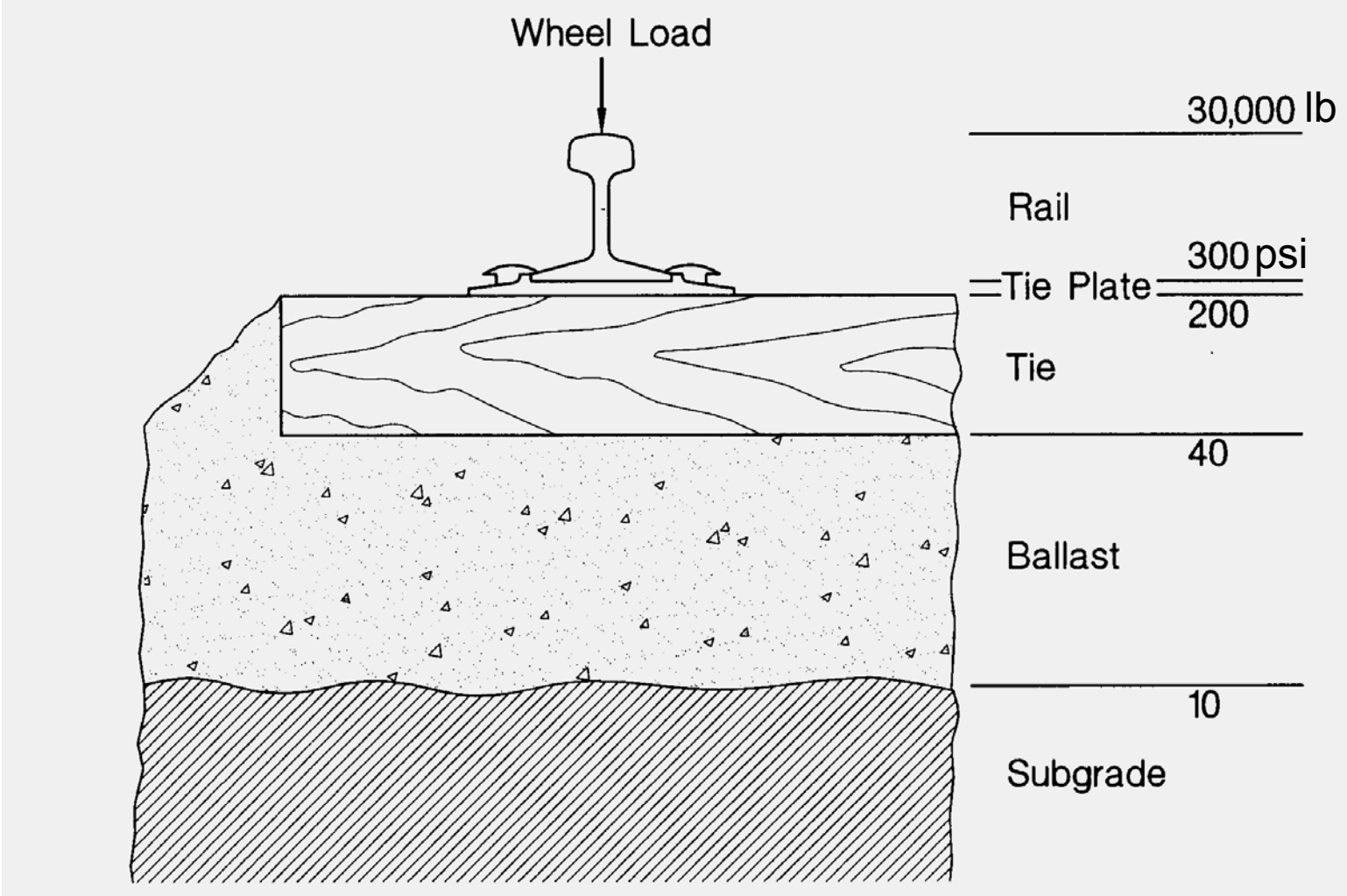
Primary Track Impact Factors

- Wheel load
- Speed
- Rail weight
- Track modulus
  - Subgrade resilient modulus
  - Ballast depth
  - Effective tie spacing (tie condition)
- Unit trains per day

Theoretical Load Distribution



U.S. Departments of the Army and Air Force. *Railroad Design and Rehabilitation*, 1995.

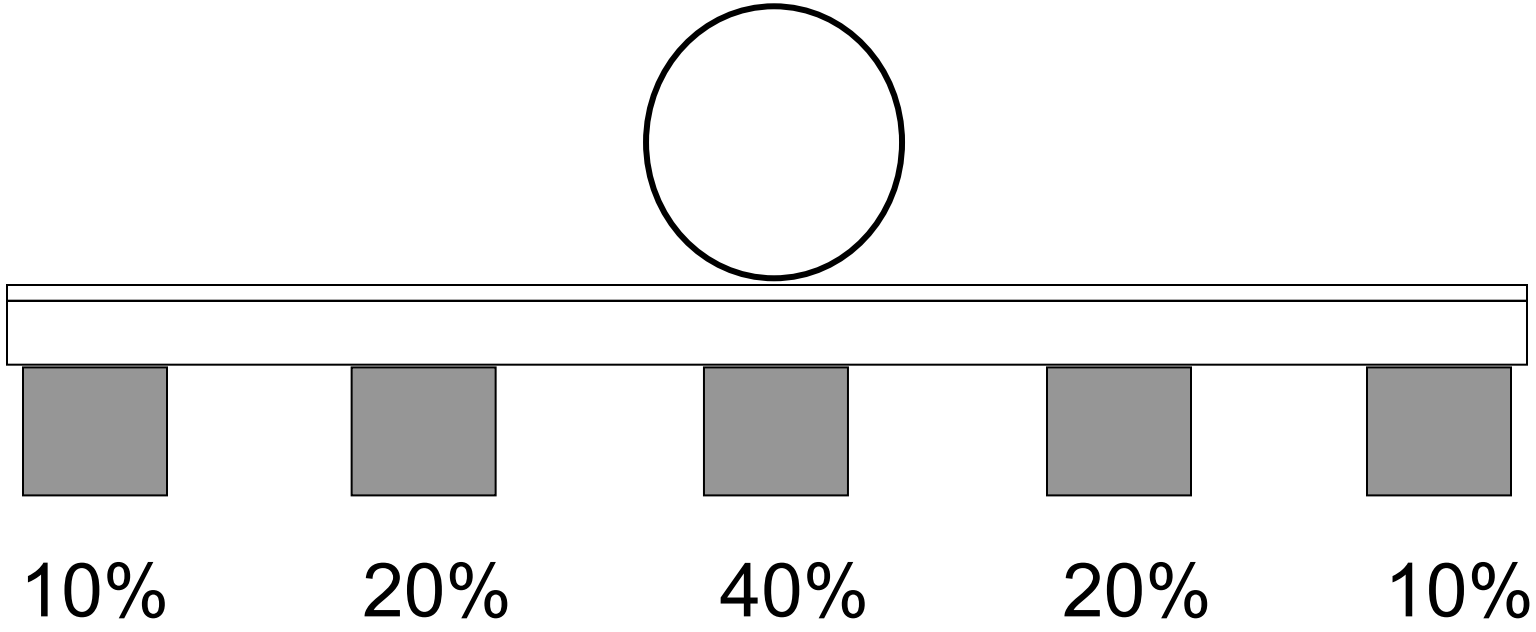
Good versus Poor Track

Comparative Track Modulus: 115-lb Rail at 25 MPH

Ballast Depth (inches)	*Subgrade Modulus (psi)*		
	Very Soft	*Soft*	*Medium*
8*	1,240	2,065	3,160
12	1,355	2,255	3,450
18	1,480	2,465	3,770
24	1,575	2,625	4,015

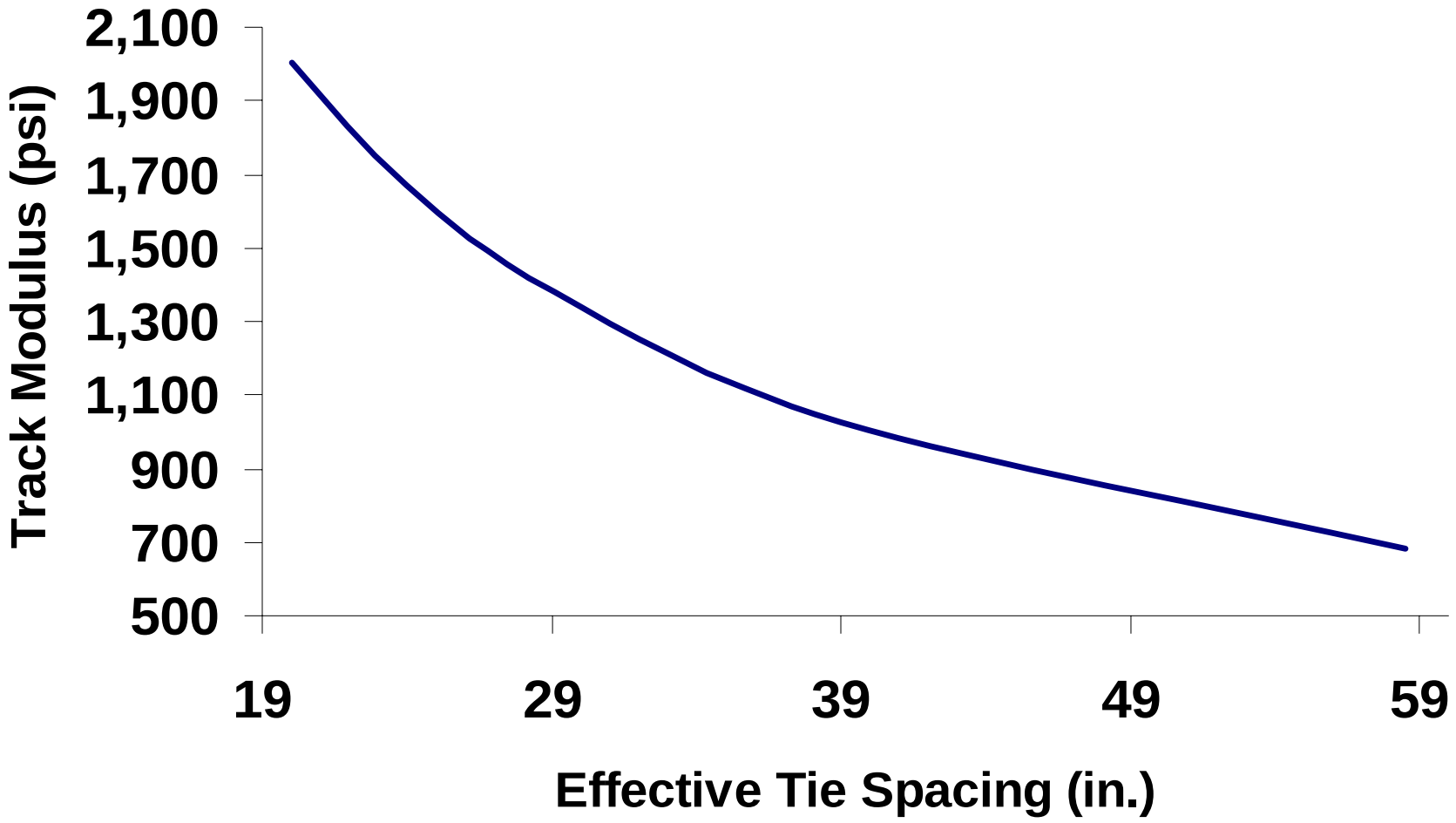
Based on AAR Illi-Track Algorithms (1989) with 20″ tie spacing

Theoretical Load Distribution to Ties



Assumes effective tie spacing ≈ 20″; with effective spacing of 28″ the center tie would bear ≈ 60% of load

Tie Spacing & Track Modulus



Vertical Track Deflection Ranges and Expected Track Behavior

Max. Deflection (Inches)	*Track Impact*
≤ 0.13	Track lasts a long time
0.13 – 0.25	Normal-to-max: heavy track
0.25 – 0.36	Normal-to-max: light track
≥ 0.40	Track deteriorates quickly

Source: Hay, 1982

Comparative Track Deflection 115-lb Rail at 25 MPH

Ballast Depth (inches)	*Subgrade*		
	Very Soft	*Soft*	*Medium*
8*	0.54	0.31	0.19
12	0.49	0.28	0.18
18	0.44	0.25	0.16
24	0.42	0.24	0.15

Based on AAR Illi-Track Algorithms (1989) with 20″ tie spacing

Comparative Track Deflection 115-lb Rail at 25 MPH

Ballast Depth (inches)	*Subgrade*		
	Very Soft	*Soft*	*Medium*
8*	0.70	0.38	0.27
12	0.68	0.37	0.26
18	0.58	0.31	0.22
24	0.53	0.29	0.20

Based on AAR Illi-Track Algorithms (1989) with 24″ tie spacing

Comparative Track Deflection 115-lb Rail at 50 MPH

Ballast Depth (inches)	*Subgrade*		
	Very Soft	*Soft*	*Medium*
8*	0.78	0.44	0.28
12	0.70	0.40	0.25
18	0.64	0.36	0.23
24	0.60	0.34	0.21

Based on AAR Illi-Track Algorithms (1989) with 20″ tie spacing

Effects of Tie Spacing, Lighter Rail, and Track Quality

- A tie spacing of 39″ further reduces modulus ≈ ⅓ from 24″ spacing
- 90-lb rail increases deflection by ≈ 15% compared to 115-lb rail
- 10 mph speed reduces deflection ≈ 10%
- Dynamic impacts based on track condition are much greater than speed alone

Equated Track Maintenance Cost Factors

Car Weight (lb)	Maintenance Factor	With Unit Trains
220,000	1.02	1.11
263,000	1.30	1.42
286,000	1.50	1.64

Assumes normal maintenance, good ties and ballast, medium subgrade

Cost Savings

- More net tons per given train size
  - Economies of utilization: crew, train adm. & other train-mile costs
- Reduced train resistance (lb/ton)
  - Fuel
  - Emissions
- Better car utilization: may offset higher initial cost of cars