Creating Value ...

... Providing Solutions

Railroad Engineering 101

Session 38

Tuesday, February 19, 2013

Presented by: David Wilcock

Baker

Railroad Engineering 101

- **Outline**
  - Overview of the Railroad
  - Track
  - Bridges
  - Signal Systems
  - Railroad Operations
  - Federal Railroad Administration
  - American Railway Engineering and Maintenance Association

Railroad Engineering 101

- **Overview of the Railroad**
  - **Classifications (Types)**
    - **Private**
    - **Common Carrier**
  - **Classifications (Function)**
    - **Line Haul**
    - **Switching**
    - **Belt Line**
    - **Terminal**

Railroad Engineering 101

- **Overview of the Railroad**
  - Classifications (Operating Revenues)
    - Class 1: $250 M or more
    - Class 2: $20.5 M - $249.9 M
    - Class 3: Less than $20 M
  - Classifications (Association of American Railroads Types)
    - Class I: $250 M or more
    - Regional: 350 miles or more; $40 M or more
    - Local
    - Switching and Terminal

Railroad Engineering 101

- **Overview of the Railroad**
  - Class 1 Railroads – North America
    - BNSF
    - Canadian National
    - Canadian Pacific
    - CSX
    - Ferromex
    - Kansas City Southern
    - KCS de Mexico
    - Norfolk Southern
    - Union Pacific
    - Amtrak
    - VIA Rail

Railroad Engineering 101

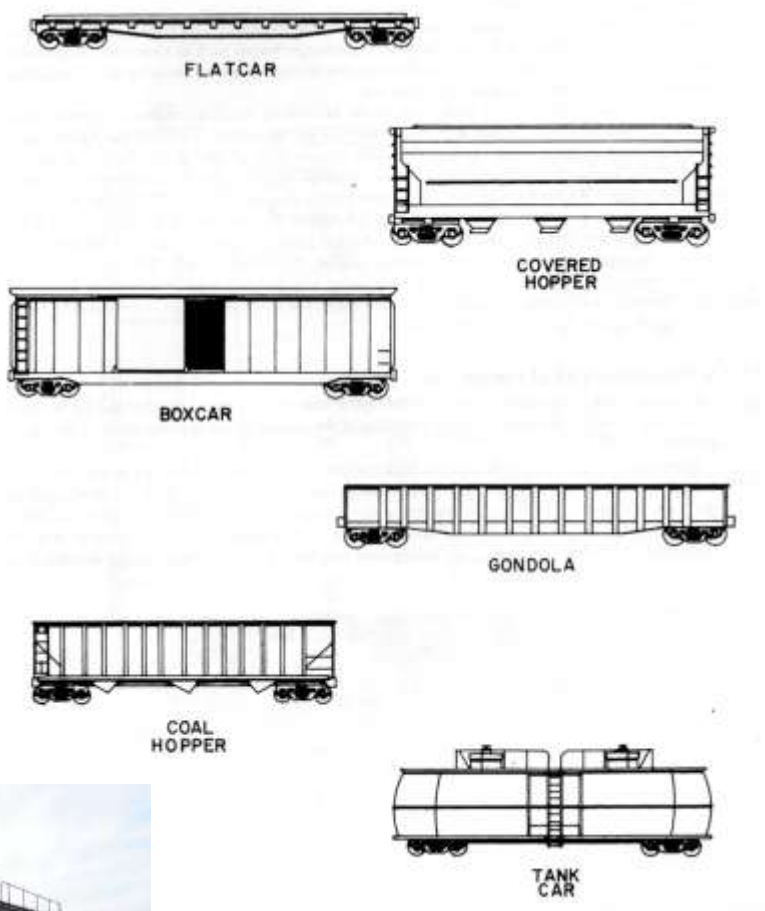
- **Overview of the Railroad**
  - Organization of a Railroad
    - Transportation
      - Train & Engine Crews
      - Dispatching
      - Operations
    - Engineering
      - All Right of Way Engineering
    - Mechanical
      - Equipment Maintenance
    - Marketing

Railroad Engineering 101

- **Overview of the Railroad**
  - **Equipment - Locomotives**
    - All Units rated by Horsepower
    - Horsepower is converted to Tractive Effort to propel locomotive
    - Types:
      - Electric – Pantograph trolley or third rail shoe
      - Diesel-Electric – self contained electric power plant
      - Dual Mode – Can use either electric or diesel

Railroad Engineering 101

- **Overview of the Railroad**
  - **Equipment - Freight Cars**
    - Boxcar
    - Flatcar
    - Gondola
    - Covered Hopper
    - Coal Hopper
    - Tank Car
    - Auto Racks
    - Container “Tubs or Boats”



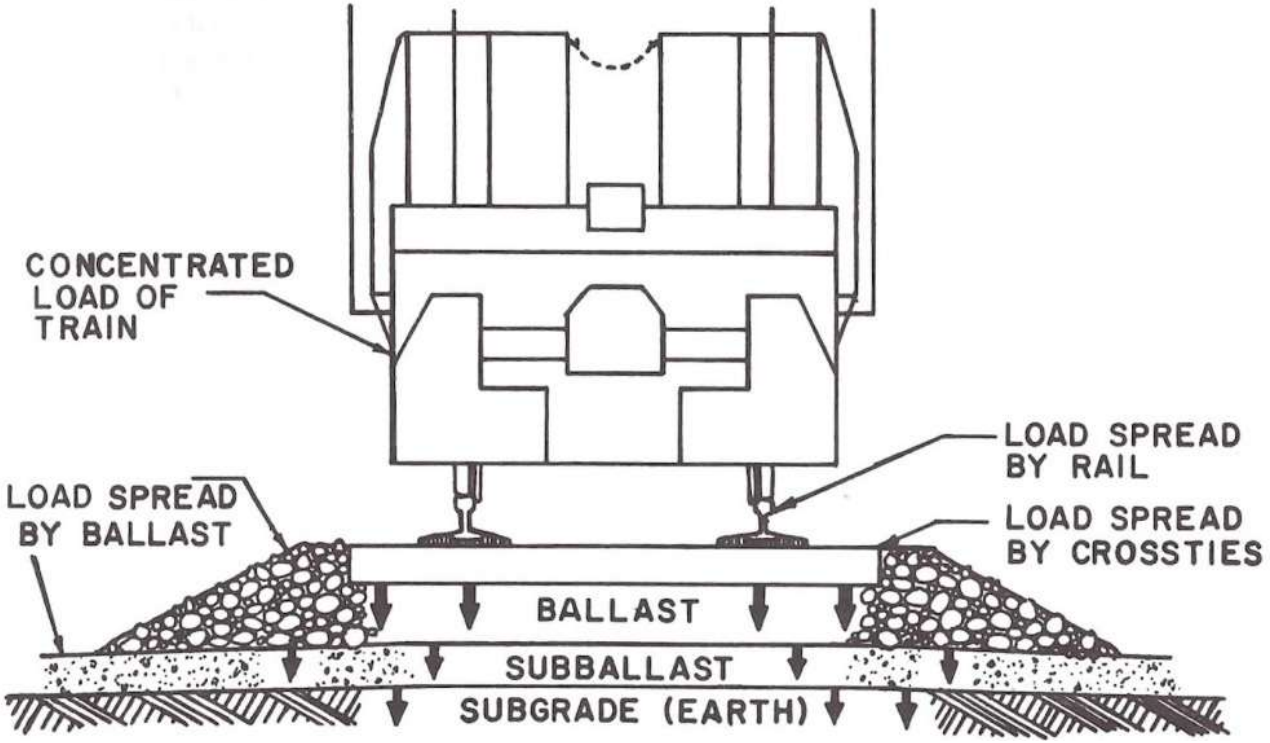
- **Overview of the Railroad**
  - **Resistance**
    - **Resistance is important especially for freight operations as they are dealing with heavy loads. Types include:**
      - **Internal (Locomotive)**
      - **Axle Loading - Bearing**
      - **Flange**
      - **Air**
      - **Track Modulus (Rigidity of track structure)**
      - **Wind**
      - **External Axle Load**
      - **Curve**
      - **Grade**
      - **Acceleration**
      - **Starting/Inertia**

Railroad Engineering 101

- **Track**
  - Loads
  - Rail
  - Crossties
  - Other Track Materials
  - Ballast
  - Sub-ballast
  - Typical Track Section
  - Roadway
  - Special Trackwork
  - Geometry
  - Track Charts

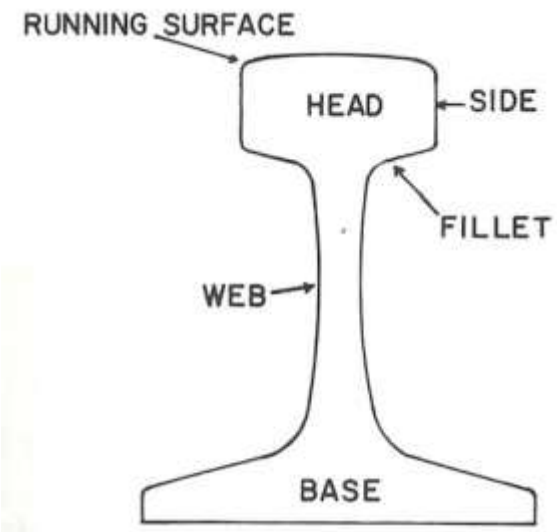
Railroad Engineering 101

- **Track Structure - Loads**



Railroad Engineering 101

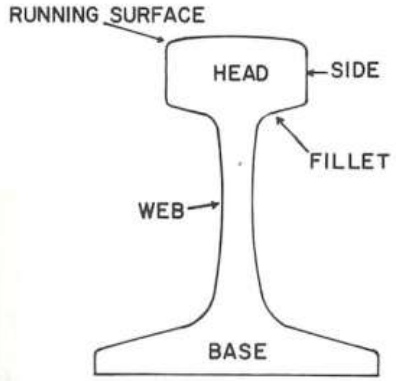
- **Track – Rail**
  - **Lengths**
    - 39 foot Sections (Jointed Rail)
    - Continuously Welded (CWR)
  - **Section**
    - Pattern design or cross-sectional shape
    - Standard Sections:
      - » RE: American Railroad Engineering Association
      - » ARA: American Railway Association
      - » ASCE: American Society of Civil Engineers
  - **Weight**
    - Pounds per Yard



Railroad Engineering 101

- **Track – Rail**

Section	Weight Per Yard (lb)	Area (sq in)	Height (in)	Base Width (in)
90 RA	90.0	8.8	5 5/8	5 1/8
115 RE	114.7	11.3	6 5/8	5 1/2
132 RE	132.1	13.0	7 1/8	6
155 PS	155.0	15.2	8	6 3/4

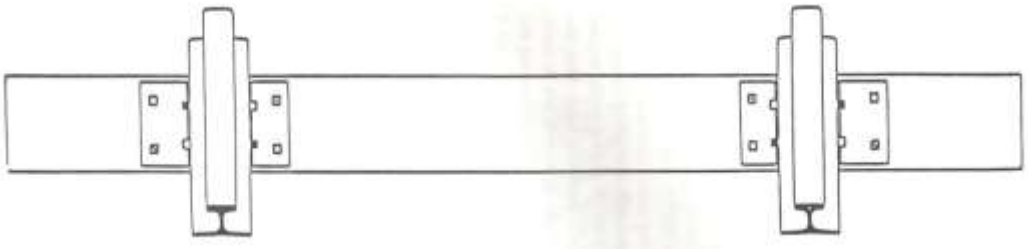


HOT STAMP

Weight Per Yard (lb)	Rail Section	Cooling	Mfg	Plant	Year Rolled	Month Rolled
132	RE	CC	BSCO	STEELTON	1961	IIIIIII

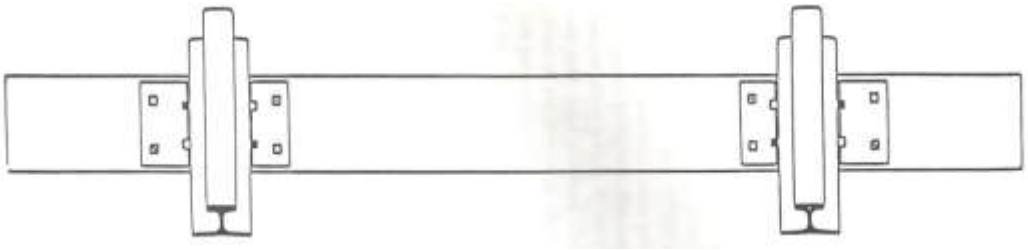
Railroad Engineering 101

- **Track – Crossties**
  - **Materials**
    - Wood
    - Concrete
  - **Functions**
    - Hold gage and line of rail
    - Transmit train weight from rail to ballast
    - Distributes train weight
    - Provide a base to anchor rail
    - Provide support to distribute load maintaining more uniform cross level of rails



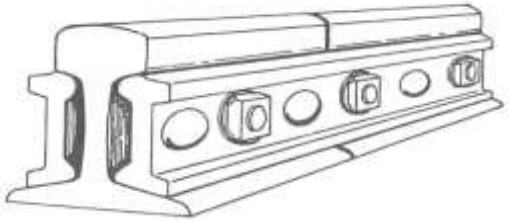
Railroad Engineering 101

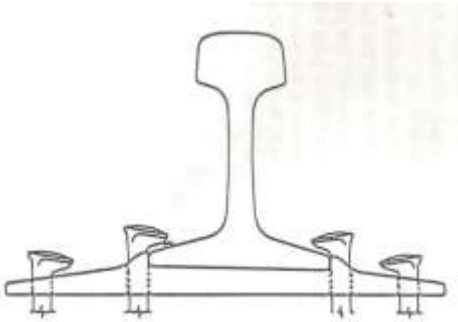
- **Track – Crossties**
  - **Dimensions**
    - **Wood: 7” x 9” x 8’-6”; 200 lb**
    - **Concrete: 8’-6”; 600 lb**
  - **Spacing**
    - **Wood Ties: 19” Main Line, 24” Light Traffic Lines**
    - **Concrete: 24”**

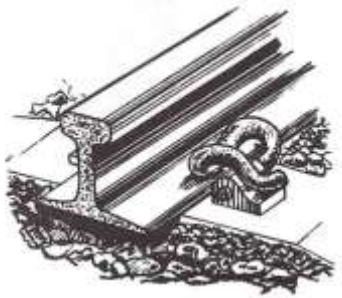


Railroad Engineering 101

- **Track – Other Track Materials**
  - Joint Bars and Bolts
    - Standard Joint
    - Compromise Joint
    - Insulated Joint
  - Tie Plates
  - Track Spikes
  - Concrete Tie Fastenings
  - Tie Plugs
  - Rail Anchors

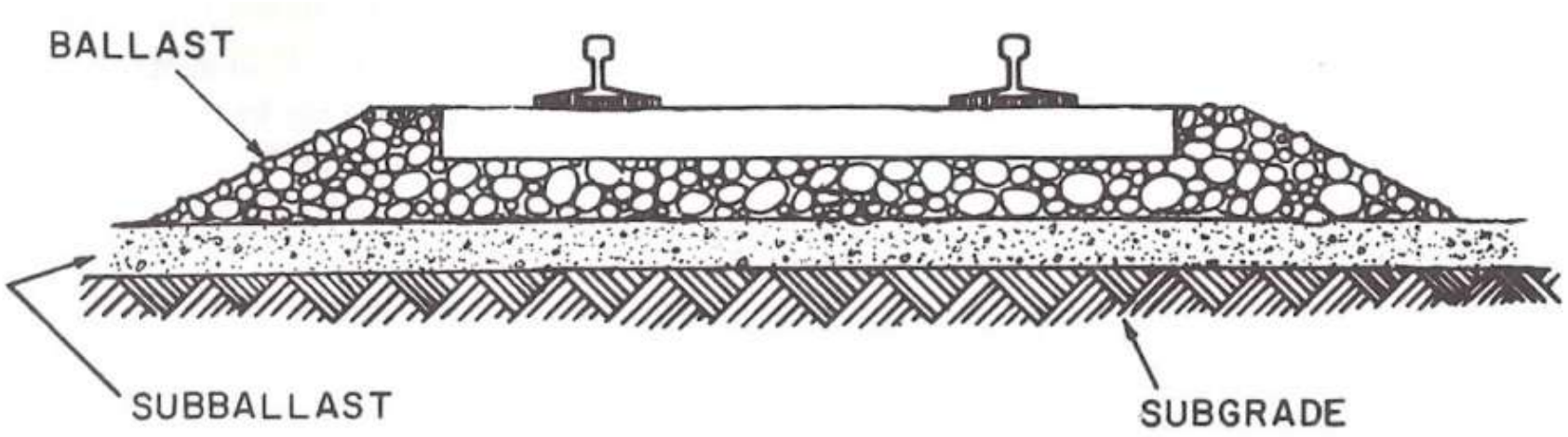






Railroad Engineering 101

- **Track – Ballast**
  - **Function**
    - **Support**
    - **Distribution of Load**
    - **Stability**
    - **Drainage**



Railroad Engineering 101

- **Track – Typical Track Section**

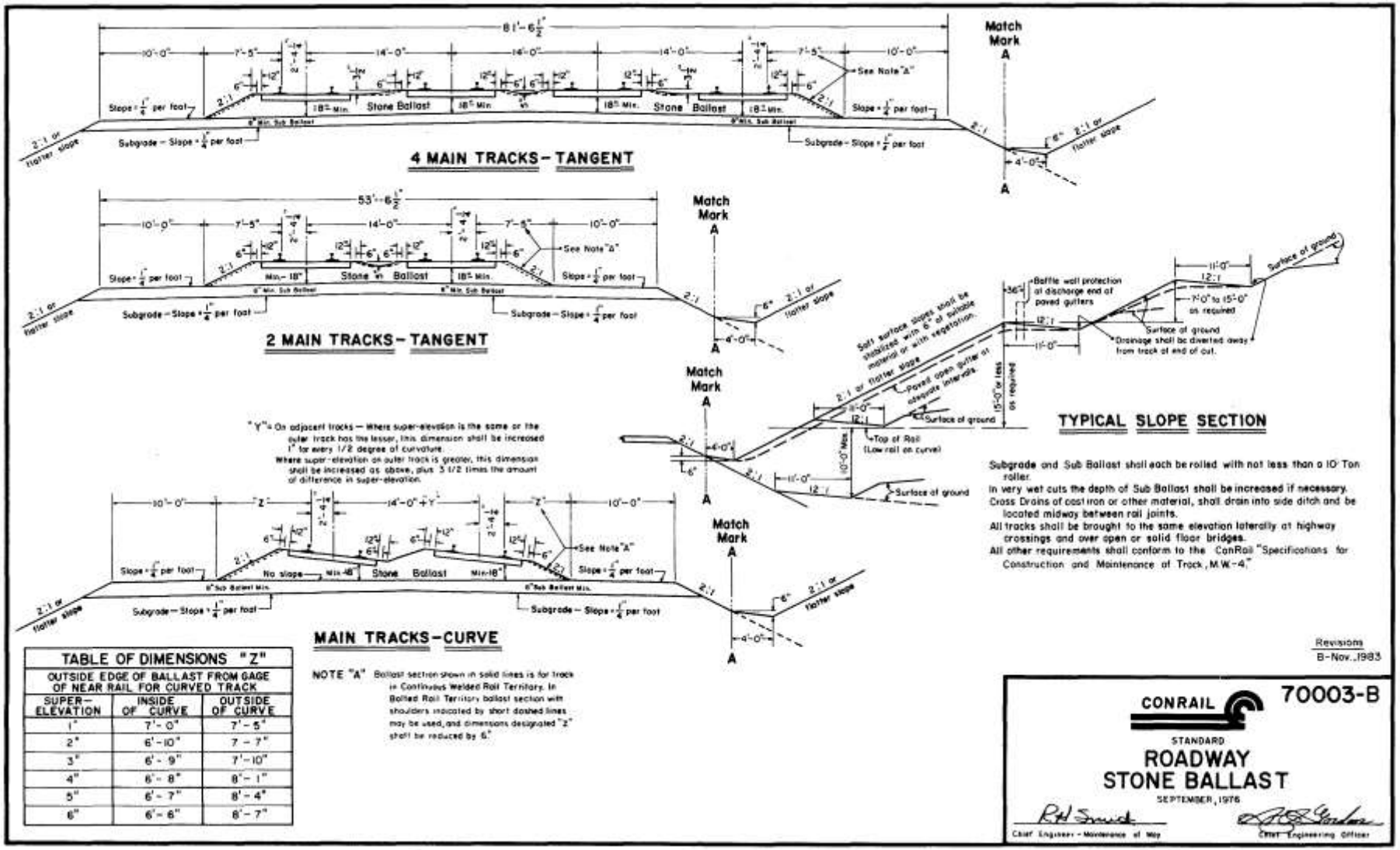
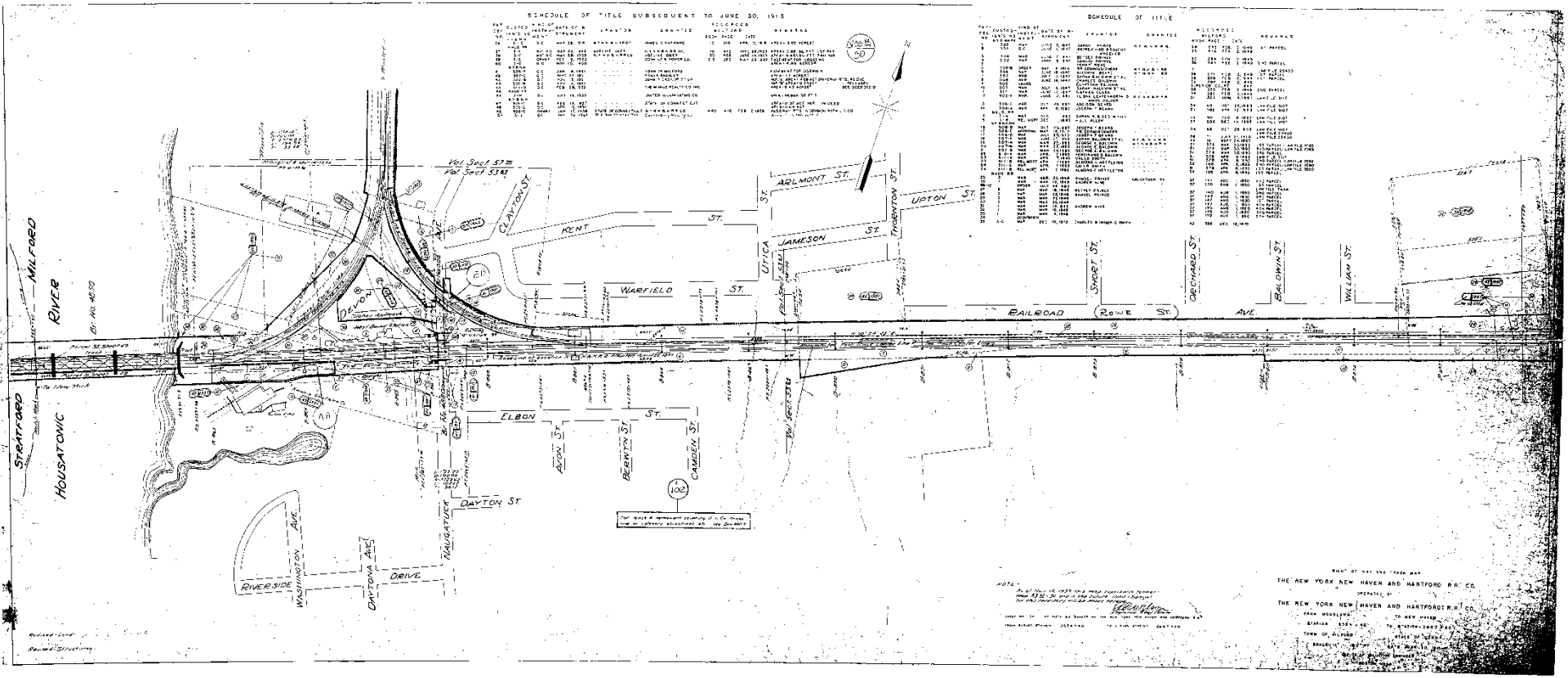


TABLE OF DIMENSIONS "Z"		
OUTSIDE EDGE OF BALLAST FROM GAGE OF NEAR RAIL FOR CURVED TRACK		
SUPER-ELEVATION	INSIDE OF CURVE	OUTSIDE OF CURVE
1"	7'-0"	7'-5"
2"	6'-10"	7'-7"
3"	6'-9"	7'-10"
4"	6'-8"	8'-1"
5"	6'-7"	8'-4"
6"	6'-6"	8'-7"

Railroad Engineering 101

- **Track – Roadway**
  - **Right of Way - Valuation Plans**

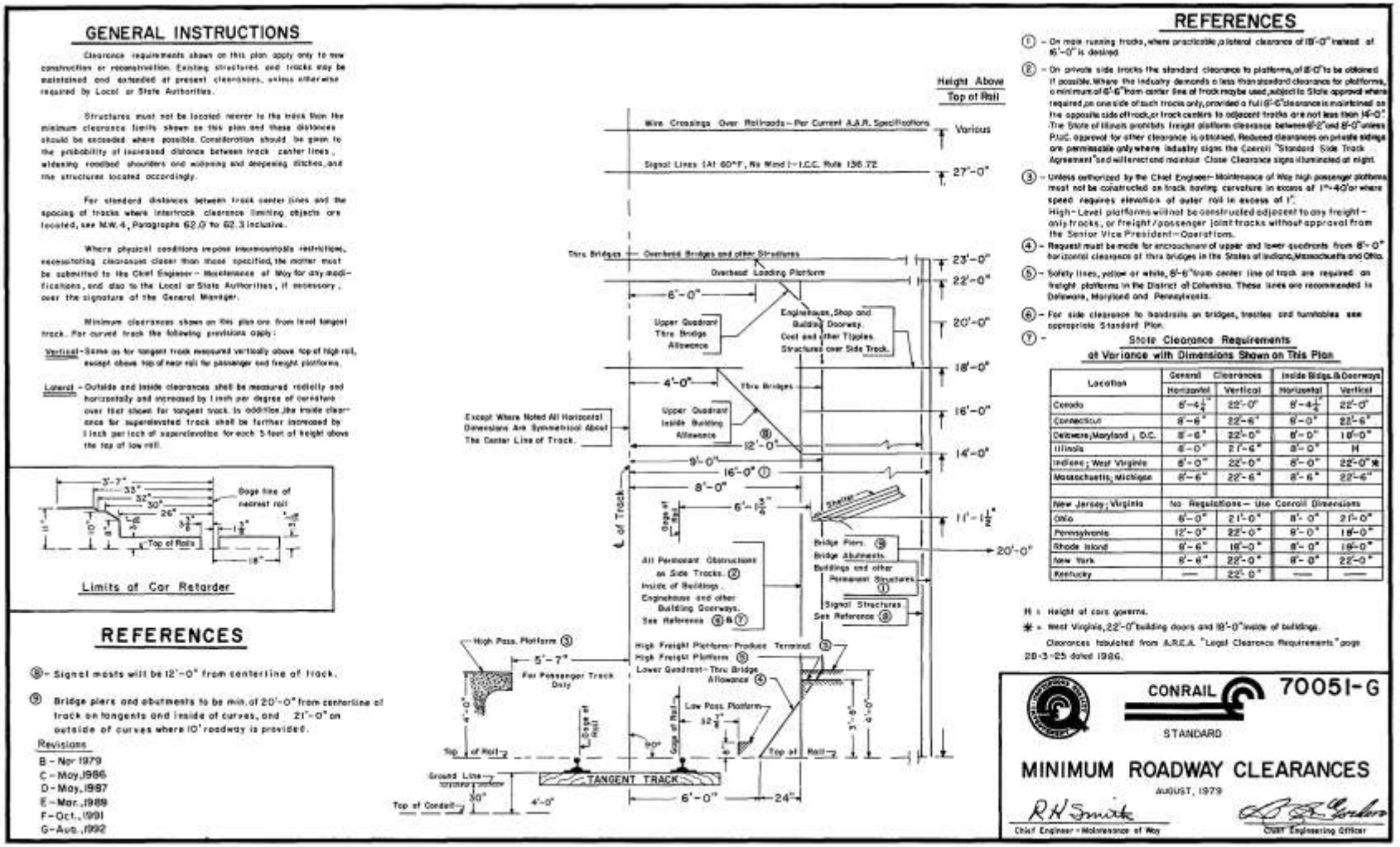


Railroad Engineering 101

- **Track – Roadway**
  - **Grade**
    - **Generally as flat as possible: 2.5 to 3% is the general "rule of thumb" for maximum main line grades**
    - **Compensated Grades: adjust for horizontal curve and/or stopping on grade (.03 to .05% reduction in grade/degree of curve)**
    - **Ruling Grade: Limiting grade on a route**

Railroad Engineering 101

- **Track – Roadway**
  - **Clearances**



GENERAL INSTRUCTIONS

Clearance requirements shown on this plan apply only to new construction or reconstruction. Existing structures and tracks may be maintained and extended at present clearances, unless otherwise required by Local or State Authorities.

Structures must not be located nearer to the track than the minimum clearance limits shown on this plan and these distances should be exceeded where possible. Consideration should be given to the probability of increased distance between track center lines, widening roadbed shoulders and widening and deepening ditches, and the structures located accordingly.

For standard distances between track center lines and the spacing of tracks where intertrack clearance limiting objects are located, see M.W.4, Paragraphs 62.0 to 62.3 inclusive.

Where physical conditions impose insurmountable restrictions, necessitating clearances closer than those specified, the matter must be submitted to the Chief Engineer – Maintenance of Way for any modifications, and also to the Local or State Authorities, if necessary, over the signature of the General Manager.

Minimum clearances shown on this plan are from level tangent track. For curved track the following provisions apply:

Vertical – Same as for tangent track measured vertically above top of high rail, except above top of near rail for passenger and freight platforms.

Lateral – Outside and inside clearances shall be measured radially and horizontally and increased by 1 inch per degree of curvature over that shown for tangent track. In addition, the inside clearance for superelevated track shall be further increased by 1 inch per inch of superelevation for each 3 feet of height above the top of low rail.

Limits of Car Retarder

REFERENCES

⑧ – Signal masts will be 12'-0" from centerline of track.

⑨ Bridge piers and abutments to be min. of 20'-0" from centerline of track on tangents and inside of curves, and 21'-0" on outside of curves where 10' roadway is provided.

Revisions
B – Nov 1979
C – May, 1986
D – May, 1987
E – Mar., 1989
F – Oct., 1991
G – Aug., 1992

REFERENCES

① – On main running tracks, where practicable, a lateral clearance of 15'-0" instead of 8'-0" is desired.

② – On private side tracks the standard clearance to platforms, of 8'-0" to be obtained if possible. Where the industry demands a less than standard clearance for platforms, a minimum of 8'-6" from center line of track may be used, subject to State approval where required, on one side of such tracks only, provided a full 8'-6" clearance is maintained on the opposite side of track, or track centers to adjacent tracks are not less than 14'-0". The State of Illinois prohibits freight platform clearance between 8'-2" and 8'-0" unless P.U.C. approval for other clearance is obtained. Reduced clearances on private sidings are permissable only where industry signs the Conrail "Standard Side Track Agreement" and will erect and maintain Close Clearance signs illuminated at night.

③ – Unless authorized by the Chief Engineer – Maintenance of Way high passenger platforms must not be constructed on track having curvature in excess of 1°-40' or where speed requires elevation of outer rail in excess of 1".
High-Level platforms will not be constructed adjacent to any freight-only tracks, or freight/passenger joint tracks without approval from the Senior Vice President – Operations.

④ – Request must be made for encroachment of upper and lower quadrants from 8'-0" horizontal clearance of thru bridges in the States of Indiana, Massachusetts and Ohio.

⑤ – Safety lines, yellow or white, 8'-6" from center line of track are required on freight platforms in the District of Columbia. These lines are recommended in Delaware, Maryland and Pennsylvania.

⑥ – For side clearance to handrails on bridges, trestles and turntables see appropriate Standard Plan.

⑦ – State Clearance Requirements at Variance with Dimensions Shown on This Plan

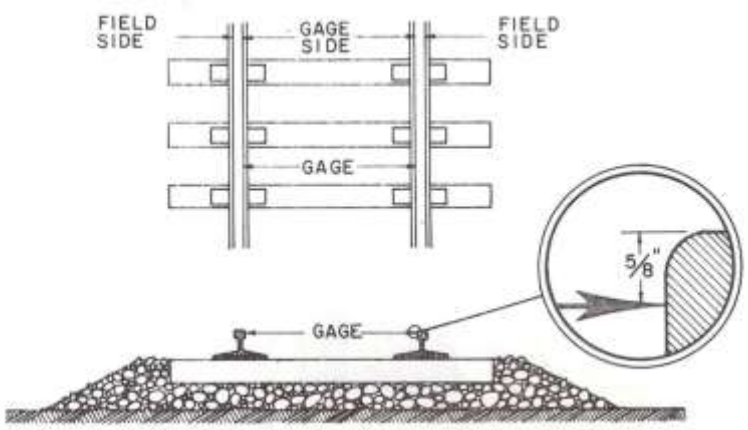
Location	General Clearances		Inside Bldgs. & Doorways	
	Horizontal	Vertical	Horizontal	Vertical
Canada	8'-4½"	22'-0"	8'-4½"	22'-0"
Connecticut	8'-6"	22'-6"	8'-0"	22'-6"
Delaware, Maryland & D.C.	8'-6"	22'-0"	8'-0"	18'-0"
Illinois	8'-0"	21'-6"	8'-0"	H
Indiana; West Virginia	8'-0"	22'-0"	8'-0"	22'-0"*
Massachusetts, Michigan	8'-6"	22'-6"	8'-6"	22'-6"
New Jersey; Virginia	No Regulations – Use Conrail Dimensions			
Ohio	8'-0"	21'-0"	8'-0"	21'-0"
Pennsylvania	12'-0"	22'-0"	8'-0"	18'-0"
Rhode Island	8'-6"	18'-0"	8'-0"	18'-0"
New York	8'-6"	22'-0"	8'-0"	22'-0"
Kentucky	—	22'-0"	—	—

H = Height of cars governs.
* = West Virginia, 22'-0" building doors and 18'-0" inside of buildings.
Clearances tabulated from A.R.E.A. "Legal Clearance Requirements" page 28-3-25 dated 1986.

CONRAIL 70051-G
STANDARD
MINIMUM ROADWAY CLEARANCES
AUGUST, 1979
R H Smith
Chief Engineer – Maintenance of Way
Chief Engineering Officer

Railroad Engineering 101

- **Track – Roadway**
  - **Gage**
    - **Standard gage: 4’-8 ½”**
    - **Minimum Allowable: 4’-8”**
    - **Gage Variance: 4’-8” to 4’-9 ¾ “ depending on class of track and tangent vs. curved track**



Railroad Engineering 101

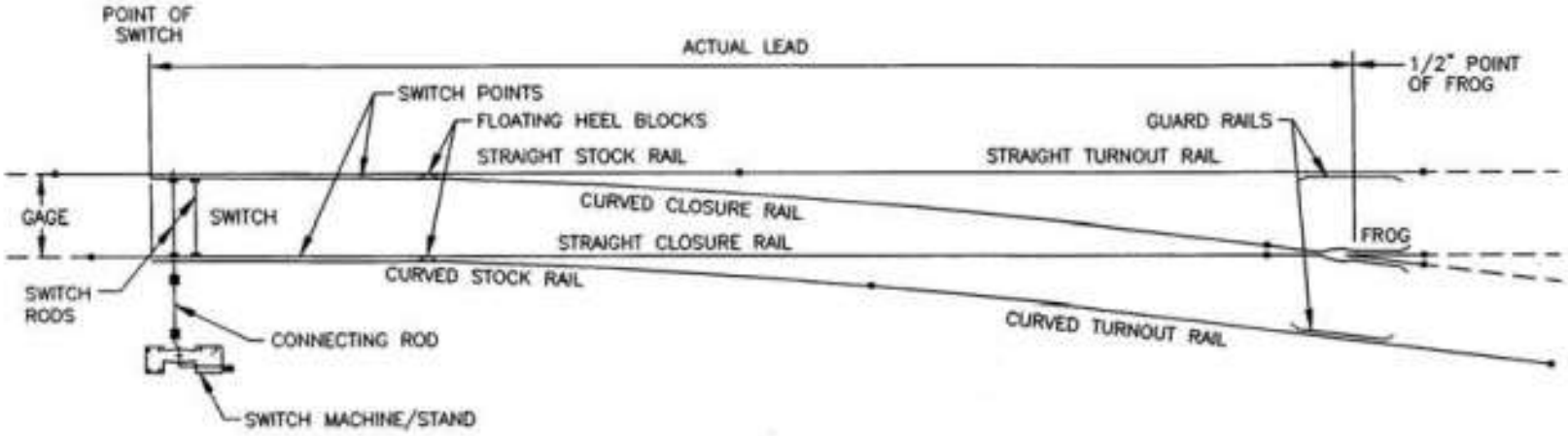
- **Track – Roadway**
  - **Grade Crossings**
    - **Types:**
      - » **Paved**
      - » **Timber**
      - » **Concrete Panel**
      - » **Rubber Panel**
    - **Key Elements:**
      - » **Flangeway**
      - » **Good Drainage**





Railroad Engineering 101

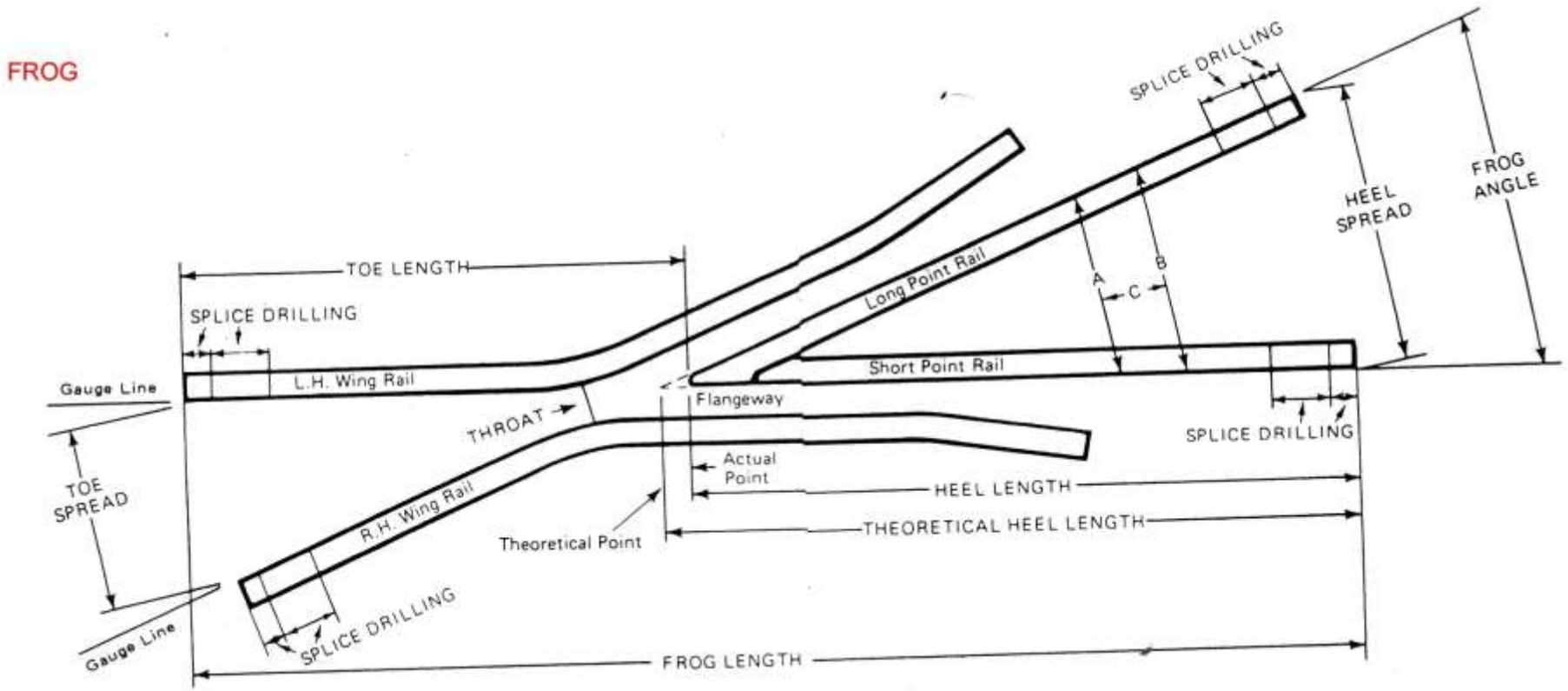
- **Track – Special Trackwork**
  - **Turnouts**
    - **Designated by Frog size**
    - **Preference is to orient turnout in trailing point position; train passes over frog before passing point of switch**



Frog No.	6	8	10	15	20	26.5	32.75
Maximum Authorized Speed (MPH)	5	15	15	30	45	60	80

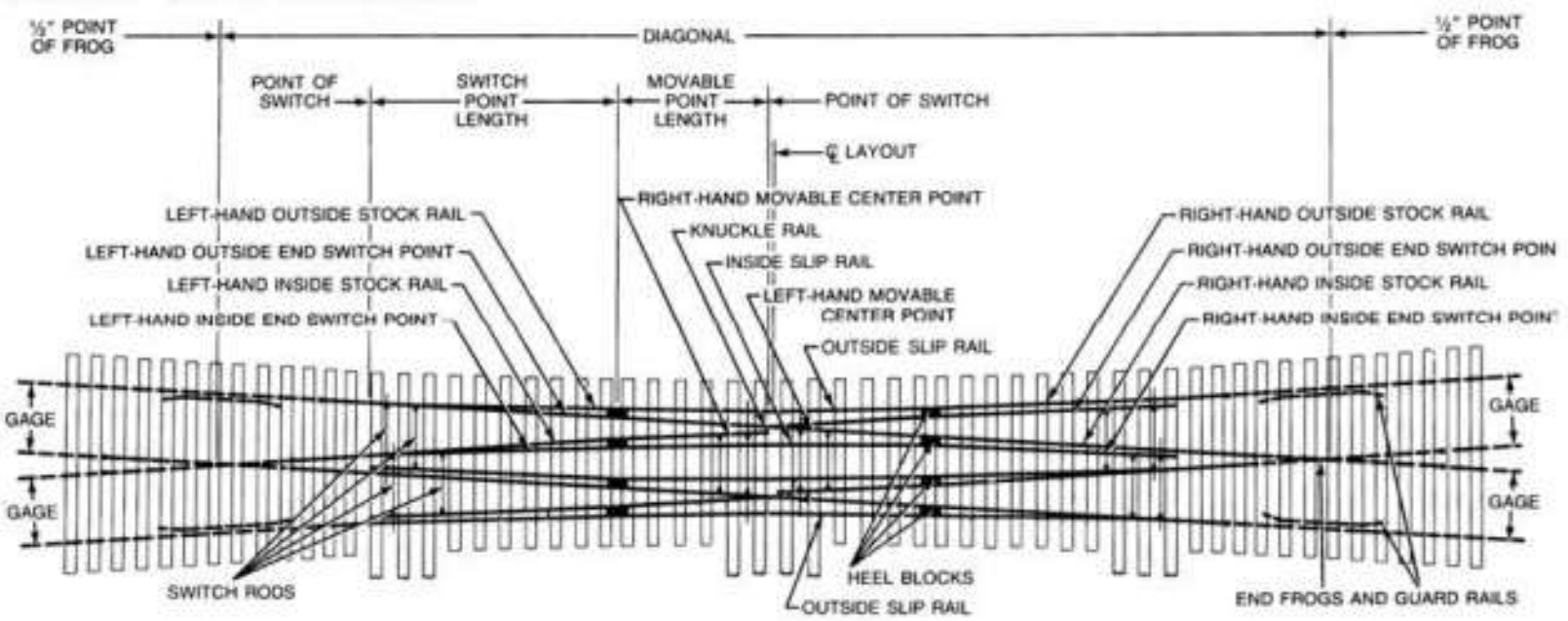
Railroad Engineering 101

- **Track – Special Trackwork**
  - **Turnouts – Frog**
    - **Frog No. is the ratio of its length to its width (inches)**
    - **A No. 8 Frog spreads 1 in 8**



Railroad Engineering 101

- **Track – Special Trackwork**
  - **Slip Switch**
    - **Used primarily in passenger terminal areas**

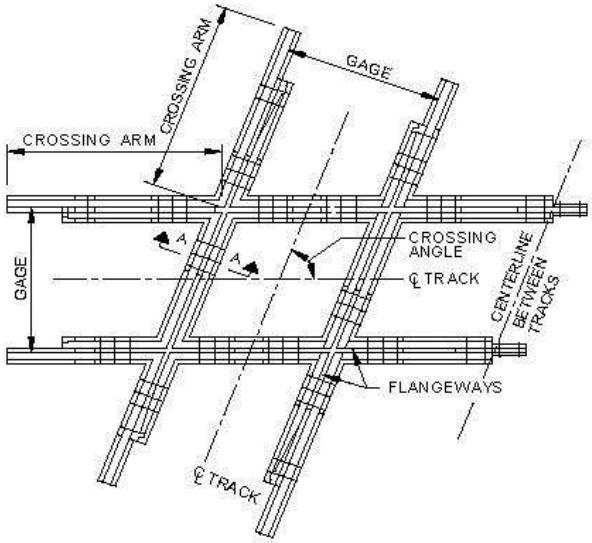


Railroad Engineering 101

- **Track – Special Trackwork**
  - **Slip Switch**
    - **Union Station, New Haven CT**

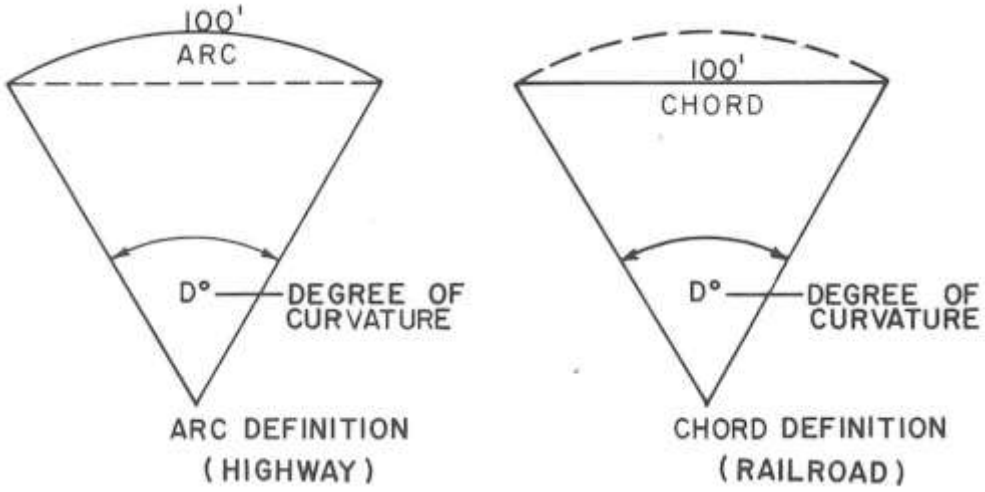
Railroad Engineering 101

- **Track – Special Trackwork**
  - **Bolted Rail Crossing**



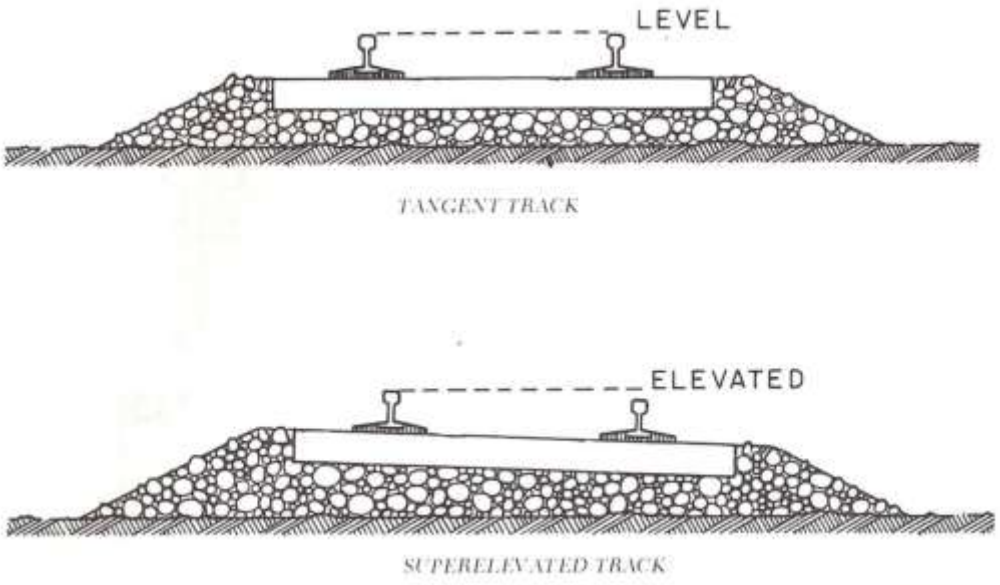
Railroad Engineering 101

- **Track – Geometry**
  - **Railroads use chord definition for degree of curve**



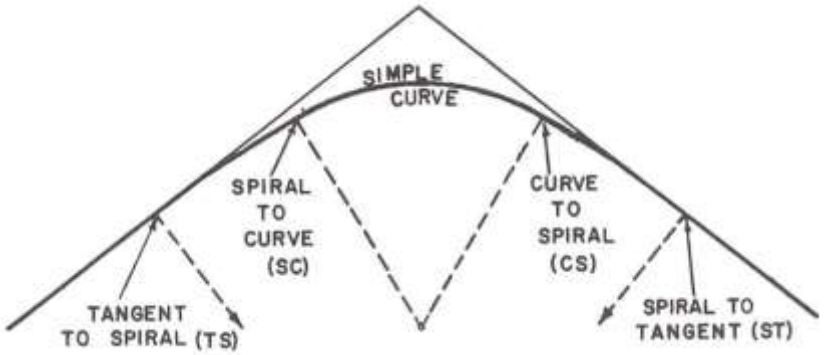
Railroad Engineering 101

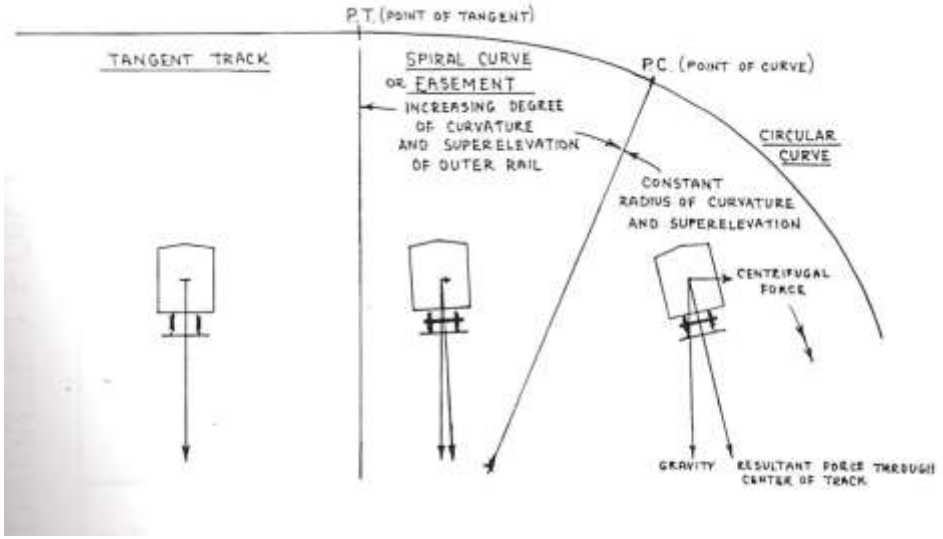
- **Track – Geometry**
  - **Superelevation**



Railroad Engineering 101

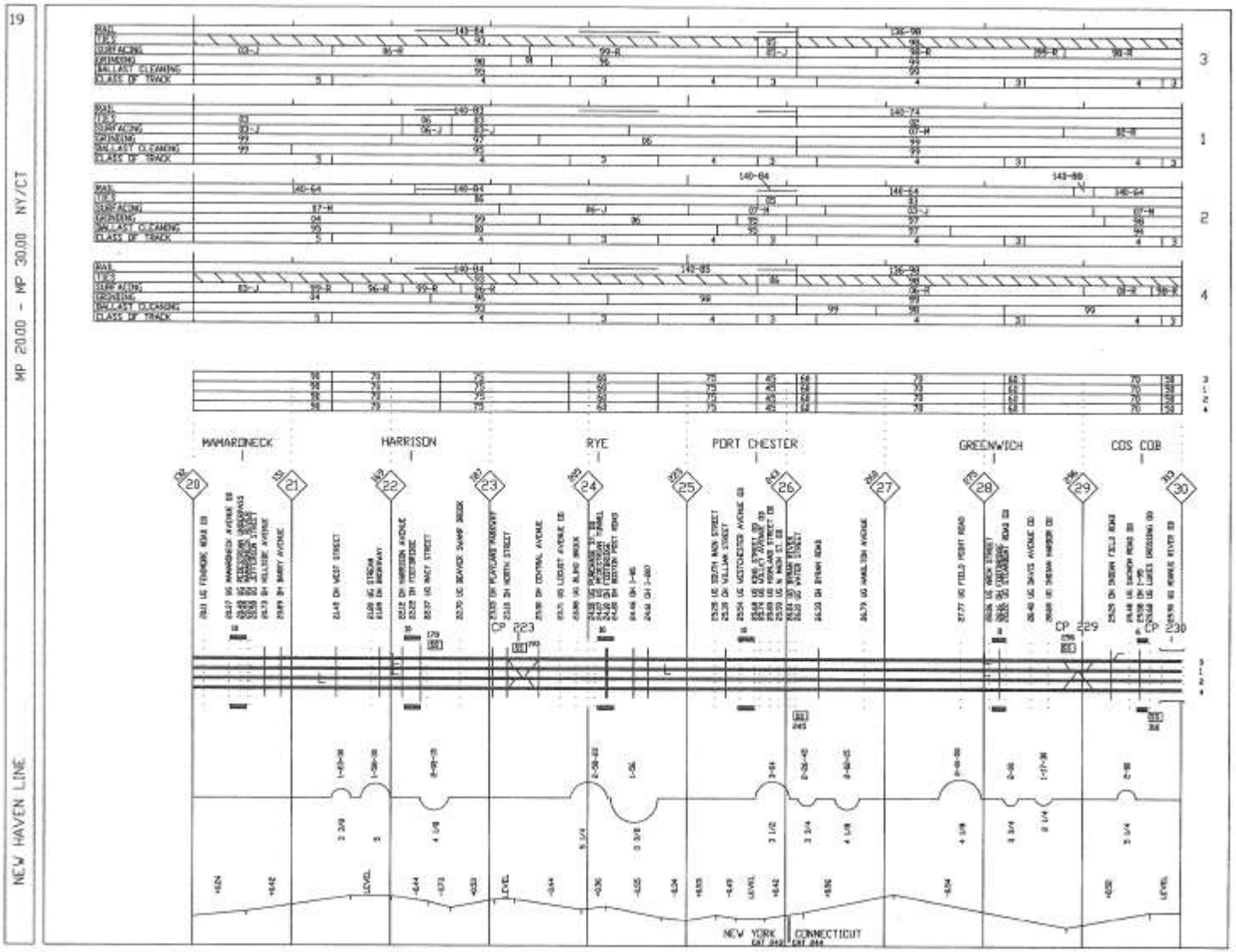
- **Track – Geometry**
  - **Spiral Transitions –used to ease into a curve and superelevation**





Railroad Engineering 101

- **Track – Track Charts**



Railroad Engineering 101

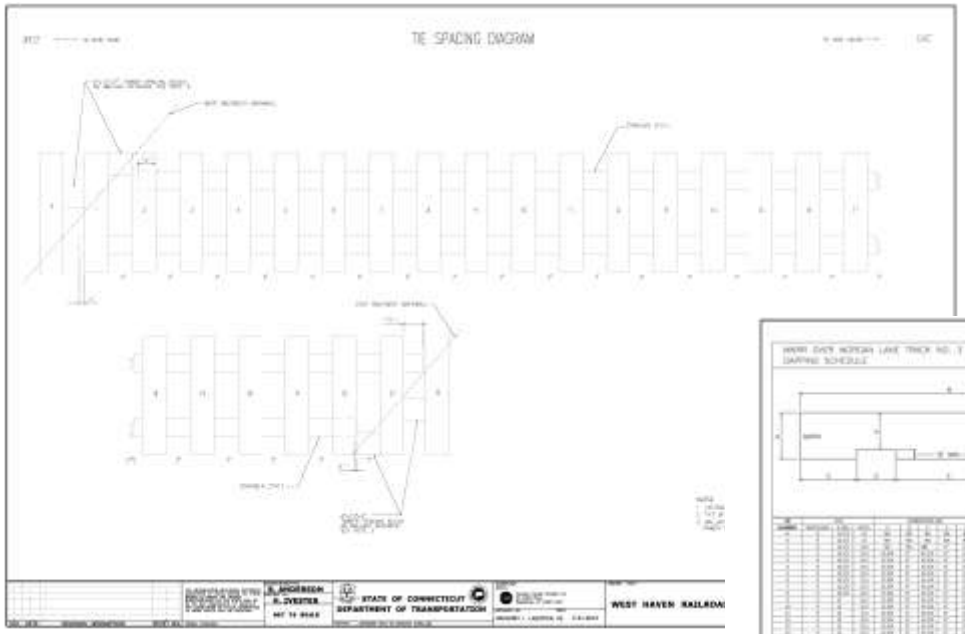
- **Bridges**
  - Many types of rail bridges:
    - Movable:
      - Bascule
      - Swing Span
      - Lift Span
    - Fixed:
      - Through Truss
      - Through Girder
      - Plate Girder
      - Deck Girder

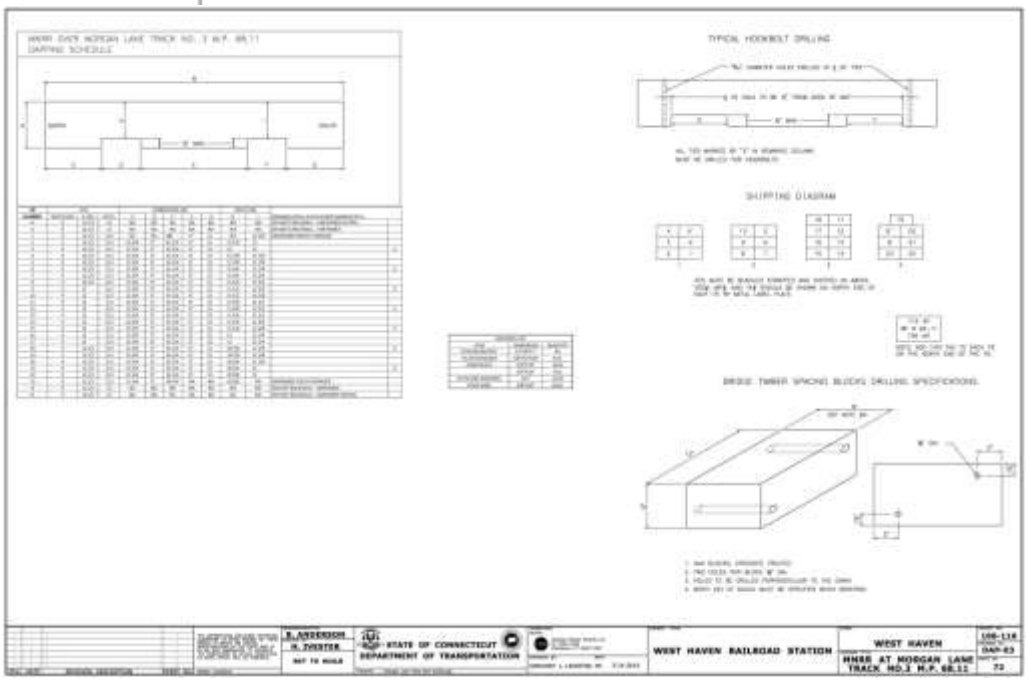
Railroad Engineering 101

- **Bridges**
  - **Four types of bridge decks:**
    - **Open Deck**
      - » **Less costly to maintain; free draining; lighter**
      - » **Inability to adjust line/grade w/o replacing timbers**
    - **Ballasted Deck**
      - » **Easy to adjust line/grade; conventional ties; better ride quality**
      - » **Heavier dead load; more costly to const; retain moisture**
    - **Trough Floor**
    - **Direct Fixation**
      - » **Only used on open deck steel bridges**

Railroad Engineering 101

- **Bridges**
  - **Open Deck Timber Dapping**



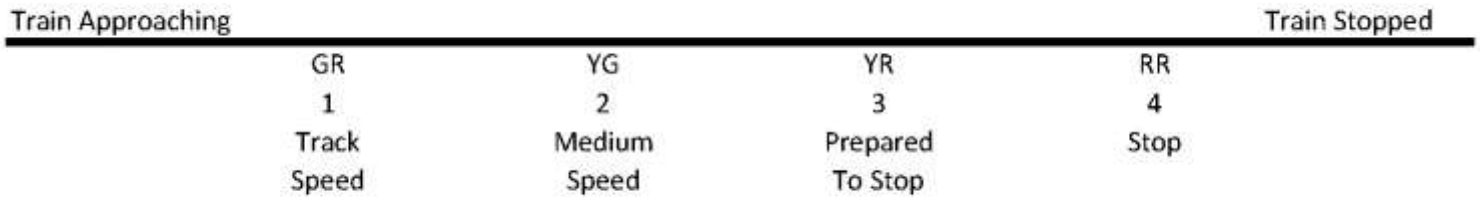


Railroad Engineering 101

- **Signal Systems**
  - Used to provide for the safe and efficient movement of trains
  - Types of Controls:
    - Train Orders
    - Manual Block
    - Automatic Block
    - Automatic Train Control
    - Centralized Traffic Control

Railroad Engineering 101

- **Signal Systems**
  - **Automatic Block Signals**
    - **Track is divided up into blocks**
    - **block length based on maximum train length and safe braking distance**



Railroad Engineering 101

- **Rail Operations**
  - Main Line Operations
    - Freight Rail
      - Longer, heavier, slower trains
    - Passenger Rail
      - Shorter, lighter, faster trains
  - Yards and Terminals

Railroad Engineering 101

- **Federal Railroad Administration**
  - Railroad Safety
    - Track Safety Standards
    - Work Force Rules
    - Grade Crossing Safety
    - Trespass Prevention
  - Rail Network Development
    - High Speed Rail
    - Freight Rail
  - Research & Development
    - Track
    - Rolling Stock
  - Grants & Loans

Railroad Engineering 101

- **American Railway Engineering and Maintenance Association**
  - **Manual for Railway Engineering**
    - **Recommended Practices for:**
      - **Track**
      - **Structures**
      - **Infrastructure and Passenger**
      - **Systems Management**