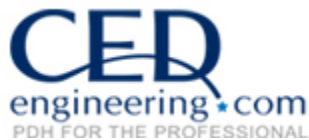

An Introduction to Railroad Trackage

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CONTENTS

1. INTRODUCTION
2. ROADWAY
3. BALLAST AND SUB-BALLAST
4. TIES
5. TRACK
6. RUNNING TRACK GRADE AND ALIGNMENT
7. TURNOUTS AND CROSSOVERS
8. HIGHWAY GRADE CROSSINGS
9. TRACKAGE IN PAVEMENT
10. SIDINGS
11. WAREHOUSE TRACKAGE
12. TRACK SCALES
13. YARDS

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The Figures, Tables and Formulas in this document are in some cases a little difficult to read, but they are the best available. **DO NOT PURCHASE THIS COURSE IF THE FIGURES, TABLES AND FORMULAS ARE NOT ACCEPTABLE TO YOU.**

1. INTRODUCTION

1.1 SCOPE. This publication provides an introduction to design of railroad trackage. Included are roadways, ballast, ties, rails, track grade, turnouts, crossovers, highway crossings, sidings, warehouse trackage, track scales, and yards. This publication is not a design manual. Design and construction of railroad trackage is highly regulated in the United States. In particular, the American Railway Engineering Association (AREA) publications are highly authoritative. For application to actual projects, current and applicable regulations and standards must always be consulted and applied.

1.2 DESIGN CRITERIA USAGE. The criteria presented herein are applicable to the design of new trackage and for major rehabilitations.

1.3 RAILROAD TRACKAGE STANDARDS. Standards in railroad trackage design appear in:

- American Railway Engineering Association (AREA) Manual for Railway Engineering;
- AREA Portfolio of Trackwork Plans

The AREA Manual is revised annually and the user shall refer to the current edition, which can be verified by contacting the AREA at: 50 F Street, N.W., Washington, D.C. 20001. Manual owners receive revision notices yearly.

1.4 RAILROAD CAR CURVATURE STANDARDS. Minimum curvature negotiability standards for railroad cars appear in Section 2.1, Design Data, Association of American Railroads (AAR) - Mechanical Division, Specifications for Design, Fabrication and Construction of Freight Cars, Volume 1.

1.5 FEDERAL RAILROAD ADMINISTRATION (FRA) TRACK SAFETY STANDARDS.

The Code of Federal Regulations (CFR) Title 49 Part 213 - Track Safety Standards prescribes minimum safety standards which may be used by maintenance personnel. Under these standards tracks are classified as Class 1, 2, 3, 4, 5, or 6 wherein the maximum allowable speed limits for freight and passenger trains are assigned to each class. If a segment of track does not meet all the conditional requirements for its intended class, it is classified to the next lowest class for which it does meet all the requirements. The FRA Track Safety Standards "prescribes initial minimum safety requirements for railroad track" and shall be used for safety inspections only. They are not to be used for design purposes or as construction inspection criteria.

2. ROADWAY

2.1 WIDTH. Provide a minimum of 18 inches from the toe of the ballast to the edge of the finished grade. See AREA Manual, Chapter 1, Part 2, Design.

2.1.1 CUT SECTIONS. Provide a minimum of 9 feet from track centerline to the shoulder line.

2.1.2 FILL SECTIONS. Provide a minimum of 11 feet from track centerline to the shoulder line.

2.1.3 MINIMUM CUT DIMENSIONS. Consideration is to be given to drainage, snow removal, debris removal, rock falls, and maintenance. See AREA Manual, Chapter 1, Part 1.2, Design.

2.2 SLOPES AND SUBGRADE. Slope and subgrade criteria are as follows. See AREA Manual, Chapter 1, Part 1, Roadbed.

2.2.1 SLOPE. Cut and fill slopes shall be designed according to a slope stability analysis unless adequate local experience has shown a particular slope to be stable.

2.2.2 SUBGRADE. For subgrade criteria, see AREA Manual, Chapter 1, Part 1, Section 1.2.5, Roadbed. Subgrade cross slopes shall be 48 horizontal to 1 vertical. The subgrade shall slope in one direction beneath a single track and shall be crowned between tracks for multiple tracks. In no case shall the crown of the subgrade occur under the ties.

2.3 GEOTEXTILE FABRIC. When the subgrade has a large amount of fines, a geotextile fabric should be used between the subgrade and the ballast. Geotextile fabrics should be man made and not biodegradable. Geotextile fabrics should be

designed to provide tensile reinforcements, filtration and soil separation. Typical properties and standards specified should include:

- Fabric Weight
- Thickness
- ASTM D 1777
- Grab Strength ASTM D 1682
- Elongation (Percentage) ASTM D 1682
- Puncture Strength ASTM D 751
- Burst Strength ASTM D 3786
- Trapezoid Tear Strength ASTM D 2261 or ASTM D 2262

When a geotextile fabric is used, there should be a minimum of 12 inches of ballast between the bottom of the ties and the fabric.

2.4 DRAINAGE. Water is a principal influence on soil stability in roadbed, subgrade, and slopes. Control of surface and subsurface water is one of the most important factors in railroad design.

2.5 MONUMENTS. Right-of-way monuments should be reinforced concrete posts (or similar) 6 inches square, 4 feet long, and embedded 3 feet in the earth. The specification for monuments from the Department of Transportation in the state where the work is being done may be used where appropriate.

3. BALLAST AND SUB-BALLAST

3.1 ECONOMICS. Select ballast and sub-ballast with due consideration of cost and availability.

3.2 SPECIFICATIONS AND APPLICATIONS. See AREA Manual, Chapter 1, Part 2, Ballast, for material specifications. The following materials are acceptable in order of quality as listed:

- (1) Crushed stone.
- (2) Crushed slag.
- (3) Prepared gravel.
- (4) Pit run gravel.
- (5) Cinders or other local materials may be used temporarily or in an emergency.

3.3 DEPTH. The combined thickness of ballast and sub-ballast required for a given axle load and subgrade strength should be determined on basis of engineering calculation and experience. For main running tracks, provide a minimum of 12 inches of ballast under the ties and 6 inches of sub-ballast. For all other locations, provide a minimum of 8 inches of ballast under the ties and 6 inches of sub-ballast. The design strength of the subgrade shall not be exceeded by the traffic load. See AREA Manual, Chapter 1, paragraph 1.2.5.4, Ballast Thickness. When a geotextile fabric is used between ballast or sub-ballast and the subgrade, there should be a minimum of 12 inches of ballast between the bottom of the tie and the geotextile fabric.

3.4 CROSS SECTION DIMENSIONS. See AREA Manual, Chapter 1, Part 2, Ballast.

3.5 SHRINKAGE ALLOWANCE. See AREA Manual, Chapter 1, Part 2.2, Ballast. Use 12 to 15 percent Shrinkage Factor.

4. TIES

4.1 SPECIFICATIONS AND APPLICATIONS. Ties may be of wood, concrete, or other material.

4.1.1 WOOD TIES. All wood ties shall conform to Federal Specification MM-T-371, Ties, Railroads, Wood (Cross and Switch) and have protective treatment, conforming to Federal Specification TT-W-571, Wood Preservation: Treating Practices.

4.1.2 CONCRETE TIES. See AREA Manual, Chapter 10.

4.1.3 TIES OF OTHER MATERIALS. Consider other materials such as steel in place of wood or concrete ties when practicable.

4.2 ECONOMIC SERVICE LIFE AND TESTS. See AREA Manual, Chapter 3, Part 3, Tie Tests and the Economics of Service Life.

4.3 HANDLING AND PROTECTION OF TIMBER TIES. To prolong the life of protected ties, specify the following practices:

- Use steel tie plates under the rails.
- Treat all cut surfaces with preservative.
- Use care in handling with sharp-pointed tools to avoid damage.
- Fill empty spike or bolt holes by driving treated wooden plugs into the holes. See AREA Manual, Chapter 3, Part 1.7, Timber Cross Ties.

For additional information, refer to AREA Manual, Chapter 3, Part 5, The Handling of Ties From the Tree into the Track.

4.4 DIMENSIONS. Use the following dimensions:

4.4.1 CROSS TIES. For running track, cross ties of 7 by 8 inches, or 7 by 9 inches, by 8 feet 6 inches long should be used. For yards and sidings, 6 by 8 inches by 8 feet 0 inches long may be used. See Federal Specification MM-T-371, Table I.

4.4.2 TIMBER SWITCH TIES. Should be the same cross section as adjacent cross ties. Each tie shall be of the length specified in AREA Portfolio of Trackwork Plans. See AREA Manual, Chapter 3, Part 2, Timber Switch Ties and Federal Specification MM-T-371.

4.4.3 BRIDGE OR TRESTLE TIES. Shall conform in spacing and length to the bridge or trestle design. See AREA Manual, Chapter 7.

4.5 TIE SPACING. Use the following spacing:

4.5.1 RUNNING TRACK. Use 24 ties per 39-foot rail.

4.5.2 YARDS AND SIDINGS. Use 20 ties per 39-foot rail.

4.5.3 SWITCHES AND CROSSTIES. For switches and crossovers, follow AREA Portfolio of Trackwork Plans.

5. TRACK

5.1 RAIL SPECIFICATIONS. Choose sections conforming to AREA recommended sections. Use 115 RE rail for new construction and major rehabilitation projects unless quantities of larger sizes are stockpiled. For minor replacement or repair work match existing size rail where adequate.

5.1.1 MATERIAL. Rails shall be manufactured to specifications for hydrogen eliminated standard rail steel as recommended in the AREA Manual, Chapter 4, Rail, Part 2, Specifications.

5.1.2 RAIL DRILLING. Rails shall be drilled according to AREA Manual, Chapter 4, Rail, Part 1, Design, Table 1, Recommended Rail Drillings, Bar Punchings and Track Bolts, for new construction and major rehabilitation projects. For minor replacement or repair work, match existing where adequate.

5.1.3 CURVED RAIL. Where conditions are such that curves of 20 degrees (288-foot radius) or more are absolutely necessary, rails should be pre-bent to the design radius prior to installation.

5.2 GAGE. For straight track and curves up to 12 degrees (478-foot radius), use a gage of 4 feet 8-1/2 inches measured between the inside heads of rail 5/8 inch below the top of rail. For curves greater than 12 degrees (478-foot radius) widen gage 1/8 inch for each additional 2 degrees (except through turnouts) to a maximum allowable of 4 feet 9 inches. Gage tolerance should be minus 1/4 inch to plus 3/16 inch.

5.3 SPIKES. Use 6-inch by 5/8-inch cut spikes conforming to specifications as recommended in the AREA Manual, Chapter 5, Part 2.3, Spikes for track spikes, including 0.20 percent copper, soft-steel or high carbon. The smaller 5-1/2-inch by 9/16-inch cut spikes may be used in sidings where 6 by 8-inch cross ties are used.

5.3.1 HOLES BORED FOR SPIKES. For size, see AREA Manual, Chapter 3, Part 1.9, Timber Cross Ties.

5.3.2 SPIKE QUANTITIES. Use two spikes per side per tie plate on tangent track and curved track with not more than 6 degrees of curvature (radius 955 feet or larger). On curved track with not more than 6 degrees of curvature that has some superelevation and heavy loads operating at slow speeds, use three spikes per side per tie plate. Use three spikes per side per tie plate on curved track with more than 6 degrees of curvature (radius 955 feet or less). Use four spikes per side per tie plate where traffic, curvature, speed, and superelevation indicate a need, with care being taken to minimize "spike killing" of the tie (i.e., weakening of a tie where spike holes are too close together).

5.4 TIE PLATES. Use tie plates conforming to specifications for hot-worked, high-carbon steel tie plates including 0.20 percent copper. For size and material, see AREA Manual, Chapter 5, Track, Part 1, Tie Plates.

5.5 RAIL JOINT SPACING. Rail joint spacing shall be provided to insure space for expansion of the rail as specified in AREA Manual, Chapter 5, Part 5, Track Maintenance.

5.6 RAIL JOINT BAR. Use high carbon-steel, head-free, head-eased sections as specified in AREA Manual, Chapter 4, Part 1, Design and Part 2, Specifications. For bar punching pattern and application, see AREA Manual, Chapter 4, Rail, Part 1, Design, Table 1, Recommended Rail Drillings, Bar Punchings and Track Bolts.

5.7 BOLTS AND NUTS FOR RAIL JOINT BAR. Use oval neck, heat-treated, carbon steel track bolts and carbon-steel nuts as specified in AREA Manual, Chapter 4, Part 1, Design and Part 2, Specifications. For bolt size and application, see AREA Manual, Chapter 4, Rail, Part 1, Design, Table 1, Recommended Rail Drillings, Bar Punchings and Track Bolts.

5.8 SPRING WASHERS. Use washers conforming to specifications as recommended in the AREA Manual, Chapter 4, Part 2, Specifications for Spring Washers.

5.9 RAIL ANCHORS. Use a one-piece anchor. Anchors shall be used on grades to restrain rail movement in the predominant direction of traffic and to resist temperature expansion. Anchors shall be applied in pairs on opposite rails so that they both bear against either the tie or tie plate. Anchors shall be uniformly distributed along the rail without application on joint ties. See AREA Manual, Chapter 5, Part 5, Track Maintenance. For light density lines, a minimum of 8 rail anchors per a 39-foot section is recommended per AREA Bulletin 709.

5.10 RAIL GAGE RODS. To prevent rail spread and overturning on curves over 10 degrees (574-foot radius), adjustable gage rods (for standard or widened gage) may be used. Gage rods shall not be used as a substitute for competent ties.

5.11 RAIL BRACES. Use braces on rails subject to overturning and, if required, on outside rails on curves of 16 degrees or more (359-foot radius or less).

5.12 GUARDRAILS. Use guardrails as follows:

- Opposite the frog point for protection, except for self-guarded frogs.
- Where derailment is likely.
- Where derailment would be hazardous or costly, such as on steep embankments and bridges.

5.12.1 GAGING. For gaging, see AREA Portfolio of Trackwork Plans, Plan No. 791.

5.12.2 MATERIAL. Relay rail of the same size as the running rail may be used.

5.13 TRACK CONSTRUCTION. Use specifications as recommended in the AREA Manual, Chapter 5, Part 4, Track Construction.

6. RUNNING TRACK GRADE AND ALIGNMENT

6.1 GRADIENT. Track gradients are determined by the cost of construction versus the operating costs. Maximum design gradients should not exceed 3 percent compensated. Steeper gradients, only up to 5 percent compensated may be acceptable. See AREA Manual, Chapter 16, Part 1.

6.2 CURVES. The type and character of equipment that must negotiate the curves, available right of way, desired operating speed and traffic density shall be considered in determining track curvature. The chord definition for curves shall apply for railroad track.

6.2.1 RULING RADII, HORIZONTAL. For design of new tracks and for major track rehabilitation, the maximum degree of curvature shall be 16 degrees (359-foot radius). If a tighter curve than 16 degrees (359-foot radius) is required because of space limitations, prior approval must be obtained. Larger radii, especially less than 10 degree curves (574-foot radius), are desirable and every reasonable effort shall be made to achieve such radii. A spiral curve is desirable between tangents and curves and between the different radii of compound curves on Class 3 or higher tracks. Spirals shall be according to AREA Manual, Spiral Curves, Chapter 5, Part 3. Curves should be designed in terms of degree of curvature, and should be whole degrees of curvature.

6.2.2 REVERSE CURVES. The minimum allowed tangent distance between reverse curves, including crossovers, shall be according to the AREA Manual, Chapter 5, Part 3, Reverse Curves. The desirable tangent distance between reverse curves in yards and terminals should be 100 feet or more.

6.2.3 VERTICAL CURVES. The maximum rate of change should be 0.20 foot per 100 feet in sag curves and 0.40 foot per 100 feet on summit curves. For tracks of lesser importance, such as sidings, rates of change can be relatively large but not greater than practical considerations will permit.

6.3 SUPERELEVATION. Superelevation is generally not required on tracks used at low speeds, i.e., in yards and sidings. Where required, superelevation shall be computed per AREA Manual, Chapter 5, Part 3, Elevations and Speeds for Curves. See AREA Manual, Chapter 5, Table 1 for equilibrium elevations. An unbalanced elevation of 3 inches is recommended on railroads where trains will operate at different speeds. Railroad track shall not be superelevated where common with crane track.

6.4 TRACK CENTERLINE SPACING. Between parallel running tracks, 14 feet shall be provided.

6.5 CLEARANCES. Clearance (horizontal and vertical) shall be in accordance with Plates B, B-1, C, C-1, D, E, and F in AAR Supplement to Manual of Standards and Recommended Practices, which is reproduced in the National Railway Publication Railway Line Clearances. Clearance of fixed obstructions shall be in accordance with AREA Manual, Chapter 28.

7. TURNOUTS AND CROSSOVERS

7.1 TURNOUTS. The geometry of the turnout is governed by the size of the frog. Where commercially owned and operated switching equipment is used, turnouts shall meet the minimum requirements of the connecting railroad. Where owned and operated switching equipment is used, No. 8 frogs should be used. If a smaller than a No. 8 frog is required because of space limitations, No. 7, No. 6, or No. 5 frogs may be used with caution. Spring rail frogs shall not be used.

7.2 CONNECTING CURVES. Connecting curves shall have radii greater than the lead curve.

7.3 CROSSOVERS. Criteria for crossovers are given below:

7.3.1 DESCRIPTION. Crossovers consist of two turnouts from adjacent tracks, connected by a tangent or by reversed curves with a tangent between, and placed between the ends of the frogs.

7.3.2 REVERSE CURVES. Consider reverse curves only because of space limitations.

7.4 TURNOUT LOCATION. No part of the turnout shall be located on a vertical curve.

8. HIGHWAY GRADE CROSSING

8.1 WIDTH OF CROSSING. Crossing widths shall be 4 feet wider on each side than adjacent roadway surface measured at right angles to the highway or as prescribed by local law.

8.2 PROFILE OF CROSSINGS. The surface of the highway shall be in the same plane as the top of the rails for a distance of 2 feet outside of the rails. The top of the rail plane shall be connected with the gradeline of the highway, each way, by vertical curves which satisfy highway requirements for riding conditions and sight distances.

8.3 MATERIALS FOR CROSSING. Materials used are as follows: See AREA Manual, Chapter 9, Part 1, Guidelines for the Construction or Reconstruction of Highway - Railway Crossings.

8.3.1 HEAVILY TRAVELED ROADS. Prefabricated rubber, precast concrete, prefabricated treated timber, or sectional treated timber shall be used. Welded rails should be used through the crossing.

8.3.2 LIGHTLY TRAVELED ROADS. Treated wood plank or bituminous pavement shall be used.

8.4 SIGN, SIGNALS, AUTOMATIC CROSSING GATES, AND FLOODLIGHTING. See U.S. Department of Transportation, Federal Highway Administration, D6.1 Manual on Uniform Traffic Control Devices, Part VIII, "Grade Crossings".

9. TRACKAGE IN PAVEMENT

9.1 HIGHWAY GRADE CROSSING. See Section 8.

9.2 SPECIFICATIONS. Trackage in pavement shall be avoided where practicable. Where unavoidable it should be built as follows: for light to medium traffic conditions the track can be in flexible pavement (ballast, timber ties, and bituminous pavement); and for heavier applications rails set in a rigid pavement should be used. New 115 RE or heavier rails shall be used in all pavement installations. Welded rails should be used through heavily used crossings.

9.2.1 BITUMINOUS PAVEMENT. Provide 7 by 9 inches by 8 feet 6 inch creosoted cross ties on 19 1/2-inch centers. Provide a minimum of 12 inches of well compacted ballast below the ties and in the tie cribs (space between the ties). Care shall be taken to maintain uniform bearing throughout the length of each tie. The bituminous paving material shall be applied in multiple layers with a 2-1/2 to 3-inch wide by 2-inch minimum deep flangeway formed on the gage side of each rail.

9.2.2 CONCRETE PAVEMENT. For new construction or major rehabilitation, tracks constructed in concrete pavement should be built according to the details in Figure 1, Railroad Track Support. Flangeways shall be 2-1/2 to 3-inch wide by 2-inch minimum deep on the gage side of each rail. A gage rod may be substituted for the 3/4-inch diameter tie rod shown in Figure 1.

9.3 TURNOUTS. Switches or frogs should not be installed in paved areas. Where unavoidable, use tongue and mate switches as per AREA Portfolio of Trackwork Plans.

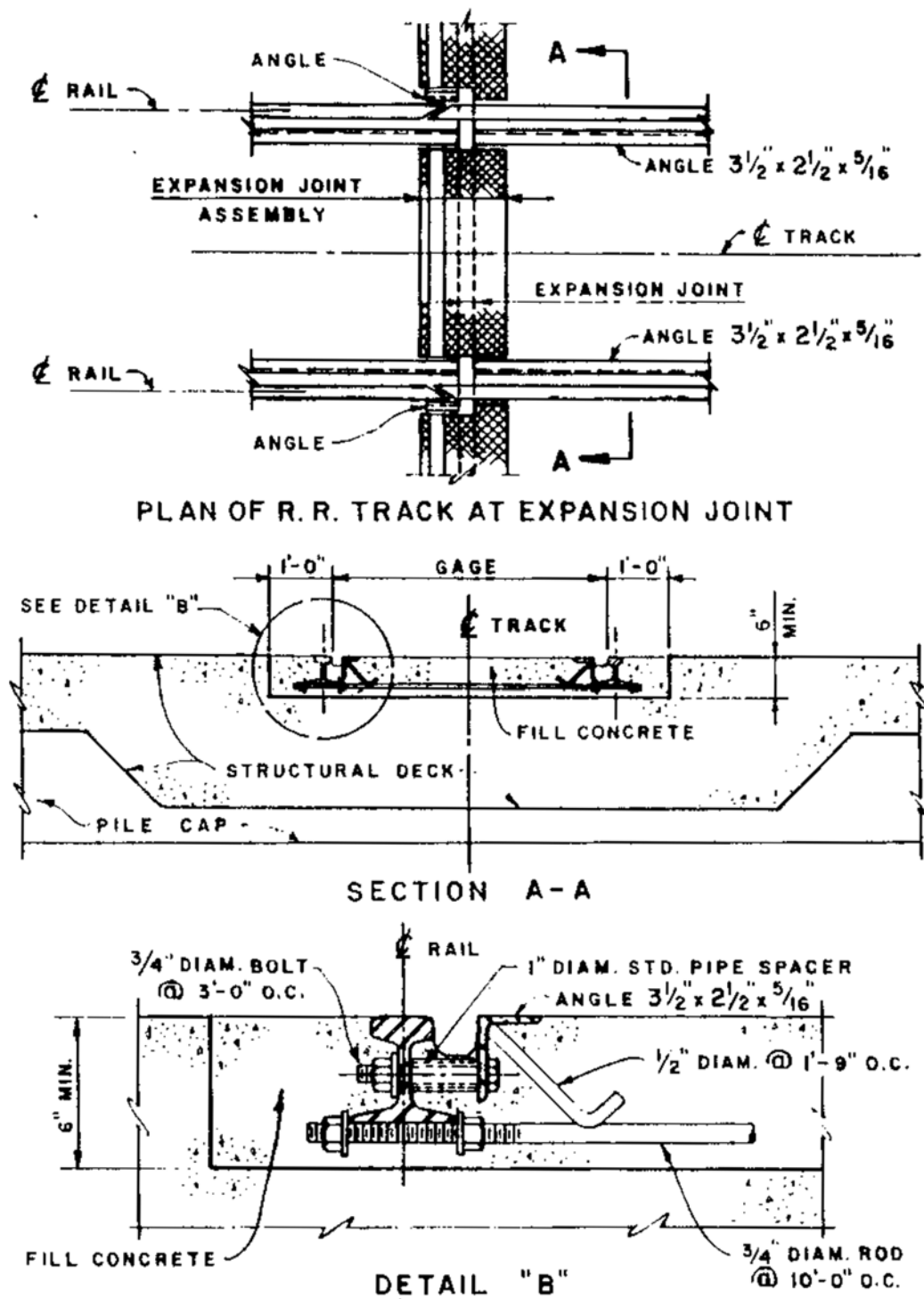


Figure 1
Railroad Track Support

10. SIDINGS

10.1 TRACK CENTERLINE SPACING. Between parallel siding tracks 14 feet shall be provided. Between parallel and mainline tracks 15 feet shall be provided.

10.2 MINIMUM TANGENT DISTANCE. The minimum allowed tangent distance between reverse curves, including crossovers, shall be according to the AREA Manual, Chapter 5, Part 3, Reverse Curves. The desirable tangent distance between reverse curves in yards and terminals should be 100 feet or more.

10.3 GRADIENTS. Level or non-rolling gradients are most desirable. If necessary, a maximum of up to 1.5 percent may be used.

10.4 TRACK ENDS. Track ends shall be provided with stops or bumpers as follows, based on cost and traffic density:

- Commercially available fabricated stops.
- A timber fastened across the rails.

11. WAREHOUSE TRACKAGE

11.1 GRADIENT APPORTIONMENT. The gradient shall be apportioned to make certain that:

- The maximum gradient along warehouse loading platforms shall be 1 percent.
- The maximum gradient along tracks between individual warehouses shall be 3 percent for short distances.
- Crossovers shall not be located on the 3 percent gradient where long trains of cars will be pushed upgrade through the crossovers.

11.2 HORIZONTAL AND VERTICAL CLEARANCES. For clearances to fixed obstructions such as walls, doorways, and platforms, see Section 6, paragraph 6.5 of this handbook and local servicing railroad.

12. TRACK SCALES

12.1 SCALES. There are two types of scales available for weighing cars, static and weight-in-motion. See AAR Scale Handbook.

12.1.1 STATIC SCALE. One car at a time is rolled onto the scale, stopped, and weighed. The scale usually is a beam balance type, but can be a load cell type.

12.1.2 WEIGH-IN-MOTION SCALE. This scale weighs cars coupled together while being pulled over the scale by a locomotive at slow speed. The scale is a load cell type.

12.2 SELECTION. If a scale is necessary, a static scale may be adequate. Weigh-in-motion scales are sophisticated devices used where large numbers of cars are to be weighed each day.

12.3 LOCATION. Scales shall be located to minimize switching.

12.4 ALIGNMENT. A minimum of 100 feet of tangent tracks shall be provided on scale approaches. Gradients should be less than 0.05 percent over a static scale. Weigh-in-motion scales tracks should be level or slightly upgrade allowing the train to be stretched during weighing.

12.5 DEAD RAILS. Where a by-pass track cannot be built around the scale, use dead rails to gauntlet equipment not to be weighed over the scale.

13. YARDS

13.1 SCOPE. Yards are places for the storage and sorting of railroad cars. A freight terminal can also be a railroad yard. Larger yards usually include car and locomotive service and maintenance facilities. Background data for design and layout of yards can be found in the AREA Manual, Chapter 14, Yards and Terminals, and shall be used as a guide for new construction and major rehabilitation.

13.2 GENERAL CONSIDERATIONS. Features of a more general nature are discussed as follows:

13.2.1 FIRE PROTECTION. Hydrants with hose houses shall be located to comply with applicable codes and regulations. Chemical extinguishing systems shall be installed where appropriate to protect against oil and electric fires.

13.2.2 THEFT AND VANDALISM. Protective measures shall be carefully considered in the design of yards.

13.2.3 EFFICIENCY. Yards shall be designed for efficient switching and handling tasks and to minimize delays and demurrage charges.

13.2.4 EXPANSION. Yard layouts shall provide for anticipated future expansion so that the number and length of tracks in them may be increased as required with minimum interference to operation or minimum relocation of existing trackage.

13.2.5 TRACK CAPACITY. In computing track capacity in terms of number of cars, a minimum of 50 feet per car shall be used for all tracks other than those to be used for special equipment.

13.2.6 YARD LIGHTING. Where necessary lighting should be installed following the recommendations of the AREA Manual, Chapter 33, Part 10, Illumination.

13.2.7 DRAINAGE. An adequate drainage system is essential and shall be installed so that it can be easily cleaned and maintained.

13.2.8 COMMUNICATIONS. Facilities such as teletype, pneumatic tube systems, loud speakers, talkback, paging systems, television, telephones, and radios shall be considered to expedite operations.

13.3 TRACK ARRANGEMENTS. Main tracks should not pass through a yard, but should be connected to yard tracks as directly as practicable. Crossovers to facilitate all normal and regular movement in the yard, with minimum interference between the different movements, shall be provided.

13.3.1 BODY TRACKS. A series of parallel tracks which could be part of a storage, repair, receiving, classification, or departure yard shall have a minimum of 14 feet between centers. Where a body track parallels a main or important running track, a minimum of 20 feet between centers shall be provided, subject to state regulations on clearances. See AREA Manual, Chapter 28, Part 3, Section 3.6, Legal Clearance Requirements by States.

13.3.2 LADDER TRACKS. At one or both ends of the body tracks, there is a diagonal track which is called the ladder track which connects the body tracks to a main or running track. The angle the ladder track makes with the body track should equal the frog angle. Where space is a problem, tandem ladder tracks, with angles twice or triple the frog angle, should be used. Ladder tracks shall have a minimum of 15 feet between centers from other tracks. Parallel ladder tracks shall have a minimum of 20 feet between centers.

13.4 GRADIENTS. Wherever practicable, gradients should be level on tracks used for standing of cars. Maximum yard gradients shall not exceed 1.5 percent without prior approval

13.5 REVERSE CURVES. The minimum allowed tangent distance between reverse curves, including crossovers, shall be according to the AREA Manual, Chapter 5, Part 3, Reverse Curves. The desirable tangent distance between reverse curves in yards and terminals should be 100 feet or more.