THESIS.

CEDAR CREEK VIADUCT.

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Candidate for C.E.
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CEDAR CREEK VIADUCT.

The history of this structure dates back to the Civil War when the Confederates burned the bridge then standing to keep Sherman back on his March to the Sea. General Sherman on arriving and finding no means of getting his train load of supplies and ammunition over, set his army to work and soon constructed a rough crossing out of pine timber. The timber was cut near by and bents were roughly framed. Observers state that when the train pulled over the structure it shook considerably and they expected to see the bridge give away under the vibration. However this was a case of emergency and time was the greatest factor in the engineering.

The location of CEDAR CREEK VIADUCT is approximately two miles South of the town of Franklinton, North Carolina and it spans a little valley drained by the two branches of Cedar Creek.

After the war was over the SEABOARD AIR LINE RAILROAD began the construction of a wooden deck span Howe truss with relieving arches as shown on print B-481-2. This was in continuous service until June 1909 when the modern Viaduct was begun, or rather until December of that year when the last span of the new bridge was placed. The old wooden structure was a magnificent piece of workmanship and the material was of the best heart pine obtainable. The parts were framed according to prints and each member fitted as in a steel bridge. There were three spans of 166'-4 1/2", 179'-6", and 166'-11" respectively North to south and these rested on two masonry piers about 48' (forty-eight feet) high and the two abutment bridge seats also of masonry construction. The members were joined by means of bolts and rods and the bearings were fitted with heavy iron castings. For years this bridge stood the strain of heavy railroad traffic and only lately it was found necessary to strengthen same by wooden tower bents as shown on drawings. The yearly inspections showed some broken castings and failure of the upper and lower chords in places. The whole structure had a heavy tin roof and the sides were closed in for protection from the weather. As a result of this precaution the timbers were in a remarkable state of preservation and when torn out were used again for other purposes. The new structure was so designed as to encircle the old masonry piers so that it could be erected without interfering with train movements. One of the most important duties of the Inspector on the work is to keep the track clear at all times or delay regular traffic as little as possible.

After the layout had been made and the lines and levels checked the first thing to be done was to erect wooden bents at points that would clear the foundation work and then remove old bents in the way. No single unsupported bents were allowed and bents braced in towers had to be built as those then in use. This was slow work and had to be done as we went along from pier to pier. Test piles were driven, one on each side of the Creek and far enough away to get the average. The first on the South side gave a hard bottom at a penetration of eighteen feet below the ground while the one on the North side went twenty-six feet before obtaining the same result. We were uncertain then as to what length piles to order but finally decided to get them from twenty to twenty-five feet long.

The specifications called for Long Leaf yellow pine piles eight inches at the point and at least twelve inches at the butt with a gradual taper from end to end. The contractor was afterwards allowed to use the North Carolina pine pile instead and these were found in the neighborhood. Twenty-five piles were driven to the pit except at piers 2-3 and 10-11 which called for thirty to each pit. At piers 10 and 11 both East and West we found rock bottom and hence the piles were here omitted. The rock was first seen to be rotten granite but after working this off the Bridge Engineer accepted the remaining rock as sufficient for a good foundation. A heavy footing was placed on this and the pedestal form built above.

The specifications for the piles called for the following, " All piles must be good sound, straight white oak, long leaf yellow pine or cypress, not less than eight inches in diameter at the small end measured under the bark, and not less than twelve inches in diameter at the large end cut off measured under the bark. All piles shall be of such length and shall be driven to such a depth that the penetration for any blow of the last five blows of a two thousand pound hammer falling freely twenty feet, or its equivalent, shall not exceed one inch." After driving, the piles were cut off square at elevation 27.00 the bark and loose pieces stripped off to the bottom of the pit and two feet of concrete placed solidly around them forming the footing course on which the pedestals were built.

The concrete for the abutment caps was composed of one part Portland cement, two parts sand and four parts crushed stone or gravel to pass a one inch ring. All the other concrete was made of a one, three, five mixture the stone to pass a two and a half inch ring. The Seaboard Standard Specifications require as to cement that one barrel of four bags of cement will be taken at three and three quarters cubic feet of cement and shall not be remeasured. In case the fine material in the aggregate is not uniform so the amount of sand to be added cannot be fixed the Inspector may require all aggregate to be screened over a screen with a one quarter inch mesh- the screened aggregate to be tested for voids and the screenings to be used as sand if suitable. A sample of each car lot was taken - enough from each

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tenth barrel to make up ten pounds- and sent to the Bridge Engr. for test. This was given a seven day test and in case of failure was held for a twenty-eight day test. The contractor has the privelege of taking the risk in case he does not want to wait to hear from the test with the understanding that he will tear out the concrete put up with the cement that has failed to stand the proscribed test. Cement was used on the last four pedestals that was found unsatisfactory on the first test, the contractor taking the risk, but the final test was accepted and none was torn out. The work then was being rushed as the steel men were on the site ready to begin erection and it was necessary to have the bridge in such a shape so that the slow order could be removed by January 4th. when the fast Florida Limited trains were to be put on schedule.

The sand required was to be clean, sharp sand (pit or bank sand preferred)amd might contain small pieces of gravel. It should not contain mica and the grain should not be flakey or flat. In a mixture of one to three it might contain ten percent loam or clay but in less than a one to three mixture it should not contain over one percent clay. The sand used on the CEDAR CREEK VIADUCT substructure was clean, sharp sand taken from the Creek bed and the gravel and trash screened out. A saw mill operating up the stream caused sawdust to be brought down one branch and this one had to be abandoned but sufficient material was obtained in the other to finish the work.

The stone used was clean, hard crushed granite, crushed to pass a two and a half inch ring and free from dust. During the last of the work it was found impossible to obtain stone as specified and gravel was substituted. The concrete was much harder on the forms, it was noted, when gravel was used in place of the stone. Before we had no trouble in keeping our forms

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from bulging but just as soon as we began using the gravel the trouble began and we had to put extra braces on to hold them in place.

The concrete was mixed by machine, the old style Ransome mixer being used, and everything was carefully measured so as to obtain the proper proportions. Each batch was mixed separately as continuous and gravity mixing is not allowed. It was required that the concrete when mixed ready for laying should be of such consistancy as to quake slightly before ramming yet stiff enough to retain its shape in the barrow but soft enough not to require much tamping. The concrete was deposited in layers about six inches thick each layer, when possible, being completed before the next was begun. When unable to complete a layer a stop plank was placed vertically where the layer ended temporarily and the concrete filled and tamped solidly against it. When more than one layer was incomplete stop planks were to be put not less than three feet back of the last one. The layers were kept as nearly horizontal as possible and in case that the work was stopped for some length of time (due to lack of material or breakdowns, weather etc.)the top surface all around the outer edge was carefully finished so that when the work was continued the point between the old and the new concrete would show only as a straight line. Bars of iron, bolts etc. were also imbedded in the concrete and left out six or eight inches so as to form a bond between the old and new work. This precaution had to be taken on several occasions when the mixer was out of running order or when short of material.All concrete was deposited by means of spouts or dumped from barrows when impossible to reach the pit with spout. A special dump car operating on an inclined track carried the concrete from the mixer to the forms and dumped same into a hopper from which it was spouted to the

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forms. It was so delivered as not to require much rehandling except to level off. It was rammed sufficiently so as to insure the filling of all voids, but in most cases it was mixed so as not to require much tamping. All horizontal or inclined exposed surfaces not formed by molds, such as tops of piers, bridge seats back walls, parapet walls, wing walls, etc. were finished by a float and trowel to an even surface on the original concrete without the use of floating mortar. All chamfered corners were finished in a similar way.

Four anchor bolts for the steel superstructure were set in each pier and the accurate setting of these caused no little trouble. Templates of quarter inch steel were furnished by the steel company with the center lines etched on the plates and these were fastened to the forms and set to the proper lines. The bolts were placed and held thus in position until the concrete had begun to set. A space was left around each bolt by means of small forms so as to allow shifting if necessary to fit the steel shoes on the columns.

The forms were made up of inch boards dressed one side and both edges and reinforced with two by four studding about eighteen inches on centers. The forms were well constructed and bolted together in such a way that they could be easily removed without injury and used again as most of the piers were similar in design and size. Wooden collars of four by four timber were placed over the forms to stiffen them against the weight of the concrete. In some cases the concrete was hard to hold and the form was slightly sprung and it was necessary to put up extra braces to bring it back in shape. All angles were finished with a three inch chamfer by nailing moulding in the corners of the forms and this made a neat appearance to the finished pier. After thirty six hours the forms could be removed and all rough

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places smoothed up and the whole pier washed with cement.

The reinforcement for all piers and the two bridge seats consisted of a steel of three inch number ten gauge expanded metal placed not less than three inches from the top and faces of the piers. In the two abutment caps were placed the two series of rods crossing each other as shown in the drawings so as to take care of the overhang.

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Diary Of Work.

June 18th. - Foreman on grounds , unloaded tools and equipment.

July 10th. - Removing old timber and erecting new.
Building tram track , stone chute etc.

July 20th. - Sheet piling and excavating.

July, 21st.- Driving piles, building forms.

Aug. 19th. - Began Concreting.

Nov. 15th. - Finished concreting, started to unload steel.

Nov. 24th. - Began Steel Erection.

Dec. 24th. - Last Span placed.

Dec. 15th. - Started riveting on girders.

Jan. 27th. - Riveting finished.

Feb. 1-28th. Tearing out old structure, grouting base plates,
Painting.

Mch. 10th.- Old timber removed and painting finished.
Viaduct turned over to the Railroad.
Final Inspection.
Accepted.

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STEEL.

This viaduct is a deck girder structure consisting of six main spans and five tower spans, the two end spans being 60'-11" long, the rest 60'-00" long and the tower spans 30'-00" each, making eleven spans in all. The approximate total weight of girders and columns is roughly five hundred tons and there were thirteen thousand field rivets to be driven. The rivets with the exception of some of the top laterals on the sixty foot girders were driven with air hammers and at first because of poor equipment in the line of hammers many had to be cut out and be redriven. At the tower bases alone one hundred and forty were cut out for being loose and off the metal.

The bents were constructed of two columns braced together transversely and the towers formed of two bents braced together longitudinally. The towers and bents have horizontal struts at caps and bases and at a sufficient number of intermediate points to make the angle of the member to the vertical as near forty-five degrees as practicable. The transverse struts intersect the columns at the same elevation as the longitudinal struts. The two large towers 4-5 and 8-9 encircling the old masonry piers have transverse plate girders riveted to the tops of the columns. These girders are 5'-6 1/2" back to back of angles, the distance center to center of columns being 19'-6". Hence the webs were 66"x3/8"x19'-6 5/8" and the rivets were spaced about 3 1/2" center to center. The stiffeners consisted of four angles 3 1/2" x 3 1/2" x 3/8"-5' - 5 1/2" longand two fillers 7" x 1/2" and 4'- 6 1/2"long. The girders had one cover plate 20" x 7/16" x 18'- 1 7/8" at the top and 20" x 7/16" x 14'-00" at the base. The end batter of the girders being the same as that of the columns to which connections were made. The lateral bracing consisted of one angle section 5" x 3 1/2" x 3/8" riveted to plate connections.

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The main girders were 6'-1/2" deep and 59'-11" out to out of steel, the extra inch being allowed for expansion. The web was six feet deep and three eights of an inch thick and the angles were 6" x 6" x 5/8"and 59'-11" long. The stiffening members were spaced 3'-11 1/4", 4'-1 1/4", 4'0 3/4" 5'-8 3/4", and 6'-01/4" and reversely to the far end of the girder. These were made up of two angles each 5" x 3 1/2" x 3/8". The laterals were made up of one angle section 6" x 4" x 3/8" and connected to the girders by plates. The approximate weight of the steel in one of the sixty foot girder spans is fourteen tons.

The longest columns were at the towers 4-5, 6-7 and 8-9 and these were 60'-1 11/16" from milled end to milled end. on the center line of the column. They were built up of two channel sections and plates with lattice bars of 2 1/2" x 3/8" in dimensions. The distance back to back of channels is ten inches, the out to out dimension being fourteen inches. All towers were arranged for future connections to serve as supports for extra girders to be placed for a double track. The towers 4-5 and 8-9 are already wide enough to carry the extra girders but the remainder require extra columns as shown on prints. The lattice bars were placed at an angle of forty - five degrees and the rivets were spaced from three and a quarter to four and a half inches center to center.

The erection of this work was done by the Pennsylvania Steel Company of Steelton, Pa., and the structure was also built by them. The entire work was handled by one derrick car having a fifty ton capacity and it could boom out and pick up a load at a distance of one hundred and seven feet. The boom was collapsable and could be shortened for close work. The car had one engine that had to do the propelling as well as the hoisting and this fact caused considerable strain on the friction.

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SUMMARY OF GENERAL SPECIFICATIONS.

Viaducts shall be riveted structures with no adjustable members, consisting in general of alternate tower and intermediate plate girder spans. Consecutive spans supported by single bents shall be generally avoided.

There shall be a footwalk on one side formed by nailing two lines of two inch plank twelve inches wide on each second tie extended for the purpose. The walk shall be protected by a gas pipe railing two feet six inches high above the walk, made of one and one halh inch pipe posts, securely bolted to every eighth tie, carrying two lines of one and one quarter inch pipe railing. Posts shall be made of one piece of pipe without joints, and rails shall be secured to posts with malleable pipe fittings threaded to the rails. The railing shall be set nine feet from the center of the track.

Bents shall usually be constructed of two columns braced together transversely. Towers shall be formed of two bents braced together longitudinally. Towers and bents shall have horizontal struts at caps and bases, and at sufficient number of intermediate points to make the angle of the bracing with a vertical line as near forty-five degrees as practicable, care being taken to have the transverse struts intersect the columns at the same elevation as the longitudinal struts where possible. Longitudinal and cross girders may be made to act as struts.

Splices in columns must be proportioned for total stresses and must be located above and as near to a longitudinal strut as possible.

Girders connecting bents together shall be securely riveted to tops of columns at each end, and free girders shall be provided with an approved expansion joint at one end. In double track

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viaducts the inner lines of girders shall preferably be supported by cross girders. Cross frames shall be used at each end of each pair of girders, but shall not be common to two adjacent spans. In single track viaducts, the width center to center will usually be six feet six inches. Girder spans shall conform to sectionX.

In each tower two bases diagonally opposite, shall be fixed and the two remaining bases shall be free to move horizontally in a direction parallel to the diagonal line drawn through the center lines of the two movable bases. The lower story of such towers shall be of such a height that the temperature movement of the sliding bases shall be less than one sixteenth of an inch for each foot of vertical height of the lower story. Such towers shall not have horizontal diagonal members below the top of the lower story.

Loose bed plates not less than seven eighths of an inch thick shall be placed under the foot of each column. Anchor bolts arranged so as not to interfere with the expansion and contraction shall be furnished of proper size and length to engage a mass of masonry the weight of which is at least one and one half times the uplift.

When single bents are used, if the top of the bent may move from temperature changes, one sixteenth of an inch or more per foot of vertical height of bent, the columns of the bent shall be hinged at the top and bottom.

LOADS.

The dead load shall consist of the entire weight of the suspended structure. For bridges under three hundred feet span the dead load shall be considered as concentrated two-thirds on the loaded and one third on the unloaded chord. For longer spans the distribution of the dead load shall be determined by calculation. Rails and their fastenings shall be taken as one

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Loads.

hundred pounds per linear foot of track, ballast at one hundred pounds per cubic foot, and timber at four and one half pounds per foot board measure.

Unless otherwise specified, the live load for each track shall consist of two typical engines followed by a uniform train load according to Cooper's series E-50.

The dynamic increment of the live load shall be added to the maximum computed live load stresses and shall be determined by the formula,

$$I = S\left(\frac{300}{L + 300}\right)$$

in which I is the increment to be added to live stress

S = the computed maximum live static stress

L = the loaded length of track in feet producing the maximum live stress in the member. For bridges carrying more than one track, the aggregate length of all tracks producing the stress shall be used.

In solid floor structures the impact stresses as determined by the above formula shall be reduced by the dead stresses due to the solid floor and ballast. Impact shall not be added to stresses produced by longitudinal, centrifugal, or wind forces.

Lateral bracing when alignment is straight, shall be proportioned for a lateral force on the loaded chord of two hundred pounds per lineal foot plus ten per cent of the specified uniform train load on one track, and two hundred pounds per lineal foot on the unloaded chord, all forces considered as moving.

When alignment is curved, there shall be added to the above lateral forces, a moving lateral force along the line of the loaded chord of three and one half per cent of the specified uniform train load for each degree of curvature up to the maximum of five degrees.

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In viaduct towers, the transverse bracing shall be proportio -ed for the lateral forces given above and in addition for a lateral force of one hundred pounds per foot of height of each bent. For determining the anchorage, train load shall be assumed as one thousand pounds per lineal foot of track.

Viaduct towers and similar structures shall be designed for a longitudinal force applied to the rail amounting to twenty per cent of the live load.

Proportion of Parts.

Assumed length for calculations shall be taken as the distance center to center of end bearings for girders and trusses, center to center of trusses for floor beams, and center to center of floor beams for stringers.

In calculating stresses from a uniform load, the load shall cover the panel in advance of the point considered, but that part going to the forward point is to be neglected.

When the track is curved, both inner and outer trusses or girders are to be alike, and are to be figured for the distribution of the live load as determined by the reactions at each panel point taking into consideration the eccentricity of the center lines of the track and bridge.

Each floor beam and stringer is to be figured for the maximum live load to which it will be subjected. Stringers are to be set as nearly symmetrical with the track as possible.

Plate girders shall be proportioned either by the moment of inertia of their net section, or by assuming that the flanges are concentrated at their centers of gravity. One eighth of the gross section of the web if continuous the full length of the girders, may be used as flange section.

The gross section of the compression flange shall not be less than the gross section of the tension flange, and the width

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of the flanges shall not be less than one twelfth of the distance between lateral supports.

The flanges of plate girders shall be connected to the web with a sufficient number of rivets to transfer the total shear at any point in a distance equal to the effective depth of the girder at that point combined with any load that is applied directly on the flange. The wheel loads, where ties rest on the flanges, shall be assumed to be distributed over three ties.

Members subjected to the action of both transverse and direct stresses shall be proportioned so that the combined fiber stress in either tension or compression will not exceed the allowed limits.Members under flexure shall be considered as independent beams of one panel length, or if continuous, the bending moments at points of support are to be assumed equal and opposite to those at the center of the panel.Proper amount of impact must be added to each kind of stress.

Members and their connections subjected to alternate stresses of tension and compression shall be proportioned to resist each kind of stress, but each stress shall be considered as increased by an amount equal to eight- tenths of the smaller when determining the sectional area. Whenever the live load and dead load stresses are of an opposite character, only seventy per cent of dead stress shall be considered as effective in counteracting the live stress.

For stresses produced by longitudinal and lateral or wind forces combined with those from live and dead load and centrifugal forces, the unit stresses may be increased twenty-five per cent over those given below, but the section shall not be less than required if the longitudinal and lateral or wind forces be neglected.

When a double system of lateral bracing is used , it shall be assumed that both systems will be effective , when extreme lengths of the compression members do not exceed one hundred and twenty times their least radius of gyration. Diagonal sway braces in deck bridges will be proportioned to carry one half the maximum stress increment due to wind and lateral forces.

The center of bearings of stressed members are to be considered as the points of application of loads on pins when determining bending moments. The diameter of pins shall not be less than three fourths of the width of the widest bar attached. Heads of eyebars must not be less in strength than body of bar.

Pin connected riveted tension members shall have a net section through the pin hole at least twenty-five per cent in excess of the net section of the body of the member, and the net section back of the pin hole parallel with the axis of the member shall not be less than the net section of the body of the member.

In proportioning rivets, the nominal diameter of the rivet before it is driven shall be used.

The net section of any tension member or flange shall be determined by a plane, cutting the member square across at any point. The greatest number of rivet holes which can be cut by the plane, or come within an inch of the plane, is to be deducted from the gross section. Holes are to be taken one eighth inch greater than diameter of rivets.

No column shall have a length exceeding forty diameters, or value $\frac{l}{r}$ exceeding one hundred for main members, or one hundred and twenty for wind bracing.

No material shall have a less thickness than three-eighths of an inch. In posts of through bridges, no channel whether built or rolled shall be less than twelve inches wide. The smallest angle allowed will be 3 1/2 in. x 3 in. x 3/8 in.

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All parts of structures shall be so proportioned that the sum of the maximum stresses shall not exceed the following amounts per square inch except as modified above *

Tension 17,000 pounds per square inch.

$$\text{Compression} = \frac{17,0000}{1 + \frac{l^2}{11,000\ r^2}} \text{ Pounds per square inch.}$$

Shear on shop rivets and pins, 12,000 pounds per square inch.

Shear on field rivets and turned bolts 10,000 lbs. " "

Shear on webs, gross section, 10,000 pounds per " "

Bearing on pins and shop rivets, 24,000 " " " "

" " field rivets and turned bolts, 20,000 lbs." "

Fiber stress on pins, 24,000 pounds per square inch.

Expansion bearings on flat surfaces, 2,000 lbs. per " "

Expansion bearings on rollers, 600 d per lineal inch.

Bearing on concrete, 600 pounds per square inch.

Bearing on granite masonry, 600 pounds per square inch.

Bearing on sandstone and limestone, 300 pounds per square inch.

l is the length of the member in inches.

r is the least radius of gyration in inches.

d is the diameter of roller in inches.

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Details of Design.

Structures shall be so designed that all parts will be acessible for inspection, cleaning and painting.

Pockets or depressions which would hold water shall be filled with Portland cement mortar or other approved material.

Main members shall be so designed that the neutral axis will be as nearly as practicable in the center of the section, and the neutral axis of intersecting main members of trusses shall meet at a common point.

Rigid counters are preferred, and where subject to reversal of stress, shall preferably have rigid connections to the chords. Adjustable counters shall have open turnbuckles.

The strength of connections shall be sufficient to develop the full strength of the member, even though the computed stress is less, the kind of stress to which the member is subjected being considered.

The minimum thickness of metal shall be three-eighths of an inch except for fillers.

The minimum distance between centers of rivet holes shall be three diameters of the rivet, but the distance shall preferably be not less than three inches for seven-eighths inch rivets, and two and a half inches for three-quarter inch rivets. The maximum pitch in the line of stress for members composed of plates and shapes shall be six inches for seven-eighths inch rivets and five inches for three-quarter inch rivets. For angles with two gage lines and rivets staggered the maximum shall be twice the above in each line. Where two or more plates are used in contact, rivets not more than twelve inches apart in either direction shall be used to hold the plates well together. In tension members composed of two angles, a pitch of five times the width of the riveted leg of the angle will be allowed for riveting the angles together.

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The minimum distance from the center of any rivet hole to a sheared edge shall be one and one half inches for seven-eighths inch rivets, and one and one-quarter inches for three-quarter inch rivets, and to a rolled edge one and one-quarter and one and one-eighth inches respectively. The maximum distance from any edge shall be eight times the thickness of the plate, but shall not exceed six inches.

The diameter of the rivets in any angle carrying calculated stress shall not exceed one quarter of the width of the leg in which they are driven. In minor parts, seven-eighths inch rivets may be used in three inch angles, and three-quarter inch rivets in two and a half inch angles.

At ends of all built sections, the pitch of rivets shall not exceed four diameters for a length equal to one and one-half times the maximum width of the member.

In compression members, the metal shall be concentrated as much as possible in webs and flanges. The thickness of each web shall not be less than one sixtieth of the distance between its connections to the flanges. Cover plates shall have a thickness not less than one sixtieth of the distance between rivet lines.

Flanges of girders and built members without cover plates shall have a minimum thickness of one-twelth of the width of the outstanding leg.

The open sides of compression members shall be provided with lattice and shall have tie plates as near each end as ~~pos-~~ practicable. Tie plates shall be provided at intermediate points where the lattice is interrupted. In main members, the end tie plates shall have a length not less than the distance between the lines of rivets connecting them to the flanges, and intermediate ones not less than one-half this distance. Their thickness shall not be less than one fiftieth of the same distance.

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The minimum width of lattice bars shall be two and one half inches for seven-eighths inch rivets, two and one-quarter inches for three quaretr inch rivets and two inches if five-eighths inch rivets are used. The thickness shall not be less than one-fortieth of the distance between end rivets for single lattic and one-sixtieth for double lattice. Shapes of equivalent strength may be used.

The inclination of the lattice bars with the axis of the members shall not be less than forty-five degrees, and when the distance between the rivet lines in the flange is more than fifteen inches, if single rivet bar is used, the lattice shall be double and riveted at the intersection.

Lattice bars shall be so spaced that the portion of the flange included between their connections shall be as strong as the member as a whole.

Abutting joints in compression members when faced for bearing shall be spliced on four sides sufficiently to hold the connecting members accurately in place. All other joints in riveted work, whether in tension or compression, shall be fully spliced.

Pin holes shall be reinforced by plates when necessary and at least one plate shall be as wide as tha flanges will allow and be on the same side as the angles. They shall contain sufficient rivets to distribute their portion of the pin pressure to the full cross-section of the member. Plates shall be so placed that the center of pressure on the pin shall coinside as nearly as possible with the center of gravity of the segment to which the plates are riveted.

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Details of Design.

Forked ends on compression members will be permitted only where unavoidable; where used, a sufficient number of pin plates shall be provided to make the jaws of twice the sectional area of the member. At least one of these plates shall extend to the far edge of the farthest tie plate and the balance not less than six inches beyond the nearest edge of the same plate.

Pins shall be long enough to insure a full bearing of all parts connected upon the turned body of the pin. They shall be secured by the chambered nuts, or be provided with washers if solid nuts are used. The screw ends shall be long enough to admit of burring the thread.

Members packed on pins shall be held against lateral movement. Where members are connected by bolts, the turned body of these bolts shall be long enough to extend through the metal.

Rivets carrying stress and passing through fillers shall be increased fifty- per cent in number; and the excess rivets, when possible, shall be outside of the connected member.

The eye bars composing a member shall be so arranged that adjacent bars shall not have their surfaces in contact; they shall be as nearly parallel to the axis of the truss as possible the maximum inclination of any bar being limited to one inch in sixteen feet.

Spans of eighty feet or over resting on masonry shall have turned rollers or rockers at one end; and those of less length shall be arranged to slide on smooth surfaces. Fixed bearings shall be firmly anchored to the masonry.

The bolsters or shoes of all spans shall be so designed that the bridge seats will be level and the distance from base of rail to bridge seat will be alike at both ends of the span.

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Material.

Steel shall be made by the open hearth process.

If the ultimate strength varies more than four thousand pounds from that desired, a retest shall be made on the same gage which, to be acceptable, shall be within five thousand pounds of the desired ultimate.

Chemical determinations of the percentages of carbon, phosporus, sulphur, and maganese shall be made by the manufacturer from a test ingot taken at the time of the pouring of each melt of steel, and a correct copy of such analysis shall be furnished to the Engineer or his Inspector. Check analyses shall be made from finished material, if called for by the Company, in which case an excess of twenty-five percent above the required limits will be allowed.

Rivet rods shall be tested as rolled.

At least one tensile and one bending test shall be made from each melt of steel as rolled. In case material differing three-eighths of an inch and more in thickness is rolled from one melt, a test shall be made from the thickest and thinnest material rolled.

Bending tests may be made by pressure or by blows.

Rivet steel, when nicked and bent around a bar of the same diameter as the rivet rod, shall give a gradual break and a fine silky uniform fracture.

Finished material shall be free from injurious seams, flaws cracks, defective edges or other defects, and have a smooth, uniform and workmanlike finish. Plates thirty-six inches in width and under shall have rolled edges.

Every finished piece of steel shall have the melt number and the name of the manufacturer stamped or rolled upon it. Steel for pins and rollers shall be stamped on end. Rivet and lattice steel and other small parts may be bundled with the above marks on an attached metal tag.

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Material.

Material which subsequent to the above tests at the mills and its acceptance there, develops weak spots, brittleness, cracks or other imperfections, or is found to have injurious defects, will be rejected at the shop and shall be replaced by the manufacturer at his own cost.

A variation in weight or cross section of each piece of steel of more than two and one-half per cent from that specified will be sufficient cause for rejection, except in case of sheared plates which will be covered by permissible variations.

Plates will be accepted if they measure not more than one hundredth of an inch below the ordered thickness.

The manufacturer shall furnish all facilities for inspecting and testing the weight and quality of all material at the mill where it is manufactured. He shall furnish a suitable testing machine for testing the specimens, as well as prepare the pieces for the machine free of cost.

When an Inspector is furnished by the Company to inspect material at the mills, he shall have full access at all times to all parts of the mills where material to be inspected by him is being manufactured.

Workmanship.

All workmanship and finish shall be strictly first class in every particular. All portions of the work exposed to view shall be neatly finished.

The several pieces forming one built member must fit closely together, and when riveted shall be free from twists, bends or open joints. All holes in flanges of beams and channels must be neatly drilled.

Drifting for purpose of enlarging holes will not be permitt-ed in shop or in field. If rivets will not enter, the hole must be reamed. If necessary larger diameter rivets must be used in such reamed holes.

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Workmanship.

Where reaming is required, the punch used shall have a diameter not less than 3-16 inch smaller than the nominal diameter of the rivet. Holes shall then be reamed to a diameter not more than 1-16 inch larger than the nominal diameter of the rivet. All reaming shall be done with twist drills.

Rivets shall look neat and finished , with heads of approved shape , full and of equal size. They shall be central on shank and grip the assembled pieces firmly. Recupping and calking shall not be allowed. Loose, burned or otherwise defective rivets shall be cut out and replaced. In cutting out rivets, great care shall be taken not to injure the adjacent metal. If necessary they shall be drilled out.

All rivets when driven must completely fill the hole the heads to be in full contact with the surface, or countersunk when required.

Whenever possible all rivets shall be machine driven. Power riveters shall be direct acting machines, worked by steam, hydraulic pressure or compressed air.

Spliced joints whether in tension or compression shall have abutting ends dressed straight and true. All pins or bolts in shear or rollers shall be turned true to gage; sliding surfaces of bed plates and bearings shall be planed. Ends of stiffners shall be made to come to a snug fit under the flanges. The ends of all stringers and floor beams shall be faced off true and square.

Material shall be thoroughly straightened in the shop by methods that will not injure it before being laid off or worked in any way.

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Workmanship.

The size of rivets on the plans shall be understood to mean the actual size of the cold rivet before heating.

The outside burrs on reamed holes shall be removed.

Web splice plates and fillers under stiffners shall be cut to fit within one-eighth inch of the flange angle.

Lattice bars shall have neatly rounded ends unless otherwise called for.

All steel castings shall be annealed. Welds in steel will not be allowed. Field rivets shall be furnished to the amount of fifteen per cent plus ten rivets in excess of the nominal number required for each size.

Painting.

Unless otherwise specified, all material must be painted at the shop one good coat of pure red lead and linseed oil. freshly mixed. well worked into all joints and open spaces.

In riveted work, surfaces coming into contact shall be painted beforebeing riveted together.

Pieces which are not accessible after erection shall have two good coats in the shop.

Painting shall be done only when the surface of the metal is perfectly dry. It shall not be done in wet or freezing weather, unless protected under cover.

Machine finished surfaces shall be coated with white lead and tallow before shipment.or before being put into the open air.

Special ready mixed paint, when specified, shall be delivered and kept in the original package, and shall be used in the condition in which received from the manu-

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Painting.

facturer without the addition of any substance. Each pack -age shall bear the manufacturer's label and the seal shall not be broken until the paint is used on the work.

After erection the metal shall be cleaned carefully and thoroughly and painted two coats of paint of the kind and color specified.The first field coat must be dry before the second is applied and after the finishing coat the surface must present a neat appearance as required by first class work.

Erection.

Contractor for erection shall submit drawings and description of the method of erection he proposes to pursue. These plans must be approved by the Bridge Engineer before work is commenced.

The erection of any structure will generally include unloading the material after delivery; the furnishing, placing and removing of all falsework for support of both existing and new structure, storing at site, or loading same on cars, as may be directed; framing and placing tie and guard rails; furnishing special paint and painting all steel work two coats . Also drilling of masonry and setting anchor bolts in Portland cement.

The Company , unless otherwise agreed, will furnish ties and guard rails amd make any changes required in masonry to fit new bridge.

The Contractor shall so conduct his work as not to impede the operations of the road, interfere with the work of other contractors or close any thoroughfare on land or water. Erection must be carried on in a manner and with dispatch satisfactory to the Engineer.

The Contractor shall assume all risks from floods,

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Erection.

and storms, damage to persons and properties, and casualities of every description until the final acceptance of the completed structure.

When old structures are in condition to be used again, they must be dismantled without damage or loss of parts.

Where bolts are used to connect parts, all nuts must be effectively locked by checking the threads.

The threads of all pins shall be protected by pilot and driving nuts while being driven in place, the necessary nuts to be furnished by the manufacturer with the steel work. These nuts are to be delivered to the Railroa Company by erecting contractor upon the completion of the work.

When free transportation for men and tools is provided for in the invitation and contract for the work such free transportation shall be conditional upon application being made to the Bridge Engineer a sufficient time in advance to enable him to make proper arrangements.

Shipments entitled to above free transportation must be consigned in the manner directed and must have all charges prepaid to point of delivery on the tracks of the Seaboard Air Line.

Before shipping outfit to site, the contractor must obtain written authority to proceed with the work, or otherwise be solely responsible for all expenses occasioned by any holdup due to unfinis hed masonry or approaches or other conditions.

Cars must be released promptly upon their delivery or Contractor will be required to pay regular demurrage

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Erection.

charges.

The Company may require the Contractor to furnish a bond from an approved bonding company for a sum equal t to twenty-five per cent of the amount of contract, or such part thereof as the Company may consider necessary to fully protect its interests.

Inspection.

The Company will have properly qualified Inspectors to examine materials, shop work and erection. This inspection is for the protection of the Company and shall no not be considered as relieving the Contractor of his responsibility for furnishing good materials and accurate work of the character required by these specifications.

The Company will be furnished complete shop plans and must be notified well in advance of the start of the work in the shop in order that it may have an Inspector on hand to inspect material and workmanship. Complete copies of shipping invoices shall be furnished to the Company for each shipment.

The Engineer or Inspector shall have free access to all parts of the mills or manufacturing establishments in which any portion of the workmanship is executed or materials made.

The Inspector shall stamp each piece accepted with a private mark. Any piece not so marked may be rejected at any time and at any stage of the work. If the Inspector, through an oversight or otherwise , has accepted material or work which is defective or contrary to the specifications, this material no matter in what stage of completion may be rejected by the Company.

Full sized parts of the structure may be tested at

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Inspection.

the option of the Company. If tested to destruction , such material shall be paid for at cost, less its scrap value if it proves satisfactory.

If it does not stand the specified tests, it will be considered rejected material, and be solely at the cost of the contractor, unless he is not responsible for the cause of the failure.

Extra Work.

If, during the progress of the work under these specifications, it shall be necessary to furnish any materials or labor not contemplated by the original contract, which cannot , in the opinion of the Engineer, be furnished under the terms of the contract, such materials and labor shall be furnished by the Contractor at actual cost for labor and materials plus a percentage to be agreed upon.

Daily reports of such labor shall be mailed each day to the Bridge Engineer, giving the name of each man employed on such work, his rate per hour, the number of hours worked and the work done. These reports shall be signed by the foreman in charge of the work and the Inspector.

Bills for such labor shall be sent in duplicate to t the Bridge Engineer and shall be accompanied by payrolls showing the amount paid to the men. Such payrolls shall b be signed by each man.

Extra material furnished shall be billed at the end of each month. Bills in duplicate shall be sent to the Bridge Engineer and shall be accompanied by satisfactory voucher showing the amount and cost of materials.

E.A.F.--B.E.
W.L.S.--C.E.

Respectfully submitted by Charles E. Dexter
April - 1910.